Guest Editorial for JEE and IJRUME

Towards the STEM DBER Alliance: Why we need a Discipline-Based STEM Education Research Community

Running Head: Towards the STEM DBER Alliance

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What is DBER?

Discipline-Based Education Research (DBER) is a term that has emerged in the last few decades to describe research that "investigates learning and teaching in a discipline using a range of methods with deep grounding in the discipline's priorities, worldview, knowledge, and practices. It is informed by and complementary to more general research on human learning and cognition." (NRC, 2012, p. 9) DBER seeks to develop evidence-based knowledge and practices that improve teaching and learning in the Science, Technology, Engineering, and Mathematics (STEM) disciplines. While new knowledge developed within DBER has led to meaningful improvements in student learning and participation in STEM disciplines (NRC, 2012; Singer & Smith, 2013), there remain significant opportunities for additional advances (Snow & Dibner, 2016).

DBER represents a collection of fields that sit at the intersection of a STEM discipline and educational research. Although one could imagine DBER occurring within any discipline, the term has so far only been used to describe this type of work within STEM disciplines. An important feature of DBER is the strong role that the discipline plays in setting the priorities for the research and making sure it is relevant and focused on improving what is most important in moving undergraduates towards expertise in the discipline. For each discipline there is a body of disciplinary content (or, perhaps several bodies: e.g., electrical engineering, mechanical engineering, etc.), a culture that shapes how members of the field think about and approach their work, and established research methods and tools that practitioners use. Each DBER field combines these discipline-based perspectives with theoretical frameworks and research methodologies from education research (Lohmann & Froyd, 2011). For example, engineering education researchers frequently make use of qualitative and mixed-method research methodologies that are more common in education research than in traditional engineering fields.

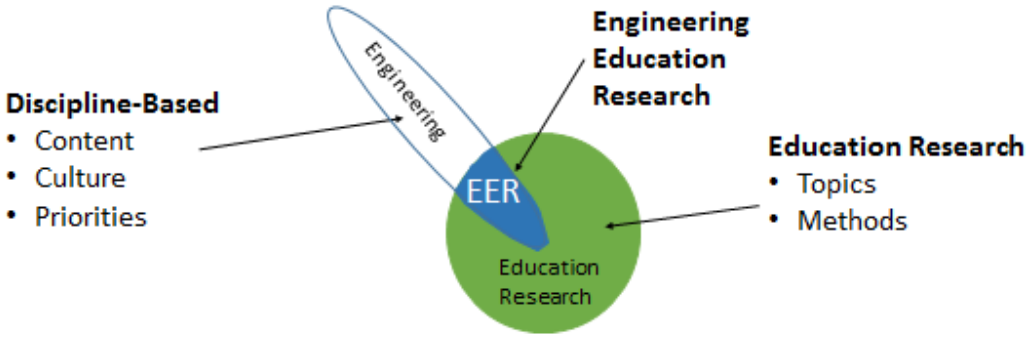


Figure 1. Each DBER field exists at the intersection of a STEM discipline and more general areas of education research. (Image based on initial conceptualization by Mark Connolly.)

The National Academies DBER report helped legitimize DBER work within individual STEM disciplines and bring the term “DBER” into common usage (Rasmussen & Wawro, 2016). Within individual STEM disciplines “recognition of DBER can be seen in statements by professional societies, the establishment of journals, and the emergence of graduate and postdoctoral opportunities.” (NRC, 2012, p. 20) There are also a growing number of DBER faculty positions each year at all types of higher education institutions (Bush et al., 2016).

Individual STEM DBER disciplines (e.g., physics education research, biology education research) developed independently and have largely remained separate, with separate conferences, journals, and research interests.[1] Additionally, relevant knowledge exists in related but currently disconnected disciplines such as cognitive science, higher education, and

economics.

