The Mathematical Inquiry Project

Request for Proposal
Collaborative Research and Development
Academic Success Skills

The Mathematical Inquiry Project (MIP) is a statewide collaboration among mathematics faculty in Oklahoma to improve entry-level undergraduate mathematics instruction through three guiding principles:

Active Learning: Students engage in active learning when they work to resolve a problematic situation whose resolution requires them to select, perform, and evaluate actions whose structures are equivalent to the structures of the concepts to be learned.
For more information on the MIP Active Learning Principle, visit https://okmip.com/active-learning/

Meaningful Applications: Applications are meaningfully incorporated in a mathematics class to the extent that they support students in identifying mathematical relationships, making and justifying claims, and generalizing across contexts to extract common mathematical structure.
For more information on the MIP Meaningful Applications Principle, visit https://okmip.com/applications/

Academic Success Skills: Academic success skills foster students' construction of their identity as learners in ways that enable productive engagement in their education and the associated academic community.
For more information on the MIP Academic Success Skills Principle, visit https://okmip.com/academic-success-skills/

Description of CoRD products
The products produced by each Academic Success Skills CoRD should address the following:

- Articulate a conceptualization—informed by the research literature—of the targeted topic (e.g., mathematics anxiety) and a describe its relation to or emergence from particular aspects of students' affect and/or cognition.
- Review and synthesize the empirical research literature on the targeted topic that clarifies its ontology, demonstrates its significance for students' mathematics learning, or documents the effectiveness of interventions designed to address it.
- Propose research-based principles of instructional and/or curricular design to address the targeted topic and specify how these principles should be incorporated into the work of the CoRDs focusing on mathematical content and represented in the modules they produce.
- Explicitly describe how the CoRD's products relate to and/or support the other two MIP components of inquiry: active learning and meaningful applications.

After a successful review the CoRD will test their products with a class or group of students and incorporate a description of test implementation and its results, a discussion of the refinements and recommendations made based on test implementation, and short video clips with commentary to illustrate effective implementation.

Review and Revision
Once a CoRD submits a module, it will be reviewed by at least two other faculty with expertise in the topic to inform an editorial decision of “accept with minor revision,” “revise and resubmit,” or “reject,” along with directions for revision if appropriate. After a favorable review, the CoRD will revise and pilot their module, incorporating feedback gained during the review process and submit a final module for publication on the project website.

Author Stipends
Each author in the CoRD will receive a $2,500 stipend after delivery of a complete initial draft of the module and an additional $1,000 stipend after delivery of a complete revision of the module based on the editorial decision.

Opportunities for leading regional workshop
The MIP will leverage faculty leadership and expertise developed through its Initiation Workshops and CoRDs to also develop and deliver 40 institutional and regional professional development workshops, across the state of Oklahoma, on teaching the new courses, incorporating applications and active learning with the modules, and addressing academic success skills. Each Regional Workshop will last a full day and engage approximately 20 mathematics faculty in implementing one or two of the modules developed by the CoRDs and ensuring familiarity with the module resources. Each workshop will be led by faculty from the respective CoRDs with support of MIP personnel who will also assist the leaders in designing the workshop activities with advice from project consultants. A goal of the Regional Workshops will be to engage all relevant faculty in hosting at nearby institutions and to develop a structure that will provide training for new faculty and continuing professional development for all faculty.

Proposal requirements
The MIP seeks to support the development of research-based instructional and curricular design principles on the following targeted topics. See the following pages for details of each of these topics.

- Mathematics Anxiety
- Problem Solving and Critical Thinking
- Developing Classroom Communities
- Mindset
- Productive Struggle, Persistence, and Perseverance
- Motivation and Interest
- Beliefs about Mathematics

Proposals should include each of the following:

1. A cover page designating which of the targeted topics the proposed CoRD will address, names of all proposed CoRD members (3-5 people), their institutions, email addresses, and phone numbers.

