Connecting SEERNet and Improvement Science to Pursue Better Outcomes in Schools

Co-Authors: Jojo Manai and Jeremy Roschelle

November 2024

Abstract

In every school, dedicated teachers strive to support their students' unique learning journeys. Imagine a classroom where potential challenges are quickly identified and met with precise interventions. Imagine a school or school district where the many potential ways to solve problems can be quickly tested, and the best solutions rapidly scaled up across the district. We explore how this vision can become a reality through the integration of Improvement Science with SEERNet's data and research capabilities. Improvement Science offers a structured approach to identifying and solving problems. SEERNet—a network of digital learning platforms, researchers, and educators—provides a method to use evidence to compare alternative approaches to supporting students on the basis of detailed data from students' experiences in digital learning platforms.

However, this vision cannot be realized in isolation. Collaboration between researchers and practitioners is vital for improving student outcomes. Researchers contribute theoretical knowledge and empirical skills, while practitioners bring on-the-ground professional experience and knowledge about what works for their students. Working together, they can advance how educational technologies are used for student learning in ways that are research based, practical and relevant.

This white paper explores how and why SEERNet could be combined with Improvement Science methodologies. We delve into the collaborative power of Networked Improvement Communities (NICs), a core method in Improvement Science. We then examine the dynamic interplay between SEERNet's approach and Improvement Science. A scenario illustrates how a school district could use Terracotta, a platform that enables research within a popular LMS, to address reading comprehension barriers in STEM subjects for English learners and students with disabilities. Researchers and teachers collaborate to test assignment modifications, such as adding text-to-speech tools and steps to clarify questions. Using iterative Plan-Do-Study-Act (PDSA) cycles, they refine these strategies based on data, resulting in improved outcomes. The paper concludes with five recommendations: fostering collaboration, enhancing data sharing, leveraging root cause analysis, implementing iterative improvements, and scaling successful interventions.

Acknowledgements

We would like to thank the SEERNet research teams and digital learning platforms for their valuable contributions and review of this paper. Special thanks to Ben Motz and Harmony Jankowski for their insights, as well as the dedicated staff at Digital Promise and Empirical Education, whose feedback and support were instrumental in this work.

Suggested Citation:

Manai, J., & Roschelle, J. (2024, November). *Connecting SEERNet and Improvement Science to Pursue Better Outcomes in Schools*. Digital Promise. https://doi.org/10.51388/20.500.12265/234

This project is supported by the Institute of Education Sciences, U.S. Department of Education through Grant R305N210034 to Digital Promise. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

Table of Contents

Purpose and Scope

To improve how school technologies enable every student's learning journey, we explore the advantages of combining the strengths of Improvement Science with the advanced analytic capabilities of SEERNet's five digital learning platforms (DLPs). This white paper evaluates the potential benefits and challenges of this integration, emphasizing collaboration between researchers and practitioners. By merging the disciplined methodologies of Improvement Science with SEERNet DLPs' intensive data, researchers and practitioners can work together toward more effective and equitable educational outcomes.

The purpose of this white paper is to:

- Introduce the principles, relevance, and utility of Improvement Science in guiding improvement efforts.
- Provide a concise overview of the new capabilities being developed by SEERNet's digital learning platforms.
- Explore the synergies and benefits of integrating these approaches.
- Identify challenges to and recommendations for successful integration.

Introduction to Improvement Science

What Is Improvement Science?

Improvement Science is a systematic approach to identifying and solving educational problems through iterative testing, data collection, systematic reflection, and refinement. It focuses on enhancing processes and systems within education to achieve better outcomes for all students. This approach recognizes that educational systems are complex and dynamic, requiring methodical and reflective strategies to address challenges effectively.

Why Is Improvement Science Important?

Improvement Science provides a framework for continuous improvement. By engaging in cycles of inquiry, reflection, and action, educators can identify root causes of problems, prototype and test solutions, and refine practices based on data. This iterative process ensures that interventions are evidence-based and continuously improved to meet the evolving needs of students.

