Chapter 7

Five Phases of Collaborative Data-Intensive Improvement

In Chapter 6, we described two cases for how researchers and practitioners can come together to collaboratively analyze and take productive action using data from digital learning environments and administrative data systems. When we launched the partnerships with Summit and Carnegie, we sought to develop a process that other research groups could adopt and follow. Our reasoning at the time was simple: We wanted a clear process to help guide our work, there were few examples to be found, so we set out to develop our own over time. Building off of the supporting conditions described in Chapter 6, this chapter describes the outcomes of those efforts and outlines a five-phase approach for organizing a collaborative data-intensive improvement (CDI) project. Figure 7.1 illustrates each phase and the key activities within each phase. The logic behind each is as follows. Phase I involves setting up a partnership, from identifying key members to jointly defining the aim of the partnership. Phase II entails developing an overarching theory for how the partnership will reach its aim. Phase III is where the data-intensive research workflow introduced earlier fits within a CDI project—the aims and theory from Phases I and II shape data wrangling, exploration, and modeling. Phase IV is where insights from data-intensive analyses get translated into change ideas through iterative, collaborative design. Lastly, Phase V is where members of a partnership test out change ideas in real learning environments and improve upon the change ideas over time. In the remaining parts of this chapter, we describe each of these phases in further detail and follow our hypothetical high school introduced in Chapter 3 across steps and phases.

Phase I

Organizing a partnership for success involves identifying project team members, clarifying problems the partnership is trying to solve, and specifying aims for the partnership. Research–practice partnerships are best formed around pressing needs and challenges experienced by practitioners (Coburn, Penuel, & Geil, 2013). Oftentimes, partnerships begin

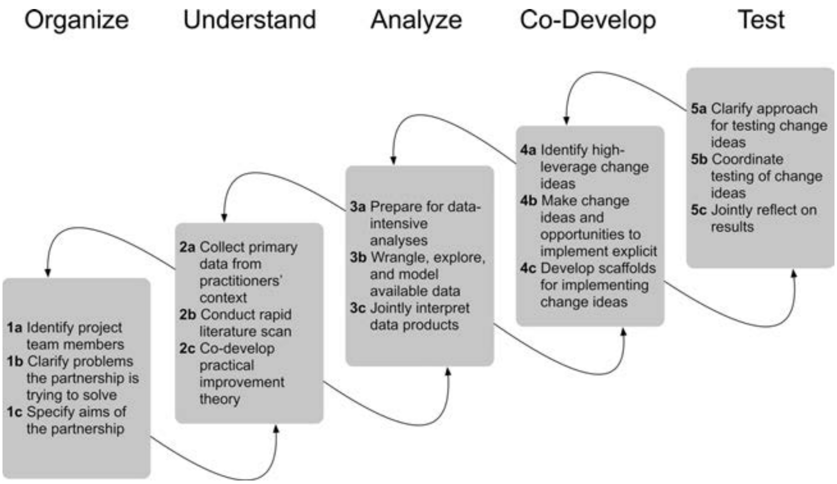

Figure 7.1 Five Phases of a CDI Project

around issues that engender emotional responses due to unsatisfactory conditions or outcomes (Gomez, 2016). Going from a general sense of a need to a well-specified aim that the partnership will collectively work toward is the purpose of Phase I. Unlike a broad issue that animates people to act but does not set a direction, an *aim* is a quantifiable focus for improvement that sets the overall direction for a project (Langley et al., 2009). Before setting an aim, however, a partnership often needs to develop an understanding of the problem it is going to address. Focusing on problems at the outset of a partnership and collectively working to best understand the conditions leading to the problem can help in avoiding the familiar tendency of creating solutions first and searching for problems second (Bryk, Gomez, Grunow, & LeMahieu, 2015). In the following sections, we describe three key steps involved in Phase I.

Identify Project Team Members

For a CDI project, there are often multiple roles that need to be filled and key organizational members that need to be coordinated with: champions, practitioners, data stewards, researchers, organizational leaders, and stakeholders. A key lesson from research on instructional improvement more generally is that it often takes the collective action of multiple individuals working in a coordinated way to effect change in learning environments (e.g., Cohen, Peurach, Glazer, Gates, & Goldin, 2014). A key role to identity within each partnering organization is a *champion*, who is the primary point of contact for big decisions, helps to ensure that tasks are completed on time, and keeps members of the partnership focused on key activities. Importantly, champions encourage members of the partnership to regularly update their assumptions about the project's direction and the degree to which trust is being built and sustained (Spurlock & Teske, 2015). In addition to champions, a partnership depends upon a core set of individuals who regularly attend meetings across each phase of the work and engage in specific project activities. Continuity is key, and we have observed that partnerships, especially at the outset, benefit from a consistent group of *practitioners* and *researchers*. Practitioners are individuals who work directly with learners (e.g., teachers) or are those who directly support other practitioners in working with learners (e.g., building-level leaders or central office staff who work directly with teachers). Figuring out which practitioners will attend regular meetings is not a trivial task; throughout a project, practitioners who can regularly attend partnership meetings can become the *de facto* voice for multiple constituencies.