2. The CoRD's initial image of how the CoRD will address the four foci outlined in the "Description of CoRD Products" above.
3. A description of prior experience of each CoRD member relevant to their development of the proposed module.

Proposal Length
The full text of a proposal should not exceed 2,000 words.

Consultation
The MIP encourages discussions with any of the project team on the planning and preparation of a proposal. Throughout the CoRD's work, MIP project personnel will provide associated resources and advice. The MIP will also organize events throughout the year to allow multiple CoRDs to present their progress and discuss ways to benefit from and integrate their approaches.

Proposal Submission
Completed proposals should be emailed to William (Bus) Jaco at william.jaco@okstate.edu. We strongly encourage discussions with the project team to avoid proposing work on topics that have already been assigned a CoRD. The MIP generally responds to proposals within one month of their submission. During the review of proposals, the MIP may request additional information or modifications before approval.

Proposals for Academic Success Skills CoRDs may be submitted on a continuing basis until July 31, 2020 with work typically extending up to six months from the start date. Variations on topics and timing may be arranged through individual discussions with the MIP project leadership.

Academic Success Skills Topic Descriptions for Collaborative Research and Development Teams

MATHEMATICS ANXIETY

Mathematics anxiety initiates unproductive behavioral responses and makes mathematical reasoning, sense-making, and critical thinking more difficult, if not impossible. Because mathematics anxiety emerges from a variety of subjective appraisals and cognitive constructions, instructors can manage students' anxiety by structuring various features of the learning environment—including the curricular resources they design for students—to reduce the likelihood that they will engage in the cognitive activity that results in their feeling anxious. A goal of entry-level mathematics instruction is to create the conditions for students to participate and engage in ways that are necessary for them to learn the mathematics meaningfully. A focus on reducing or even preventing students' mathematics anxiety is essential to addressing this goal. Anxiety and its effects can be magnified when gender or racial stereotypes of performance are activated in the learners, and instructors need resources to help frame learning situations in ways that promote confident and productive participation by all students.

The module developed by the CoRD focusing on mathematics anxiety should:

1. Provide a research-based description of mathematics anxiety as a real phenomenon that can be addressed through instructional and curricular innovations. The CoRD should address common perceptions that mathematics anxiety is a trait that an instructor has neither the responsibility nor agency to influence.
2. Provide a research-based description of how to recognize mathematics anxiety, including self-handicapping behavior and stereotype threat.
3. Identify and/or develop strategies both for preventing students' anxiety and for helping students cope with the anxiety they experience. The development or identification of these strategies will involve reviewing the research literature, and might involve consulting an educational psychologist
4. Describe the relationship between anxiety and stereotype threat, growth and fixed mindset, goal structures, and identity.
5. Provide recommendations for addressing students' anxiety that apply to a variety of instructional contexts (e.g., online, large lecture, small classes, different types of institutions

Initial Resources

Aronson, J., & Steele, C. M. (2005) Stereotypes and the Fragility of Academic Competence, Motivation, and Self-Concept. In A. Elliot & C. S. Dweck (Eds.) *The Handbook of Competence and Motivation*. New York: Guilford.

This chapter provides a detailed description of the nature of stereotype threat, conditions under which it may occur, and strategies to reduce stereotype threat and minimize its impact on academic performance.

Tallman, M. & Uscanga, R. (in press). Managing students' mathematics anxiety in the context of online learning environments. In J. P. Howard & J. F. Beyers (Eds.), *Teaching and Learning Mathematics Online*. Boca Raton, FL: CRC Press.

In this chapter, Tallman and Uscanga define mathematics anxiety as an emergent construction, progressively elaborated and refined through iterative cognitive appraisals of environmental stimuli and somatic states. They synthesize contributions in the areas of emotion, identity, goal theory, and Piaget's genetic epistemology to propose a theory of the cognitive antecedents of mathematics anxiety. Based on this synthesis, they recommend design principles for online learning environments to minimize students' anxiety by purposefully affecting the cognitive appraisals and constructions that contribute to its emergence. This resource is most relevant to addressing foci (1), (3), (4), and (5) above.