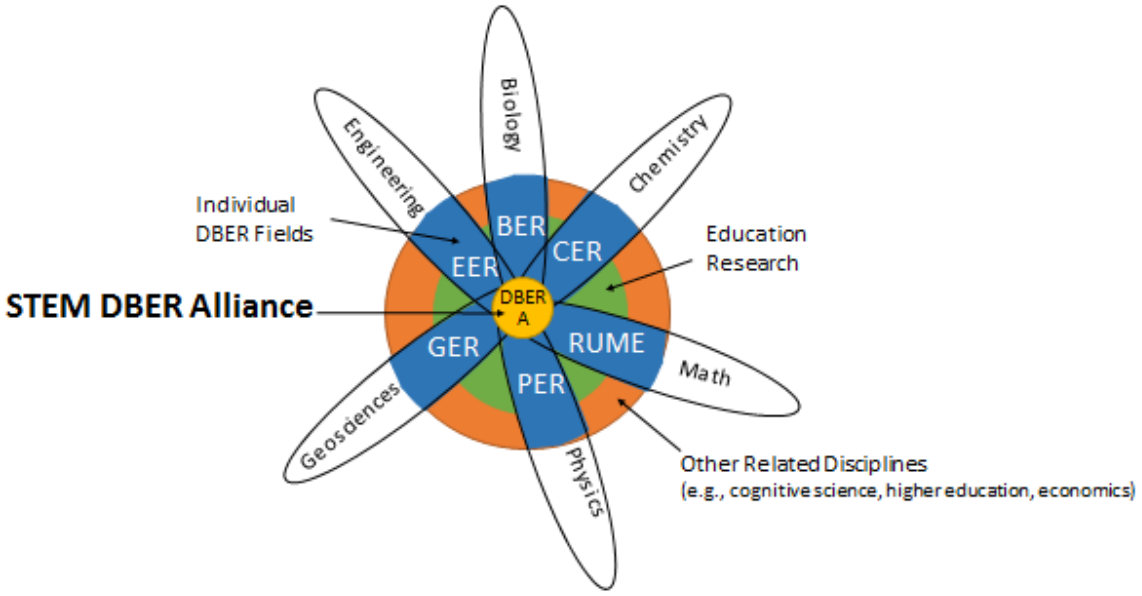


Figure 2. The STEM DBER Alliance (DBER-A) exists at the intersection of multiple DBER fields. (Image based on initial conceptualization by Mark Connolly.)

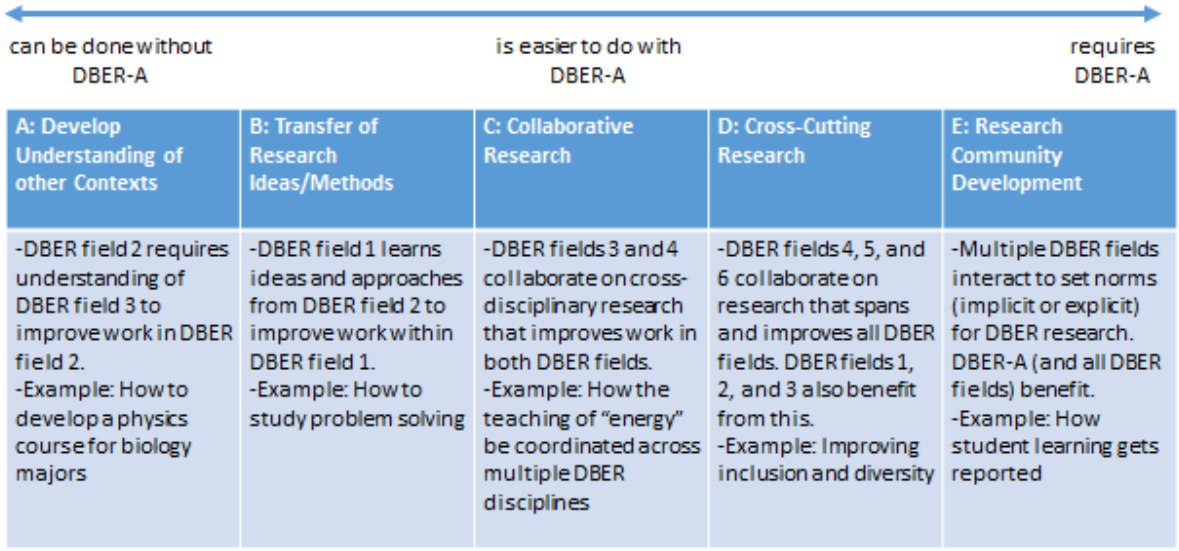
Building on prior discussions across DBER communities,[2] on November 18-19, 2016, the American Association for the Advancement of Science (AAAS) and the Association of Public and Land-grant Universities (APLU) brought together a group of 26 thought leaders from the DBER communities to begin articulating the affordances of developing an intersectional DBER community, envisioning what structures might best support such a community, and developing plans for advancing this agenda (O'Neil, 2017). It quickly became clear that tremendous advantage and synergy could be gained through the formation of an overarching DBER community that spans disparate disciplines (Talanquer, 2014). We have begun to refer to such a community as the STEM DBER Alliance (DBER-A).

