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

Charles Henderson[1] · Mark Connolly[2] · Erin L. Dolan[3] · Noah Finkelstein[4] · Scott Franklin[5] · Shirley Malcom[6] · Chris Rasmussen[7] · Kacy Redd[8] · Kristen St. John[9]

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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" (National Research Council [NRC] 2012, p. 9). DBER seeks to develop evidence-based knowledge and practices that improve teaching and learning in the

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✉ Charles Henderson
charles.henderson@wmich.edu

Mark Connolly
mark.connolly@wisc.edu

Erin L. Dolan
eldolan@uga.edu

Noah Finkelstein
noah.finkelstein@colorado.edu

Scott Franklin
svfsps@rit.edu

Shirley Malcom
smalcom@aaas.org

Chris Rasmussen
chris.rasmussen@sdsu.edu

Kacy Redd
kredd@aplu.org

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 and Smith 2013), there remain significant opportunities for additional advances (Snow and Dibner 2016).

DBER represents a collection of fields that sit at the intersection of a STEM discipline and education research. Although one could imagine DBER occurring within any discipline, the term has so far been used only 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 in making sure it is relevant and focused on improving what is most important in moving undergraduates towards expertise in the discipline. Each discipline has bodies of disciplinary content, a culture that shapes how members of the discipline 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 and Froyd 2011). Figure 1 shows that the field of engineering education research exists at the intersection of the disciplines of engineering and education research. One result of this intersection, for example, is that engineering education researchers frequently make use of qualitative and mixed methods research methodologies that are more common in education research than in traditional engineering fields.

The National Academies' DBER report (NRC 2012) helped legitimize DBER work within individual STEM disciplines and bring the term *DBER* into common usage (Rasmussen and Wawro 2017). 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,

Kristen St. John
stjohnke@jmu.edu

[1] Department of Physics and Mallinson Institute for Science Education, Western Michigan University, 1903 W. Michigan Avenue, Kalamazoo, MI 49008-5252, USA

[2] Wisconsin Center for Education Research, University of Wisconsin–Madison, 1025 W. Johnson St., 570A Educational Sciences Bldg, Madison, WI 53706, USA

[3] Biochemistry and Molecular Biology and Georgia Athletic Association, University of Georgia, B210B Davison Life Sciences, Athens, GA 30602, USA

[4] Department of Physics, University of Colorado Boulder, UCB 390, Boulder, CO 80309-0930, USA

[5] Center for Advancing STEM Teaching, Learning & Evaluation, Rochester Institute of Technology, 1 Lomb Memorial Drive, Rochester, NY 14623-5603, USA

[6] Education and Human Resources Programs, American Association for the Advancement of Science, 1200 New York Avenue, N.W, Washington, D.C 20005, USA

[7] Department of Mathematics and Statistics, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182-7720, USA

[8] Science and Mathematics Education Policy, Association of Public and Land-grant Universities, 1307 New York Ave N.W, Washington, DC 20005, USA

[9] Department of Geology and Environmental Science, James Madison University, 395 S. High Street, Harrisonburg, VA 22807, USA

