Eliminating Mathematics Barriers through Evidence-based Reforms: A Guidebook

TPSEMath
Transforming Post-Secondary Education in Mathematics

PROJECT EMBER
ELIMINATING MATHEMATICS BARRIERS THROUGH EVIDENCE-BASED REFORMS

Association of Public & Land-Grant Universities

everylearner everywhere

Association for Undergraduate Education at Research Universities

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Recommended Citation:

Ström, A., Pilgrim, M.E., and Gehrtz, J. (2026). *Eliminating Mathematics Barriers through Evidence-based Reforms: A Guidebook*. Every Learner Everywhere. everylearnereverywhere.org/resources/eliminating-mathematics-barriers-through-evidence-based-reforms-a-guidebook

About Our Organizations

TPSE Math is a professional organization of mathematicians, statisticians, data scientists, educators, and administrators who strive to ensure that all students are prepared for a variety of career opportunities.

Project EMBER is a network of 50-100 institutions that empowers teaching-focused faculty at research institutions to adapt evidence-based reforms in introductory mathematics, track progress to improve overall student success and eliminate equity gaps, all in collaboration with departmental and institutional leaders.

The **Association of Public and Land-grant Universities (APLU)** is a research, policy, and advocacy organization dedicated to strengthening and advancing the work of public universities in the U.S., Canada, and Mexico. The association's membership consists of more than 250 public research universities, land-grant institutions, state university systems, and affiliated organizations. The association and its members collectively focus on: increasing student success and workforce readiness; promoting pathbreaking scientific research; and bolstering economic and community engagement. Drawing on the powerful collective action of its members, APLU's advocacy arm helps shape federal policy that maximizes the positive impact of public and land-grant universities.

Every Learner Everywhere is a network of partner organizations with expertise in evaluating, implementing, scaling, and measuring the efficacy of education technologies, curriculum and course design strategies, teaching practices, and support services that personalize instruction for students in blended and online learning environments. Our mission is to partner with institutions to harness digital learning technology, driving innovation in higher education to improve outcomes for every learner. We build capacity in colleges and universities to improve student outcomes with digital learning through direct technical assistance, timely resources and toolkits, and ongoing analysis of institutional practices and market trends. WCET (the WICHE Cooperative for Educational Technologies) and WICHE (the Western Interstate Commission for Higher Education) serve as the intermediary organizations for the Every Learner Everywhere Network. For more information about Every Learner Everywhere and its collaborative approach to advance student success in higher education through digital learning, visit everylearnereverywhere.org.

The **Association for Undergraduate Education at Research Universities**, or UERU, is a national consortium of R1/2 research university leaders with expertise in the theory and practice of undergraduate education. UERU includes a robust network of Undergraduate Vice Provosts/Presidents -- strategically positioned leaders who work collaboratively with their colleagues to advance equity and excellence in undergraduate education.

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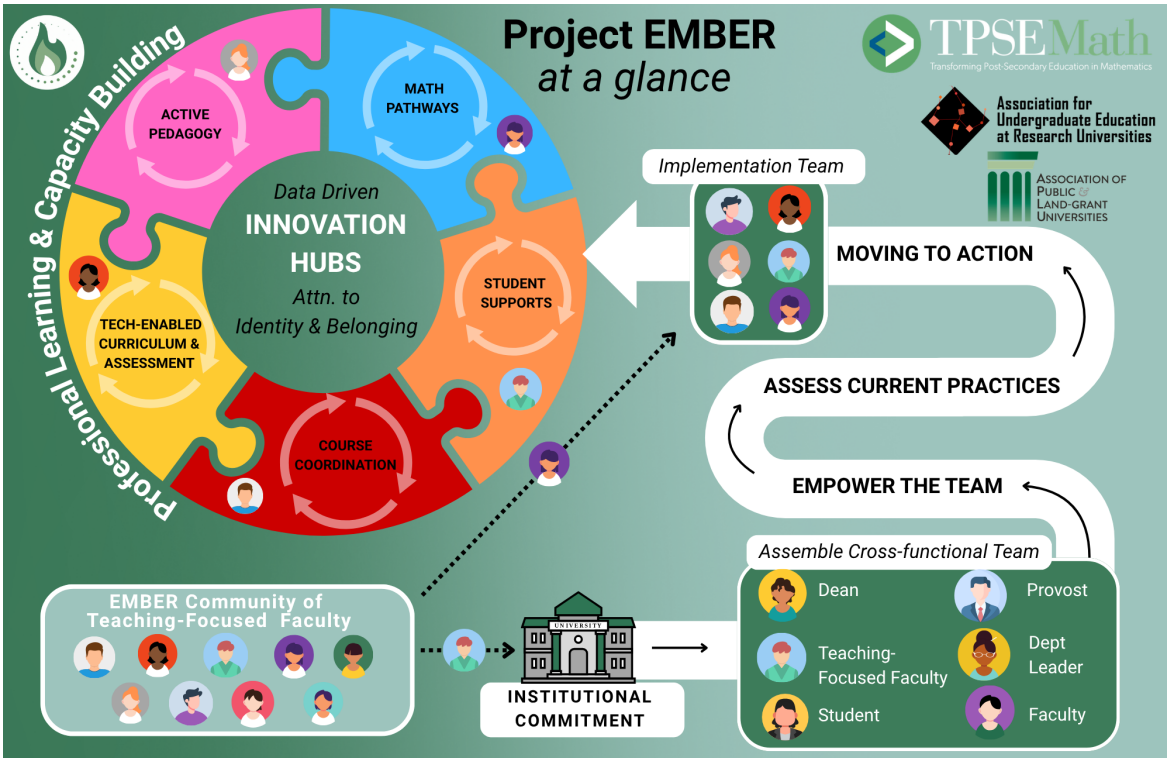
I. OVERVIEW AND PURPOSE

Welcome to Project EMBER (Eliminating Mathematics Barriers through Evidence-based Reforms) where we envision a world where:

Every higher education math student succeeds in introductory mathematics aligned with their interests and aspirations.

Introductory college mathematics is the largest academic barrier to college completion and STEM success, particularly for students from historically underserved groups. At most universities, these courses have the highest DFW rates, derailing student progress, wasting talent, and weakening the nation's STEM workforce and national security pipeline. The problem is not a lack of effective solutions. Decades of research and practice have produced proven, scalable reforms that improve student outcomes, including redesigned pedagogy, better alignment of mathematics pathways with students' majors, and restructured developmental sequences. Yet these reforms remain unevenly adopted.

Leading change, especially at research universities, will be the teaching-focused faculty (TFF) who are responsible for teaching and coordinating most introductory mathematics courses. Project EMBER aims to support and elevate TFF while simultaneously engaging with departmental leaders and institutional leaders. At each institution, those faculty collaborate with departmental and institutional leaders to establish a cross-functional team, assess current practices, and plan for transformation. Members of the implementation team then join faculty from other institutions in communities of practice centered on particular innovations.



The Project EMBER model.