Zeidner, M. (2014). Anxiety in education. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 265-288). New York, NY: Routledge.

Zeidner surveys the research literature on anxiety in educational contexts to describe its nature, antecedents, consequences, and treatments. He focuses specifically on evaluative anxiety in educational settings. This resource is most relevant to addressing foci (1), (2), and (4) above.

Zeidner, M. & Matthews, G. (2011). *Anxiety 101*. New York, NY: Springer.

Zeidner and Matthews provide a comprehensive overview of anxiety. Specifically, they discuss the biological origins of anxiety, describe its cognitive, somatic, and behavioral facets, summarize various theoretical models of anxiety, distinguish its major forms, describe scales for measuring anxiety, identify its cognitive and behavioral consequences, and describe various treatments for anxiety. This resource is most relevant to addressing foci (1), (2), (3), and (4) above.

PROBLEM SOLVING AND CRITICAL THINKING

Developing productive problem-solving habits, and a disposition for critical thinking on which these habits rely, are essential components of mathematical proficiency. Additionally, problem solving and critical thinking provide a foundation for learning new mathematical concepts. A goal of entry-level mathematics instruction is to enhance students' problem-solving ability while leveraging it as a foundation for their learning of central ideas.

The module developed by the CoRD focusing on problem solving and critical thinking should:

1. Identify the cognitive habits and characteristics of effective problem solvers and critical thinkers.
2. Describe how the conceptual activity entailed in effective problem solving and critical thinking might develop.
3. Identify the mathematical ways of reasoning on which effective problem solving and critical thinking in algebra, precalculus, and calculus depends and describe how these ways of reasoning facilitate students' problem solving in these areas.
4. Propose specific principles of curriculum design and instructional practice (including assessment) to enable students to develop the cognitive habits of effective problem

solvers, and give at least one example of a task sequence that would make a good problem for each college algebra, precalculus, and Functions and Modeling.

5. Describe the potential affordances of the MIP focus on promoting students' active engagement and leveraging meaningful applications for supporting students' problem solving and critical thinking.

Initial Resources

Carlson, M. P., & Bloom, I. (2005). The cyclic nature of problem solving: An emergent multidimensional problem-solving framework. *Educational studies in Mathematics*, *58*(1), 45-75.

This resource details some of the cognitive habits and characteristics of effective problem-solvers. Specifically, the authors generalize the problem-solving behaviors of 12 mathematicians in a *Multidimensional Problem-Solving Framework* that includes the following four phases: orientation, planning, executing, and checking. Carlson and Bloom describe how progressing through these phases involves robust and well-connected knowledge of mathematical concepts, facts, and heuristics, as well as the ability to regulate one's emotions during the problem-solving process.

Silver, E. A. (Ed.). (2013). *Teaching and learning mathematical problem solving: Multiple research perspectives*. Routledge.

Among other things, this comprehensive resource reviews the history of scholarship on the teaching and learning of mathematical problem solving and surveys its key insights (Chapters 1 and 13), identifies significant implications of research in cognitive psychology for instruction in mathematical problem solving (Chapters 7 and 8), argues for the necessity to attend to students' experience when designing curricula to develop students' mathematical problem solving (Chapters 11 and 12), describes various affective issues relevant to students' problem solving (Chapter 13), discusses the role and significance of the teacher in promoting students' problem solving (Chapters 14 and 15), identifies the cognitive habits and characteristics of effective and ineffective problem solvers (Chapter 16 and 21), and discusses features of social contexts that are most propitious to fostering students' problem solving (Chapter 18).

Thompson, P. W. (1985). Experience, problem solving, and learning mathematics: Considerations in developing mathematics curricula. In E. A. Silver (Ed.), *Teaching and learning mathematical problem solving: Multiple research perspectives* (pp. 189–243). Hillsdale, NJ: Erlbaum.

