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Continuous Improvement in Mathematics Departments

Some thoughts from the field

2020

The University of Texas at Austin
Charles A. Dana Center

Continuous Improvement . . .

Learning, improving, and succeeding—together

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Introduction

As of early 2019, colleges and universities in nearly 20 states are implementing the Dana Center Mathematics Pathways model.

Successfully implementing the DCMP model requires that reforms happen not only within mathematics departments, but across the institution as well.

The model requires scaling math pathways institution-wide, through reforms to course requirements, math instruction, and support services. Full implementation of the DCMP model thus requires math departments to lead and carry out broad structural changes.

Math departments and higher education institutions enacting math pathways following the DCMP model aim to better serve all students by enacting policies and programs that address these four principles:

1. All students, regardless of college readiness, enter directly into mathematics pathways aligned to their programs of study.
2. Students complete their first college-level math requirement in their first year of college.
3. Strategies to support students as learners are integrated into courses and are aligned across the institution.
4. Instruction incorporates evidence-based curriculum and pedagogy.

Why continuous improvement?

To fully realize the promise of math pathways, the Dana Center recommends that math departments engage in a deliberate and thoughtful process of continuous improvement throughout the initial structural changes and beyond.

Putting into place new, aligned math pathways is a significant step, but that step must be followed by questioning and confirming that students are being placed in the appropriate pathways—and that each pathway covers relevant content that will be useful to the student's future progress.

This brief provides guidance for such efforts by presenting examples of effective continuous improvement processes at the departmental level. These examples are intended for use with professional learning experiences designed to foster cultures of continuous improvement in DCMP implementation.

How we gathered data

Through its higher education network, the Dana Center identified promising continuous improvement processes evident in a variety of mathematics departments based in 14 institutions in diverse settings across the country—including equal numbers of two-year and four-year institutions. Dana Center staff then conducted qualitative interviews of higher education professionals at these institutions to dig deeper into the details of their local continuous improvement processes.

Dana Center staff used a semi-structured interview protocol to conduct interviews with department chairs or mathematics faculty; this approach gave the interviewer the flexibility to ask probing questions and pursue interesting paths of discussion. Interview questions focused on changes undertaken by the entire department as opposed to changes made only by individual instructors or within individual classes.

The interview protocol was intentionally structured around four general topics: *catalyzing*, *communicating*, *implementing*, and *sustaining* reforms.

Organization of this brief

Below, we summarize various respondents' descriptions of continuous improvement and then present elements critical to its enactment—as revealed in the interviews.

We conclude with recommendations for developing cultures of continuous improvement in mathematics departments.

What Is Continuous Improvement?

Continuous improvement is broadly understood as a system or method that uses data to guide adjustments in products or processes. These systems or methods lead to higher quality products or greater fidelity of implementation. In our higher education work, the Dana Center enacts continuous improvement as a multistep cyclical process and includes it as Stage 4 in the DCMP implementation process. [1]

In the field of education, this kind of continuous improvement work is often also described as *collaborative inquiry-based learning*, in which education professionals investigate problems together using evidence to spur changes in practice and then to reflect on the results (Palmisano, 2013).

Continuous improvement in departments of mathematics

Interviewees were asked for their own definitions of continuous improvement—and to describe how— they would know if continuous improvement was present.

There was broad consensus that the primary purpose of continuous improvement in mathematics departments is to enhance the student experience and student learning outcomes. Educators interviewed also generally agreed on the necessity of using data to guide improvement, both for monitoring the success of an initiative and for determining next steps.

For example, here are thoughts from four different respondents about what constitutes continuous improvement:

> **Respondent one:** "So continuous improvement would be not assuming that what you're doing now is the best that it could ever be, that there's always opportunity to grow, to do things better, to achieve better outcomes for students, achieve a better working environment for faculty, that there are lots of different ways we could grow and improve year to year."
>
> **Respondent two:** "Continuous improvement means to me a plan-do-check-act cycle. So, in this particular process, we planned what we wanted to do, we did it, we went back and checked it through assessments, and then we redid whatever it was we thought we needed to do."

> **Respondent three:** "To use some informed data process to try new things in teaching, evaluate what works, and make improvements based on the data that is collected."
>
> **Respondent four:** "Using student performance with respect to certain learning outcomes to decide whether to make changes in the way courses are done."