Project EMBER has developed tools to guide faculty and institutions through this process, all available at the Project EMBER Tools page:

- Project EMBER Guidebook
- Project EMBER Self-Assessment
- Project EMBER Innovation Overviews

The purpose of this guidebook is to support an institution in transforming introductory mathematics programs. While each institution's journey will differ, this resource aims to inspire and provide practical guidance for efforts to improve student success, promote learning for all students, and reimagine the role of introductory mathematics. The transformation will begin by establishing and empowering a cross-functional team. This team will support the reflective analysis of current practices using the Self-Assessment Tool designed to spark ideas for change. The process will culminate in developing a shared vision for the future of introductory mathematics and creating a strategic action plan to help realize that vision. Additionally, this guidebook offers ideas for professional learning throughout the process to support those at the institution who are engaging in this transformation.

Milestones

Below is a list of milestones through which an institution's cross-functional team will progress. Depending on the local context, an institution may not necessarily begin at the first milestone. It may be that an institution already has an established team or committee similar to that of the cross-functional team. Depending on local context, an institution may not necessarily need to begin at Milestone 1A, if a team is already in place. However, they will likely need to establish norms (1B) and/or engage in a visioning process (1C). Entry points and timelines will vary and will be unique for each institution.

The milestones provide opportunities for coordinating progress (as appropriate) to relevant stakeholders who are not directly involved in the work (e.g., department colleagues, the college dean). For example, results from the self-assessment process should be communicated to the department before moving forward with an action plan. This will enable the team to advocate for support for their efforts. Further, a team may want to draw upon the expertise of the campus Center for Teaching and Learning (CTL) once they identify areas for such support.

Milestone 1: Empowering the Team

A cross-functional team needs to be established and empowered to engage in positive, sustained change in introductory mathematics. As this work focuses on introductory mathematics, recognizing and empowering individuals who are in teaching-focused roles for those courses will be critical. Teaching-focused faculty are those whose role is focused primarily on teaching; TFF may or may not be in tenure line positions, but, in comparison to research-focused faculty, they make up one-third of the full-time faculty at research institutions, according to internal Project EMBER research. The majority of TFF are teaching introductory mathematics courses and/or serving as course coordinators of these courses. Thus, it is this group that will be best positioned to drive and sustain educational innovation in introductory mathematics.

1.A. Assembling the Cross-Functional Team

The cross-functional team (Figure 1) will consist of individuals who will engage in and/or provide support for change efforts across a variety of roles within the institution and department. A critical part of assembling the cross-functional team will be to ensure that the team has a wide spectrum of voices from roles that impact the teaching of introductory mathematics the greatest. Details about this team and the work they will do can be found in the more detailed *Empowering the Team* section of this guidebook.

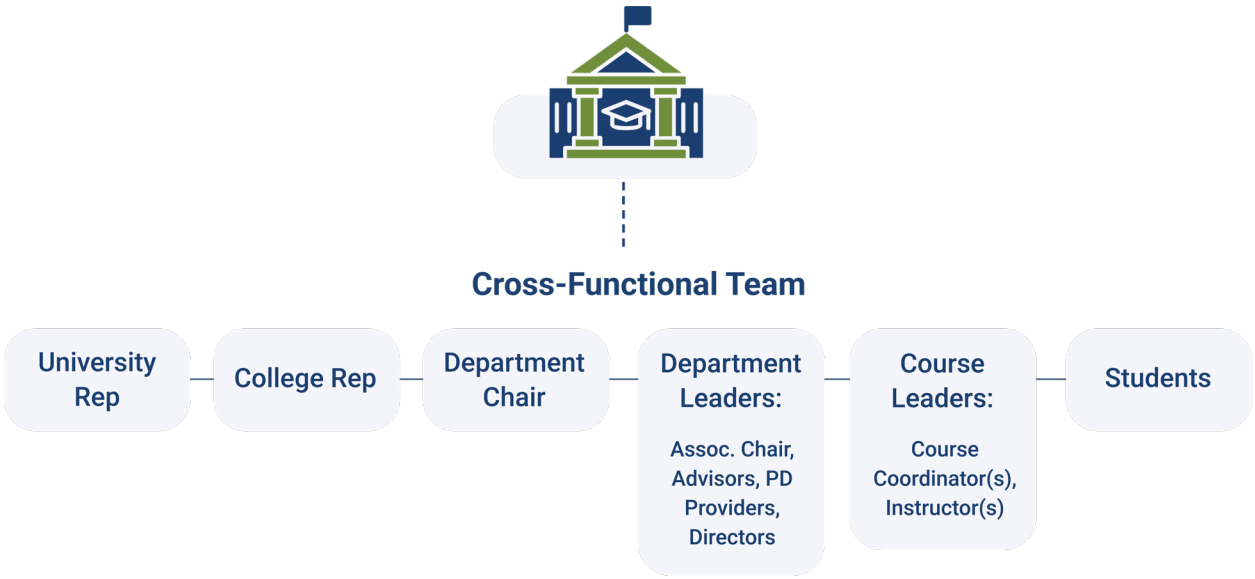


Figure 1. Potential cross-functional team membership.

1.B. Establishing Norms

It is important for a team to have shared ways of working collaboratively (team norms) and methods of transparency and communication to key stakeholders (communication norms).

1.C. Visioning for Introductory Mathematics: Phase 1

Making sustained and effective change in introductory mathematics is a collaborative and intentional process with shared ownership of efforts. An optimal driver of this process is a shared vision among the team members; thus, an initial step is to engage in visioning. The result of visioning is a clear, motivating, and inclusive vision statement that provides direction, fosters collective ownership, and serves as a touchstone for continuous improvement. Using the input from an initial brainstorm, the cross-functional team will collaboratively draft a vision statement to be shared with the cross-functional team or other relevant stakeholders, as well as the entire department. With a clear vision, programs are equipped to push forward and drive toward collective and meaningful transformation.

1.D. Professional Learning: Becoming a Change Agent

Transforming introductory mathematics will involve systemic change that will need to be sustained over time. Thus, team members need to take on the role of *change agents* within their institution, coordinating with relevant university stakeholders, and may need professional learning in order to engage in this work.

Milestone 2: Assessing Current Practices

The self-assessment process creates opportunities for a team to engage in rich discussions about their introductory mathematics program. This process involves a tool that helps a team identify the areas where an introductory mathematics program is succeeding and where the program can be improved.

2.A. The Self-Assessment Tool

The cross-functional team (or some subset of the cross-functional team) will complete the Self-Assessment Tool discussed in more detail in the *Assessing Current Practices* section of this guidebook. There are seven rubrics contained in the Self-Assessment Tool which assess the current landscape of introductory mathematics at the institution:

Rubric 1: **Student Success Data**

Rubric 2: **Climate for Transformation**

Rubric 3: **Intro Math Course Structure**

Rubric 4: **Student Support**

Rubric 5: **Course Coordination and Curric Materials**

Rubric 6: **Instructor Professional Developoment**

Rubric 7: **Instruction and Assessment**

2.B. Collecting Additional Relevant Data & Information

The self-assessment process will support an institution in developing an understanding of the current state of introductory mathematics through the collection of data (see Rubric 1 of the Self-Assessment Tool). Additional data (e.g., placement, course success, retention and course throughput, etc.) may be relevant for teams to collect prior to, during, and after the self-assessment process. Data provide information about the local context, helping inform the narrative around introductory mathematics.

2.C. Creating a Wish List

The self-assessment process will illuminate ideas for change that the team may want to capture. As areas for change are identified, the team completing the self-assessment will create a wish list of ideas for potential change. This wish list will guide the cross-functional team as they consider innovations to implement in their introductory mathematics program.