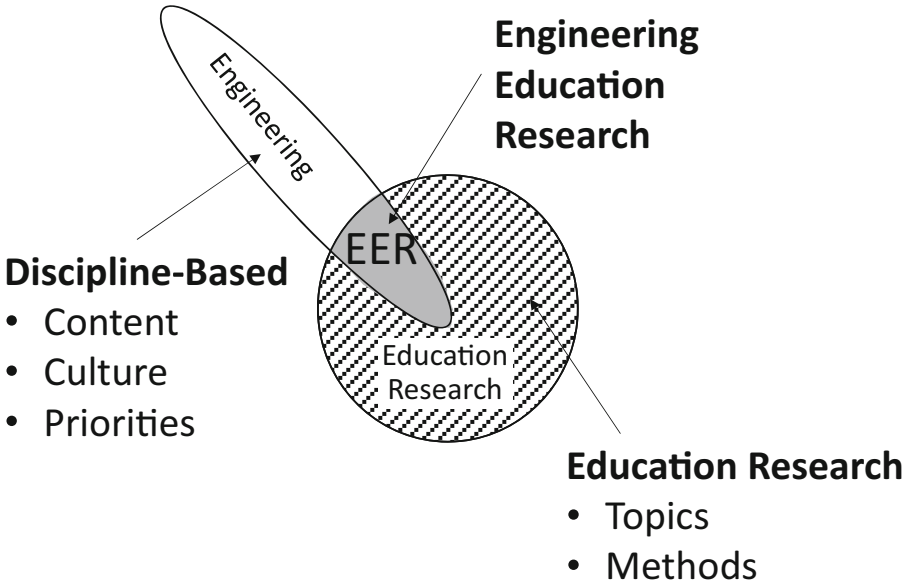

Fig. 1 Each DBER field exists at the intersection of a STEM discipline and the discipline of education research. (Image based on initial conceptualization by Mark Connolly)

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).

While significant growth in DBER has occurred within individual STEM disciplines, there has been minimal cross-discipline work. Individual STEM DBER fields, such as physics education research or biology education research, developed independently and have largely remained separate, with separate conferences, journals, and research interests. Opportunities for cross-discipline work also exist between STEM DBER fields and non-STEM disciplines, such as cognitive science, higher education, and economics.

Building on prior discussions across DBER communities and at at the Transforming Research in Undergraduate STEM Education (TRUSE) conferences (https://www.chem.purdue.edu/towns/truse/), in November, 2016, the American Association for the Advancement of Science and the Association of Public and Land-grant Universities 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). As shown in Fig. 2, DBER-A exists at the intersection of multiple DBER fields.

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 fields? Second, how could different stakeholders – individual faculty, the DBER community, and broader society – each benefit from such a STEM DBER alliance? Developing and

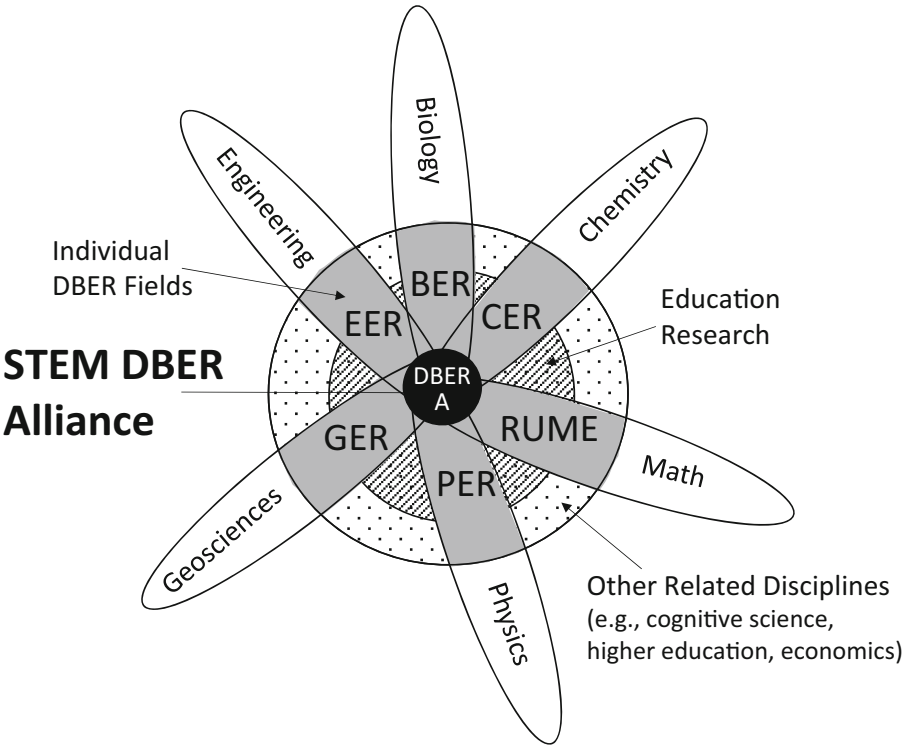

Fig. 2 The STEM DBER Alliance exists at the intersection of multiple DBER fields. (Image based on initial conceptualization by Mark Connolly)

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 field, but might be facilitated by DBER-A, to activities that require committed collaboration of multiple DBER fields. Figure 3 summarizes each type of activity and provides a brief example. The existence of the STEM DBER Alliance is increasingly important as the integration of ideas and development of shared frameworks increases from left to right in the figure.