Thompson's purpose in this chapter is to describe efforts to develop curricula that are based in research on mathematical problem solving while also being informed by an image of a student progressing through a curricular sequence. Thompson characterizes mathematical problems solving as a constructive and reflective activity that is essential to learning mathematics generally. This chapter is most relevant to addressing foci (2), (3), and (4) above.

DEVELOPING CLASSROOM COMMUNITIES

Feeling a sense of belonging to a community is essential to participating fully in that community's activities. Engineering the social context of a classroom to foster the establishment of a community in collective pursuit of the joint enterprise of learning mathematics through inquiry is a complex and difficult process, and for this reason is often ignored or neglected. However, the potential affordances of developing such communities are significant. It is therefore a goal of entry-level mathematics to cultivate communities of mathematics learners that establish the social, cognitive, and affective conditions for students to engage in mathematical inquiry to develop productive conceptions of course content.

The module developed by the CoRD focusing on developing classroom communities should:

1. Identify the essential characteristics of classroom communities that promote students' learning by inquiry and describe how these characteristics relate to the mindsets, identities, and beliefs of individual participants of the classroom community.
2. Describe how an instructor might establish a classroom community through particular course management, instruction, and assessment practices that embody the characteristics identified in response to (1).
3. Articulate the features of a mathematics curriculum that might promote the establishment of a classroom community that embodies the characteristics identified in response to (1).
4. Describe the potential affordances of the MIP focus on promoting students' active engagement and leveraging meaningful applications for establishing a classroom community that is supportive of students' conceptual learning.

Initial Resources

Frey, N., Fisher, D., Everlove, S. (2009). *Productive group work: how to engage students, build teamwork, and promote understanding.* Alexandria, VA.

> This is a comprehensive resource that presents strategies for a teacher's effective implementation of group work. The authors identify the essential features of impactful group work and describe how to promote productive face-to-face interaction, ensure individual accountability, and build interpersonal skills. Although the authors' recommendations are not situated in a mathematics learning context exclusively, the suggestions they propose are relevant to focus (2) above.

Goos, M., Galbraith, P., & Renshaw, P. (2003). Establishing a community of practice in a secondary mathematics classroom. In *Mathematics Education* (pp. 101-126). Routledge.

> Goos et al. describe how to establish a classroom community that embraces the practices, values, and beliefs of the mathematics community at large. They present the case of an upper secondary mathematics classroom to highlight the roles that teachers and students must assume for such a community to develop, and interpret such roles through the lens of social learning theory and Vygotskyian social constructivism.

Goos, M. (2004). Learning mathematics in a classroom community of inquiry. *Journal for Research in Mathematics Education*, 258-291.

In this research article, Goos leverages sociocultural theories of learning in general, and the notion of *zone of proximal development* in particular, to identify how a teacher established norms and practices that contributed to the cultivation a community of inquiry in a secondary mathematics classroom. This resource is most relevant to addressing foci (1), (2), and (4) above.

Sherin, M. G. (2002). A balancing act: Developing a discourse community in a mathematics classroom. *Journal of Mathematics Teacher Education*, *5*(3), 205-233.

In this research article, Sherin explores the tensions a secondary teacher experienced while attempting to use students' mathematical ideas as the basis of his instruction to achieve particular content objectives. In doing so, Sherin identifies specific discursive strategies the teacher employed to harmonize his commitment to fostering a student-centered classroom community with his intention to promote students' construction of significant mathematical understandings. This resource is most relevant to addressing foci (1), (2), and (4) above.

Sherin, M. G., Mendez, E. P., & Louis, D. A. (2004). A discipline apart: the challenges of 'Fostering a Community of Learners' in a mathematics classroom. *Journal of Curriculum Studies*, *36*(2), 207-232.