In our partnership work, we typically take on the *researcher* role. As we have noted previously, a researcher brings to a partnership multiple skills in preparing for and conducting data-intensive analyses along with developing and testing change ideas that are informed by an analysis. Early on in a partnership, it can be useful to think of a researcher as someone who devotes his or her data analysis work to data wrangling and exploration. As we observed in both of our partnerships with Summit and Carnegie, there can be tremendous value in merging once-disparate data sources. Wrangling and exploring takes on further value as insights from theory and practice are brought together in Phase II of a CDI project and in feature engineering and predictive modeling in Phase III.

A *data steward* is a key role within an educational organization because of his or her access to data, such as databases for digital learning environments or administrative data systems. A data steward helps the partnership understand what data are available and provides the partnership with updates of data as the project progresses. Data stewards can also play a role in negotiating access to data that are collected and stored by digital learning environments but not directly held by the educational organization. In some partnerships, the data steward might regularly attend project meetings; in others, the data steward supports the project only when technical expertise is needed. Regardless of the intensity of participation, a data steward should help to ensure the secure transfer of data between organizations, such as between a school and a research organization, and can be a valuable resource in understanding the history of data systems as well as data quality issues that are present in almost every system.

Along with identifying champions and core team members, we have found that it is important to identify and coordinate with *organizational* *leaders* at both the site (e.g., principals) and district levels (e.g., central office staff or assistant superintendents). Organizational leaders can be crucial gatekeepers to resources and can play a supporting role in implementing as well as scaling change ideas. In addition, *stakeholders* can be important team members as they are most affected by the actions of the partnership. Stakeholders in educational organizations can include students and parents, and depending upon the purpose of the project, they can be regular or intermittent partners. One way in which we have interacted with students in a CDI project is through interviews and focus groups. Research–practice partnership models described by McLaughlin and O'Brien-Strain (2008), for example, outline additional ways in which parents and community members can be brought into a partnership to provide their perspectives on learners, problems to be solved, and opportunities to improve.

Clarify the Problems the Partnership Is Trying to Solve

As multiple improvement science researchers and practitioners note, projects should be based on a partnership's understanding of the problem facing practitioners (Nelson, Batalden, & Godfrey, 2007). Clarifying the problems that the partnership is working to solve entails moving from the issues that initially brought potential partners together to discussions on specific processes, norms, and structures that may be contributing to the problem. There are several activities that we have drawn on in helping us to clarify problems with our partners, and one of the most useful has been a *fishbone diagram*, which is also called a root cause analysis, causal systems analysis, or Ishikawa diagram. A fishbone diagram places a problem to be addressed at the "head" of the diagram (see Figure 7.2). Above and below the line originating from the head, broad categories of factors contributing to the problem are placed. Example factors can include people, processes, materials, and norms; they are intended to be general, with increasingly more specific elements of each factor placed underneath. Connecting categories to the "spine" are perpendicular "ribs" that provide a space for capturing more specific causes. Ribs can continue to branch out in a perpendicular fashion as deeper factors are identified.

Figure 7.2 represents a fishbone diagram for our hypothetical high school introduced in Chapter 3. Recall that the problem practitioners were working to better understand were the large number of students who earned a C– or lower in the first year of the course. Practitioners brainstormed four initial categories: (1) students' study habits and strategies, (2) course design, (3) access to resources, and (4) schedule. Within these broad categories, members of the partnership identified the negative effects of students starting off track or falling behind. One potential reason for falling behind was that students did not know how to effectively

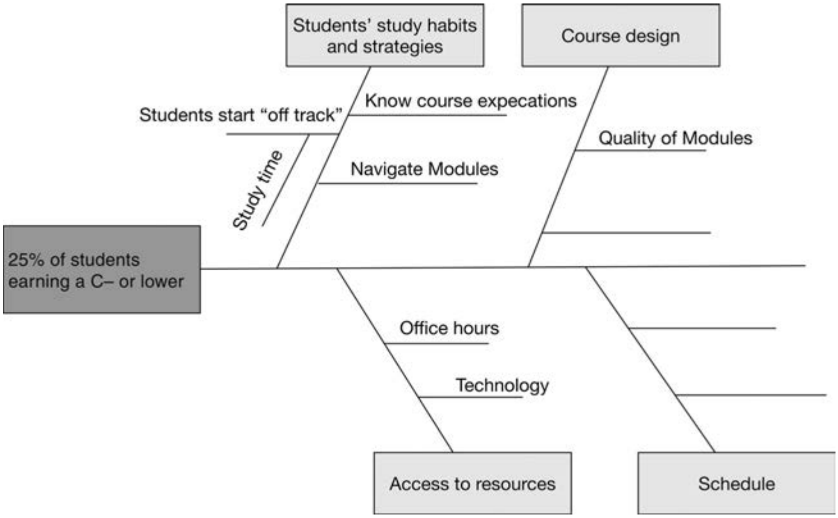

Figure 7.2 Fishbone Diagram

use their study time in and out of school. Multiple topics such as knowing course expectations for a dual-enrollment course, navigating the modules within the learning management system (LMS), and the overall quality of the modules themselves surfaced as broad categories of potential causes for high numbers of students earning a C– or lower in the course. Mapping potential causes helped the partnership clarify which factors they wanted to prioritize in their improvement work. As we demonstrated in Chapter 3, this problem clarification work can help in providing specific questions to explore using data-intensive research techniques.