Milestone 3: Planning for Transformation

Once the self-assessment process is complete, the cross-functional team will be positioned to craft an action plan for enacting positive change in introductory mathematics. Because introductory mathematics impacts institutions broadly, playing some role in most programs and majors, the development of an action plan should involve the cross-functional team. In addition, we highly recommend making sure that efforts align with the institution's strategic plan. When change initiatives are aligned with institutional priorities, administrators are better positioned to allocate resources and elevate the work.

3.A. Moving Forward on the Visioning Process: Phase 2

Using the input from the Visioning for Introductory Mathematics: Phase 1, the team will collaboratively draft a vision statement to be shared with the cross-functional team or other relevant stakeholders. With a clear vision, programs are equipped to push forward and drive towards collective and meaningful transformation.

3.B. Actioning the Vision: Creating an Action Plan

When the cross-functional team understands the current context and state of introductory mathematics at the institution (from the Self-Assessment Tool results) and has a clear vision statement, they will then be well-positioned to identify what needs to change and determine the best way to advance and engage the identified change. The goals of any change effort will vary depending on where the issues lie. Once the team identifies the goal(s) they want to focus their efforts on, they need to identify which innovation(s) they can adapt to their local context.

Project EMBER has identified five potential areas of innovation (see Figure 2) that could serve as a hub for creating an action plan. Once an area of innovation is selected, the cross-functional team will map out short-term goals, long-term goals, and immediate next steps to work toward actioning the vision and implementing the innovation(s).

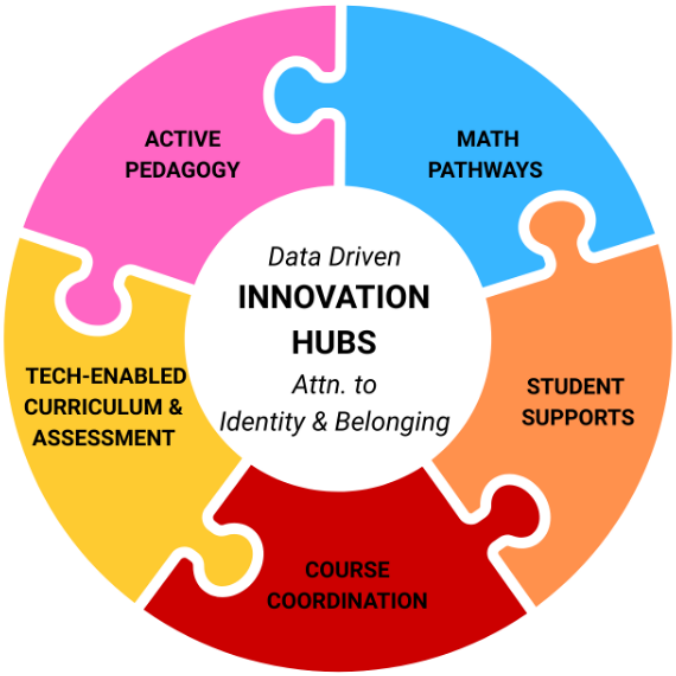


Figure 2. Project EMBER's evidence-based areas of innovation.

3.C. Assembling the Implementation Team

Once the action plan is developed, the cross-functional team will be encouraged to seek out change agents who will help enact the planned innovation. These change agents can be internal or external. The membership of the implementation team will depend on the context and innovation selected for the action plan. For instance, selecting an implementation team for course coordination would look different than math pathways as the chosen reform.

3.D. Professional Learning: Learning How to Enact Innovation

It is important to carry out the action plan in a way that leads to sustained transformation. As such, the team might consider engaging in professional learning to support the development of transformation leaders who can inspire and lead positive change within the department (or campus unit) and the institution.

II. EMPOWERING THE TEAM

Assembling the Cross-Functional Team

Transformation in introductory undergraduate mathematics education is institutional work. Enacting and sustaining positive change in introductory mathematics goes beyond the classroom level, as issues are typically complex and involve a variety of stakeholders. This guidebook approaches this work with that in mind — recognizing the influence that stakeholders in different roles and positions can have on change efforts.

Institutional stakeholders at various levels bring unique expertise and experience that can inform how change efforts can be enacted. For example, individual instructors may not be aware of institutional resources that could support change initiatives. In contrast, deans and provosts are not usually aware of needs at the classroom level. However, both groups of stakeholders bring valuable perspectives to consider when implementing and sustaining change. Thus, it is important to consider any change effort holistically, and all stakeholders who can support, implement, and/or are impacted by a change effort should have a voice in the decision-making and the change process. This includes (but is not limited to) administrative leaders at the dean and provost levels, university and/or department advisors, campus units such as the registrar's office and Institutional Research (IR), faculty (especially TFF), and students. It is critical to note that institutional and department leaders develop support structures that ensure that the team, and TFF specifically, are empowered to do their work.

Members of the Cross-Functional Team

The cross-functional team is a group of individuals with knowledge, experience, and positionality that can support change. Each member brings unique expertise to characterize the state of introductory mathematics at the institution, and their various positions enable them to support change in unique ways. At a minimum, the team should include members whose collective roles span the university level, department level, and course level (see Figure 3 for possible team membership).

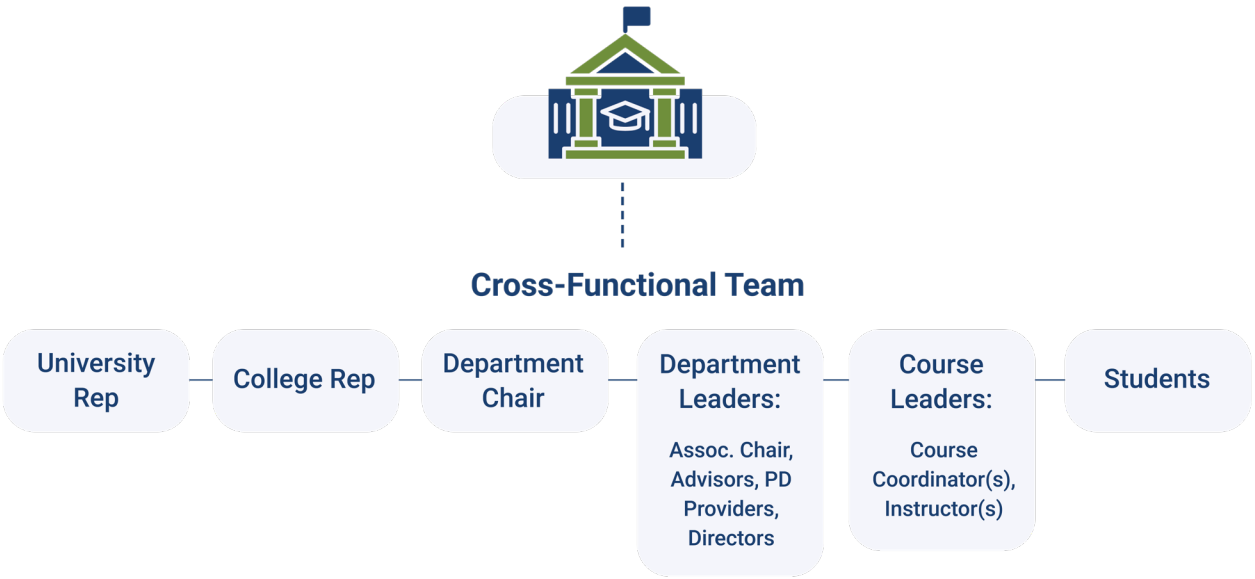


Figure 3. Potential cross-functional team membership.