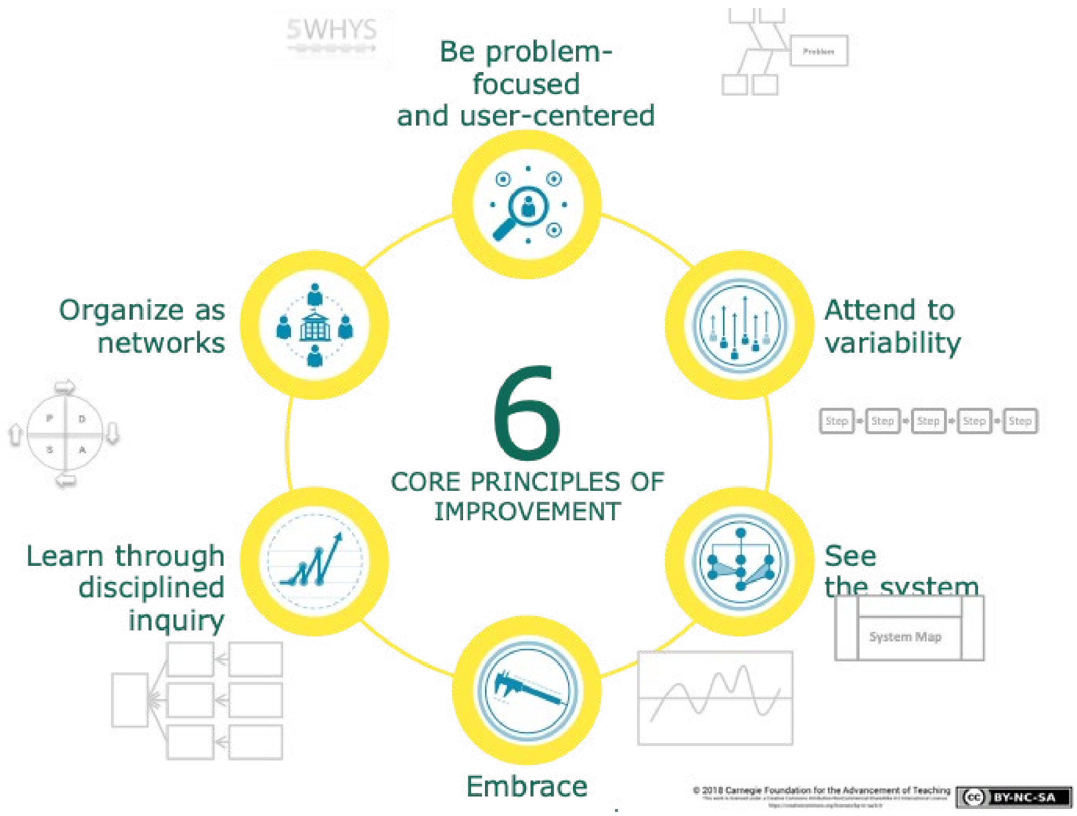
How Is Improvement Science Implemented?

Improvement Science is implemented through collaborative efforts, often within Networked Improvement Communities (NICs). These communities bring together researchers, practitioners, and stakeholders to address shared challenges through iterative cycles of planning, doing, studying, and acting (PDSA). NICs leverage collective expertise and insights, fostering a culture of shared learning and continuous improvement.

The principles of Improvement Science (see Figure 1) can be described as follows:

- **Problem-focused and user-centered:** Focus on real-world problems faced by students and educators with a persistent concern for outcomes.
- **Address variation** in performance: Understand and address variations in educational outcomes.
- **Analyze the system:** Identify factors contributing to current results to ensure solutions address the underlying causes.
- **Measure to improve:** Utilize data to test innovations, measure progress, and inform decisions.
- **Disciplined inquiry:** Use structured, scientific approaches (PDSA cycles) to test and refine interventions.
- **Networked Improvement communities:** Accelerate learning through collaboration within NICs, recognizing that collective efforts surpass individual capacities.

Figure 1: The Major Processes in Improvement Science



An example of the success of Improvement Science is the Carnegie Math Pathways program:

The Carnegie Math Pathways initiative began by addressing a critical problem of practice: the high failure rates and prolonged time-to-degree for community college students enrolled in traditional developmental math courses. National statistics revealed that more than 60% of students placed in remedial math never completed the required sequence, leading many to drop out of college entirely. The impact was especially severe among underrepresented groups such as low-income students and students of color, who faced additional structural barriers within a disconnected and ineffective math education system. Recognizing these inequities, the Carnegie Foundation set out to redesign math education, starting with the goal of more equitable access to college success by tackling systemic issues like misaligned curricula and inadequate support systems.

