Epistemic cognition and in-class activities of engineering students (0274)

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Abstract

Do a student's epistemic beliefs about engineering influence the in-class activities s/he deems appropriate? Eleven semi-structured phenomenological interviews were used to produce a 4 stage model, where the 3 lower levels were populated. This communication will also report the results of a large scale administration of a quantitative instrument planned for autumn 2016, however the optimisation data (N=518) indicates that year of study, gender and study concentration each have small, significant effects certain dimensions and not on others. The combined frequencies for the two most epistemically complex responses for a "good professor" was <15% (N=322) and constant across year of study. Students expectations for "good students" were more complex and weakly correlated to year of study ($p<.01$, Cramer's $v = .162$).

The apparent lack of significant development of engineering students' epistemic beliefs is vexatious, consistent with prior studies and should prompt engineering educators to develop approaches to address this stagnation.

Summary

Epistemic cognition can be understood to be a person's perception of the nature of knowledge (Greene, Sandoval & Bråten, 2016), and recent developments increasingly underline the disciplinary specificities of epistemic beliefs (Buehel & Alexander, 2006; Muis, Bendixen & Haerle, 2006; Elby, Macrander & Hammer, 2016). Thus, a student's epistemic beliefs about engineering are expected to influence the in-class activities s/he will deem appropriate to identify, capture and develop "important" concepts (Bricker and Bell, 2016; Marshall, Summers & Woolnough, 1999). For example, a student who perceives engineering knowledge to be static and dispensed exclusively by experts will likely engage in different in-class activities than a student who sees knowledge as an interconnected web of evolving elements to which s/he can personally contribute.

This study employed semi-structured phenomenological interviews and a questionnaire to explore the in-class strategies judged relevant by engineering students. Eleven interviews were conducted using the student's weekly class schedule as an anchor for the conversation, from which three exploitable units of analysis for in-class behaviours were identified (listening behaviors, checking understanding behaviors, goals for exercise sessions). The synthesis of these elements enabled the construction of a 4 stage developmental model of students' goals for attending class. The participants of this study populated the first 3 levels, which were characterised directly from their descriptions of their in-class behaviours. Level 4 was largely extrapolated from the behaviour of a single student and reinforced with an existing model (Ashwin, 2005). A prior phenomenographic study of students' conceptions of learning in an engineering context by Marshall et al. (1999) identified 6 levels of epistemic beliefs but did not report the relative frequencies.

Working Model for Engineering Students Epistemological Conceptions

Perceived objective	Student role	Teacher role
1. Teacher presents information, provides narrative to facilitate understanding	To follow lecture, to have complete notes on the information presented	To provide information, to set assessment tasks
2. Teacher shows students how to see the subject as she does, solves example problems	To describe, to apply the concepts presented to the assigned problems	To set tasks with clear solutions which prepare student for assessment
3. Teacher demonstrates connections and relevance of concepts in specific and diverse contexts	To perceive the relationship between concepts, to apply in novel contexts	To demonstrate the relevance of the concepts and assigned tasks, to set challenging tasks with multiple solutions
4. Teacher proposes and explores tricky, cutting edge topics and concepts	To discuss own hypotheses, ideas	To challenge illogical assumptions, to facilitate class discussion

In order to generate a quantitative profile of engineering students, a series of Likert items presenting different in-class activities, informed by the interviews and coordinated with the model, were generated. When responding, students were asked to place themselves in the context of the class which they deemed to be the most interesting in the current semester. This strategy sought to have students respond in terms of the class which best matched their personal conception of learning, as students reported a significant variety in their behaviour in different courses during the interviews (particularly for note taking, use of feedback, and perception of professor's expectations; these aspects were not probed by the questionnaire). A large scale administration is programmed for autumn 2016, however data from the three optimisation iterations of the questionnaire (N=518 total) indicate that year of study, sex and area of engineering study each have small, significant effects certain dimensions and not on others (Cramer's v, $.0005 < p < .05$). Country of prior study was not observed to have any effect.

Additionally, 2 nominative items asked students to identify the 'one characteristic that makes a really good student/professor stand out.' In order of frequency of students' responses, a "really good professor" demonstrates relevance and connections, provides complete information, shows how to solve problems, challenges students to explore difficult areas, and challenges students to explore open-ended problems. The sum of frequencies for these final 2 items combined is <15% (N=322) and is relatively constant across year of study. Expectations for "good students" are more epistemologically complex: apply concepts in novel contexts, develop their own ideas, solve all the exercises and take complete notes (in order of frequencies of responses). Once again, the relationship with year of study is significant but weak ($p<.01$, Cramer's v = .162). The relationship between students' responses to "good professor" and "good student" is significant but weak ($p<.000$, Cramer's v = .202).

The apparent weak effect of year of study on the epistemic complexity of engineering students' in-class activities is coherent with previous work in science, where teachers and students have consistently been found to reject the notion that science is both subjective and tentative (Lederman, 2007; Talanquer, 2013). This stagnation is nevertheless vexatious in terms of the impact on students' perception of their role as learners and their conceptions of engineering. The more thorough exploration of the epistemic beliefs profile of engineering students which will be available through the results of the large scale administration of the instrument may help identify programmes or contexts that stimulate the development of epistemic beliefs in engineering.

Ashwin, Paul. (2005). Variation in Students' Experiences of the 'Oxford Tutorial'. *Higher Education, 50*(4), 631-644. doi: 10.1007/s10734-004-6369-6.

Bricker, L. A., & Bell, P. (2016). Exploring images of epistemic cognition across contexts and over time. In Greene, J. A., Sandoval, W. A., & Bråten, I. (Eds.), *Handbook of epistemic cognition (pp.1-15)*. New York: Routledge.

Buehl, M. M., & Alexander, P. A. (2006). Examining the dual nature of epistemological beliefs. *International Journal of Educational Research*, *45*(1), 28-42.

Elby, A., Macrander, C., & Hammer, D. (2016). Epistemic cognition in science. In Greene, J. A., Sandoval, W. A., & Bråten, I. (Eds.), *Handbook of epistemic cognition (pp.1-15)*. New York: Routledge.

Greene, J. A., Sandoval, W. A., & Bråten, I. (2016). Introduction to epistemic cognition. In Greene, J. A., Sandoval, W. A., & Bråten, I. (Eds.), *Handbook of epistemic cognition (pp.1-15)*. New York: Routledge.

Hofer, Barbara K, & Pintrich, Paul R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*(1), 88-140.

Lederman, N.G. (2007). Nature of science: Past, present and future. In S.K. Abell & N. Lederman (Eds.), *Handbook of Research on Science Education*, (pp. 831-880). Mahwah, NJ: Erlbaum.

Marshall, D., Summers, M. & Woolnough, B. (1999). Student's conceptions of learning in an engineering context, *Higher Education*, 38, 291-309.

Muis, K. R., Bendixen, L. D., & Haerle, F. C. (2006). Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review*, *18*(1), 3-54.

Talanquer, V. (2013). Chemistry education: ten facets to shape us. *Journal of Chemical Education, 90*(7), 832-838.