University leadership is critical for supporting change efforts, as they can "pull levers" that others cannot. University leaders, such as a representative from the provost's office and/or the dean, can help navigate university structures and provide necessary resources. Department leadership, such as a department chair or associate chair, is positioned to support changes in department policy and teaching assignments. It may also be necessary to include other department members, such as research faculty invested in introductory mathematics, who could engage in and support the change effort. Course-level stakeholders include course coordinators as well as faculty who teach the impacted course. These are the individuals who know what the reality is at the classroom level and the specific challenges that may inhibit change.

The cross-functional team should also include students. Student members could include a graduate student who teaches impacted courses, and students who have taken the courses and can share their lived classroom experiences. Students who have supported impacted courses through tutoring or a learning assistant program should also be considered. The involvement of students will depend on the goals, and certainly students can become involved at any point in the process. Students have valuable input and perspectives others will not have.

For example, consider the following two scenarios, one in which the student perspective was included and one in which the student perspective was not included. For those wanting to think through ways in which students can be involved, one resource could be the Department Action Team Project (NSF Award No 1626565) as they have leveraged students as partners in department-level change efforts (Ngai et al., 2020, 2023; Reinholz et al., 2020).

Scenario 1: **Inclusion of Student Perspective**

A department-level group of various stakeholders (department coordinators, advisor, students, faculty, and department chair) came together with a goal of revising student learning outcomes (SLOs) for the department's undergraduate program. The non-student members of the team had assumed certain experiences had occurred in specific courses. The student member was positioned to speak to the lived experiences that actually occurred in courses. This afforded the team the opportunity to recalibrate their assumptions and adjust SLOs appropriately.

In addition, the team were better positioned to redesign courses or aspects of courses to be better aligned with the program's SLOs. The inclusion of a student on the team provided insight that the team would otherwise not have had.

Scenario 2: **Exclusion of Student Perspective**

A faculty-focused group collaborated on a project to infuse active learning in the teaching of College Algebra. The group did not include students on the team as the faculty did not believe that students would understand the complexities of teaching via active learning. They perceived that students would only be opposed to active learning and that they would not engage in the learning process as envisioned for active, thinking-focused classes.

It turned out some students had previous experience in active learning either in high-school math or in a math class at another institution. These students, who had experienced active learning in the past, later mentioned specific ideas that the faculty had not considered. Some ideas were: (1) regrouping students more often is helpful when groups of students are not functioning optimally and (2) instructors need to discuss the math after students work on the task together so that they know if they are approaching their thinking correctly or not.

The group missed out on capitalizing on students' past experiences in active learning that could have informed their work and provided a better learning experience for students.

Team Flexibility

While the cross-functional team plays a significant role in the work, there will be subgroups of this team engaging in various aspects as needed. For example, it is likely that provost representation (and possibly dean's office representation) is not needed for completing the Self-Assessment Tool. However, these leaders will be critical for supporting the change initiative. As another example, while not formally a part of the team or engaged in the self-assessment process, an IR representative may support the team's effort by providing necessary data to inform understanding of current issues and decision-making for change as well as provide future support for ongoing assessment and evaluation of a change effort.

On the other hand, it may be fruitful to have an IR member as part of the self-assessment subgroup, as they have intimate knowledge of how data are collected and interpreted. There may also be other institutional folks who could bring insight and knowledge during this process that may or may not be officially part of the cross-functional team. Another example is to include staff from an institution's Center for Teaching and Learning, as they have expertise in professional learning and development, course design, and use of technology in the classroom. Ultimately, this subgroup completing the Self-Assessment Tool should be composed of members who can speak to specific introductory mathematics courses within the department.

Establishing Norms

To foster positive outcomes and more equitable interactions, there should be shared norms and practices that occur at the meeting level (among team members) as well as more broadly at an institutional or project level. This will establish consistency for engagement among team members and establish expectations for how information is shared externally. It is important for each team not only to be high functioning but also to have predictable and consistent mechanisms in place to allow teams to engage externally regarding their change effort.

Interpersonal: Norms at the Team Level

Many examples of norms exist for collaborative teams. We see norms as being aspirational. We acknowledge that culture and experience can sometimes cause individuals to fall into habits or behaviors that are not necessarily aligned with productive engagement. Norms provide intentional structures that can foster productive collaboration. As an example, we have found the following set of norms to be useful with teams engaging in this sort of work. These norms are a variation of those used by MAA Project NExT:

- Encourage participation from all team members.
- Be sure to share talk time with other team members.
- Listen to understand.
- Recognize that everyone has expertise and unique experiences.
- Be present.
- Impact and action are greater than intent.
- Critique ideas, not people.
- Keep asset perspective for people; save deficit perspective for systems.
- *Others?*

After sharing these norms, we ask individuals to adjust these as desired or contribute additional norms to the list: *Are there any norms not listed that you believe would be important to include?* We also ask individuals to be mindful of their strengths and weaknesses with regard to norms: *Which norms do you do well? Which norms are a struggle for you?*

It will be important for teams to revisit these norms regularly so that teams do not slip into unproductive practices. While we are providing a list of norms, it is also okay for a team to develop their own set of norms through a consensus-building process. Regardless, it is important for a team to establish a set of norms or "community standards" that guide their interactions as they work, allowing for trust building and the prevention of problems before they arise (Ngai et al., 2020, p. 65). *Facilitating Change in Higher Education* (Ngai et al., 2020, p. 19) provides a rubric to help teams determine if they are engaging in positive collaboration practices.

Communication: Norms at the Institution Level

The cross-functional team should be communicating regularly about their efforts. Such communication may be within the team itself or from the team to external stakeholders. Not only is it necessary for stakeholders to be aware of the work but those in specific positions may be able to help facilitate certain actions or provide resources to support the work.

That said, standardized communications (type and frequency) help establish expectations and keep teams on track. Communications may come in the form of emails or newsletters, luncheons or receptions (e.g., coffee/tea), formally scheduled meetings, etc. In addition, this allows for cycles of feedback as the cross-functional team engages in their work. We also see this as an opportunity for leaders to demonstrate support for TFF and to be cheerleaders for the change effort. Regular communications can help establish new relationships and cultivate allies.

Visioning for Introductory Mathematics: Phase 1

Transforming introductory mathematics begins with a collective act of imagination: visioning. Visioning is a collaborative and intentional process of imagining a compelling future that reflects shared values, aspirations, and goals, and using that future-focused image to guide strategic planning, decision-making, and cultural change. This is the process of stepping away from current status quo, constraints, and barriers, and instead envisioning the ideal future state of the introductory mathematics program in support of enhancing opportunities for students. Visioning requires courage, creativity, and collaboration, and it is the foundation upon which meaningful transformation is built. Visioning involves engaging all stakeholders in reflective, generative thinking to articulate what success looks like in the long term, independent of current limitations. The result of visioning is a clear, motivating, and inclusive vision statement that provides direction, fosters collective ownership, and serves as a touchstone for continuous improvement.