The initiative's success was largely due to a collaborative partnership between researchers and practitioners, which allowed for a deep, context-driven study of the challenges faced by both students and instructors. Faculty, administrators, and researchers worked together to uncover specific pain points—such as disengaged students, poor alignment between course content and students' needs, and a lack of academic and emotional support. This informed the development of a theory of change that emphasized not only relevant math content but also non-cognitive factors like growth mindset, belonging, and peer collaboration. Through the innovative Statway and Quantway course models, math content was contextualized to real-world applications, helping students see its relevance to their lives and future careers. The Carnegie Math Pathways initiative's continuous improvement model, grounded in the six principles of Improvement

Science, ensured that each iteration of Statway and Quantway courses incorporated feedback to better serve students. By applying Principle 1, the initiative was user-centered, focusing on specific barriers faced by low-income and minority students. Principle 2 addressed variation in performance by tailoring courses to meet diverse student needs, while Principle 3 involved mapping out systemic issues like misaligned curricula and lack of support.

Regular data collection, aligned with Principle 4, allowed for measurable improvements, and Principle 5 ensured a disciplined, iterative approach through PDSA cycles. Finally, Principle 6 fostered collaboration through a networked improvement community, accelerating shared learning and scaling success across institutions.

As reported in the latest impact report, the Carnegie Math Pathways initiative has demonstrated significant outcomes. Over 80,000 students from more than 140 institutions have participated, earning college-level math credits at three to four times the rate of their peers in traditional sequences and in half the usual time. Moreover, Pathways students graduate at double the rate of those in traditional remedial math programs.

Additionally, online versions of Quantway and Statway have shown similar success rates, demonstrating the scalability of the model. This success has proven that, with the right support and contextualized learning experiences, all students, regardless of background, can thrive in math, transforming math from a barrier into a gateway to academic and professional success.

Looking at the above principles and the example of Carnegie Math Pathways, we see see that Improvement Science uses data to improve educational systems yet often has had access only to administrative data (e.g., student rosters, surveys, course grades, etc.) and not detailed records that reflect how students learn with online resources.

Overview of SEERNet

SEERNet connects platform developers, researchers, and practitioners to utilize DLPs as research infrastructure. By highlighting research possibilities within these platforms, SEERNet enables comparing different approaches to the same educational challenge, as well as conducting exploratory studies to better understand variation in how students learn today on digital platforms. SEERNet is well suited for iterative cycles of research in authentic educational environments to evaluate alternatives and improve the learning resources within digital learning platforms.

The SEERNet approach allows practitioners and researchers to collaborate in cost-effective investigations of how to improve learning on digital platforms. The investigations can both use strong research techniques, like randomization, and be implemented in real school settings with fewer headaches associated with doing so (e.g., difficulty of using new software in schools, logistical challenges in coordinating research across school sites, etc). Further, when the research yields results in real school settings, the new ways of supporting student learning via digital learning platforms can more easily be scaled, via the platforms, to many more students. Yet, both researchers and practitioners often have to think in new ways to make use of these capabilities. For example, researchers must adapt methodologies to fit the data that is actually available via the platforms (Schellinger et al., 2024). Practitioners must look for ways to solve educational challenges that fit within what digital learning platforms can reasonably do.

In one example of research using a SEERNet DLP, researchers Ben Motz and colleagues (2024) investigated whether the type of weekly review assigned to students had an impact on subsequent exams. Specifically, they sought to replicate an existing finding, which is that students who review material by taking a multiple choice test (retrieval practice) outperform students who review by reading answers to quizzes (restudy). If the finding replicates across different types of courses and instructional environments, then it could be beneficial to students and instructors because it is easy to implement in a course and can be used with all types of course content. Further, "review before an exam" is a very common type of assignment.

The researchers used the Terracotta platform for their investigation. Terracotta works with the common Learning Management System Canvas. An instructor can make multiple forms of the same assignment in Canvas, e.g., a retrieval practice and a restudy assignment. Terracotta handles the logistics of randomizing the assignment of these two forms to the population of students, as well as many other important details (e.g., obtaining students' consent, de-identifying data, exporting results, etc.). Motz et al. (2024) found that retrieval practice was better—as expected—and they also reported some interesting findings on the retrieval questions. For example, students were able to answer three-quarters of the questions correctly, suggesting they were neither too hard nor too easy. Also, when students got a question wrong and tried it again, they were more likely to get it right. This suggests that the questions were useful for learning during study.

