Understanding Epistemological Change Due to a Course in Anthro-design: New insights for Engineering Epistemologies

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Engineering Epistemic Education through Anthro-Design: New insights for Engineering Epistemologies (Work in Progress)

Introduction

Academic literature shows growing interest on addressing social phenomena through 'complexity thinking' (Davis & Sumara, 2014). In the context of Engineering Education, addressing authentic engineering challenges resolving open-ended, ill-defined problems has been characterized as a major component of educating future engineers (Litzinger, Lattuca, Hadgraft & Newstetter, 2011). This type of challenge is consistent with the classical definition of 'wicked problems' (Rittel & Webber, 1973) in the domain of design. On the other hand, more attention has been placed on expanding the understanding of engineering knowledge (Adams et. al, 2006). Figuereido (2008) proposes a model of engineering epistemology consistent of four dimensions of engineering: (1) engineer as sociologist (2) engineer as designer (3) engineer as scientist (4) engineer as doer. In sum, there is a pressure to educate future engineers able not only to apply mathematics and science to address social issues but also to be competent in the navigation of social science, humanities and engineering design (Hynes & Swenson, 2013).

Adams et. al (2006) formulated a research agenda for Engineering Education. This proposal still guides future authors in the description of the Journal of Engineering Education (JEE). In the five central research areas proposed, the first one is 'Engineering Epistemologies', that is, research on what constitutes engineering thinking and knowledge (Adams et. al, 2006). This area of research has pursued relevant integrations with other domains of knowledge, but nonetheless, has put little attention on its educational implications beyond exceptional publications (e.g. Faber & Benson, 2017; McNeill, Douglas, Koro-Ljungberg, Therriault & Krause, 2016). In terms of educational psychology the main question to expand the engineering epistemologies research area could be formulated as: How to instill adaptive and contemporary epistemological beliefs through engineering education?

This Study

This study examines the epistemic change of 45 undergraduate engineering students in Chile. Traditionally, engineering education has been characterized as having a strong emphasis on applied math and paying little attention to the social science and humanities dimensions of engineering (Hynes & Swenson, 2013). The goal of this study is to understand 'How are engineering undergraduate students' epistemological beliefs changed due to a course on Anthro-Design'? A sequential explanatory mixed method research design was conducted in order to investigate the following research questions.

RQ1: Does epistemic change happen during the Anthro-Design course?

RQ2: (if produced) How is this change experienced by the students?

Theoretical Framework

The concept of personal epistemology gathers the beliefs of the nature of knowledge and the knowing how process (Hofer, 2001). In the field of education, diverse theoretical traditions refer to it as "epistemological beliefs" (Jehng et al., 1993; Kardash and Howell, 2000), "epistemic beliefs" (Bendixen, Schraw & Dunkle, 1998), "epistemic theories" (Hofer and Pintrich, 1997), or "epistemic resources" (Hammer and Elby, 2002). In higher education, the concept of personal epistemology offers a comprehensive and methodological promotion of one of the main objectives in tertiary education: critical thinking crítico (Holma & Hyytinen, 2015).

In agreement with Lee, Godwin & Nave (2018), we believe that there is a need to adapt and and contextualize the constructs and educational theories to the particularities of engineering education. Epistemic education should be directed to the challenges and sensemaking of engineering. In the same line as Lattuca, Knight, Ro & Novoselich (2017), we believe there is a need to showcase concrete educational experiences in the study of engineering education. Following a Vygotskian (1931) argumentation, there is a need to understand which is the educational scaffolding needed for learning to take place. Throughout this case study, we will expose some insights on how an Anthro-Design course promotes epistemic change in the context of engineering design education.

Case Study: The Anthro-Design Course

Anthro-Design is a third year minimum course corresponding to the Major in Engineering Design and Innovation. This major is part of the undergraduate curriculum at the School of Engineering at Pontificia Universidad Católica de Chile and was deployed on 2013 following a major curricular reform undertaken by the government agency CORFO and its program Engineering 2030. This school has been accredited by ABET and has a series of international interactions with American universities at the graduate and undergraduate level. In particular, this course looks to teach the students about applied ethnographic research from a cultural anthropology point of view but taking advantage of the visual hands-on potential of the design practice. The teaching practices in the classroom have a comprehensive focus (Campbell, Cabrera, Michel & Patel, 2017). They combine strategies such as lecturing, active learning and project-based group activities. The course works with an organizational real-life counterpart (a company, the State or an NGO). At the end of the course the student will be able to understand and apply qualitative research methods to inform innovative design solutions. The focus of the course is to prepare students to face ill-defined issues using tools to understand the human interface and culture and to synthesize in innovative opportunities; to identify a qualitative research question; to detect and delimit opportunities for innovation using tools to tackle ill-defined issues and imperfect knowledge; and to develop an ethical standpoint and critical thinking on the social responsibilities of an engineer-designer" (Pontifia Universidad Católica, 2018). The working methodology is based on a divergent process for the detection of design opportunities. Figure 1 shows how the anthro-design process antecedes divergent and convergent process of ideation and construction of a prototype in our curriculum. This is done by using context assessment tools, creating a thick description and recognizing different actionable design spaces to promote change in the context provided.