Why Visioning Matters

A shared vision answers the questions: *"What role do we want introductory mathematics to play in our students' lives?"* and *"What do we want our introductory mathematics program to look like in five years if we are truly successful?"*

A clear vision anchors shared decisions to meet a common goal.

The vision serves several vital **purposes**:

Direction:
A clear vision anchors shared decisions to meet a common goal.

Motivation:
It inspires faculty and staff by painting a picture of purpose and potential.

Alignment:
It promotes shared ownership, which strengthens cohesion and focus.

Change-Readiness:
By focusing on aspirations rather than problems, visioning cultivates openness to innovation and transformation.

A vision statement **should be**:

Aspirational:
It reflects what you *hope* to become as a program for introductory mathematics.

Inclusive:
It embraces inclusivity, innovation, and student success.

Clear and Concise:
It is a statement that faculty can rally around and students can understand.

Without a vision, programs risk becoming reactive rather than strategic, or stagnant rather than progressive. With a vision, programs are equipped to push forward and drive toward collective and meaningful transformation.

The Visioning Process — Getting Started

The visioning process unfolds through facilitated collaboration and input from a variety of stakeholders, both internal and external to the cross-functional team. Internal stakeholders may include instructors/faculty, teaching and learning experts, instructional designers, administrators, staff, tutors, and students. External stakeholders may include IR officers, advisors, the registrar, etc. This input can be gathered by the cross-functional team members.

The initial process of visioning could unfold by cross-functional team members gathering input (via Google Slides, Padlet, or another tool) from team members with an intentional focus on situating the vision for introductory mathematics within the broader vision for the department and institution. Team members could engage in a couple of rounds of questions, such as: (Round 1) *What does student success look like?* And (Round 2) W*hat is the evidence that supports this success?*

Professional Learning: Becoming a Change Agent

This guidebook leverages the work of the Department Action Team (DAT) project, which has engaged in extensive research on understanding how academic departments change, principles that support department-level teams as they engage in a change effort, and how individuals, such as TFF, develop into *change agents*. In particular, Ngai et al. (2020, p. 84) call out four capacities in which an individual can focus on for developing into a change agent:

1. Collaboration
2. Local Context
3. Project Focus
4. Change

These capacities, which are unpacked in greater detail in the *Developing DAT Members' Change Agency* (Ngai et al., 2020, pp. 84–93) chapter, "involve knowledge, skills, and resources that are necessary" to (1) engage in productive group collaboration involving a diverse group of stakeholders, (2) understand the local context and setting in which the introductory mathematics program is situated, (3) deeply understand the problem impacting introductory mathematics, and (4) enact and sustain change.

While the individuals who may take on this work hold expertise in their respective fields of study, it is likely that they are not equipped in all four capacities. Professional learning within these areas will help address these gaps and build capacity for change.

The Accelerating Systemic Change Network (ASCN) provides resources for those who engage in change in science, technology, engineering, and mathematics (STEM) higher education. For example, ASCN provides the Critical Resources for Change Agents, which is a list of resources for individuals, administrators, and professional organizations who wish to lead effective change efforts at their institutions.

Additionally, the community of TFF supports each other through the EMBER community gathering on Zulip. As of this writing, nearly 400 math professors, mostly TFF at research institutions, are exchanging ideas, sharing challenges, brainstorming solutions, and providing each other support. Interested faculty can join the community.

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III. ASSESSING CURRENT PRACTICES

Why is navigating the Self-Assessment Tool helpful? The process of navigating through the Self-Assessment Tool helps identify the areas where an introductory mathematics program is succeeding and where the program can be improved. The rubrics contained in the Self-Assessment Tool also facilitate a mathematics department's ability to identify how to make improvements by offering exemplar definitions of criteria to aspire to. We see the self-assessment process as a mechanism to promote deep discussions about introductory mathematics. Through this process and through the meaningful discussions among the team members, ideas will emerge on next steps for leveling up the success of the program to improve students' experiences. The discussions that will occur while completing the self-assessment will allow the team to share their individual knowledge of the program to arrive at a collective understanding of the current status.

The Self-Assessment Tool

The process of engaging with the Self-Assessment Tool will help a team in focusing their efforts in enacting change in introductory mathematics. The following is a list of the rubrics contained in the Self-Assessment Tool:

Rubric 1: **Student Success Data**

Rubric 2: **Climate for Transformation**

Rubric 3: **Intro Math Course Structure**

Rubric 4: **Student Support**

Rubric 5: **Course Coordination and Curric Materials**

Rubric 6: **Instructor Professional Developoment**

Rubric 7: **Instruction and Assessment**

The cross-functional team (or some subset of the cross-functional team) will complete the Self-Assessment Tool by first individually rating the criterion in each rubric, then collaborating with the team to determine consensus ratings for each criterion. Exploring the Self-Assessment Tool provides opportunities for team members to discuss their various perspectives about introductory mathematics within their department and develop a deeper understanding of where they are and where they want to be. Once the self-assessment process is complete, the team can connect their gained insights back to their vision statement.

This subteam will likely be of size 6–8[1] members who span a variety of roles more directly related to introductory mathematics. It is crucial to have a diversity of voices that can speak to specifics regarding introductory mathematics, but the team should not be so large that it impedes the work. Figure 4 provides an example of a possible subteam of the cross-functional team that may engage in the self-assessment process. At minimum the subteam should include relevant course coordinators and TFF instructors, but we also recommend including appropriate department leaders and students who can provide other perspectives and knowledge. In some cases, a department chair or college representative may also be able to provide insight.

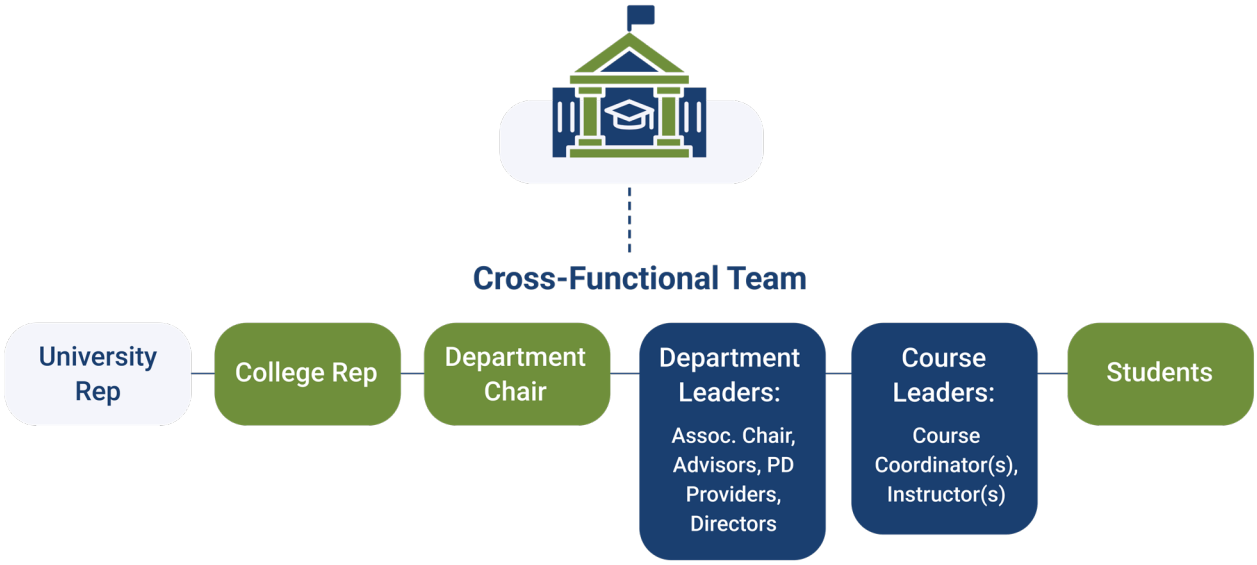


Figure 4. Potential self-assessment subteam with membership from core partners represented by the blue boxes and optional supporting partners represented by the white and green boxes.