To consider how this SEERNet example relates to Improvement Science, it is useful to broaden the lens from a scientific goal (replication) to a broader systems goal (improvement across varied classrooms and courses in a district). Let's imagine a school district that wants to improve the effectiveness of study habits for its high school students. Let's also imagine the district wants to do this not just in one high school course but across all of them. Narrowly, the district could use Terracotta to replicate the retrieval vs. restudy effect in all its high school courses; however, an actual district would be more likely to want to improve many related factors, such as:

- Including other related effects, such as the benefit of interleaving previously studied questions with current questions.
- Investigating how to achieve good question quality, such as trying generative AI as an approach to writing study questions and comparing that to teacher-written questions.
- Exploring whether instructions to review study questions with a peer student are beneficial.
- Considering whether supporting related factors such as executive function, self-regulation, or motivation in review assignments is beneficial
- Investigating how best to support study on skills that don't lend themselves to multiple choice questions.

Terracotta capabilities could be used to evaluate ideas like these in PDSA cycles, and thus, more than one idea for improving study skills could be tested in the district. These smaller PDSA cycles would address just one idea at time; the ideas that work could be integrated into a more comprehensive approach to improving how students study. Further, an Improvement Science approach would be oriented to measuring variation—for example, are there situations where a "proven" study technique does not work well? Indeed, a core principle of Improvement Science is to understand and address variation in educational performance. The district could explore which variations matter to their students and which forms of study best support the diverse students and settings in their district. Other research methods, beyond what Terracotta supports, would likely be needed to conduct summative evaluations that measure the benefit to students when all the improvements are implemented together across the district.

Bridging Both Disciplines

Unlocking the Power of Improvement Science: Collaborative Innovation Meets Data-Driven Precision

Improvement Science is praised for its collaborative, iterative approach, which fosters continuous refinement of practices by leveraging the expertise of educators, researchers, and stakeholders. However, it often relies on administrative data, such as attendance records and test scores, which may overlook classroom-specific factors influencing student outcomes, such as the details of how and when students receive feedback or customized lessons. More granular data, such as detailed student interaction logs from learning management systems (LMSs) and curricular resources for learning mathematics or other subjects, can offer richer insights into moment-by-moment learning processes. But working with these data can present challenges due to the volume of data generated and the usual form the data takes. SEERNet complements Improvement Science by connecting researchers, practitioners and platforms with learning process data, making it feasible for practitioners and researchers to work together to improve teaching and learning on the basis of data collected with real students in ordinary classrooms.

Elevating SEERNet: Harnessing a Problem-Based Approach for High-Impact Educational Research

Research teams funded as part of the SEERNet initiative excel in conducting large-scale, data-driven educational research within digital learning platforms (DLPs). However, most of the research questions to date have come from ideas in scientific theories about learning, and these questions may not address what educators consider to be their most pressing challenges. Improvement Science, on the other hand, always begins with identifying an important problem of practice—it begins with educators' sense of what is important and what could enable student success more widely. Hence, we conjecture that SEERNet's contribution could be enhanced by integrating a problem-based approach inspired by Improvement Science—that is, by collaborating with educators to identify the right problem of practice to focus on. By starting not only with theory, but also with problems of practice, SEERNet could identify specific, context-sensitive issues that educators face, leading to more precise and relevant interventions.

This approach could enable targeted and effective solutions, fostering stronger collaboration between researchers and practitioners. It could ensure that interventions are not only theoretically sound but also practically applicable and sustainable, addressing both technological and social aspects of educational challenges.

Importance of Integrating Improvement Science and SEERNet

Improvement Science offers a systematic process to identify and address the root causes of educational challenges, while SEERNet DLPs aim to provide actionable insights into specific student needs, allow testing possible improvements, and track progress over time. This combination enables educators to develop more effective ways to use their digital learning platforms to meet the varied needs of their students.

For example, data from SEERNet DLPs might highlight uneven student performance in math, prompting Improvement Science to guide a systematic inquiry into potential causes of why some students do well yet others do not. Not only could potential factors be explored, but also alternative solutions could be tested—and all with data close to the learning process, not just more general administrative data.

Hypothetical Example Using Terracotta (a SEERNet Member Platform)

Terracotta is a SEERNet member platform that allows research by varying the assignments given to students in Canvas, while collecting data on how well students do after they complete the assignments (as well as data on the work they completed on the assignments). Consider a school district that has determined that reading comprehension issues appear to be a barrier to some students learning in STEM subjects like algebra and biology. The teachers notice that some student groups take longer to read the assignment before beginning to work; they also notice that some errors appear due to not understanding the question, rather than not understanding the science. Teachers have many ideas about how to streamline assignments to reduce reading comprehension issues for populations such as their English learners (ELs) or their students with disabilities; as STEM teachers, they really want all students to enjoy and learn from their science and math assignments and don't want reading levels to present a barrier. But the teachers are not sure which improvements to assignments will be most helpful to their students.

