

Here are some ideas and questions we might take up when we meet, although I am happy to discuss other issues as well.

1. Are there dimensions to the “transformative” characteristic? Through the threshold concept literature and the reading done to prepare for the Teagle grant, I believe that students can be transformed along four dimensions:
  - *personal* – This reflects a transformation in the students thinking about themselves. There are ‘small’ and ‘large’ facets to this dimension. On the ‘small’ side are such things as confidence and a sense of self. On the ‘large’ side are things such as value system and worldview. So, personal experiences of transformation would include a shift in one’s sense of self, value system, and/or worldview.
  - *social* – Looking beyond oneself into a community; again, there are ‘small’ and ‘large’ facets. On the ‘small’ side there is one’s position within, say, a disciplinary or professional community. The ‘large’ side describes one’s position within society. The transformation can mean moving between communities or further into one. For example, becoming more identified with a disciplinary community, which is what I see happening when students move along the kind of learning trajectory Peter and Jean talk about.
  - *epistemological* – We expect the student to (eventually) ask: What is the source of knowledge? How do I know what I know? How is knowledge constructed? These kinds of insights surely must be central to “thinking like an economist (or a biologist or a ...)”. A student’s episteme makes it possible to ask questions, but also, by its very nature, limits the kinds of questions that can be asked. I think there is more going on here when combined with the integrative characteristic (more on this below). The transformation here is in the development (Jerry prefers “evolution”) of the student’s episteme in terms of its effectiveness to explain phenomena, to predict events, and to generate new knowledge.
  - *ontological* – When a student masters a threshold concept, another concept within a discipline’s ontology is understood, as well as its connections to other concepts in the ontology. This is the most benign of the dimensions; more like an accretion of knowledge than anything else.

As part of the work on the grant proposal we submitted, I was reading the work of Baxter Magolda (2001) who talks about student growth as a journey toward “self-authorship.” What is really interesting is that she identifies three aspects to growth in self-authorship: Who am I? (what I call the personal dimension); How do I know? (what I call the epistemological dimension); and, What relationship do I want with others? (close to my social dimension). According to Baxter Magolda, key to growth in these dimensions is the extent to which “hearing one’s own voice” is part of answering these questions. She identifies four phases we go through in finding answers to these questions. What differentiates the phases is largely the degree to which you see knowledge as objective truth imparted by someone else (the earliest phase) or as something generated and contextual (the latest stage). As students move through the phases they are transformed along the personal, social, and epistemological dimensions.

2. Are there dimensions to the integrative characteristic? This is less clear to me, but perhaps there are the following. Much of this comes from the work Jerry and I have done trying to see a threshold concept in the context of the concepts it connects (integrates). We have seen this as providing the path toward making curricular and pedagogic changes that will result in improved student learning.
  - *additional meaning* – A previously understood concept takes on additional meaning in the context of a threshold concept.
  - *additional connections* – New connections between concepts become possible with understanding of a threshold concept. These connections might be source of the additional meaning described above.
  - *conceptual coherence* – This is the most compelling of the dimensions. A characteristic of the integration for a threshold concept is that “seeing things in a new way” means that what was already known now has an explanatory and perhaps predictive coherence that was previously missing. It is relatively easy to see this producing one or more dimensions of transformation in a student; imagine that prior to understanding a threshold concept, you have a collection of concepts that are loosely connected and which consequently have little or no explanatory or predictive capacity. Acquisition of the threshold concept forges new connections between the associated concepts, providing not just additional meaning for them individually or connections between them, but a more generative ability as a whole.
3. I have worked from the premise that if concept X is a threshold concept in discipline Y, then it is so for everyone studying in discipline Y. That is, if you and I are studying discipline Y, then concept X is a threshold for both of us. It might be troublesome for me and not for you, but it should be equally (?) transformative and integrative for us. However, I wonder about this. Is it likely that there are particular *concepts* within a discipline that have (at least some dimensions of) the transformative and integrative characteristics? Or is it more likely that there are transformative/integrative *moments* and that the trigger is a concept or skill that fills some epistemological gap a student has? In which case, the triggers may differ by student. That is, the trigger that transforms me and helps me see some part of a discipline in a new way is not necessarily the trigger that does it for you. The work of Baxter Magolda suggests these moments exist. Further, what about a broader notion of *threshold experiences*? For example, asking a different set of questions, which allows you to formulate a problem differently resulting in a very different perspective on a topic that opens up a wide variety of possibilities not previously visible? Does this overlap with threshold concepts, or is it a separate experience altogether?
4. Epistemological obstacles and ideology (Piaget and Garcia, 1989). I could see a threshold concept arising from an epistemological obstacle that is itself the result of an ideological framework (worldview?) that may not allow certain questions to be raised or may frame thinking such that the questions are considered irrelevant. Alternatively, might some epistemological obstacles (and consequent threshold concepts) be of our own creation through poor or ill-considered teaching practices (Schoenfeld, 1988)? The concept of ‘limit’ in mathematics may be an example (Artigue, 2001).

- Artigue, M. 2001. What can we learn from educational research at the university level? In D. Holton, editor, *The Teaching and Learning of Mathematics at University Level*. Kluwer Academic Publishers
- Bauer, K.W., and Bennett, J.S. 2003. Alumni Perceptions Used to Assess Undergraduate Research Experience. *Journal of Higher Education*, 74: 210-230.
- Baxter Magolda, P. M. 2001. *Making Their Own Way: Narratives for Transforming Higher Education to Promote Self-Development*. Stylus, Sterling Virginia.
- Kardash, C.M. 2000. Evaluation of an Undergraduate Research Experience: Perceptions of Undergraduate Interns and Their Faculty Mentors. *Journal of Educational Psychology*, 92.1: 191-201.
- Lopatto, D. 2006. Undergraduate research as a catalyst for liberal learning, *Peer Review*, 8, 22-25
- Lopatto, D. 2004. Survey of Undergraduate Research Experiences (SURE): First Findings. *Cell Biology Education*, 3: 270-277.
- Lopatto, D. 2003. The Essential Features of Undergraduate Research. *Council on Undergraduate Research Quarterly*, 139-142.
- Piaget, J. and Garcia, R. 1989 (1983). *Psychogenesis and the History of Science*. Columbia University Press, New York. Translated by H. Feider.
- Schoenfeld, A. 1988. When good teaching leads to bad results: The disasters of 'well-taught' mathematics courses. *Educational Psychologist*, 23(2):145-166.
- Seymour, E., Hunter, A.B., Laursen, S.L., and Deantoni, T. 2004. Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings From a Three-Year Study. *Wiley InterScience*, 493-534. 20 Nov. 2007 <<http://www.interscience.wiley.com>>.