Collecting Additional Relevant Data & Information

The team may find that in order to complete aspects of the Self-Assessment Tool they need to collect additional data or do deeper analyses. Questions that a team can ask themselves as they engage with data include: *What do the data tell us? What else do we want to know? What have we learned?*

[1] The size of the team will depend on a number of factors including the size of the department and the number of individuals engaged with introductory mathematics.

Regular examination of data will also help teams understand if and how change is occurring. If teams are unsure of how to engage with data, a good resource for guidance is the Cycle of Progress described by Rehrey et al. (2020), which outlines an approach to enacting change and engaging in continuous improvement through a cycle of awareness, understanding, action, and reflection. Increasingly, someone in the department has access to these sorts of data; if not, sources include IR and the registrar's office.

Tools for data analysis that have proven useful to mathematics departments looking to improve their introductory mathematics programs include course-level equity analyses and, if student-level data are available, ribbon tools to generate Sankey diagrams to show students' paths through connected courses. Those tools will be posted on the EMBER website as they become available.

Creating a Wish List

The team completing the self-assessment process will keep track of innovations (e.g., evidence-based innovations identified from Project EMBER) that could be a focus of change initiatives as they are coming to consensus on the various ratings within the self-assessment. Ideas for these innovations could be inspired by looking at what would take the department to the next level on the rubric (e.g., from developing to accomplished). Or it could be in light of information shared with the group while discussing individual ratings for a particular criterion on a rubric (e.g., one or more faculty members share how they are implementing something in their class(es) that could be expanded to more members of the department). For example, a team may identify the establishment of new placement procedures in combination with the creation of a corequisite course as innovations for change.

After completing the self-assessment process, the team will compile a wish list of possible innovations they might consider actioning and implementing in the future. Keep in mind that creating this wish list is more about envisioning an ideal or considering the possibilities rather than eliminating innovations because of existing barriers or because they do not align with what has been done in the past.

In future stages of this work, the team will have a chance to reconsider this wish list and potentially select some ideas to target with an action plan. At this stage, either overarching ideas or specific innovations are welcomed.

Reflection Questions for Guiding Idea Generation

The following are a few reflection questions that may help promote discussion to guide idea generation for the wish list:

- For which criterion was the department in between two levels of the rubric? What would your department need to do in order to be on the next level for this criterion?
- What other ideas/innovations came up in the discussion while completing the rubric that you want to capture/remember?

- How can the department build on our strengths and existing structures to introduce new practices or approaches?
- What small, immediate changes could serve as a starting point for larger transformations?
- What were some previous programs that the department used to do that were interesting and could be reinstated if the resources were available?
- What is something that one member of the team was working on that was interesting or the team would like to learn more about or expand to other courses?
- What are some takeaways that the team would like to share with the rest of the department?

References

Rehrey, G., Molinaro, M., Groth, D., Shepard, L., Bennett, C., Code, W., Reynolds, A., Squires, V., & Ward, D. (2020). Supporting faculty adoption of learning analytics within the complex world of higher education. In D. Ifenthaler & D. Gibson (Eds.), *Adoption of data analytics in higher education learning and teaching: Advances in analytics for learning and teaching* (pp. 221–239). Springer.

IV. PLANNING FOR TRANSFORMATION

Moving Forward on the Visioning Process: Phase 2

In moving the visioning process forward, the cross-functional team might consider the following steps for creating a vision for introductory mathematics after completing the Self-Assessment Tool:

1. Collaborative Brainstorming — Beginning with the Future in Mind

- Working together (in person or virtually), review the input provided from "The Visioning Process — Getting Started" and then imagine the introductory mathematics program *five years from now* after significant, successful transformation. Ensure that all voices are heard.
- Ask: *What are we doing? What does success look like? What impact are we having on students, faculty, and the institution?*
- Remind the group about the difference between a vision statement and a mission statement. We are aiming for a vision statement that describes the desired future for the department, while a mission statement describes how, with specific actions, the department will enact the vision.
- Brainstorm on keywords that are important to include in a vision statement. Have participants write these keywords for all to see, which can be done on sticky notes or Google Slide deck (or a virtual whiteboard such as Padlet or Miro).

Begin with the future in mind!

2. Collaborative Drafting — Formulating the Vision

- As a group, prioritize keywords that the group wants to weave into the vision statement, then collectively draft an initial vision statement. More than one version of the statement can emerge at this state of the process.
- Encourage creativity and suspend judgment — each idea is worth exploring.
- Review the initial vision statement(s) for clarity and conciseness, yet thoroughness.
- Return to the initial questions (*What are we doing? What does success look like? What impact are we having on students, faculty, and the institution?*) to ensure that the vision statement(s) sufficiently address(es) them.

Formulate the vision!

3. Collaborative Vetting — Finalizing the Vision

- Share the vision statement(s) for introductory mathematics with the full cross-functional team and seek their input.
- If more than one vision statement is shared with the teams, request their input on which statement best captures the vision.
- Discuss which statements speak the most to the group. A voting process (e.g., sticky dots) helps prioritize the most resonant ideas.
- Identify key phrases to include in the final draft statement, especially if more than one vision statement is under review.
- Through discussion and consensus, the team arrives at a final draft vision statement.

Finalize the vision!

4. Collaborative Endorsing — Sharing the Vision

- Once the vision statement is drafted, the team is ready to share with the broader department. The idea here is that the vision should be a shared vision with the department to ensure that it is more permanently positioned within the work of the full department.

Share the vision!

A sample vision statement from University Y is provided in the box.

Sample Vision:

Introductory mathematics courses at University Y are learning environments where all students actively engage in exploring mathematics and building skills in content that aligns with their interests. We take an asset perspective toward students and their prior experiences, providing supports and building community to increase their opportunities for success.

Actioning the Vision: Creating a Plan

Leveraging Evidence-Based Innovations

Project EMBER has curated evidence-based resources to support institutions engaging in transformation in introductory mathematics. These innovations leverage research that showcases advances in facilitating student learning and success. Figure 5 illustrates these innovations, which serve as a driving force for Project EMBER.