Not all the respondents said that they use the phrase *continuous improvement* purposefully, or that their department or institution uses the phrase.

Yet, for most respondents, not formally putting a name to these efforts was not considered a shortcoming, since respondents in general did not view "continuous improvement" as a discrete activity but as an integral part of the operation of the department.

That is, continuous improvement is an intrinsic and ongoing process that is never complete.

The Critical Elements of Continuous Improvement

Using data to show the need for urgent change

Math department improvement efforts generally start with the recognition that student outcomes are lower than desired within individual courses—or entire course sequences.

In continuous improvement organizational cultures, the finding of poor student outcomes is used not to lay blame, but to catalyze a process of trial-and-error efforts to make changes that will improve outcomes. Looking at data jump-starts the process—and since math faculty are typically comfortable with, and value, quantitative data, it is expected that the work will entail analyzing and discussing student data.

One math department chair described starting a collective conversation in a department meeting about the need to improve in this way:

> "Here's our data, what do you guys think?" I think we try to get as many people in the conversation as possible, and pose it as, 'Here's the data. Let's talk about it, let's get a work team around it, and work on it.' That's our traditional method."

Another chair said:

> "And typically, I would start the discussion by telling them what the problem is, what the data says... and they always have lots of ideas—'This would be good, let's try this'. And then we'd talk. We usually talk a long time before we come to any sort of a conclusion. But eventually we get steered around to somebody proposing something."

Several interviewees said that it could be painful for faculty to see poor student outcomes data but that such data can make the faculty more receptive to making changes.

For example:

> "It is difficult to own pass rates that are low. It's very hard on faculty to come out of classes and feel like you're failing, and to own that and not take it personally."

And:

> "My department was on board right from the get-go. It isn't fun to fail everybody, you know? Nobody really wants to do that."

Reflecting on different kinds of data

Interviewees also talked about the multiple types of data they use to inform the change process. Some departments look at how students perform on individual assessment items or projects to see if students are meeting learning outcomes. They look at student passing and failing rates in individual courses.

Some departments examine student progress through a sequence of courses, such as a developmental course and the subsequent college-level course or courses.

Through those analyses, math departments aim to identify any particular bottlenecks in the curriculum.

One community college math department chair said that they can access data from their four-year university partners to track how students who have transferred do in their first university math courses.

Several respondents mentioned collecting data directly from students—such as through end-of-course surveys—saying that it is critical to understand the students' perceptions of their math courses.

Some math departments reported conducting focus groups with students. For example:

> "We're getting ready to send out some additional surveys to students to say, 'Do you feel like you were placed in the right class? Do you feel like you took the right class?' That kind of thing to help us with this. At least—are the small steps that we've made making a difference? One of the things we're embarking on is a focus group study asking students who were successful—and students who were not successful—questions because we need to find out from those that were not successful why they feel they weren't successful. Did they feel they were over-placed? Did they feel it was on them? They didn't study enough? What could we have done to help maybe push them past that brink, so they would have known they needed to study more? Is there something we could do? Sometimes there isn't, but maybe there is. The only way to find out is to ask students."

As another example, a community college math department head described a "math confidence survey" that is administered to students:

> "We do a confidence survey for our students… it was actually based off the MAA's [Mathematical Association of America's] calculus climate survey from a couple years ago. So, we took their massive survey and kind of shrunk it down. So, like some of the questions we ask is, how has your confidence in your ability to successfully pass a math course changed over the course of the semester? And so, about week 14 in a 16-week semester, we'll send that out and ask them [students] to judge that. Or, how is their ability to read, write, and interpret mathematics in real life, how has the confidence in their ability to do that changed? We use that to look at that, do we need to change anything here, are we not succeeding with the objectives that we think are important in all these courses?"

Examining data more frequently—or less—depending on context and need

Course outcomes data may typically be reviewed only once a semester or annually. But when a change is in process, data are analyzed more frequently so that adjustments can be made in a timely way.

In some situations, course coordinators—faculty members who support all sections and instructors of a particular course—check in with faculty frequently. For example:

"Coordinators keep track of progress in those classes almost on a weekly basis in terms of how students are responding to homework, how students are responding to different kinds of treatment, in terms of methodologies… We do have around 50% of the teachers who are very much into active learning, for instance, and we still have around 50% of those that are in the classical mode of lecture and testing… We are continuously monitoring the performance of those two approaches to decide and maybe to convince some people that one approach is better than the other."

