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Synthesis-Identity Essay 3: History and Philosophy of Engineering Education

Collective as well as personal positions about the nature of knowledge seem to influence almost every aspect of individuals' daily life (Driscoll 2000). Therefore, in this final essay and inspired by Palmer (1998) I attempt to adopt a holistic view by not only revisiting how aspects of my philosophy of knowing and learning shape my philosophy of teaching, but also how these same aspects of knowing and learning shape my scientific philosophy and consequently my practice as engineering educator and as engineering education researcher (see Figure 1).

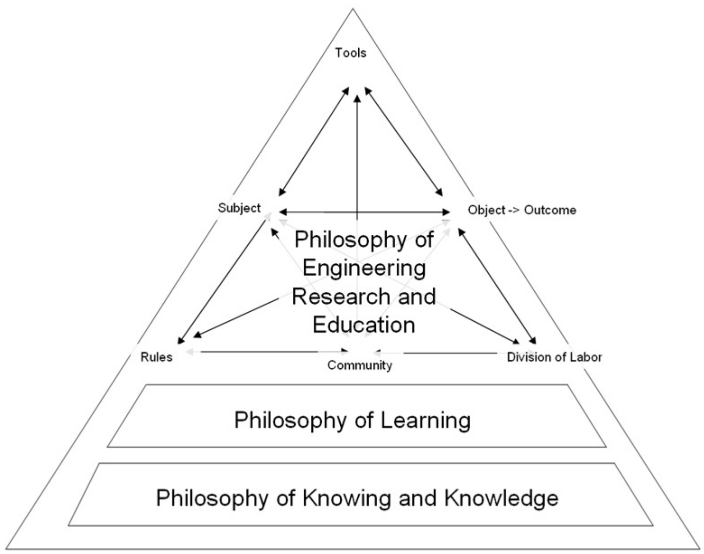

Figure 1: Philosophy of Education

Personal Epistemological Orientations

My philosophy of knowledge namely my epistemology, is oriented towards pragmatism and Dewey's ideas about knowing and knowledge. Under this epistemological view, knowledge is conceived as a body of information and skills applied to a process of inquiry in which experience takes a key role; experience that is connected to prior knowledge. This experience at the same time is intentional, social, cultural, and with an emphasis on personal meaning and social interaction (Noddings, 2007). My philosophy of learning is informed by the pragmatism view and can be defined as a social lifelong process that may occur intentionally and incidentally in formal instructional settings and through experience (Driscoll, 1994). Therefore, in my philosophy the two main sources of knowledge are experience and reason. While the experiential part of learning is informed by the constructivist perspective, the reasoning part is informed by the cognitive perspective. The basic premise of the constructivist perspective as well as the basic tenet of cognitive psychology is that knowledge is not the result of passive reception, but constructed by the learner (Noddings, 2007). Consequently, in practice these two perspectives are not mutually exclusive, but complement each other in order to accommodate changes in context, content, and learners.

Constructivism has been described as a philosophy, an epistemology, a cognitive position, or a pedagogical orientation (Noddings, 2007). However, I refer to it as a perspective that has multiple roots in psychology and philosophy (Driscoll, 1994). Constructivism is not a single theory, but a set of approaches that have the common assumption that knowledge is constructed by learners as they attempt to make sense of their experiences (Driscoll).

In contrast, the cognitive perspective assumes that the mind possesses a structure consisting of components for processing information and procedures for using such components. While the processing of information may involve storing, retrieving, transforming, and using, the components for processing information are referred to as sensory memory, short term memory, and long term memory. Under this perspective the learner is viewed as the processor of information. Learning occurs when information is captured from the environment, processed and stored in memory, and assimilated in the form of some learned capability (Driscoll, 1994). As I mentioned above, these two perspectives are the ones that inform my philosophy of education and my philosophy of educational research.

Linking my Epistemological Orientations with my Teaching

My philosophy of education has the main tenet that practice should be informed by theory. While my main goal is to focus on learners' growth in the cognitive and motor, and affective domains when applicable, my educational practice revolves around a combination of inquiry-based learning and direct instruction. The type of practice that I may adopt will depend on the particular situation, considering the culture, the context, the content, the learner, and the learning goal. In particular, my instruction is guided by one general model, followed by specific procedures, and meeting certain principles of instruction. The model that guides my instructional design is informed by the How People Learn framework (HPL). This framework assumes that effective learning environments are composed of a balance between instruction that is knowledge-centered, learner-centered, community-centered and formative and summative assessment-centered (Bransford, Vye and Bateman, 2004). Through this model I expect my learners to develop their own competence. Therefore, in my role as instructor or as instructional designer my goal is to shape and enhance my teaching style by linking educational research findings into practice. Linking research into practice by reconciling and relating different theories, instructional design processes, models, instructional strategies, and pedagogies may result in the desired changes in learners' knowledge, skills, and attitudes in the cognitive and affective domains.

