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Undisciplined Epistemology: Conceptual Heterogeneity in a Field in the Making

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Introduction

> *"…conceptualization and theorization may be complemented by technique, but the technique cannot be substituted for this intellectual labor."*[1]

In 2006, a group of leading engineering education researchers produced a research agenda for the emerging field of engineering education research. *The Research Agenda for the New Discipline of Engineering Education* delineated five research areas around which it was believed the field should focus its efforts: engineering epistemologies, engineering learning mechanisms, engineering learning systems, engineering diversity and inclusiveness, and engineering assessment.[2] Engineering epistemologies was defined as "research on what constitutes engineering thinking and knowledge within social contexts now and into the future."[3]

In 2014, a guest editorial in *Journal of Engineering Education*, sought to clarify the difference between *theory* and *epistemology*, explaining that, "Often, engineers writing and reviewers critiquing in this new domain do not understand what epistemology is and how it differs from theory, yet it is important to understand and to articulate both within research studies."[4] However, it goes on to explain epistemology in a way quite different from how it was conceptualized in the 2006 Agenda. At first glance, confusion over the difference between theory and epistemology may be perplexing to scholars from humanities and social sciences; however, a closer look at the emerging field of engineering education research reveals heterogeneous conceptualizations of epistemology that likely contribute to the confusion that reportedly motivated the editorial.

This paper begins to sketch the intellectual history of a heretofore-unexamined piece of the history of engineering education research. The emerging field offers an opportunity to study a field in the making. In this paper, we focus on one facet of the field, the concept of epistemology, and examine what it reveals about engineering education research in particular and disciplinary development in general. Our motivation for examining the concept of epistemology stems from longstanding interest in the history and sociology of academic disciplines, combined with a more immediate fascination that developed after the publication of the 2014 editorial mentioned above. We explore three "data points" on the status of the concept of epistemology in the engineering education community, identify heterogeneous conceptualizations of the term, and discuss how the findings contribute further support to other analyses of the development of engineering education as a field. The data points were chosen as the most prominent and publically available evidence of engagement with epistemology in the field to date.

Background: Interdisciplinary Fields and the Borrowing of Knowledge

While interdisciplinarity as a topic of study increasingly attracts the interest of scholars in a wide range of fields and has led to copious amounts of literature, very little empirical research has

examined what actually happens as interdisciplinary fields develop or how concepts travel and transform across disciplinary boundaries in social science fields. In one notable exception, Dogan and Pahre analyzed ways in which concepts travel and transform within and between fields/disciplines.[5] Their analysis of other fields may provide instructive points of comparison for engineering education. Explaining the development of concepts, they contend that when a concept first enters a field, "its meaning may be imprecise or of limited usefulness for research;" however, "in the second stage, scholars develop the concept for scientific use…Once developed and given a specific meaning, concepts can be used by any scholar, and that scholar's use of the term should be easily understood by all other scholars in the field."[6] More recently, Kellert examined borrowing across fields, specifically how social science and humanities fields, including economics, legal theory, and literary studies, have differentially borrowed pieces of chaos theory from the natural sciences.[7] He poses questions of relevance to engineering education as well, including, "Why do people borrow knowledge, and how do they go about it? What do they hope to accomplish by borrowing knowledge, and what do they actually accomplish? When does it work well, and when does it work poorly?"[8]

Abbott's work also provides instructive points of reference for analyzing engineering education.[9] Based on Abbott's analyses of interdisciplinary formation, engineering education seems typical of other interdisciplinary fields in that it is organized around a problem (rather than a method, relationship, or theory), and in that it borrows concepts from disciplines, making it dependent on knowledge that is transportable. However, not all knowledge is transportable and borrowing is not always successful.[10]

Data Point 1: The 2006 Engineering Education Research Agenda

As mentioned above, a group of leaders in the engineering education community developed a research agenda for the field in 2006. *Engineering epistemologies* was one of five research areas prioritized. Engineering epistemologies was defined as "research on what constitutes engineering thinking and knowledge within social contexts now and into the future."[11] Within that area, four specific lines of inquiry were further identified:

> 1) What knowledge, skills, processes, values, and attitudes characterize engineering as a unique field, and what are the mechanisms by which these defining elements change over time?
> 2) How do elements such as innovation, critical thinking, systems thinking, biology, mathematics, physical sciences, engineering sciences, problem solving, design, analysis, judgment, and communication relate to each other to characterize the core of engineering as a profession?
> 3) What is the source of these core elements, and how are they shaped? Is engineering best characterized by the people it serves, the problems it addresses, the knowledge used to address problems, the methods by which knowledge is applied, or its social relevancy or impact?
> 4) What is the connection between what students are taught and how (and if) they practice engineering once they graduate? Where *do* and where *should* engineers learn core elements, and who is involved in these decisions?[12]

The conceptualization of epistemology presented in the Agenda is thus very broad, encompassing many things related simply to knowledge, and sets the stage for explaining subsequent heterogeneity.