Thus, the continuous improvement process is data-informed, and it is collaborative. The process is launched within math departments by faculty examining different data points and openly asking questions about "what new things can we try to improve student outcomes?"

Structures to encourage collaboration for change

While accessing different kinds of data—and analyzing the data to identify problems—are critical first steps, the data may not point clearly to a best solution. As one department chair said:

> "Just because you know you're deficient in an area doesn't mean that we can easily recognize, well, this is what we need to do to fix it. So, there's some trial and error involved."

The trial-and-error process—trying, measuring, correcting, and trying again—can play out in different ways depending on a variety of factors, such as the scope and the driver(s) of the change initiative.

The math departments interviewed for this brief tended to have existing structures in place that encourage both the generation of ideas and the trial-and-error experimentation needed to test them.

Multiple meeting formats and multiple avenues for communication and collaboration

While departmental meetings are, of course, common to all institutions, some interviewees noted that departmental meetings are required for full-time faculty and optional for adjunct faculty. Interviewees emphasized that it is important for all faculty to know that open discussion at departmental meetings is welcome.

These meetings are where everyone should have a voice, with department chairs ensuring that all views are taken into account, even when there is no universal agreement. For example:

> "It was not really a consensus that was reached… We documented very carefully, these were the things that were decided, and we summarized the discussion, too. When the discussion was happening, my point was that everybody gets to talk until they're done talking and making their point, and somebody else gets to speak and they don't get interrupted."

As another university math department chair described it, freewheeling dialogue often leads to agreement on the changes to try:

> "When you're brainstorming solutions, you have to end up somewhere. I would say it's together as a department we end up together somewhere. It may be that one or two people aren't 100% sure that's the right thing, but that's part of, I guess, the democracy, if most people are like, 'Well

> I can't think of anything better, so let's just go down this road, but we obviously are going to look at it and make sure it's working, right?' Very rarely do we have a vote that isn't unanimous."
>
> Interviewer: "Because you have the conversations to get there?"
>
> "Yes."

Other opportunities for communication and collaboration include smaller configurations of faculty, such as the course leads and the faculty members teaching a particular course.

The role of a course lead, also called a course captain, is to represent that course to the rest of the department.

At one college, all the faculty who teach a particular course are known as a community of practice and have regular meetings; at another college, these are called discipline groups. Some departments also have teaching triangles—groups of three teachers who visit one another's classrooms and provide feedback and support.

One interviewee said:

> "It also happens organically from faculty when they're meeting in these discipline groups, and they're like man, our students are just not getting [the concept of] exponential growth by themselves—we need to change something here. Well maybe one faculty [member] is like, 'well they get it really good in mine, and then well, what are you doing?' And they bring it up, which is I think a real big benefit of these weekly, regular meetings where we talk about what we're doing in these classes so we can collectively make each other better."

Another faculty member said:

> "We do have a formal peer review structure that is also sometimes I think a conduit for discussions like this. We have what we call 'teaching triangles.' At the beginning of the term, everybody in the department, everybody who's teaching, which includes graduate students, adjuncts, whatever, is divided into groups of three. And each group of three is supposed to have a tenured person on it, and those groups meet regularly and visit each other's classes once a month. But they meet regularly and talk about what they saw and talk about if there are problems."

When a department is undertaking reforms such as math pathways, these types of small groups can be agile in managing change, monitoring data, and making adjustments more frequently than could happen with the whole department involved.

For example, small faculty groups can focus on the adoption and implementation of particular courses. This approach also ensures that faculty take on leadership and ownership of the reform process.

Using already institutionalized structures and creating new groups and meetings as needs arise

While these are examples of some already institutionalized avenues to support a continuous improvement process, the colleges and departments also create new groupings and meetings to serve specific purposes when they are taking on major change initiatives, such as the implementation of co-requisite supports.

For state- or institution-mandated reforms, stakeholder convenings specifically dedicated to the change effort may take place within both the math departments and the other departments or even colleges.

For example:

> "We're going to have a college-wide meeting to kick it off.... and so we'll have the college-wide meeting to show the data on the pathways, subsequent course pass rates, how courses are doing individually, [and we'll] have a conversation on data, have a conversation on what strategies are out there, what strategies that we're doing, how many on campus, how many college-wide. So, we can share, and talk about those, and then the hope is—cross your fingers if everything works well—is to actually develop a work team for each pathway... I don't want any decisions to come out from a college-wide conversation, I want that to be a true discussion that leads to work teams, and the work team will work on solutions."

