Board 48: The Epistemic Beliefs of Chemical Engineering Faculty (Part I)

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Epistemic Beliefs of Chemical Engineering Faculty
(Work in Progress)

This paper is a work-in-progress for proposed research. The purpose of this paper is to introduce the engineering education community to the field of epistemic beliefs research and to seek feedback concerning a planned research study.

Background

Engineering education researchers frequently call for improving students' critical thinking as a primary skill to be developed in future engineers (Benson et al., 2010; Felder & Brent, 2004; Woods et al., 2000). Many educators believe these skills are important to teach their students but are unaware of how or are ill-equipped to teach them (Woods et al., 2000). Some authors have recommended adopting a cognitive development framework to assist in teaching critical thinking skills (Felder & Brent, 2004; Woods et al., 2000) and have encouraged the idea of moving students into more sophisticated cognitive levels where thinking becomes less authority-based and more abstract and independent. However, a few precautions must be considered with incorporating cognitive development frameworks. For example, the language some frameworks use to describe a student's position within (or progression between) distinct cognitive stages can be viewed as patronizing, especially for students in much lower stages and for those who never reach a so-called "mature" stage. Alternatively, these stages can be seen as simply different ways of knowing. As Belenky's (1986) explains, as well as the abstract, researchers can privilege some ways of knowing by creating an intellectual power structure in labeling their own type of thinking as advanced. Moreover, research has shown that individuals can move backwards in stages, skip stages, and exhibit different types of knowing in different contexts (Baxter Magolda, 1992; King & Kitchener, 1994, 2001, 2004; Pavelich & Moore, 1996; Perry, 1970; Wise et al., 2004), thus utilizing a linear and static approach can limit understanding of the complex relationship between individuals and their ways of knowing. A preferable framework to discuss this topic is through the lens of epistemic beliefs.

Epistemic beliefs refer to an individual's beliefs about knowledge, its nature and certainty, and which criteria are valid to distinguish opinions from facts from beliefs from knowledge. A faculty member's beliefs about the process of knowing will no doubt have an impact on their pedagogy (Lederman, 1992; Felder & Brent, 2004). In academic engineering environments, however, these beliefs are rarely made explicit and minimal attention is given to differing beliefs and their impact to the department. While some research had been done on student belief, little research has been conducted on engineering faculty in order to make these beliefs known or emphasize their impact on teaching (Faber & Benson, 2017; Montfort, Brown & Shinew, 2014; Yu & Strobel, 2012). Though some quantitative research has been done across engineering and studies have been focused within a few specific disciplines, the epistemic beliefs and, more broadly, practices of chemical engineering students and faculty has yet to be investigated. Thus, this study aims to begin to characterize the epistemic beliefs within the chemical engineering academic environment. Considering that faculty heavily influence students and spend some time reflecting on teaching practices, faculty seem to be a logical place to begin this characterization process. Therefore, the primary research question of this study is, **What are the Epistemic**

Beliefs of Chemical Engineering Faculty? An important sub-question in this study is, what epistemic beliefs are being communicated to chemical engineering students in their classrooms?

Why study epistemology within chemical engineering departments? Chemical engineering requires systems thinking in process design, a complex topic which faculty must teach their students. Therefore, it should prove useful to learn the epistemic beliefs of these faculty and how this impacts their students. Some researchers posit that the ability to achieve epistemic aims through epistemic cognition is the true goal behind the oft ill-defined umbrella term of critical thinking (Chinn et al. 2014). Both the broad term of critical thinking and the more niche term of systems thinking share similar meanings of thoughtful analysis or analytical reasoning, and call to mind King & Kitchener's Reflective Judgement Model (King & Kitchener, 1994, 2001, 2004), a stepping stone between the cognitive development research started in the 1970s and more recent epistemological research. This researcher argues that discovering the epistemic beliefs of faculty and the ideas being disseminated to students in their chemical engineering classrooms will prove useful in the field of chemical engineering education as well as related academic fields concerned with systems and critical thinking.