Data Point 2: *Journal of Engineering Education*

Searching the term *epistemology* in *JEE's* online archive, which covers 1993 to the present, yielded 58 hits in January 2015. Twelve of these were disregarded because the term only appeared in a reference list, two were disregarded because the term only appeared in a book review, and three were disregarded because the term only appeared in an author bio. Two others, the EERC Agenda and Colloquies report, were also disregarded.[13-14] That left 39 articles to be analyzed in greater depth. Table 1 summarizes the remaining types, uses, and numbers of articles in which epistemology appeared.

Table 1. Typology of articles and uses

Use	# of Articles
Empirical investigation of epistemology or personal epistemology	7
Editorial/Forward	7
Methodology paper	6
A central part of the framework	4
Term appears in intro, literature review, or discussion only: not central to article	12
Citing EERC Agenda to justify their study	3

Within these categories of articles, epistemology is not always conceptualized in the same way however. As we continue our work, we intend to analyze each empirical, methodology, and framework article. In the analysis at hand, we discuss our examination of the editorials. Obviously, there is much more work in the journal that would fall under the *Engineering Epistemologies* research agenda as outlined in 2006, but here we are concerned only with those who are choosing to use the term *epistemology*.

In the editorial articles most authors discuss the different epistemologies of engineering and social sciences, often with an emphasis on how those differences can cause confusion between scholars conducting engineering education research. Several editorials only used epistemology in summarizing an article or chapter that appears elsewhere, and another listed epistemology as one of the goals of the 2006 Agenda. In sum, most of the editorials use epistemology similarly, or use it only in reference to another paper.

One editorial, however, invokes epistemology in a noticeably different sense: the authors cite ongoing confusion about what counts as quality scholarship (in *JEE* in particular) between the interdisciplinary contributors to engineering education research as a central motivation for writing the piece.[15] They highlight many elements of research design, including epistemology, methods, methodology and theory as a source of confusion in the field. In that sense, the editorial provides further evidence for our claims of lack of clarity over epistemology (and related concepts) in the field. Yet, the editorial deserves attention for other reasons as well. In it, the authors draw parallels between epistemology and methodology. In so doing, the authors list

some well established social science or educational qualitative methodologies as being both a methodology and epistemology, namely discourse analysis, phenomenography and critical theory, and they present this conceptualization of epistemology as *the* right conceptualization. However, this conceptualization of epistemology would not necessarily be accepted by scholars in other fields.

Although methodologies may imply a particular epistemology, many methodologies can and are used with different epistemological stances. For instance, discourse analysis, which includes many different approaches,[16-17] may take into account the social meaning of language, thereby aligning with a more interpretivist epistemology, or may focus on the words, grammar and functional linguistic components, thereby aligning with a more positivistic epistemology. The latter approach is more common in research by linguists;[18] critically, however, such variation shows that there is not a strict connection between methodology and epistemology. It is also worth noting that the social sciences had a strong positivistic stance toward inquiry as they began to emerge as a set of fields,[19] and that differences in the application of methodologies, including in qualitative research, are still marked by positivistic and interpretivist approaches.[20]

Thus, while seeking to clarify complex research design concepts (such as epistemologies, methodologies, and theories) is important and represents crucial discipline-building work, given the interdisciplinary character of engineering education research, it is likewise important to take note of how these concepts are deployed in contributing fields. For example, as discussed above, for contributors to engineering education research from social science backgrounds, tying an epistemology and methodology together as above may be a point of confusion.