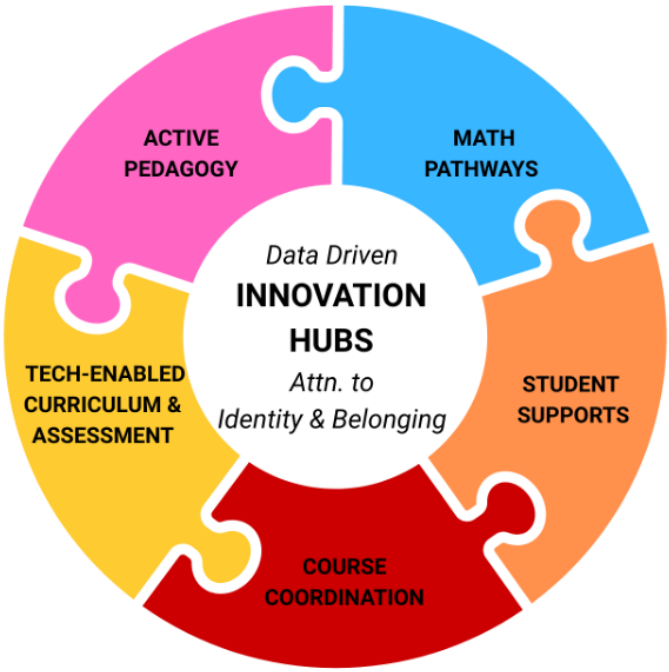


Figure 5. Project EMBER's evidence-based areas of innovation.

The innovation hubs represent a collection of common areas of concern that arise from the self-assessment process; thus, they can provide a unifying place to start when creating an action plan. The team is encouraged to consider how the innovations of **active pedagogy** (e.g., active learning strategies), **math pathways** (e.g., SLOs review to ensure that course sequences are aligned and meet the needs of partner disciplines), **student supports** (e.g., corequisite model, high-touch advising, tutoring), **course coordination** (e.g., establishing course coordination), and **tech-enabled curriculum and assessment** (e.g., alternative grading, digital courseware) could serve as a launchpad for the action plan. These innovations are not intended to be disjointed; innovations in active pedagogy, for example, are inherently tied to student support and other areas. Additionally, all innovations require some sort of professional

learning for those directly involved in enacting the change. We also acknowledge that these innovations are not the only innovations that exist, but they are a selection of research-based strategies to consider when embarking on a change effort. Learn more about the innovations and read about the research supporting them.

When thinking about the innovations, it might be helpful to first select a course(s) to focus on, then identify which innovation(s) will be the target of the work. Alternatively, teams may select an area of innovation(s) first, then choose the course(s) to target. For example, if the team decides that establishing (or improving) course coordination is what they would like to focus on, there also should be discussion about which course(s) will be targeted. These decisions are based on the needs of the introductory mathematics program and insights from the Self-Assessment Tool.

Revisiting Self-Assessment Results, Wish List, & Vision

In addition to leveraging the innovations as potential areas of focus, the team should revisit the insights gained from the self-assessment process, the wish list that summarized potential areas of focus for their work, and the vision statement drafted at the beginning of the process. During this review process, the team should pay attention to any recurring patterns or common themes that shed light on areas for departmental growth related to introductory mathematics. The team should add to or expand on ideas as necessary, then work to curate the list of potential areas to prioritize. It may be helpful to organize ideas generated by theme and classify them in terms of short- and long-term goals. Afterwards, the team will determine and articulate immediate next steps to take to move the innovation forward. An example of an institution's change journey, along with a matrix for goals and next steps, is provided in the *Story of Institution X's Change Journey*, which you will find later in this guidebook.

Selecting Innovations to Target Action Planning

After generating a list of potential areas of growth to focus on, the team should select one or two areas to focus on for the action plan. The number of innovations selected to focus on will depend on available resources and capacity to implement the innovation(s) (e.g., infrastructure, people). What the team chooses to focus on should be informed by the self-assessment process, wish list, and vision statement. In addition, we highly recommend making sure that efforts align with your institutional strategic plan.

A team may wish to focus on changing placement procedures, offering corequisite courses, implementing gateway exams, and/or providing alternative grading structures, etc. For additional information on an array of evidence-based teaching practices you might integrate into your action plan, see Every Learner Everywhere's Transform Learning website and example library.

Developing an Action Plan

The process of developing an action plan will begin with the cross-functional team. At this stage of the work, however, it is especially important to communicate with and bring in institutional leaders and other key stakeholders, including course coordinators who are not on the team. These leaders are well-positioned to leverage their institutional knowledge and relationships, and can support access to resources for developing, implementing, and sustaining an action plan. These leaders tend to have specialized knowledge of what barriers can be removed and what existing structures can be leveraged to realize the action plan. For example, if the team decides to focus on developing and implementing a new course to better support math pathways for partner disciplines, a college or institutional-level leader may know about a temporary course number that could be used while the course is piloted, removing the potential delays of having to go through the formal levels of approval before initial implementation (e.g., curriculum committee, adding a course to the catalog, changing degree plans).

In order to develop an action plan targeting the innovation selected by the team, it may be helpful for the team to discuss the following questions:

1. What does the department have working in its favor? What resources or personnel support are currently in place?
2. What will help the department achieve this goal?
3. What resources or personnel support are needed? What other supports can make this goal happen more effectively?
4. What barriers stand in the way of the department achieving this goal?
5. Who owns/controls the barriers?
6. What are some ways to work to remove these barriers?
7. What are the short- and long-term goals for actioning the vision?
8. What are some immediate next steps for action?

After discussing these questions, the team will start to map out specific steps to take to achieve their goal(s). These steps should be specific and actionable; in other words, it should be clear to key team members and stakeholders what needs to be done and who is responsible for taking the action. Then the team will create an ideal timeline for achieving each of the steps, considering how the team will measure progress and ensure accountability in implementing each of the steps. Once a draft of the action plan is in place, the team will identify and communicate with key stakeholders (that were not already part of the action plan development process), gather feedback, and revise the action plan as necessary. A template for guiding the action plan development is available for use.

Assembling the Implementation Team

After the action plan has been developed, it is important to assemble the appropriate team for carrying out the plan — *the implementation team*. The composition of the implementation team should depend on which innovation areas and which courses will be the focus of the effort. For continuity, there should be at least one member who was engaged in the self-assessment, visioning, and development of the action plan who continues with the implementation team. This allows for more continuity of work, transparency in processes, and ongoing communication across the team and to other relevant stakeholder groups.

The membership of the implementation team will depend on the context and innovation selected for the action plan. Suppose the team decided to focus on course coordination. Depending on the specific context and rationale for focusing on course coordination, it may or may not make sense to include a college-level representative on the team.

Scenario 1:
Inclusion of college-level representative

Suppose the action plan involves introducing a structure of course coordination for introductory mathematics courses, including a teaching reduction for course coordinators. In order to realize this innovation, it will be critical for a college-level representative to be part of the implementation team as they will be able to speak to what funds or resources could be made available, such as lines for new TFF or additional funds that could be allocated for course releases.

Scenario 2:
Exclusion of college-level representative

Suppose that a course coordination structure is already in place, and the action plan involves focusing instruction for one (or more) coordinated courses on active learning and fostering student engagement. This innovation could remain focused at the course level, and so there is less need to include a college-level representative, especially if there are already members of the team aware of institutional initiatives for supporting some of this work (e.g., mini-grants for summer funding to dedicate time to develop course materials that foster student engagement).