Sherin et al. examine the dialectic between the pedagogical approach of fostering a community of learners and an instructor's goals for students' mathematical learning. Sherin et al. argue that effectively establishing a community of learners requires a teacher to reconceptualize her instruction in relation to the content of the subject-matter. This resource is most relevant to foci (2), (3), and (4) above.

MINDSET

Students' perspectives about the source of mathematical aptitude and the factors that contribute to its development either encourage them to engage productively in mathematics instruction, or not. A student who believes that enhancing her mathematical ability requires struggle, critical thinking, and sense-making will participate in and benefit from instructional experiences in ways that a student who considers mathematical ability an unalterable trait will not. A goal of entry-level mathematics courses is to foster the development of students' growth mindsets with regard to mathematics learning so that they are prepared to engage in genuine mathematical inquiry.

The module developed by the CoRD focusing on mindset should:

1. Distinguish growth and fixed mindset and describe the implications of each for students' conceptual learning of mathematics.
2. Describe the process by which a student might construct a growth mindset with respect to learning mathematics.
3. Discuss the relationship between growth mindset and related topics such as identity, self-efficacy, stereotype threat, mathematics anxiety, and beliefs about mathematics and mathematics learning.
4. Propose specific principles of curriculum design and instructional practice (including assessment practice) to enable students to construct a growth mindset.

5. Describe the potential affordances of the MIP focus on promoting students' active engagement and leveraging meaningful applications for supporting students' construction of a growth mindset.

Initial Resources

Boaler, J. (2013, March). Ability and mathematics: The mindset revolution that is reshaping education. In *Forum* (Vol. 55, No. 1, pp. 143-152).
Boaler examines how established practices of schooling reinforce fixed mindsets about mathematical ability. She also provides a neurophysiological justification for growth mindsets by reviewing scientific evidence for brain plasticity and discusses how messages about growth mindsets might be communicated through particular classroom practices. This resource is most relevant to foci (1), (2), (4), and (5).

Dweck, C. S. (2008). *Mindset: The new psychology of success*. Random House Digital, Inc..
Carol Dweck and Ellen Leggett's original work in the 1980s spurred a significant reformulation of motivation theory, framed in terms of one's implicit theory of intelligence and goal-orientation. Dweck's book covers much of this research trajectory, relevant studies, and practical strategies to promote productive growth mindsets. This resource is most relevant to addressing foci (1) - (4) above.

Sun, K. L. (2018). The role of mathematics teaching in fostering student growth mindset. *Journal for Research in Mathematics Education*, *49*(3), 330-355.
In this brief research report, Sun identifies particular teaching practices that contribute to students' development of a fixed or growth mindset about their mathematical aptitude. Sun conveys her primary results in the form of a framework that locates teaching practices on a continuum from promoting a fixed mindset to promoting a growth mindset about mathematical ability. This resource is most relevant to addressing focus (4) above.

Project for Education Research that Scales College (PERTS) https://www.perts.net/
This website provides resources for promoting and assessing a growth mindset, summaries of applicable research with links to original papers, and programs for supporting educators at both K-12 and higher education institutions.

California Acceleration Project Materials
These materials were developed by the California Acceleration Project to be used in entry-level mathematics programs. An electronic copy is available through the MIP.

PRODUCTIVE STRUGGLE, PERSISTENCE, AND PERSEVERANCE

Persistence and perseverance, and the productive struggle they enable, are often considered traits that some students possess, rather than behaviors that emerge from a variety of subjective appraisals students make in the context of particular situations. Productive struggle, perseverance, and perseverance involve a complex interplay between mathematical tasks, mathematics as an intellectual pursuit, and the goals, beliefs, interests, and resources students bring to the learning environment. It is a goal of entry level mathematics instruction to engage students in productive struggle and to foster the persistence and perseverance that engaging in genuine mathematical inquiry requires.