Data Point 3: Taxonomy

A third data point in this story comes from the recent *Taxonomy for the Field of Engineering Education Research* project. The project, which was funded by the National Science Foundation, sought to standardize terminology and create a new taxonomy to map and communicate the field's research.[21] To date, seven different versions of the taxonomy have been developed. The first version was developed during a workshop for the project at the University of Michigan in 2013. Each subsequent version was developed at a workshop at a different engineering education conference, and built upon and revised the prior version. Some people may have attended more than one workshop, but no group was exactly the same at any workshop. Epistemology appears in versions one through five, but then is absent from six and seven. We inquired with the project's lead researcher to try to find out more about why and how this happened, but were able to learn only that the organizers relied on the groups attending the workshops to develop the taxonomies and that they did try to have a less comprehensive taxonomy at the end. We invite anyone who was part of those workshop discussions on epistemology to contact us if they would like to provide more information.

Figure 1 displays the first four versions of the taxonomy and all instances of epistemology in each respective version. In the versions of the taxonomy in which epistemology does appear, it appears under different categories and with different sub-categories of its own. In version 1 it was listed as a component of part of the engineering curriculum dedicated to social, political and organizational studies along with topics like ethics. In version 2 it appears in 3 places, as a

category under research methodologies and as two components of developmental theory (which is a category under theoretical frameworks), epistemology and personal epistemology, respectively. In version 3 it is no longer listed under research methodologies, but instead listed in very similar form as its own category in theoretical frameworks with components such as critical theory, positivism and social construction. Personal epistemology also remains a component of developmental theories. In version 4 it remains in the same positions, but the components under developmental theory shrink and the ones under epistemology as a theoretical framework grow. Version 5 is the same as version 4 (with respect to epistemology). Epistemology then disappears from versions 6 and 7. None of these terms is defined in the taxonomies.

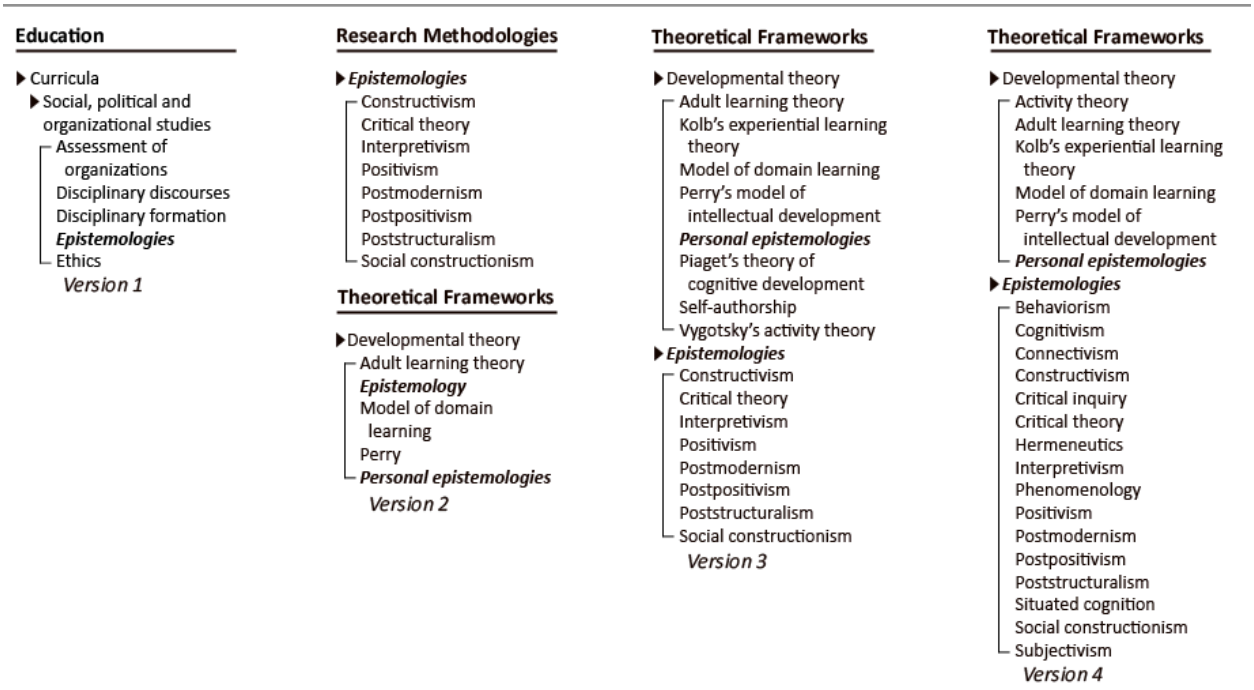

Figure 1. Epistemology in Taxonomy Versions 1-4

What we see here is epistemology being conceptualized in a variety of fashions: as something students should learn about, as part of the methodological design of research, as a particular kind of theoretical framework, and as a broad category of theoretical frameworks. While these shifts and re-categorizations may represent an emerging understanding of epistemology as a concept in the field, its disappearance from curriculum, re-categorization from one part of research design to another and then outright disappearance entirely from the later versions suggests that as a community engineering education scholars may struggle with identifying where and to what topics epistemology is relevant.