While there are no guarantees that engaging in causal systems analysis and completing a fishbone diagram will surface the right problem and the right causes, the simple act of having partners think deeply and explore multiple facets of a problem can help set a partnership on the right track. Another added benefit of engaging in a causal systems analysis is captured in the word "systems." Moving away from simple solutions and appreciating the ways in which undesirable situations are a function of multiple, interrelated factors can both reveal the true complexity of a problem as well as help a partnership prioritize factors to begin working on.

Specify Aims of the Partnership

Setting concrete aims is an initial set of activities where practitioners and researchers can come together to begin integrating their respective knowledge, skills, and experiences (Coburn et al., 2013). As the partnership identifies members' roles and develops a better understanding of the problems it is trying to solve, an aim statement can become a useful resource in organizing the next steps for the collaboration. A quality aim statement answers the question "What are we trying to accomplish as a partnership?" Being clear on what the partnership is trying to accomplish can help in identifying what a partnership might need to do differently in order to achieve its aim. Said differently, a clear aim can put a partnership in a position to develop a plan necessary for achieving its aim. The causal systems analysis done earlier can be useful in this task: Problems or undesirable circumstances anchor causal system analyses; aims are often positive versions of a problem with targeted benchmarks and timelines.

A quality aim statement specifies what a partnership is working toward, the degree of improvement sought, and a timeline by which the aim will be accomplished. While there are various models for aims, such as SMART goals (specific, measurable, achievable, realistic, and time bound), we have found that answers to the simple question "what, by when?" are often sufficient in specifying an aim. Importantly, an aim statement should naturally flow from the causal systems analysis done previously, and the partnership, as a whole, should work to develop consensus around the aim statement. Bryk et al. (2015) discuss the benefits of multiple versions of a similar aim: an aspirational version and a technical version. An aspirational aim addresses the broader problem that a partnership is working on, which can provide a direction to a partnership, help in motivating members of a partnership, and serve as a reminder that a partnership is working on important problems. While aspirational aims help in motivating individuals, technical aims help a partnership measure progress toward a specific future state.

For example, in our hypothetical case high school, the aspirational aim focused on "100% of students, 100% of credit." The technical version answered the "what, by when?" question over a two-year period and acknowledged the full complexity of the problem that surfaced during the causal system analysis and available resources: "At the end of the 2019–20 school year, 95% of students who enroll in the dual-enrollment math course will earn a C or higher."

Phase II

Understanding the best way to achieve a partnership's aim involves collecting primary data from practitioners' context, scanning pre-existing research, and co-developing a practical theory that will guide improvement work. As partnerships discuss issues, problems, and goals, multiple perspectives will emerge. Often, these perspectives are informed by the knowledge and information that individuals contributed to Phase I activities. The purpose of Phase II is to expand upon these perspectives by collecting new information grounded in both practice and research. The location for bringing these multiple sources of information together is a *practical improvement theory*, described in a later section, which can help in shaping subsequent data-intensive analyses as well as co-development work around potential change ideas for practitioners to test in their classrooms. Next, we describe three key steps involved in Phase II.

Collect Primary Data From Practitioners' Context

Collecting data from practitioners' context provides an opportunity for a partnership to learn about what is happening in real learning environments. Going into Phase II, a partnership has identified a key problem of practice, made conjectures regarding the factors contributing to the problem, and clarified an aim worth pursuing. Collecting data from practitioners' context can help to confirm or disconfirm factors thought to contribute to a problem. Furthermore, collecting data from practitioners can help in developing an understanding of the key processes that make up teaching and learning. Collecting data from learning environments is particularly important for making sense of data from digital learning environments. It is easy to draw the wrong conclusions from data without an understanding of the broader instructional activities that may have contributed to what students were doing and why they were doing it (e.g., Murphy et al., 2014).

In many ways, collecting data from practitioners' context is about cataloguing and understanding how particular processes play out in an environment. A process is "a series of related work activities that together transform *inputs* into *outputs* for the benefit of someone" (Nelson et al., 2007, p. 299). Within complex systems, such as schools, there are multiple processes that build on one another in intricate and often opaque ways. To help make processes less opaque, partners can engage in *process mapping* as a structured way of articulating key steps and decisions that make up the process. Process mapping is "a method for creating a diagram that uses graphic symbols to show the steps and the flow of a process" (Nelson et al., 2007, p. 299). A central tenet of improvement science is that improved outcomes come only through improved processes. Making a process explicit can help in identifying where key processes break down, are wasteful, or are needlessly complex.

Process mapping typically begins by gathering information from practitioners through surveys, interviews, or observations with the goal of understanding how a process unfolds. This can also be accomplished by gathering a group of practitioners to discuss the sequence of steps and decisions involved in an activity or task. Within a partnership, process mapping can entail collaboratively constructing flowcharts by identifying steps, drawing boxes around each step, and connecting boxes using arrows. If a step in a process represents a decision, this decision point is signified with a diamond shape. The beginning and end of a map is signified with an oval. Using these basic building blocks, a process map highlights how well a group actually understands a process—steps that are not understood well are an invitation to learn more.