This editorial begins to articulate the rationale for such a community by exploring two important questions. First, what could an allied STEM DBER community accomplish that cannot be accomplished now by individual STEM DBER disciplines? Second, how do different stakeholders -- individual faculty, the DBER community, and broader society -- each benefit from such a STEM DBER alliance? Developing and maintaining such a community is not without costs, both real costs and opportunity costs. So, it is important to have compelling reasons to move forward.

What can a cross-discipline STEM DBER alliance do?

We envision a cross-discipline STEM DBER community engaging in five basic activities. These occur on a spectrum from activities that can be done within an individual DBER discipline (e.g., physics education research) to activities that are more effective with collaborations across

DBER disciplines (for example, biology education researchers working with chemistry education researchers) to activities that require committed collaboration of multiple DBER disciplines. Figure 3 summarizes each type of activity and provides a brief example. The existence of an overarching STEM DBER community (such as DBER-A) is increasingly important as the integration of ideas and development of shared frameworks increases from Activity A to Activity E.



A: Develop Understanding of other Contexts	B: Transfer of Research Ideas/Methods	C: Collaborative Research	D: Cross-Cutting Research	E: Research Community Development
-DBER field 2 requires understanding of DBER field 3 to improve work in DBER field 2. -Example: How to develop a physics course for biology majors	-DBER field 1 learns ideas and approaches from DBER field 2 to improve work within DBER field 1. -Example: How to study problem solving	-DBER fields 3 and 4 collaborate on cross-disciplinary research that improves work in both DBER fields. -Example: How the teaching of "energy" be coordinated across multiple DBER disciplines	-DBER fields 4, 5, and 6 collaborate on research that spans and improves all DBER fields. DBER fields 1, 2, and 3 also benefit from this. -Example: Improving inclusion and diversity	-Multiple DBER fields interact to set norms (implicit or explicit) for DBER research. DBER-A (and all DBER fields) benefit. -Example: How student learning gets reported

Figure 3. Five basic types of interaction between the individual DBER fields that are expected to take place within the STEM DBER Alliance.

What is the value of establishing a cross-discipline STEM DBER alliance?

The value of DBER-A exists at multiple levels. In this section we identify three basic levels where value could be realized. The first is the value to individual DBER researchers. These researchers will be the people who will need to work to create and maintain such a community; the community will not exist if researchers do not find value in it. The second level is the DBER-A community itself as well as each individual DBER field. Communities, including research communities, form and are maintained because groups and individuals working together are, under the right conditions, capable of accomplishing more than these groups or individuals could accomplish working alone (NRC, 2004; Nersessian & Newstetter, 2014; Uzzi et al., 2013). Therefore, the community we envision will behave in many ways as a Community of Practice (Kastens, 2017; Wenger-Trayner & Wenger-Trayner, 2015) that supports individuals while simultaneously accumulating and creating community-wide capacity to improve "practice" (DBER).

Finally, a third level is the value to the larger society. One of the core values of DBER is to advance STEM education, which has strong value to society by improving science literacy

(snow & Dibner, 2016), increasing workforce development (Malcolm, Comedy, & Grant, 2015) broadening participation in STEM (NSF, 2013; NSF, 2017) and addressing complex societal challenges (e.g., health, environment/climate, energy, national security (Levy & Plucker, 2015)). By integrating STEM education, DBER-A can support increased work towards tackling these important problems that are most effectively addressed cross-DBER.

Of course, these levels of value for a cross-disciplinary STEM DBER alliance do not exist independently and there is significant overlap. Yet, it is useful to think about the levels separately because each level has a different target audience and a different value proposition for that target audience.