Some interviewees spoke of convenings or gatherings with other colleges within the state that were undertaking the same reforms.

Strategies learned at these convenings are taken back to the math department and shared and discussed. Then, smaller designated teams such as work groups or task forces can focus on specific courses or discrete aspects of a change initiative, and they can report their activities and findings back to the department as a whole.

For example:

> "As we created these pathway courses, there was a team of people that taught the course... We had two team leads, and those team leads convened the people that taught that course every week, every two weeks, there was constant conversation. As department chair, I was involved in the conversation: what's going well, what's not going well, what we need to revise for next

> semester, or what we need to revise for next year if it was something big that needed to go through curriculum change. Is the software working? Is the software not working? It literally was a constant conversation…."

Thus, existing structures in the math departments, such as regular faculty meetings (and other meetings), organically produce and support ideas for change. Departmental chairs and faculty raise issues in departmental meetings, have open discussions, and then decide on a course for change and strategies for testing that change.

Sometimes there is consensus immediately, while other times, to earn consensus, pilots are undertaken to collect data on the effectiveness of proposed changes.
At times, such as when major changes are being imposed from outside the department, additional structures must be created to facilitate communication and collaboration that go beyond the department.

Across all these communication avenues, faculty have a strong voice and core responsibility for improvement processes.

Celebrating success

An important note on communication is that it should focus not only on where things are going wrong, but also on acknowledging success:

> "If you don't celebrate progress as you go, then you lose people's desire to make continuous improvement. You have to say, 'We have done so well. Look at where we are. Look at the number of students that have gotten through, that would never have gotten through before. The number of students that now have an opportunity to graduate—they never would have been given that opportunity before, because they never would have finished their math.'"

Data such as improved course passing rates should be shared and celebrated across the department. Higher student confidence and comfort with math topics should be applauded.

Such recognition can be done through a variety of approaches, such as setting aside a portion of departmental meetings to cheer progress, a celebratory faculty lunch, or "going out for a beer," as one interviewee said.

As the respondent above said, changes made through continuous improvement—even changes to one course—can make the difference between a student graduating or not.

Gaining stakeholder support from outside the math department

Mathematics department reforms such as pathways implementation and modifications to placement policies, among others, affect faculty and staff across the institution, and interviewees emphasized the importance of bringing others into the change process.

They stated that meetings across the campus are helpful in describing impending changes, sharing outcomes of changes in progress, and learning of—or even forestalling—opposition to reforms.

For example, participants described meetings with advisors, counselors, and individuals from the registrar's office as helpful in facilitating the logistical changes necessary at the campus level for large-scale change:

> "When we're talking about implementation, it's the communication between faculty, the academia side, and the student services side—that has not in the past always been the strongest. So, when one side wants to make a change, the other side resists 'cause we don't know what's going on and, you know, vice versa. So, that has been a change that we've all—faculty, the leaders of faculty, and the leaders of student services—chosen to try to close that gap in communication and involve somebody from student services."

One interviewee shared that, even with all the data the department can access, faculty do not know the majors of the students in their courses (unless they ask them). They thus have to rely on the advisors, who do know the students' majors or intended majors, to place the students in the appropriate math course.

It is critical, then, that advisors understand the purpose of math pathways, and that advisors have confidence in the data showing that students are better served by the pathways. Thus there must be concerted communication efforts with the advisors.

The same is true for faculty in other departments. A university math department chair described how the math faculty met with non-math faculty to share convincing arguments that the other departments' students would benefit from the change away from algebra as the default requirement to math pathways:

> "It was the department that wanted to do that. It wasn't my suggestion. We had a meeting where we talked about how these advisors just keep putting kids in college algebra, what are we going to do about that? And somebody suggested we could take it out of the core (curriculum) and then it wouldn't count for anything, and they would stop doing that. And so, we thought about who actually needs that course and the answer is, unless you're headed for calculus, almost nobody.... And it turns out that there's hardly anybody that actually required college algebra. The school of education did, but they also have the math for elementary teachers one and two, which takes care of the core. They don't need college algebra to satisfy core. And the psychology people required it but they also required statistics. And so they didn't need college algebra to satisfy the core...."