The simplified process map represented in Figure 7.3 demonstrates how teachers at the case high school worked to understand the ways in which they made students aware of "course expectations," which was an idea that surfaced during the development of the fishbone diagram (see Figure 7.2). The thinking behind the issue involved the degree to which all students knew about the required summative assessments and the importance of the assessments toward their grades. In mapping how teachers introduced course expectations on the first day and launched work on Module 1, they recognized that they discuss the grade policy and the syllabus but that they don't introduce the LMS and where the summative assessments are located in the LMS prior to starting work on course material.

Conduct Rapid Literature Scan

A rapid literature scan is a focused way of helping a partnership learn about the problem it is trying to solve based on the findings and experiences of other researchers. Moreover, a rapid literature scan can help clarify what data to attend to and analyze as well as potential change ideas to test in Phase V. As Park and Takahashi (2013) outline, rapid literature scans can be pragmatic dives into the pre-existing literature to advance

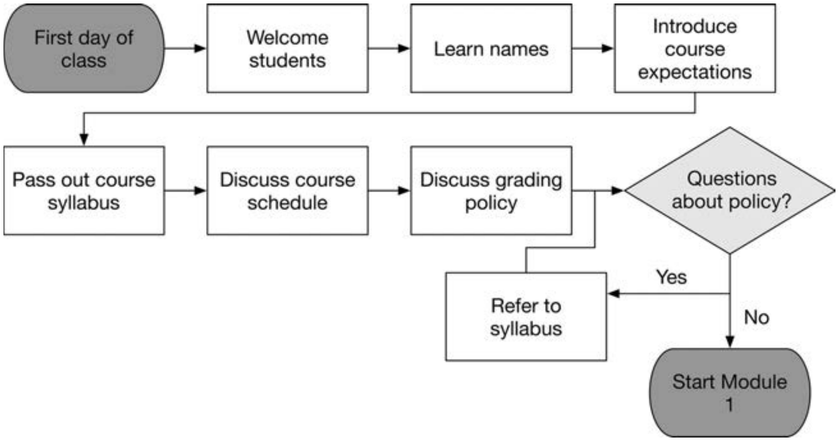

Figure 7.3 Process Map

the learning of a partnership on a specific topic. A specific purpose or topic anchors a literature scan. After identifying a topic, a scan should be bounded by a timeline, such as 90 days, to help discipline the overall process. Along with timelines, it can be important to have a specific objective for what will be delivered at the end of the scan (e.g., a framework, annotated bibliography, sample measures, change ideas). An expedient way to begin a scan is by interviewing recognized experts; Park and Takahashi (2013) recommend that rapid literature scans strike a balance between interviews and readings. Further, they recommend a set of activities for the first 30 days, for example, of a 90-day scan. The first 30 days should focus on *scanning*, which involves conducting initial interviews and article identification as well as adjusting, if necessary, the proposed deliverable. The second 30 days involve getting feedback on what was produced during the first 30 days and continuing to make progress on the proposed deliverable as more is learned. The final 30 days involve getting additional feedback and finalizing the end product for the full partnership's review and critique.

In our work with Summit, described in Chapter 6, we engaged in a rapid literature scan to better understand research on students' self-directed learning behaviors. We consulted prior research to identify candidate measures of self-directed learning (e.g., persistence and wheel-spinning) as well as potential change ideas (e.g., messages sent directly to students through the Summit Learning Platform). Similarly, in our work with the Carnegie Math Pathways, we engaged in a rapid literature review for the purpose of developing practical measures of productive persistence (Krumm et al., 2016a). We used the assessment framework known as Evidence Centered Design to identify potential constructs, meaningful tasks from which those constructs could be measured, and the potential evidence that could be gathered from the digital learning environment used as part of the Carnegie Math Pathways (Mislevy, Steinberg, & Almond, 2003; Mislevy, Behrens, DiCerbo, & Levy, 2012). Our own rapid literature review, along with prior work done by researchers at the Carnegie Foundation, helped the partnership select what data to analyze and how to initially set up feature engineering tasks.

Co-Develop a Practical Improvement Theory

A practical improvement theory is a visual representation of a partnership's approach to achieving an aim. Yeager, Bryk, Muhuch, Hausman, and Morales (2013) define a practical improvement theory as an "easily interpretable conceptual framework of the system that affects student outcomes, that practitioners view as useful in guiding their work, and that remains anchored in the best available empirical research" (p. 19). One goal of a practical improvement theory is to motivate and guide improvement work. It is *practical* because it should be used to guide local action—as opposed to supporting broader and more generalizable theory building—and because it is tentative and open to revision. As will be described later, evidence collected from practice, data-intensive work, and tests of change ideas can all be used to revise an improvement theory and a partnership's overall understanding for how to achieve a partnership-defined aim.

A popular approach for graphically displaying an improvement theory is in the form of a driver diagram, which comprises an aim, primary drivers, secondary drivers, and change ideas. In general terms, a driver diagram "consists of a team's shared theory of knowledge—which is developed by consensus—and includes relevant beliefs of team members about what must change and which ideas about how to change may result in improved outcomes" (Bennett & Provost, 2015, p. 39). As a visual tool, a driver diagram illustrates key elements of a system that need to be changed in order to achieve an aim. These key elements are aligned to specific change ideas; this alignment entails an explicit hypothesis: "If we make this change, it will affect this driver (i.e., primary or secondary), and if this driver improves, we will make progress toward our aim."