For the case of a specific engineering context—i.e. software engineering, I then argue that by means of a balance between theory and practice (Seely, 1999), I strive for my students to acquire: a) the knowledge to analyze, design, verify, validate, implement, apply, and maintain software systems by means of techniques, skills, and tools necessary for their practice, b) the skills to identify constraints when designing systems and adapt to those, skills to function on multi-disciplinary teams, and skills to communicate effectively and c) the attitudes to have professional and ethical responsibility, attitudes to understand the impact of their engineering solutions in a global, economic, environmental, and societal contexts, and attitudes to recognize the need to engage themselves in life-long learning (Criteria for Accrediting Engineering Programs [ABET], 2008). Providing students with these tools may then result in broad-based technology leaders who can accommodate innovative developments to the continual changes in technology, society, and environment (National Academy of Engineering, 2004).

Linking my Epistemological Orientations with my Educational Research

Bucciarelli (2003) argued that the scientific and the instrumental essence of how research is conducted guides and at the same time limits the way we perceive and experience engineering education. Therefore, guided by Robson's (2002) discussion of how the approaches to social research affect our conceptions of what "to be scientific" means, I would like to situate my research in two of Schon's (1995) three new forms of scholarships that are closely tied to questions of epistemology. In particular, I am identified with the scholarship of application seeking to solve practical problems, and the scholarship of teaching focusing on transforming and extending knowledge.

In general, my research focuses on common themes pervading Science, Technology, Engineering, and Mathematics that not only transcend disciplinary boundaries, but also represent ways of thinking required when performing explanation, theory, observation, and design (American Association for the Advancement of Science [AAAS], 2008). In particular, my research interests revolve around themes such as *scale* and *models* and the instructional strategies and technologies designed to leverage cognitive processes supporting these ways of thinking. Aligned then with my epistemological orientations, I would like to pose the case of my dissertation work as an example of how my philosophy of knowledge informs my research practice.

My dissertation work converges in the issues of teaching and learning with simulation tools for scientific discovery. Experts use models to help them construct mental representations and understand problems, systems, and phenomena, and facilitate solutions when appropriate. As a result, in learning contexts simulations are used with the objective for students is to understand phenomena and/or ways to represent those phenomena by means of: a) creating models, b) experimentation with pre-built-in models, c) demonstration of models, etc. Therefore, I intend to identify professors' beliefs and instructional approaches when incorporating simulation tools in their classrooms and learners' beliefs and problem solving strategies when using simulations for building and/or using models embedded in such simulation tools. According to Robson (2002) what we think about truth, and in this case about issues of teaching and learning, will also guide how we know about them. In my research I have used naturalistic approaches for identifying professors' and students' perceptions and experiences of computational simulations as learning tools. I therefore attempt to identify not only experiential ways of teaching and learning with these tools, but also cognitive aspects in the form of instructors and students' problem solving strategies.

Situating my research in the engineering education curriculum, my dissertation work then situates in one of the most important characteristics of engineering qualifications and/or skills identified by professional engineers in Mann's report—i.e. the scientific attitude (as cited in Slaton, 2001). It also directly relates to important engineering outcomes outlined in the ABET criteria for accrediting engineering programs such as: a) the ability to use techniques, skills and tools necessary for engineering practice, b) ability to formulate and solve engineering problems, and c) the ability to design and conduct experiments, as well to analyze and interpret data, among others.

Situating my research in the engineering education research agenda, I identify my dissertation work as part of the Engineering Learning Systems Area (Steering Committee of the National Engineering Education Research Colloquies, 2006). In my research, I explore the unique elements of engineering that extends learners knowledge in order to identify and exploit the capabilities of new discoveries. Extension or knowledge growth that can be attained by means of formal and/or informal learning experiences in a variety of settings (e.g. classrooms, laboratories and on-line activities).

In conclusion, through the lenses of a holistic view, I have discussed how my philosophy of knowledge and learning influence, inform, and guide my philosophy of education and my philosophy of research in education. I have also situated my philosophy of education and my philosophy of scientific research in the context of engineering education. Finally, I have brought together my personal positions of these two topics with the collective ones by mapping my practice to the needs and challenges of engineering education of this century.

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