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Editorial

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New Guidelines for Chemistry Education Research Manuscripts and Future Directions of the Field

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Supporting Information

ABSTRACT: The field of chemistry education research (CER) has matured since 1997 when Bunce and Robinson announced the CER feature in the *Journal*, and it is time to set out a revised set of guidelines for high-quality manuscripts in CER. Herein, we announce the guidelines, briefly describe them, then use the National Academy of Sciences Discipline-Based Education Research report to identify areas of research and future directions in CER. Our hope is that this stimulates high-quality research manuscripts in areas of need that will drive CER forward, influencing and impacting CER and classroom practices.

KEYWORDS: *Chemical Education Research, Curriculum, Laboratory Instruction, Interdisciplinary/Multidisciplinary*

Chemistry education research (CER) has grown and developed since the 1994 American Chemical Society (ACS) Division of Chemical Education Task Force drafted a document defining chemistry education research[1] as a field that includes the three common characteristics of discovery. First, CER is theory-based, providing foundational support that situates and shapes research questions, and that guides methodological choices. Second, CER requires data collection. Although methodologies for data collection have become significantly more sophisticated in our field, the importance of aligning clear research questions with methods of data collection, analyses, and interpretation has been unwavering. Third, in CER the results inform further research and classroom and laboratory practices.

In 1997 Bunce and Robinson announced a new feature in the *Journal* focusing on chemistry education research that met the three criteria outlined by the 1994 Task Force.[2] In the intervening 16 years, the field has matured, and it is now time to publish revised guidelines for chemistry education research manuscripts and to identify future directions for the field. The revised guidelines for manuscripts focused on CER can be found in the Supporting Information and also online.[3] I strongly encourage authors who are developing manuscripts for the CER feature to read and follow these guidelines.

The *Journal* seeks reports of research pertaining to teaching and learning chemistry in high school, undergraduate, and graduate formal environments as well as informal settings. Although the *Journal* is situated in the United States and is copublished by the ACS, research contexts of an international or global nature are welcome. Appropriate areas of research include all of teaching and learning chemistry and may involve, but are not limited to, pedagogy, laboratory learning, conceptual change, assessment, achievement, field studies, technologies (broadly defined), and curriculum development.

It is expected that the focus and relevance of the manuscript will be directly related to chemistry. Thus, the hypotheses tested or questions posed should be significant and applicable to chemistry education. The best criteria of research are the novelty, impact, and influence of the findings; therefore, it is important for authors to help reviewers and readers understand the results and findings of their research in terms of these three criteria.

In addition to announcing new CER manuscript guidelines, it is appropriate to reflect upon the types of manuscripts the *Journal* seeks and how CER as a field can use the NRC BOSE Committee on Status, Contributions, and Future Directions of Discipline-Based Education Research report, titled "Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering", known as the "DBER report", as guidance for future research directions.[4] As editor Norb Pienta noted in an earlier piece on the DBER report, "Evidence-based practices are the most likely to produce transformative changes, ones that are persistent and will produce the most progress in teaching and learning chemistry."[5] Ultimately, the goal of chemistry education researchers is to improve teaching and learning in an evidenced-based manner, using findings from empirical research (as opposed to private empiricism[6]).

The DBER report and associated committee documents demonstrated that what is unequivocally known about teaching and learning in chemistry based upon research is surprisingly limited.[4,7] These documents are an important source of guidance for future research directions in our field. For example:

There is a wide range of research in general chemistry or courses at the introductory level. However, the research on teaching and learning at the upper-division level, beginning with organic chemistry and beyond, is much more limited. Although third- and fourth-year courses primarily enroll chemistry and biochemistry majors and are often low enrollment courses, organic chemistry and second-year analytical courses are not. More research is warranted from organic chemistry on through the undergraduate curriculum.

Perhaps surprisingly, student learning in laboratory is not well characterized. Although laboratory is thought to be a part of nearly every science course and is a routine part of the

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chemistry curriculum, student learning in the laboratory has gone largely unexamined according to the DBER report.[4,7] As a starting point, the field needs studies that build an understanding of what learning outcomes—cognitive, psychomotor, and affective—can be achieved and assessed in laboratory across the curriculum.

Longer studies and longitudinal studies are sorely needed. The mean and mode of the length of studies in CER is one semester or less.[7] Sparingly few studies track students longitudinally or measure the impact of innovations across time. Such studies are needed to investigate the phenomenon of transfer, enduring conceptual change, and impacts on attitudes, attraction, and retention. It should be noted that a renewal funding model at federal agencies does not currently exist to support such research, which is a considerable challenge to researchers.

CER has a great number of studies that elucidate misconceptions, but fewer that illuminate how specific misconceptions can be meaningfully addressed in the classroom. At some point researchers must become less satisfied with identifying student misconceptions and focus more attention on investigating pedagogical approaches that facilitate durable conceptual change.

Interdisciplinary studies are required to investigate concepts and cognitive processes across fields. For example, concepts such as heat and energy, and how they are represented, cut across STEM fields. Another area would be the measurement of the very small (molecular bonds, molecules, and cellular structures) and the very large. Research across the disciplines is required if students are to create a coherent body of knowledge rather than fragmented islands of knowledge that work in one discipline but not another. This will require interdisciplinary teams of researchers to communicate across the disciplines about concepts and representations.

There exists a dearth of research in CER that informs faculty about similarities, differences, and impacts among and between different groups of students—by race and ethnicity, sex, majors, and so on. In some cases, the demographics of the student population or sample are given in the study, yet the impacts or differences between or among these groups are not often explored.

More mixed-methods studies are on the horizon. CER has a long history of quantitative research and qualitative research designs. Now is the time to move forward into appropriately putting these designs together in ways that address important research questions in our field. Mixed-methods studies are in many cases longitudinal and last more than one graduate student lifetime, which makes the research more difficult to accomplish. Still, these designs need to be used in our field where appropriate to answer valuable research questions.

For every study, researchers need to examine how answering the research questions they have posed fits into the bigger picture of CER. At times we have asked questions simply because we can, with little regard to how the answers we find can advance the field. The best measure of research is the novelty, impact, and influence of the results. High-quality CER studies address these measures and drive the field forward.

■ ASSOCIATED CONTENT

Supporting Information

Content requirements for Chemistry Education Research manuscripts. This material is available via the Internet at http://pubs.acs.org.

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Notes

Views expressed in this editorial are those of the author and not necessarily the views of the ACS.

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■ REFERENCES

(1) Bunce, D.; Gabel, D.; Herron, J. D.; Jones, L. *J. Chem. Educ.* **1994**, *71* (10), 850−852.
(2) Bunce, D. M.; Robinson, W. R. *J. Chem. Educ.* **1997**, *74* (9), 1076−1079.
(3) Information for Authors: Chemistry Education Research Guidelines. http://pubs.acs.org/page/jceda8/submission/authors.html (accessed Jul 2013).
(4) *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*; Singer, S. R., Nielsen, N. R., Schweingruber, H. A., Eds.; The National Academies Press: Washington, DC, 2012.
(5) Pienta, N. *J. Chem. Educ.* **2012**, *89*, 963−964.
(6) Cooper, M. M. *Science* **2007**, *317*, 1171 DOI: 10.1126/science.317.5842.1171.
(7) Towns, M. H.; Kraft, A. *Review and Synthesis of Research in Chemical Education from 2000−2010.* Commissioned paper for The NAS Board on Science Education Committee on Status, Contributions, and Future Directions of Discipline-Based Education Research, 2011. http://sites.nationalacademies.org/DBASSE/BOSE/DBASSE_080124#.UYJ-kpX07jI (accessed Jul 2013).