This interviewee continued, "My faculty went out and contacted, I think they said they went down the list and divided them up; each person takes three or four departments and talks to them. There was resistance, mostly from psychology and education, until we explained to them that this really did not hurt their kids at all. That they were getting core complete by other means. And, as I said, kids started passing their first math course instead of just failing college algebra."

Having other academic departments on board with major reforms, such as having each department committed to a particular, preferred math course or pathway, can also help to convince student services personnel that these changes will benefit students.

One interviewee noted that in communicating with faculty and staff across the college, it is important to find the right time and place, and to settle on the appropriate amount of information and detail, so as to not overburden their colleagues. He suggested trying to take advantage of existing meetings and conversations as the best way to share information.

A culture of professional learning in the department—and in the institution

The continuous improvement process is a form of professional learning, and therefore is more likely to occur in a department and institution that value and facilitate such learning. So it is useful to have a culture of improvement that promotes self-examination as well as collective inquiry.

Such a culture can be realized through encouraging a trial-and-error approach. In the interviews, several respondents highlighted their department's and/or college's culture of professional learning and the institutionalization of policies and practices that support it.

As an example, a math chair shared information on a tenure process that requires each instructor to complete a project grounded in elements of continuous improvement. Faculty members must try something new, assess the new thing's progress, and make adjustments—all using measures and data. This work is evaluated not based on a successful outcome, but rather on faculty's use of the department's improvement cycle.

Ensuring that all faculty have the capacity to make data-informed changes is thus clearly valued by this department.

One college indicates the worth of professional learning by providing a $1,000 stipend to tenure-track faculty who conduct "action research" projects to improve their practice.

At another college, a professor described how data reports were starting to be made available to the faculty; previously only the deans could access them. That professor said that upper-level administrators recognized that they should help faculty understand the data. That way, faculty could start using data to inform questions of where improvements are needed:

> "So, we don't want to just give faculty a report, and not explain how to use it. So, we're developing a training, where the faculty goes to the training, learns what the report is, how to use the report, what are some best practices in the report, any concerns you may have, [and] here are the people to go to if you have any questions on the reports. Once you go through the training, then you have access to the reports, just like the deans do."

One community college math faculty member praised his college for its professional development opportunities, saying:

> "I think that is one of the things that we pride ourselves on, is that we value professional development. We motivate faculty for professional development, because we find that the value is in it. We highly encourage faculty members to continuously improve, in many ways. One, is to form connections. So, if a math faculty starts, they immediately meet with the dean. They are connected with faculty right away, they're teaching a course where they can be given support materials, someone they can go to for help....They are connected to support services, and then they're also connected with a plethora of professional development opportunities that we have."

In contrast, a dean at a four-year institution said that higher-level support for professional learning is lacking:

> "That is one item that I would criticize my administration [for], is that they say, 'Our faculty are so great, they can't improve,' you know? The thinking is that the faculty need to be in the classroom and need to be teaching, and they don't need to bother themselves with professional development."

No opportunities or funds for faculty development are officially offered by his university, but this dean is encouraging his faculty to "step up your game." He asks faculty to identify metrics to assess their own effectiveness, and he encourages them to develop ideas for working on their professional growth. He then organizes poster presentations for faculty to share their process and progress.

Professional learning opportunities external to one's own institution are essential, several interviewees said, as a way of gathering ideas for how to address the problems they identify from their data.

Sometimes, decisions on interventions to try are informed by faculty attending faculty workshops and conferences, hearing about other institutions' efforts to improve student outcomes, and sharing information about those efforts with colleagues.

Respondents also mentioned the importance of faculty keeping up with the research literature.

Summary and Conclusion

As our data show, the continuous improvement process includes several necessary features.

Continuous improvement is data-driven, but not compliance-oriented.

Analyzing data and using it to inform decision making must be a regular and expected faculty activity throughout the continuous improvement process. Experimentation and trial-and-error experimentation are the aim.

Multiple types of data should be considered, including quantitative student outcomes data as well as qualitative student feedback. Faculty should be provided with professional development on accessing and using the data.

Continuous improvement is collaborative.

The individual nature of rewards and operations in an academic department may work against faculty teamwork, but our interviews illustrate how departmental leadership can encourage and support group efforts toward change.

Department chairs can promote open dialogue, idea sharing, risk taking, and multiple avenues for communication.