Theory

Research preceding scientific epistemological studies began in the 1970s with cognitive development models (Perry, 1970; Belenky et al., 1986; Baxter Magolda, 1992; King & Kitchener, 1994, 2004). The biggest drawback to this type of investigation is the lack of contextuality associated with the supposition of developed stages that *every* individual goes through. Cognitive development research transitioned into more epistemological research (Kitchener, 1983; Schommer, 1990; Kuhn, 2000), including research specifically on personal epistemologies (Bendixen & Rule, 2004; Montfort et al., 2014). While offering improvements on cognitive development models, research on personal epistemology can still fail to consider contextuality; personal epistemology is often depicted as an over-arching epistemology which accounts for an individual's beliefs in all situations. Hence, this researcher will instead be studying epistemic beliefs, that is, beliefs relating to the nature of knowledge within in a particular context (e.g. chemical engineering). In contrast to the developmental models, the frameworks of epistemic belief approach epistemic belief on multiple dimensions devoid of hierarchy, and, most importantly, allow for different epistemic beliefs in different contexts (Montfort et al., 2014; Muis, 2007). Schommer (1990, 2004) developed an oft-cited theoretical model following this line of thought and features five independent dimensions of epistemic belief. However, Hofer (2004, Hofer & Pintrich, 1997) argued that not all of Schommer's dimensions were truly epistemic and thus offered an adjusted model featuring four dimensions: certainty of knowledge (from unchanging and rigid knowledge to evolving knowledge), source of knowledge (from authority to from reason), simplicity of knowledge (from isolated bits of knowledge like a waffle pattern to highly interrelated concepts), and justification of knowledge (how does a proposition become justified "knowledge").

Current epistemological research commonly covers a range of three areas: cognitions, beliefs, and motivations (Faber & Benson, 2017). Epistemic cognitions are conscious thoughts devoted to achieving epistemic goals such as understanding or model-building (Chinn et al., 2014), however, research into epistemic cognition requires observing and discerning individual cognitions and diverges significantly from the proposed research. Epistemic beliefs are domain-specific beliefs concerning knowledge and its nature. Epistemic motivations refer to an individual's motivations regarding epistemic aims such as accumulating knowledge, processing knowledge, and discerning opposing viewpoints. Kruglanski et al. (2013) developed an instrument called the Need for Cognitive Closure Scale (NFC) to measure these motivations on five sub-scales: desire for predictability, preference for order and structure, discomfort with ambiguity, decisiveness, and closed-mindedness. While the NFC does not measure epistemic belief, it does measure factors which heavily influence epistemic belief as well as learning and decision-making (Faber & Benson, 2017).

Methods

The proposed descriptive multicase study will borrow ideas from phenomenography and primarily consist of qualitative interviews. This study will sample chemical engineering faculty from large research universities around the country. Each faculty member will be treated as an individual case, although individual epistemic practices influence others within an academic department and thus department-level beliefs will be given brief consideration. Three to five faculty will be recruited and selected for variance among gender and experience.

Each faculty member will first be interviewed in order to characterize their epistemic beliefs. Following this interview, an observation of their classroom will be conducted and filmed on a day where epistemic issues will be discussed. This researcher will prepare clips of moments in the lesson pertinent to epistemic belief, such as discussions of assumptions or ethical dilemmas (often associated with safety and process decisions). A second interview will then be conducted with this faculty member to discuss what thoughts and motivations were associated with these moments. Interviews will also be conducted with three students from each classroom in order to see how these lessons were interpreted by the students.

For the first interview, the protocol will largely follow the process described by Montfort et al. (2014), featuring semi-structured questions centered around Hofer's (1997, 2004) four dimensions and will include questions like *Can knowledge be said to be true or untrue? Are there any in-betweens?* Or, *What makes knowledge valuable? How do your students learn this value?* The second faculty interview will be more open to probe faculty members about their thoughts and motivations during key moments in lecture, paying attention to anything that might conflict with their beliefs stated in the earlier interview. Student interviews will be focused on the same clips from lecture shown during the second faculty interview and ask open questions about what they learned or took away from the particular parts of the lesson, the lesson as a whole, and any feelings or concerns associated with what they were being taught. All post-observation interviews will be scheduled in the week following lecture to preserve as much of the classroom-situated context as possible.

Analysis and Anticipated Results

All interview data will undergo multiple rounds of open-coding for epistemic practices, with the initial faculty interviews being analyzed for epistemic beliefs along Hofer's (1997, 2004) four dimensions. The proceeding interviews will be analyzed for epistemic beliefs as well as motivations (Kruglanski, 2013) and cognitions (Chinn, 2014). The observations will be analyzed for important parts of the lecture, which will be shown to the faculty and students in the follow-up interviews. These clips will also be analyzed using Chinn's (2014) AIR model of epistemic cognition, an appropriate way to examine classroom argumentation from faculty and student understanding of it.

Together, these interview data will be used to characterize faculty epistemic beliefs and examine the relationship between faculty and students' conceptualizations of disseminated ideas in the classroom. A pilot study is planned in order to present initial data and get feedback to refine interview protocols via presentation at the ASEE Annual Conference.

Significance

Beyond the primary outcome of the characterization of the epistemic beliefs of chemical engineering faculty, some connections between exhibited epistemology and pedagogy may be drawn from the observations of classroom practices and following interviews. The broader goal of this project in describing these epistemic beliefs is to lay the groundwork for future studies to explore a potential link between epistemology and teaching practices and to suggest ways to improve pedagogy and increase self-awareness for faculty and graduate teaching assistants.

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