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 those 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

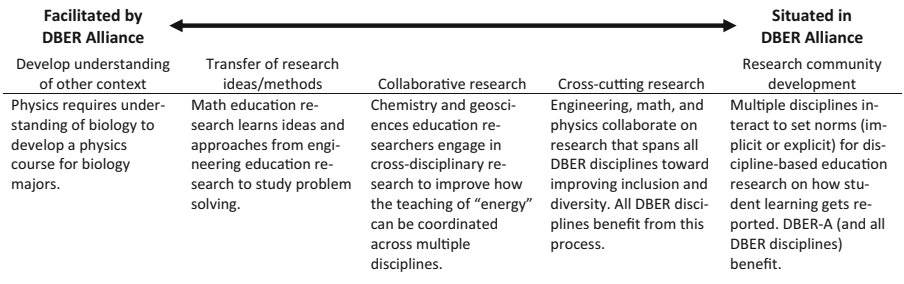

Fig. 3 Five basic types of interaction between the individual DBER fields that are expected to take place within the STEM DBER Alliance

accomplishing more than these groups or individuals could accomplish working alone (NRC 2005; Nersessian and 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 and Wenger-Trayner 2015) that supports individual researchers while simultaneously accumulating and creating community-wide capacity to improve DBER practice.

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 and Dibner 2016), increasing workforce development (Malcom et al. 2015), broadening participation in STEM (NSF 2013; 2017), and addressing complex societal challenges of health, the environment, climate, energy, and national security (Levy and Plucker 2015). By integrating STEM education, DBER-A can support increased work towards tackling these important problems that are most effectively addressed across 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.

First, the value of DBER-A to individual researchers consists of connecting researchers and legitimizing the work of individuals. A range of efforts can advance individual researchers:

Organizing conferences and workshops where researchers across DBER fields can interact and new collaborations can be developed.
Developing mechanisms, such as conferences, journals, and webinars, for researchers to share strategies, methodologies, and results.
Establishing new recognitions (awards, invited talks, etc.) that enhance the status of individual researchers and the DBER community.
Establishing a recognized organization that can sanction DBER activities, to add legitimacy to DBER work and organizational functionality for meeting cross-DBER goals.
Establishing mechanisms for researchers to develop and identify allies in other DBER disciplines on their campuses.
Opening doors to new funding directions for individuals to draw upon.

Second, the value of DBER-A to the DBER community itself and to individual DBER fields consists of creating a common voice to effectively advocate for DBER and provide a forum for community reflection and development. A range of efforts can advance the DBER community:

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.
Presenting a common message to funding agencies and policy makers that will avoid pitting one DBER field against another for funding, and will promote collaborations across DBER fields.
Presenting a unified message to political agencies, such as the national academies, federal and state departments, and legislators, to provide critical support to STEM areas, such as climate science, that may be subject to heightened political scrutiny.
Casting a wider net to diversify and enlarge the DBER community and provide professional development to potential DBER researchers.
Expanding and diversifying the publication venues and reviewer pool for DBER work.
Increasing the potential for meta-analyses and systematic reviews of published studies that span multiple disciplines; in turn, increasing the strength of evidence for making community claims and recommendations for improving STEM teaching practice and student learning.

Finally, the value of DBER-A to the broader society is improvement in STEM education for all students at all levels.

Improving student learning and participation in STEM disciplines by accelerating the rate of knowledge development and dissemination within DBER.
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 the faculty professional development community and the scholarship of teaching and learning community.
Improving the scientific, technical, and quantitative literacy of the general population by promoting coordination and alignment across the STEM disciplines. This is necessary for the public to make good decisions about the significant science- and technology-related challenges facing our country and planet.
Improving the ability of the STEM education community to develop more equitable educational environments that lead to a more diverse and productive STEM workforce.
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 a STEM DBER Alliance. Exploratory discussions have found sufficient agreement about its potential value for us 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 the AAAS collaboration web hub, Trellis, and encourage you to join. (http://www.trelliscience.com/DBER-A/.) In the coming months we will be initiating face-to-face discussions at workshops and national conferences, such as those sponsored by the American Educational Research Association or National Association for Research in Science Teaching. We also request contributions of strong examples of DBER-A work that can be used to demonstrate productive outcomes and approaches from work across individual DBER fields.

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