Conceptual Heterogeneity

What we see across these sources is that epistemology is conceptualized in drastically different ways. In the *JEE* articles, the several articles that offered specific definitions of epistemology all

differed, and all in turn differed from the one in the EERC agenda, and they likewise differ from conceptualizations in the taxonomy. The exception is the editorial that matches some versions of the taxonomy in which epistemology is conceptualized as a theoretical lens or methodology. Definitions of *personal epistemology*, on the other hand, were less varied.

Across, and within, the three data points, at least four distinctly different conceptualizations of epistemology can be identified, and we see conflation of theoretical perspectives with meta-theories about the nature of knowledge and what counts as knowledge. The first is epistemology qua knowledge: used to mean anything and everything related to knowledge, even sometimes as a synonym for *knowledge*. The second, more narrow, was epistemology as beliefs and theories about the nature of knowledge, usually related to discussions of research and in line with more common usage in social science and humanities. The third was in the sense of AN epistemology of engineering as a whole, in the sense commonly used in STS and philosophy. The forth was equating it to other theoretical and methodological frameworks/approaches.

In more established fields, such as sociology and philosophy, the shared conceptualization of "epistemology" is clearer, narrower, and much more widely shared among the community than we see in engineering education. It is not synonymous with *knowledge*, nor is it a catchall term for anything related to knowledge, or a theoretical framework.

In a Field in the Making?

On one hand, such conceptual heterogeneity could be seen as a typical feature of an interdisciplinary field in its early years. We know that knowledge is borrowed from other fields for many different reasons, in different ways, and with different levels of success.[22-23] As seen in other fields, concepts can be imprecise when first introduced into a field.[24] Our analysis of engineering education reveals that epistemology has not yet moved to the second stage of shared concepts, identified in other fields.[25]

On the other hand, such conceptual heterogeneity could serve as additional evidence of more problematic features of the field (which have been identified elsewhere), namely a hyperfocus on methods. Methodology discourses have played, and continue to play, a pivotal role in the emergence and development of engineering education.[26] Concomitant with those discourses has been a hyperfocus on methods and perceptions of rigorous methods as *the* hallmark of quality scholarship.[27] Like others,[28] we use the *hyper* prefix to emphasize that there is something problematic about an otherwise laudable ideal when it goes too far and stands in the way of other goals, limiting the field's development. The hyperfocus on methods we have observed as authors, reviewers, and readers participating in the field since 2009 stands in stark contrast to the amount of concern given to conceptual heterogeneity, in this case. As the epigraph we began the paper with suggests, however, other fields have not been able to rely on methods (technique) alone for their successful or continued development.[1] The continued hyperfocus on methods, in contrast to conceptualization, then should raise questions about the field's future development.

To be clear, we are not asserting that conceptual heterogeneity necessitates or causes a hyperfocus on methods, or vice versa. Nor are we asserting that the field must come to conceptual consensus around the term. Rather, we see the lack of concern over conceptual

heterogeneity as further evidence of a trend that we have been studying for several years now. In other words, based on the years we have spent studying the development of the field, we are suggesting that the concept of epistemology is one more example of previously identified phenomena. One might question the extent to which conceptual heterogeneity around epistemology is really a problem in engineering education. Indeed, our point is that within the engineering education community, it is not seen as a problem (with the exception of the 2014 *JEE* editorial), but that lack of concern can be contrasted with issues to which a greater amount of time and attention are devoted, such as methods. We can then ask what value those issues bring to the field, and who is served by continued preoccupation with them. Perhaps, then, beyond the history of science, the value in this analysis for the engineering education community lies in the comparative perspective it facilitates.

Our intention with this paper is not to criticize any individual or group who has contributed to the epistemology research landscape in engineering education. Rather, our intention is to contribute new insights into the development of interdisciplinary fields, the borrowing of knowledge and concepts therein, and specific trends we have observed in engineering education scholarship. By exploring the intellectual history of the concept of epistemology in engineering education, our aim is to contribute a new chapter to the history of the field.

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