In response, researchers and practitioners form a NIC to address this issue. Together, they explore a variety of assignments in algebra and biology that are already in Canvas and look at performance indicators for different groups of students. They look for clues about what might improve matters for students with ELs or IEP status, as well as for other groups. One idea that emerges is providing text-to-speech links within the assignments to enable students to hear any portion of the assignment read aloud. Another idea, inspired by research, is to provide a first step in each assigned question where students have time to confirm they understand what the question is asking and which facts are relevant to their answer.

Groups of teachers and researchers work together to implement these changes so that there are two or more versions of some assignments: the "as-is" version and a modified version. They use Terracotta to test whether the modified version works better across at least three different teachers and classrooms and to see if it works better for the students they are focused on. Analyzing the detailed data from Terracotta gives them ideas for a next cycle of investigation.

Indeed, overall, the researcher-practitioner team organizes their work as PDSA cycles—where they test many ideas over time, improving what is working and discarding those ideas that don't pan out. Over time, many different improvements to assignments are identified as valuable, and the school district recommends that all teachers incorporate these improvements on as many assignments as they can. Terracotta is used to check whether the improvements continue to work when implemented by different teachers, for different students, or in different settings. Over time, these iterative improvements lead to significant gains in reading comprehension on STEM assignments and better learning in STEM courses, demonstrating the power of integrating practitioner knowledge and research approaches through Improvement Science and data from SEERNet digital learning platforms.

Challenges and Considerations for Successful Integration

Overcoming challenges in integrating Improvement Science with SEERNet DLPs' data capabilities requires careful consideration of data-sharing protocols to ensure privacy and security. Schools must establish clear guidelines for data usage, ensuring a shared understanding among all parties. Professional development is critical, as educators and researchers need training to interpret SEERNet DLPs' data analysis results and apply Improvement Science principles effectively.

By adhering to the six principles of Improvement Science, educators can enhance their ability to innovate and improve. Problem-specific and user-centered approaches ensure solutions are tailored to the unique needs of each school and community, making them more relevant and impactful. Focusing on variation is crucial for addressing equity issues, ensuring that all students have access to high-quality education.

A holistic approach that includes consistent measurement of outcomes and processes is essential. This includes tracking not only outcomes but also the steps leading to them, ensuring that efforts to improve one area do not negatively impact another. Disciplined inquiry encourages iterative testing and refinement, allowing for adjustments based on real-time feedback. Finally, networked communities foster collaboration, enabling the sharing of best practices and the development of effective strategies to address educational challenges.

Overall, SEERNet provides an "engine of improvement" that leverages the data and malleability of digital learning platforms, while Improvement Science provides a broader framework to keep the improvements accountable to important school challenges and educators' wisdom about how to address problems of practice.

Conclusions

The integration of Improvement Science with SEERNet could empower educators and researchers to address educational challenges collaboratively, allowing for precise identification of student needs, continuous improvement, and impactful interventions that could scale widely once evidence shows they work. By incorporating SEERNet's analytic engine into Improvement Science's framework, NICs gain deep insights into student behaviors, refine interventions, and enhance student outcomes through iterative cycles of testing and refinement. This synergistic approach promises significant advancements in educational outcomes.

How to Get Started: Five Recommendations

1. **Foster Collaboration:** Encourage partnerships between researchers and practitioners to bridge theory and practice.
2. **Establish Data-Sharing Protocols:** Ensure privacy and security, building trust for effective collaboration.
3. **Leverage Data for Root Causes:** Use both practitioners' accounts of problems they want to solve and SEERNet DLPs' data to uncover underlying addressable issues and develop targeted interventions.
4. **Implement Iterative Improvement Methodologies:** Integrate comparative testing of alternative educational resources with the broader concept of PDSA cycles to refine and adapt the digital resources that students use to learn.
5. **Scale Effective Interventions:** Adapt successful strategies across various contexts, ensuring equitable benefits for diverse student populations.

References

Schellinger, A., Zacamy, J., Roschelle, J., Closser, A., & Zepeda, C. D. (2024, April). *Considerations for conducting research in digital learning platforms.* Digital Promise. https://doi.org/10.51388/20.500.12265/210

Motz, B., Chinni, A., de Leeuw, J. R., Jankowski, H., Aggarwal, A., Amato, M., … Fyfe, E. (2024, July 29). *ManyClasses 2: The effects of prequestions on media interactions and learning.* https://doi.org/10.31234/osf.io/3xbma