The value of DBER-A to individual researchers consists of connecting researchers and legitimizing the work of individuals. Efforts that advance individual research/ers include:

1. Organizing conferences and workshops where researchers across DBER fields can interact and new collaborations can be developed.
2. Developing mechanisms for researchers to share strategies, methodologies, and results. These include virtual (e.g., online communities, webinars), print (e.g., journals), and face-to-face (e.g., conferences).
3. Establishing new recognitions (awards, invited talks, etc.) that enhance the status of individual researchers and the DBER community.
4. Establishing a recognized imprimatur (similar, for example, to the American Association for the Advancement of Science (AAAS), American Educational Research Association (AERA), or National Association for Research in Science Teaching (NARST)) will add legitimacy to DBER work and and organizational functionality for meeting cross-DBER goals.
5. Establishing mechanisms to develop and identify allies in other DBER disciplines on their campuses will be especially useful for DBER scholars working alone within their departments.
6. Opening doors to new funding directions for individuals to draw upon (e.g., as NSF emphasizes convergent science as well as cross-disciplinary issues such as diversity and inclusion[3]).

The value of DBER-A to the DBER community itself and to individual DBER fields consists of creating common voice to effectively advocate for DBER and providing a forum for community reflection and development. Actions to advance the community include:

1. Presenting a common message to individual disciplinary societies to enhance the status of individual DBER fields and researchers. Presenting individual DBER fields within the landscape of an interdisciplinary endeavor solidifies the position of each.
2. Presenting a common message to funding agencies and policy makers that will (a) avoid contradictory messages that pit one DBER discipline against another (e.g. funding one discipline over another) and (b) promote collaborations across DBER disciplines.
3. Presenting a unified message to political agencies --- National Academies, Departments and State and National legislators --- that will provide critical support to disciplines that may be subject to heightened political scrutiny (e.g., climate science).

4. Casting a wider net to diversify the DBER community and providing professional development to potential DBER scholars.
5. Enlarging and diversifying the publication venues and reviewer pool for DBER work.
6. Increasing the potential for meta-analyses and systematic reviews of published studies that span multiple disciplines; this in turn increases the strength of evidence for making community claims and recommendations for improving STEM teaching practice and student learning.

The value of DBER-A to the broader society is improvements in STEM education for all students at all levels. DBER-A can advance collective welfare through:

1. Improving student learning and participation in STEM disciplines by accelerating the rate of knowledge development and dissemination within DBER.
2. Increasing the effectiveness of development and implementation of high impact educational practices by enhancing collaboration within DBER, and between DBER and other related communities, such as faculty professional development and the Scholarship of Teaching and Learning (SoTL).
3. Improving scientific, technical, and quantitative literacy of the general population by promoting coordination and alignment across the STEM disciplines. This is necessary for making good decisions about the significant science- and technology-related challenges facing our country and planet.
4. Improving the ability of the STEM education community to develop more equitable educational environments that lead to a more diverse and productive STEM workforce.
5. Fostering interactions between K-12 and college STEM education researchers, policy makers, and other stakeholders to strengthen system-wide educational practices and alignment.

Next Steps

We have argued for the formation of an allied STEM DBER community. Exploratory discussions have found sufficient agreement about its potential value to begin work to develop such a community (O'Neil, 2017). How this community should be structured will need to be considered carefully to account for the perspectives and needs of the wide variety of potential stakeholders. Success will depend on building a community structure that incorporates reinforcing mechanisms so that the benefits are realized across the individual-community-society spectrum.

We invite you to join us in this work. We have formed a DBER-A group in Trellis and encourage you to join.[4] In the coming months we will be initiating face-to-face discussions at workshops and national conferences [AERA, TRUSE]. The Trellis group will be used for ongoing virtual discussions about the why and how of DBER-A and for information sharing. We also request contributions of strong examples of DBER-A work that can be used to demonstrate productive outcomes and approaches (see Fig 3 above).

[1] DBER-related work with the math community is typically referred to as Research in Undergraduate Mathematics Education (RUME).

[2] For example, TRUSE (http://www.chem.purdue.edu/Towns/TRUSE/index.html)

[3] https://www.nsf.gov/about/congress/reports/nsf_big_ideas.pdf

[4] To join the Trellis group, please complete this short google form with your contact information: https://docs.google.com/forms/d/e/1FAIpQLSeMMwFXg7Mcxcv4dpI4J_S1KqKRwKdhRqyFizFc5tMAxODMEw/viewform.

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