An important first step in developing a driver diagram is revisiting the aim statement developed during Phase I. From this aim, team members identify three to five necessary conditions, or primary drivers. These primary drivers are informed by the causal system analysis conducted in Phase I and the primary data collection and rapid literature scans carried out earlier as part of Phase II. Secondary drivers provide more detail around what, where, and when a primary driver will be improved upon; they provide a degree of specificity for targeting a primary driver through a specific change idea. Identifying secondary drivers, therefore, involves working backward from a primary driver to specify where and when a primary driver can be acted upon.

Figure 7.4 presents a driver diagram for the high school we have been following in this chapter. The aim for the diagram is based on the more technical aim that was specified in Phase I. Using what was learned during Phases 1 and II, the following primary drivers were selected: **Students start and stay on track**, **Students interact with peers and teachers outside of class**, and **Students interact with quality resources within Modules**. These drivers where identified as necessary for achieving the aim of having 95 percent of students earn a C or higher. While primary drivers specify what a partnership believes is necessary for achieving an aim, secondary drivers identify more specific points of intervention related to a primary driver. For example, **Students are made aware of course expectations**, is a concrete point of intervention, and as a partnership further builds out its driver diagram, it can attach specific change ideas to secondary drivers. In the case of making students aware of course expectations, a specific

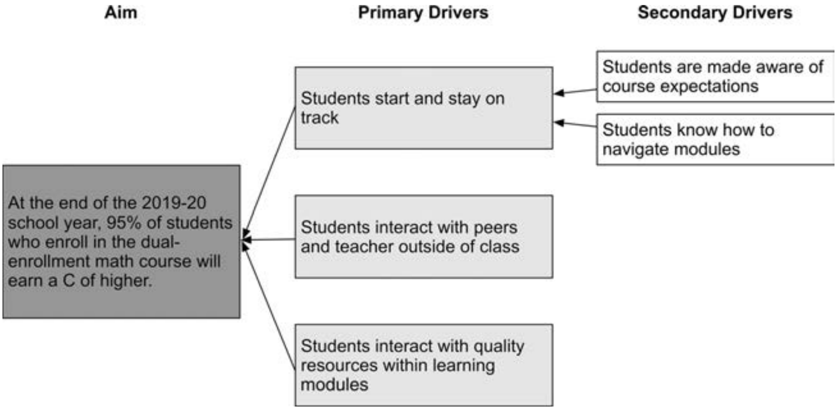

Figure 7.4 Driver Diagram

change idea entailed developing and using a checklist to help ensure that instructors introduced specific elements of the LMS before working on course material.

Phase III

Phase III involves preparing for data-intensive analyses; wrangling, exploring, and modeling available data; and jointly interpreting data products. Phase III of a CDI project is nothing more than the data-intensive research workflow introduced in earlier chapters. In Chapter 2, we introduced the overall workflow and how the steps worked in concert with one another. In Chapter 3, we introduced specific tools and examples for the wrangle, explore, and model steps. In this section, we describe how the workflow fits within a CDI project.

Within a CDI project, the purpose of data-intensive analyses is to develop and communicate *practical* data products that help a partnership develop a better understanding of the local education system, identify predictive relationships, and assess changes (Solberg, Mosser, & McDonald, 1997; Yeager et al., 2013). In *developing a better understanding of a local system*, practical data products can help a partnership appreciate previously unknown relationships between processes and outcomes. Based in the example of the hypothetical high school, visualizing when students first passed the summative assessment, especially as compared against the grades students earned, was useful in demonstrating previously unknown relationships. Both inferential and predictive modeling helped in *establishing predictive links* between the dates students first passed summative assessments and their eventual grades. Formal predictive modeling led to a model based in when students completed the second module (i.e., **mod_2**). Subsequent change ideas directed at improving when students complete certain modules used the day of the school year that modules were completed to *assess the effectiveness* of those change ideas. Our description of the "homework improvement sprint" conducted with the Carnegie Math Pathways from Chapter 6 offers yet another set of examples for the ways in which data-intensive analyses within a CDI project can be used to learn, predict, and assess changes.

Prepare for Data-Intensive Analyses

Preparing for an analysis, as we described in Chapter 2, involves developing a research question as well as getting to know the data that will be used in subsequent analyses. Within a CDI project, developing a research question involves referring back to the various products that have been developed, such as fishbone diagrams, process maps, and driver diagrams. These products can provide direction on topics to explore, and in some cases, what data to attend to and how they might be analyzed. A driving research question can help in providing direction to a data analysis, which can reduce the likelihood of aimless data exploration. The second set of activities that can help in preparing for a data analysis involves getting to know a technology, how a technology is used, and the ways a technology collects and stores data. Getting to know a technology involves, in the case of a digital learning environment, logging into the system and exploring the various tasks and activities. It also involves seeing how, again in the case of a digital learning environment, students in classrooms are expected to use it as well as actually use it. And learning about how a technology collects and stores data entails comparing one's observations from interacting with the technology and seeing how it is used in classrooms with data dictionaries or sample database queries.