Professional Learning: How to Enact Innovation

The team might consider engaging in professional learning opportunities to assist in the planned innovation. Traditional professional learning, such as one-off or non-discipline-specific workshops, often falls short in facilitating lasting change. As such, it is critical to ensure that change agents who are embarking on transforming introductory mathematics grow professionally to learn how to enact deeper professional transformation to have greater impact on student learning where the change is both sustainable and scalable. In short, the goal is to provide professional learning that creates transformation leaders who can inspire and lead positive change within their institutions. This professional learning could include (but is not limited to) the following:

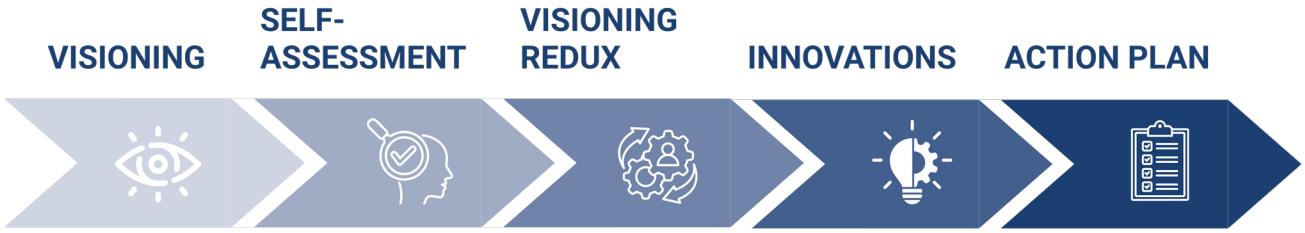
- Developing strategic visioning and goal-oriented skills
- Using data to inform decision-making at both programmatic and classroom levels
- Building capacity for carrying out innovation
- Cultivating leadership and growth-oriented mindsets
- Adapting to challenges and navigating uncertainty.

V. STORY OF INSTITUTION X'S CHANGE JOURNEY

The mathematics department at Institution X (a large, urban research university) engaged in an external evaluation of their program. They recognized that they needed to make changes in the courses leading to Calculus I — addressing student success rates and improving upon the learning experience. However, they were not completely sure how to start. Thus, various department members and university stakeholders got together to discuss how to move forward. This *cross-functional team* included:

- Department Chair and Associate Chair
- Course Coordinators (College Algebra, Precalculus, and Calculus I)
- Course Instructors (mix of tenure-track and non-tenure-track faculty)
- College Dean
- CTL Leadership
- Graduate Students.

They divided the large group into course-specific groups with department, college, and/or CTL leadership present in each. Each group then engaged in a visioning and self-assessment cycle to identify how to move forward. Specifically, each course group went through the following steps:



1. Visioning: *What does student success look like? What evidence would indicate success?*
2. Self-Assessment Tool: *Where are we and where do we want to be?*
3. Visioning Redux (refining of the vision based on results from the self-assessment process): *How has our vision changed in light of the self-assessment?*
4. Innovations: *What are the possibilities for enacting change?*
5. Action Plan: *How can we bring together Steps 1–4 to create an action plan?*

The visioning process for Institution X was a variation of that described in this guidebook — they established visions within coordinated courses and then linked their respective visions together through their course-specific self-assessments and action plans. Coordination of action plans was important to ensure that their respective course-specific visions came together in such a way that efforts were aligned and supportive of each other. This coordination of action plans also helped promote a more consistent learning experience for students across the course sequence.

All courses identified active learning, placement and vertical alignment, and the inclusion of corequisite courses as critical innovations for supporting student success. Active learning within each course established consistent expectations for students. Alignment of course content ensured that students (1) engaged with appropriate topics and (2) did not receive redundant instruction on topics. Finally, the establishment of corequisite courses allowed placing students in non-remedial courses, keeping them on track for completion of their program of study. Table 1 outlines the big picture goals and innovations for introductory mathematics at Institution X.

COURSE → / INNOVATION ↓	COLLEGE ALGEBRA	PRECALCULUS	CALCULUS I
CONTENT	Remove material not aligned to Precalculus and Calculus success.	Reduce redundancy of overlapping content with College Algebra. Establish a one-credit corequisite support course.	Reduce redundancy of overlapping content with Precalculus.
SUPPORT: COREQUISITE COURSE	Change existing mandatory recitation into a corequisite for some students.	Establish a one-credit corequisite support recitation with just-in-time teaching.	Establish a one-credit corequisite support recitation with just-in-time teaching.
ACTIVE LEARNING	Expand successful active learning in recitations to increase student engagement and strengthen the connection with large lectures.	Train TAs in active learning techniques (based on the existing College Algebra model).	Train TAs in active learning techniques (based on the existing College Algebra model).
SUPPORT: PLACEMENT	Place more students directly into Precalculus with a required corequisite.		Place more students directly into Calculus with a required corequisite.
ASSESSMENT		Add short answer questions to prepare students for Calculus assessments.	Add a standards-based grading component.
COURSE COORDINATION	Continue regular meetings with all course instructors.	Tighten coordination by sharing activities, collaboratively designing course materials, and conducting peer observations.	Tighten coordination, including collaborative creation of a common final exam.

Table 1. Big picture goals and innovations for introductory mathematics at Institution X.

Each course group identified concrete actions for meeting both short-term and long-term goals. They engaged various stakeholders in the process and leveraged university leadership to help enact aspects of their action plan. Table 2 is the first draft of the College Algebra group's action plan, which illuminates their short- and long-term goals, along with immediate next steps for each of their three overarching goals. They identified evidence-based teaching practices (e.g., active learning) and alignment of content as critical pieces of their future work.

OVERARCHING GOAL 1: **Improve content alignment**	**OVERARCHING GOAL 2:** **Increase student engagement through active learning**	**OVERARCHING GOAL 3:** **Strengthen the relationship between large lectures and recitation**
Short-term goals: • Establish alignment of content from College Algebra through Calculus 1. • Incorporate more conceptual problems into the curriculum. • Increase formative assessments. • Align exam procedures.	**Short-term goals:** • Start building shared resources that support active learning. • Focus on incorporating writing problems to give students practice in justification.	**Short-term goals:** • Common recitation structure: Start each class with an active learning activity. • GTA rep[2] and undergraduate learning assistants attend course meetings.
Long-term goals: • Vertically align the content (reduce redundancy and gaps). • Use instructional technology across courses. • Ensure consistency across exams (structure and processes).	**Long-term goals:** • Set up regular summer PD with instructors. • Introduce peer classroom observations.	**Long-term goals:** • Scaffold activities formally for recitations. • Provide instructor guides for GTAs. • Provide GTAs with PD for teaching with active learning.

Table 2. Example of overarching goals, short- and long-term goals, and immediate next steps for College Algebra at Institution X.

[2] GTA rep is a graduate teaching assistant who teaches a recitation for Calculus I.

Immediate next steps: • Hold regular meetings between course coordinators. • Collaboratively develop shared/common exam structure and procedures.	**Immediate next steps:** • Introduce small changes in section notes toward active learning. • Share ideas with each other (e.g., *What is working? Not working?*).	**Immediate next steps:** • Introduce the idea of active learning into the course.

(***Continued***) **Table 2.** Example of overarching goals, short- and long-term goals, and immediate next steps for College Algebra at Institution X.

We want to emphasize that this example illustrates the journey of a particular institution that was getting started with evidence-based innovations in their mathematics classrooms (e.g., active learning, math pathways/vertical alignment). This was their starting place how they wanted to grow from their current state. At this inflection point, their established action plan was what made sense for their needs and within their context.

Other institutions' introductory mathematics programs may be situated differently and within a unique context. We encourage such institutions to think beyond this specific example and think through what will work for them in their specific context.

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