The module developed by the CoRD focusing on productive struggle, persistence, and perseverance should:

1. Propose a conceptualization of productive struggle that makes explicit the environmental, affective, and cognitive conditions that need to be satisfied to engage in it.
2. Specify the relationship between productive struggle, persistence, and perseverance, and students' goals, mindsets, identities, and beliefs.
3. Propose specific principles of curriculum design and instructional practice (including assessment practice) that can promote students' productive struggle and foster their persistence and perseverance.
4. Describe the potential affordances of the MIP focus on promoting students' active engagement and leveraging meaningful applications for promoting students' productive struggle and fostering their persistence and perseverance.

Initial Resources

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological review*, *95*(2), 256.

This foundational study provides an empirical and theoretical interpretation of motivational factors leading to student behavior of persistence or avoidance. Most critically, even high-performing students are susceptible to unproductive strategies if they have counterproductive views about the nature of their ability and the learning situation. This resource is most relevant to addressing foci (1) and (2) above.

Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. *Journal of the Learning Sciences*, *21*(1), 45-83.

Kapur and Bielaczyc propose several principles for supporting students' engagement in productive failure. They also present the results of an empirical study that compared learning outcomes from students who experienced one of two treatments: (1) instruction that promoted productive failure and (2) students who experienced direct instruction. The authors describe the affordances of engaging in productive failure for students' development of problem-solving skills and strategies. This resource is most relevant to addressing foci (1), (2), and (3) above.

Pasquale, M. (2016). Productive Struggle in Mathematics. Interactive STEM Research + Practice Brief. *Education Development Center, Inc.*

In this brief report, Pasquale identifies various factors that promote students' productive struggle in mathematics and shares examples of how teachers might respond to students' struggles to enhance their learning. This resource is most relevant to addressing focus (3) above.

Middleton, J. A., Tallman, M., Hatfield, N., & Davis, O. (2014). Taking the *severe* out of perseverance: Strategies for building mathematical determination. In N. Alpert (Ed.), *The collected papers.* Chicago, IL: Spencer Foundation. Retrieved from http://www.spencer.org/collected-papers-april-2015

Middleton et al. define perseverance as a behavior that emerges from a variety of subjective appraisals that students make in the context of particular situations. These authors review research on students' development of interests and efficacy, academic goals, and their academic and social identities, and discuss key strategies for helping teachers engage students in experiences whereby they are able to assist students in developing persistent and adaptive mathematical dispositions. This resource is most relevant to addressing foci (2), (3), and (4) above.

MOTIVATION AND INTEREST

Motivation refers to the needs, desires, or purposes an individual seeks to satisfy through his or her engagement, and involves the individual's situational and personal interests and goal orientations (Middleton et al., 2017). Because mathematical inquiry requires high levels of engagement, an instructor's commitment to supporting students' mathematical learning through inquiry requires fostering their development of needs, desires, and/or purposes that make such engagement possible.

The module developed by the CoRD focusing on motivation and interest should:

1. Define motivation and interest in terms of their cognitive and affective components.
2. Review and synthesize the research literature to identify the types of experiences required to promote students' interest in mathematics and to foster their motivation to learn mathematics through inquiry.
3. Propose specific principles of curriculum design and instructional practice (including assessment practice) to promote students' interest in mathematics and to foster their motivation to learn mathematics through inquiry.
4. Describe the potential affordances of the MIP focus on promoting students' active engagement and leveraging meaningful applications for promoting students' interest in mathematics and fostering their motivation to learn mathematics.

Initial Resources

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*(1), 109–132.

Eccles and Wigfield provide a comprehensive review of theoretical contributions and empirical findings from research on motivation, beliefs, values, and goals. This resource is most useful for describing the cognitive basis of students' motivation and interests and their relation to other categories of affect.

Hannula, M. S. (2006). Motivation in mathematics: Goals reflected in emotions. *Educational Studies in Mathematics, 63,* 165–178.