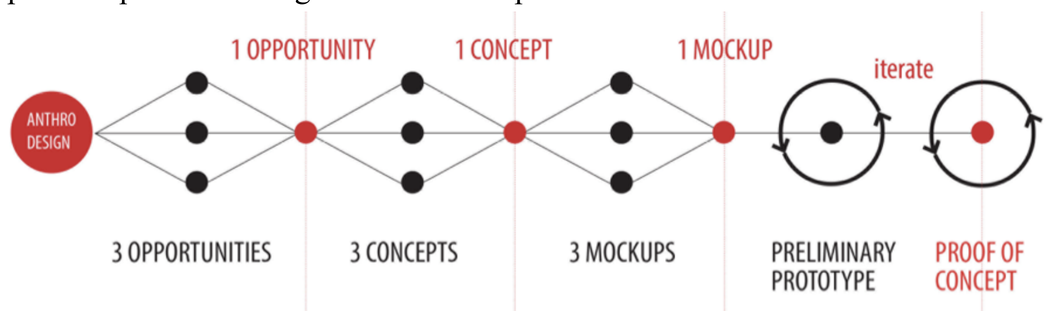

Figure 1. The engineering-design process as seen in our engineering-design and innovation program

In concrete, the first part of sessions are oriented to the delivery of diverse applied ethnographic research methods to raise and analyze data using grounded theory. Teaching practices involve lectures and active learning techniques. In parallel, the students use 5 months for putting the tools in action facing a counterpart's ill-defined challenge where there is not one correct answer. In teams, the students have to make their own decisions to develop aggregated reports that will synthesize their fieldwork and upcoming analysis. So they will diverge to do synthesis and converge in doing an analysis to report to the class and counterparts.

Methodology

To tackle our research questions, we implemented a sequential explanatory mixed design (Creswell & Clark, 2007). The participants were 45 undergraduate students from the Anthro-Design course IDI2015. Most of the students were in their third year, that being, just after the calculus and basic sciences initial portion of the curriculum which is mandatory to all of the engineering subdisciplines. This course takes place only on the second semester between August and December. The age from the participants spans from 19 to 22 years old.

In the quantitative part of the pre-post design we used the Epistemic Belief Inventory EBI (Schraw, Bendixen & Dunkle; 2002). Specifically, we used the adapted three-factor version adapted to Chile by Leal-Soto & Ferrer, 2017. These factors are: (1) Innate Ability and Fast Learning (beliefs on the nature of learning) (2) Omniscient authority (beliefs on the role of authorities as foundations of knowledge) and (3) Certain Knowledge and Simple Knowledge (beliefs on the nature of knowledge itself). Paired t-tests were used to compare pretest and posttest means in all factors and epistemic beliefs as a whole. When significant differences were detected, Cohen's D method was used to determine the effect size. The qualitative part had a descriptive focus (Flick, 2009). We used semi structured interviews (Flick, 2009) and narrative interviews (Rosenthal, 2004) to triangulate the results.

Results

Table 1 displays means, groups paired t-tests and effect sizes of the 17 items evaluated pre-and post course development. The overall mean results show a significant difference in epistemological beliefs (T= 3.34, DF=44, p.value= <0.001) between the two periods. We used the Cohen's D method, this difference proved medium (Cohen's d=0.49). factor 1 (innate ability and fast learning) and factor 2 (omniscient authority) did not show a statistically significant difference. However, factor 3 (certain knowledge and simple knowledge) showed statistically significant differences (t= 5.21, df= 44, p-value= 4.75E-06). The effect size of this difference is large (Cohen's d= 0.77) with an effect interval of [0.55, 1.44].

Items	Mean		Paired			Cohen's D	
	Pre	Post	T	*df*	*p-value*	Cohen's D	Effect Size [95% CI]
Overall	2.250889	2.064667	3.3415	44	0.001707**	0.4981182	Medium
Factor 1: Innate Ability and Fast Learning	1.700495	1.649254	0.77739	44	0.4411		
Factor 2: Omniscient Authority	3.038462	2.877863	1.693	44	0.09753		
Factor 3: Certain Knowledge and Simple Knowledge	2.589862	2.556054	5.2132	44	4.75E-06***	0.7771427	Large

Note. t-Value for paired t-tests comparing scores from baseline and posttest. Cohen's d effect sizes based on comparisons between baseline and posttest scores. *p<0.5. **p< .01. ***p <0.01

Table 1. Quantitative summary of epistemic beliefs assessment.

These results are consistent with our initial qualitative findings. It makes sense that change is quantitatively visible in the third factor that describes the ontology of knowledge (Kitchener, 1983). A salient theme coming from the qualitative analysis refers to the perceived uniqueness of this course in engineering curricula. One explanation for this sophistication in their epistemic cognition could be associated with the particularity and uniqueness of the course in the traditional engineering curricula. Students are usually exposed to evaluations with a single correct answer or a limited kind of procedures for achieving it. The Anthro-Design course uses a different methodology. This model is based in flexible evaluation criteria, giving the student the opportunity to present their ideas in both oral and written. These deliverables are based on their semester project and must gather new information and make improvements from the earlier version. In this context, the change in their epistemic cognition could be associated with the feedback the students receive.

Conclusions

The preliminary results of the study portray that epistemic change happens at many levels during and after this course. Some of it has to do with the diverse teaching practices but also with the strategies undertaken to embrace the social sciences. From a research point of view, we are still to finish up transcribing all of the in depth interviews. In order to achieve intercoder reliability, at least 3 people will be coding separately, negotiating in a final common codebook. We will use grounded theory (Glaser & Strauss, 1999) to create a theoretical model that will nurture our quantitative findings. On the other hand, we will like to repeat this research on August 2019 with another cohort of students. We are also evaluating to do a follow up study with this same students in the course to come.

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