Wrangle, Explore, and Model

Chapters 2 and 3 covered the topics of exploring, wrangling, and modeling data and the cases outlined in Chapter 6, in particular, highlighted the overall importance of data wrangling and exploration to a CDI project. As we illustrated in Figure 2.3 in Chapter 2, many of the steps involved in analyzing data are overlapping and the same analytical technique can serve multiple purposes (e.g., one can use inferential and predictive models to explore one's data). These three steps can consume a disproportionate amount of time and energy in a CDI project. We use the term "disproportionate" intentionally in that data-intensive analyses are a set of steps within a broader set of phases that, combined, can support positive changes in learning environments. A critical element to carrying out these steps is having a common workflow based in common tools and software—especially as partnerships move more and more into collaboratively engaging in data analyses where practitioners adopt the roles and routines of data scientists and researchers. Over time we have consolidated our tools to include the open source language R and several R packages referred to as the "tidyverse." R and related packages offer free and flexible ways of approaching each step in the data analysis process as well as tools for sharing and communicating data products, such as Markdown files and Shiny applications, both of which can be used in a meeting where researchers and practitioners come together to jointly interpret data products and brainstorm change ideas.

Jointly Interpret Data Products and Brainstorm Change Ideas

After data products have been developed that address a driving question, it can be useful to convene members of the partnership to interpret data products. By "interpret" we mean noticing elements within a data product and connecting them to one's prior knowledge (Weick, 1995). Interpreting a data product involves answering the question: "What does this mean?" The different experiences and prior knowledge of researchers and practitioners can shape what they notice in a data product as well as the connections they make, and ultimately the meaning they make of it. The meaning one makes of a data product can, in turn, shape the implications one derives and ultimately the actions one takes (Coburn & Turner, 2011).

In setting up a meeting where researchers and practitioners jointly interpret data products, it is beneficial to revisit the various individuals identified in Phase I: champions, practitioners, data stewards, researchers, organizational leaders, and stakeholders. Identifying who should join in the process of interpreting data products is consequential, as individuals bring with them different knowledge, skills, and abilities, and the mix of participants can influence the interpretations and implications that are developed.

Organizing a data interpretation meeting requires different degrees of preparation depending on who is likely to attend and the overall purpose for the meeting. For meetings that involve more complex data products, we have found it beneficial to put together *one-pagers* that describe the purpose of the analysis, a sample data product, and rules of thumb for interpreting the data product. These one-pagers are useful in preparing for and focusing a meeting. While a one-pager can help prepare participants for the meeting activities, we also work to frame the data-intensive analyses in two ways during a meeting, as we described in Chapter 6. First, we describe the history of an analysis: the questions we are answering, how we got to these questions, and why the partnership might find an analysis valuable. Second, we create instructional data products that take a complex data product, distill it down into its simplest units, and present it—often using made-up data that is easier to interpret than products using actual data.

It is important to have a plan, or routine, in place for jointly interpreting data products that are presented to the group. For example, we regularly use the "I Notice/I Wonder" routine from DataWise (https://datawise.gse.harvard.edu/). We typically draw on this routine while we are walking through a data product that uses a partner's data. "Wonderings," for example, can serve as useful fodder for developing implications and potential change ideas. In brainstorming potential changes, it can be useful to have specific strategies in place, such as specific brainstorming approaches, to gather and organize potential ideas. In Phase IV, these potential change ideas can be revisited and some might be turned into explicit tools and routines.

Phase IV: Co-Develop Change Ideas

With potential change ideas coming out of Phase III, the next phase in a CDI project is about further developing these ideas, selecting those to later implement, and making sure the necessary supports for implementation are put into place. In some cases, selecting, developing, and implementing a change idea can be easy because the change idea is relatively simple and inexpensive, such as having Statway faculty set due dates for online homework assignments as described in Chapter 6. Other change ideas, such as providing tailored feedback messages within a digital learning environment, can be more costly to develop and implement.

A key element in moving from identifying to developing a change idea is continuing to engage both researchers and practitioners in the process (Penuel, Roschelle, & Shechtman, 2007). Important aspects of fleshing out a change idea involve *elaboration* and *scaffolding* (Cohen & Ball, 2007). Elaboration is a strategy for making a change idea explicit:

> From one angle, extensive elaboration seems essential to illuminate an innovation's requirements for use, to alert designers and implementers to work to be done, and to reveal potential problems. Less-elaborated designs would be not only less useful but even self-defeating, for they tacitly delegate large amounts of invention to implementers, increasing the probability that the implementers would interpret interventions as versions of conventional practice, since the designs offer little guidance for anything else, and conventional practice is both familiar and understood by implementers.
>
> (p. 25)

Scaffolding relates to the supports that are put into place to help practitioners implement the change idea. Scaffolds can include everything from formal professional development sessions to worked examples that help a practitioner see what the change idea looks like in practice. Co-developing change ideas, therefore, can involve multiple steps, such as selecting high-leverage change ideas from the multiple brainstormed ideas, making the selected ideas explicit, and developing scaffolds to help practitioners learn about the change idea and implement it.

Identify High-Leverage Change Ideas

High-leverage change ideas are those where there is evidence to suggest that a small effort may lead to large improvements. The partnership's improvement theory is one tool for beginning to identify high-leverage change ideas. The primary drivers outlined in the theory are themselves intended to represent high-leverage aspects of the system that the partnership can modify to achieve its aim. Thus, the practical improvement theory developed during Phase II not only helps in shaping the data-intensive analyses, but also helps in prioritizing potential change ideas.