Hannula offers a conceptualization of motivation that emphasizes its situational characteristics and establishes its relation to goal structures and the unconscious mechanisms that control emotion. Hannula describes three aspects of motivation regulation and presents a case study to illustrate and support the conception of motivation he offers. This resource is most relevant to addressing focus (1) above.

Middleton, J. A., & Spanias, P. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the recent research. *Journal for Research in Mathematics Education, 30*(1), 65–88.

Middleton and Spanias examine research on motivation in mathematics education to identify a set of generalizable conclusions. Based on their review of the literature, the authors identify potential extensions of motivation theory and offer research recommendations. This resource is most relevant to addressing foci (1), (2), and (3) above.

Middleton, J. A., & Jansen, A. (2011). *Motivation matters and interest counts: Fostering engagement in mathematics.* Reston, VA: National Council of Teachers of Mathematics.

In this book, Middleton and Jansen provide a non-technical introduction to motivation in mathematics education for practitioners. They discuss the fundamental principles of student motivation, emphasizing its learned, adaptive, momentary, and social qualities. The authors also discuss several strategies for fostering students' motivation to learn mathematics. This comprehensive resource is relevant to addressing all foci above.

BELIEFS ABOUT MATHEMATICS

Students often view mathematics as a disconnected set of procedures. It is common for them to believe that mathematical proficiency is most clearly evidenced by one's ability to solve problems quickly. Students' beliefs about mathematics influence the ways they engage with it and, consequently, their educational outcomes. For example, students who believe all problems can be solved in under five minutes or less (Schoenfeld, 1988) are unlikely to persevere to solve novel problems and thus fail to benefit from potentially valuable learning opportunities.

The module developed by the CoRD focusing on students' beliefs about mathematics should:

1. Review and synthesize the literature about students' beliefs about mathematics, including any relevant findings about the origins of those beliefs.
2. Develop a list of beliefs we, as mathematicians and mathematics educators, would like students to hold about mathematics and describe how they contribute to students' engagement in mathematical inquiry.
3. Develop recommendations for instructional and curricular design that foster the development of the beliefs identified in (2).
4. Describe the potential affordances of the MIP focus on promoting students' active engagement and leveraging meaningful applications for supporting students' development of productive beliefs about mathematics.

Initial Resources

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman mathematics attitudes scales.

This spreadsheet, available upon request (allison.j.dorko@okstate.edu), is a Likert-scale survey that can be employed to lend insight into students' attitude toward success in

mathematics, beliefs about mathematics, confidence about their ability to do mathematics, and usefulness about mathematics. It could be useful to prompt CoRD developers in imagining what students believe about mathematics and what we want them to believe.

Kerins, B., Yong, D., Cuoco, A., & Stevens, G. (2015). Famous functions in number theory. PREFACE:

https://bookstore.ams.org/sstp-3/~~FreeAttachments/sstp-3-pref.pdf

This book preface explains the design principles behind task sequences that engage students in learning significant mathematics through inquiry. For example, the same problem shows up in multiple task sequences, allowing students to explore it repeatedly and make some progress while, throughout the other tasks in the sequences, they build the tools to eventually solve the problem. This design supports persistence in problem solving and helps counter the belief that any problem can be solved very quickly. The book's task sequences are from intensive workshops aimed at practicing high school math teachers. We suggest this resource not for the mathematical content, but as an example of how tasks can be designed and sequenced in ways which support students' mathematical inquiry as well as their beliefs about what it means to do mathematics.

Schoenfeld, A. H. (1988). When good teaching leads to bad results: The disasters of 'well-taught' mathematics courses. *Educational psychologist*, *23*(2), 145-166.

This resource contains a list of students' beliefs about mathematics that the CoRD might take as a starting point for (1).

Carlson, M. (1999). The Mathematical Behavior of Six Successful Mathematics Graduate Students: Influences Leading to Mathematical Success. *Educational Studies in Mathematics, 40*(3), 237-258.

This paper explored the characteristics and experiences of mathematics graduate students that contributed to their development and success.