In addition, collaboration must occur not only within the department but should extend to other areas of the institution.

Continuous improvement thrives where there is a culture of professional learning.

At the heart of the success of continuous improvement efforts lies an organizational culture that fosters it. That is, continuous improvement efforts thrive when there is a culture in which learning is

valued within the department—and ideally across the institution as a whole—and where practices and policies are in place to support it.

The Shingo Institute, at the Jon M. Huntsman School of Business at Utah State University, focuses on shaping organizational cultures so that they drive operational excellence.

According to the Institute's Shingo Model, creating constancy of purpose is one of ten guiding principles that anchor change initiatives. This constancy of purpose is defined as "an unwavering clarity of why the organization exists, where it is going, and how it will get there...." Constancy of purpose "enables people to align their actions, as well as to innovate, adapt, and take risks with greater confidence" (Shingo Institute, 2018).

Adapting this idea of constancy of purpose to the culture of a mathematics department could mean fostering a context in which **all faculty have a common understanding of their mission and are supported in examining whether that mission is being achieved to the highest level possible**.

Some might say that implementing math pathways is a risk.

But it could be countered that implementing math pathways in concert with a continuous improvement process increases the likelihood of success—by engaging a data-driven, scientific approach for each level and phase of reform.

The math faculty and administrators interviewed for this brief clearly believe in their purpose of providing a mathematics education that—rather than impeding students—propels students forward in their academic and career trajectories.

With that foundation, and with departmental and institutional leadership and encouragement, math departments seeking to implement math pathways initiatives are learning, improving, and succeeding—together.

Reflection

Reflection questions

Reflect for a moment, and jot down a few notes:

- What does continuous improvement mean to you?

- What led you to read this brief?

- What pathways or co-requisite course data do you already have that could be shared with the department?

- What data do you want to collect next?

For Further Reading

Relevant to math pathways

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The University of Texas at Austin
Charles A. Dana Center

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About the Dana Center

The Charles A. Dana Center develops and scales mathematics and science education innovations to support educators, administrators, and policymakers in creating seamless transitions throughout the K–16 system for all students, especially those who have historically been underserved. We focus in particular on strategies for improving student engagement, motivation, persistence, and achievement.

The Center was founded in 1991 at The University of Texas at Austin. Our staff members have expertise in leadership, literacy, research, program evaluation, mathematics and science education,

About the Development of This Resource

The Dana Center developed this resource to support the T.L.L. Temple Foundation's focus on increasing postsecondary preparation, access, and success. Through this work, we seek transformative change for equitable access to—and opportunity for success in—rigorous math pathways as a normative practice for all students.

The overall success of this work will be determined by the extent to which more students enroll in and complete an entry-level college math course and declare a program of study at the end of their first year. The Dana Center proposes to accomplish this by:

- Providing professional learning experiences to campus leadership and faculty to increase institutional scaling of math pathways.
- Facilitating policy discussions to create conditions to scale multiple math pathways.
- Developing tools and resources to support advising structures that facilitate student placement in the math pathway best aligned to their programs of study.

- Building faculty capacity to use accelerated math courses to reduce time to completion of college credit–bearing courses.
- Fostering collaboration with school districts to align transition courses with math pathways in higher education.
- Building the infrastructure to lead math pathways work.

Additional Acknowledgments

Lead Authors

Katherine L. Hughes, **Ph.D.**,
Principal, EdWordian, LLC

Patrick Saxon, Ed.D.,
Professor,
Sam Houston State University

Lead Researcher

Jennifer Dorsey, Ed.D.,
Senior Evaluation Analyst,
Charles A. Dana Center

Project Lead

Frank Savina,
Course Program Specialist,
Mathematics, Higher
Education Services,
Charles A. Dana Center

Reviewers

Connie Richardson,
Manager, Higher Education
Course Programs,
Charles A. Dana Center

Paula Talley,
Manager, Professional
Learning for Higher Education,
Charles A. Dana Center

Joan Zoellner,
Course Program Specialist,
Mathematics, Higher
Education Services,
Charles A. Dana Center

Editing & Design

Rachel Jenkins,
Lead Editor and
Production Editor,
Charles A. Dana Center

Ophella Dano,
Senior Writer/Editor,
Charles A. Dana Center

Phil Swann,
Senior Designer,
Charles A. Dana Center

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