Along with a partnership's practical improvement theory, more general criteria for selecting change ideas include the following: short lead time, low cost, and control (Nelson et al., 2007, p. 326). Partnerships can be buoyed by early wins. Selecting a change that can be implemented with a short lead time increases the odds of attaining an early win by selecting something that will be easy and fast to implement. Change ideas with a short lead time are also typically low cost (i.e., in terms of time and money). Having control means that the partnership does not need extensive permissions to try out the change idea. Starting with a change idea that has all of these features means that the collaborators can become accustomed to moving through improvement processes first, before tackling more difficult change ideas.

In addition, as Yeager et al. (2013) observe, evidence from research can be useful in selecting change ideas, particularly those studies identified during the rapid literature scan of Phase II. As partnerships use their practical improvement theories and general criteria in selecting changes, Nelson et al. (2007) note the importance of having those who will be implementing a change participate in the selection of the change to implement as well as the process of fleshing out the change idea. Based on our own experience, meaningful change ideas coming out of a data-intensive analysis sometimes involve simply collecting more data in order to understand a problem better. For example, in our work with both Summit and Carnegie, we engaged in multiple data product development and interpretation cycles and identified the need to identify as well as gather more evidence before launching into a change effort for the practitioners to implement.

Make Change Ideas Explicit

Understanding and implementing explicit processes are critical for achieving reliable performance (Bryk et al., 2015; Nelson et al., 2007). Explicitness makes what is expected of a practitioner concrete (Krumm et al., 2016c) by detailing the steps and decisions involved in a process, which is similar to the idea of a process map. However, instead of just naming a step, as in a process map, an explicit change idea includes a description of what each step entails. For example, in a recent project where we worked with a group of teachers to increase the quality of science discourse in elementary classrooms as our improvement aim, we broke down the steps involved in conducting a whole-class discussion and added content-specific phrases that a teacher could use that were unique to the lesson. Instead of telling teachers to "lead better discussions," we worked with them to develop explicit, elaborated protocols on how to actually go about leading a discussion in a way that drew on the expertise of both researchers and practitioners. Another key component of explicitness, along with having steps and decisions outlined, is clarifying the situation or context in which a practitioner should implement the change idea—for example, tailoring the protocol to specific science lessons and clarifying when during a lesson to use the protocol (Moorthy & Krumm, 2017).

There are multiple ways to make change ideas explicit. In leading the homework improvement sprint described in the previous chapter, an improvement coach from Carnegie worked with faculty to select potential change ideas and to make them explicit for testing. Selecting changes to develop and implement proved easier than making the changes explicit. For example, the idea of sending email reminders to students seemed simple and straightforward. However, the timing as well as the substance of emails proved more difficult to agree upon. Efforts to create explicit tools and routines surfaced deeper beliefs related to the purpose of homework and the responsibility of students in managing their own workloads. Thus, in the process of making change ideas explicit, a partnership can wrestle with big issues and uncover additional aspects of a problem the partnership is working to solve (Meyer, Krumm, & Grunow, 2017).

Another strategy for making a change idea explicit is to iterate on it by having one group within the partnership brainstorm how the change could be implemented and then turn their ideas into a prototype. The prototype can then be handed over to another group for their additions. Over time, an implementable change idea can emerge from this process. In our work with Carnegie, this approach helped in developing more resource-intensive change ideas, such as new visualizations of productive persistence measures that could be implemented in the online learning environment. With each iteration of the prototype, the partnership got more specific about the visualizations and the resources needed to develop and test them.

Develop Scaffolds to Support Implementing Change Ideas

While important, explicitness is not a substitute for working with practitioners on what they need to know in order to implement a change idea well. Some changes may not require a lot of up-front learning on the part of practitioners. However, we have observed that even simple change ideas can require, for example, reminders to implement them. Professional development and reminders are both examples of potential scaffolds that partnerships often need to put into place in order to implement a change idea successfully. Thus, just as the change ideas themselves need to be made explicit, so too do the different supports and scaffolds that the partnership will provide to practitioners in order to implement the change idea.

Phase V: Test

Getting to the point where practitioners test a co-developed change idea is a tangible milestone for any CDI project, and many successful projects strive to test change ideas as quickly as possible. Some of the best learning for a partnership can occur from testing change ideas in real classrooms, and there are specific activities that can help ensure successful testing of a change idea. Success is defined by what the partnership is able to learn from a test in relation to their jointly developed aim statement and improvement theory. We use the term *improvement cycle* for efforts made by researchers and practitioners to test a change idea, which can create both short- and long-term learning opportunities for a partnership. Short-term learning involves getting the most out of an individual test by starting with an explicit idea, a hypothesis about what will happen as a result of the change, data that will help in understanding what happened, and a mechanism for collecting data used to test a hypothesis. Improvement tools, such as Plan-Do-Study-Act (PDSA) cycles, can be used to structure these tests. Long-term learning involves documenting and keeping track of the multiple tests of change over time, and importantly, synthesizing what is learned from across multiple tests.

Testing can be done at different scales and with different numbers of practitioners. Bryk et al. (2015), for example, identify the role of *confidence* and *capability* in deciding on the scale at which testing can occur. Confidence stems from the strength of the evidence base, both from practice and research, for the potential positive benefits of a change idea. Capability concerns the relationship between current and necessary knowledge, skills, and abilities for enacting a change idea. Only when confidence and capability are both high should a partnership think about trying out a change idea at a scale larger than an initial handful of willing participants.

Familiarize Partnership With Approach for Testing Change Ideas

Prior to testing out a change idea, partners must agree on a specific approach and timeline for testing it. For our work with Carnegie on increasing homework completion, for example, Carnegie researchers tested the three separate change ideas by randomly assigning combinations of changes to faculty members at the beginning of a semester. This provided the opportunity to test and refine the change ideas over two cycles at the beginning of the fall and winter semesters. In other partnerships, we have worked with groups of teachers to implement and iteratively refine change ideas, using PDSA cycles on a weekly basis (e.g., Krumm et al., 2016b; Moorthy et al., 2016). No matter how the change idea is tested, those who are doing the testing can benefit from being familiar with the story of how the change idea was developed—causal system analyses, driver diagrams, and the data products produced in Phase III are key resources. Knowing the story can help those doing the testing understand the rationale for the changes being attempted, which can help in building will and in making sense of results from initial tests. Along with describing how the change idea emerged, the partnership should familiarize testers with the explicit details of the change ideas and the scaffolds that can be used to support their learning and testing.

In other scenarios, more may be asked of practitioners—from filling out formal PDSA forms to collecting data for subsequent analysis. In some situations, we have had teachers complete customized PDSA forms to document their tests of change ideas. One challenge with formality is that PDSA forms can come to be seen as added paperwork and lose their value for documenting tests. Finding ways to obtain measures of change idea implementation without burdening practitioners is a major challenge in Phase V. In the Statway test of homework completion routines, Carnegie researchers directly observed how change ideas were implemented and the partnership analyzed system log data to produce process and outcome measures. Given the variety of approaches and strategies that are available, it is important that teams are clear on an initial approach and are open to refining the approach depending upon what is helping the partnership.

Coordinate Tests of Change Ideas

Coordinating tests of change ideas involves clarifying how implementers will be brought together to share what the partnership is learning. For example, regular face-to-face or virtual meetings can provide opportunities for practitioners testing change ideas to report on what they are finding and the adaptations they are making. These meetings can also harness the knowledge of a broader set of colleagues in brainstorming further adaptations. In addition to regular meetings, tests can be coordinated by an improvement coach, common forms and reporting documents, and a collaborative infrastructure for storing and sharing what is learned from a test. An improvement coach is an individual with a background in improvement science who can help practitioners plan and document their tests. Common forms and reporting documents help each practitioner collect information from a test that can later be aggregated across tests. As we noted previously, the potential downside of common forms and documents is that they can be perceived as paperwork and not completed as intended. For this reason, an important tip when using common forms and documents is to be open to modifying them over time based on practitioners' feedback on a form's relevance and ease of use (Krumm et al., 2016c). Lastly, common forms and documents, schedules, and other resources can all be stored and shared using online collaborative tools, such as an intranet, wiki, or cloud-based file hosting service. These tools can facilitate easier communication among those doing and supporting the work of testing change ideas.

Jointly Reflect on Results From Multiple Tests

After engaging in multiple tests of change, it is often beneficial for a partnership to stop and reflect on what has been learned. The Institute for Healthcare Improvement's *Breakthrough Series Collaborative* (2003) describes the importance of a summative meeting following tests of change ideas and learning sessions. These summative sessions can give researchers and practitioners the opportunity to present their overall findings for a set of tested change ideas, to celebrate successes, and to plan for the next improvement project. Sharing findings across multiple tests can help a partnership more fully assess the overall project, and the partnership can strategize on longer-term co-development tasks that could not be accomplished originally during Phase IV as well as rethink potential data-intensive analyses.

Reflecting on the results from multiple tests often raises new issues that can serve as the starting points for additional improvement work. Aims can be revisited and refined, improvement theories can be added to, new data products can be developed, and new change ideas can be made explicit and prepared for future testing. Across multiple projects, we have found that joint reflection leads naturally to *continuous* improvement. After testing a series of change ideas, we frequently return to Phase III to explore the data collected during a set of tests to better understand the impacts of changes and to surface new questions for the partnership to explore.

Conclusion

In this chapter, we described the five phases of a CDI project. These phases were identified from our work across multiple partnerships, and when paired with the conditions outlined in Chapter 6, they capture what it means to engage in CDI. The phases of *prepare* (Phase I) and *understand* (Phase II) specify the importance of setting clear aims for a partnership and using prior research and wisdom from practitioners to shape data-intensive analyses that occur during the *analyze* phase (Phase III). Joint data product development and interpretation set the partnership up for *co-developing* (Phase IV) change ideas and *testing* (Phase V) them in local learning environments. In bringing together improvement science and data-intensive research, all in the context of collaborating with practitioners, we have sought to make explicit how the trends discussed in Chapters 5 and 6 can come together in focused partnership work. In the next and final chapter, we reflect on the future of CDI.

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