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Thresholds in Physics Learning

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THRESHOLDS IN PHYSICS LEARNING

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"Sometimes the best route to fulfillment is the path of more resistance."

– Ian Leslie

Introduction

In Fall 2012, we participated, respectively, in a faculty seminar and a series of student consultant meetings through The Andrew W. Mellon Teaching and Learning Institute (TLI) at Bryn Mawr College. The faculty seminar was on "threshold concepts in teaching and learning," which was facilitated by Peter Felten from Elon University, second Fellow of the TLI. The weekly student consultant meetings, facilitated by Alison Cook-Sather, Coordinator of the TLI, supported student consultants working with faculty members who participated in the threshold concept seminar as well as those who were focused on other pedagogical issues. In this essay we offer our two perspectives on the work of the semester.

Liz's Perspective:

My interest in participating in this seminar was to reflect on how the lens of threshold concepts might deepen my understanding of the challenges students face in courses that bridge introductory-level subject matter and advanced material. This transition is an important milestone for students, and successfully navigating it advances our goals for inclusiveness and achievement in the physics enterprise at Bryn Mawr College.

In the seminar we discussed how for each stage of learning (description, analysis, extension and application), one can distinguish deep learning from surface learning by applying the concept of thresholds. Deep learning occurs when and where an *irreversible transformation* takes place, often not visible in, or synchronous with, class time. As a result of "crossing a threshold," views are altered for good and new things are perceived for the first time. The experience can be *integrative*, connecting previously disconnected understandings; it can be *discursive*, resulting in a new set of metaphors/language to describe new insights; and it can be *troublesome*, disruptive of previous knowledge structures and stability. [1]

We extended our analysis by developing the idea of "neighborhoods of thresholds" to capture the notion that learners may cross them efficiently and quickly or may hang out near them before finally crossing them. We appreciated that to spend time in the vicinity of a threshold fosters grappling fully with the challenge of it and thereby getting the most out of it as a leaning experience.

The neighborhood metaphor highlights the solo and community aspects of learning. One spends time doing different things and with multiple people in a neighborhood and one repeats many recurring activities. One sits on a bench, one walks, individually and in the company of others. One goes places and returns multiple times over the same spaces, all the time deepening one's connection to it and insights about it.

Helping students cope with ambiguity and confusion, seeing them as not only necessary, but as strongly desired is then akin to inviting them into an unfamiliar, possibly unfriendly and unsettling neighborhood. As teachers our task is not to "make it easy." To the contrary, it is to present the "desirable difficulties" and provide support for students to tolerate the profound unease that accompanies true learning.

Helping students to navigate the transition from passive listeners to engaged learners requires asking them to "lean into challenging work" and "rehearse the hard parts" as they move through the four phases of their learning: description, analysis, extension and application. What motivates students to do this difficult and time-consuming work? One student in my class reports it is the "big ideas, which are beautiful and exciting."

In his provocative article *The Uses of Difficulty*, Ian Leslie makes several useful observations. [2]

> 1) Teachers and students often assume that if a concept has been easy to learn, then the lesson has been successful. However, numerous studies have now found that when material is made harder to absorb, students retain more of it over the longer term, and understand it on a deeper level.
>
> 2) Faced with obstacles, people increase their "perceptual scope"—they step back and see a bigger picture and hence are more likely to make leaps of association and unusual connections.
>
> 3) Constraints on self-expression spur creative thought.

> 4) We tend to equate happiness with freedom, but without obstacles to what we desire it is harder to know what we want or where we are headed.
>
> 5) As an example, many of the well-off are befuddled by the infinite options their money presents them with, the ease of acquisition. They find it hard to know what to want, creating a kind of "existential bafflement."

I identified two types of "threshold neighborhoods" in this 2nd year physics class on electromagnetism: 1) Foreign and abstract representations, symbols and notations, of idealized, yet real phenomena, 2) misleading tacit language and relationships.

Could we find elements of desirable difficulties in our classroom? I asked Chandrea to look for signs of "productive confusion" and other indications that students were able to recognize and stay in "threshold neighborhoods."

Chandrea's Perspective:

In my role as student consultant, I tried to better understand the concept of threshold concepts. I was very nervous about being paired with Liz on this project because I wasn't sure if I was qualified enough to sit in and observe a Physics class. I had not been in a Physics class since high school and I did not think I would be able to recognize threshold concepts in Physics, let alone understand what was being taught.

> In this class, I learned that troublesome learning in a science class may not be so different from troublesome learning in any other class. Below are excerpts from my notes and subsequent reflections in response to questions Liz and I generated:
>
> *When and how are students "hanging out in a threshold neighborhood"?*
>
> - *This happened when students were working together to put their work up on the board. They were doing the learning together and they consulted each other while doing the work. Although group work was not as incorporated into the daily class routine towards the middle of the semester (because students expressed the need for solo work to understand and work out problems), it was a learning experience for all.*
>
> - *In some classes (such as the week 2 class I sat in on) there were instances where some students had not taken a specific class or hadn't learned much about a certain topic, but you encouraged the other students to help those students along. And by suggesting that they help each other along, you were encouraging them to support each other in this class.*
>
> *When and how are modeling, practice, and feedback provided to students?*

- *Practice happens when students are asked to go up to the board to solve a problem. You provided feedback when students put work up on the board. Modeling often happened while you were lecturing. Rather than doling out answers, you often did the problem out yourself while standing in front of the class. You didn't just read problems off of an answer sheet. So while it may have been nerve wracking to not have the problem completely thought out when you were doing it out on the board in front of the whole class, you were putting yourself in their position and working through the problem step by step.*

- *Another example of you modeling was during week 4 when you answered a student's question about your equation by asking her questions back about what she understands. You did this with a step-by-step process. I thought this was a perfect example of student-teacher engagement in the classroom. You looked like you wanted to make sure you were being clearer on things when you had to re-explain what you just taught to her.*

- *Something that I want to praise you for is your willingness to try new things. You are open to student feedback and can change things up if your students tell you that something you're doing in class is not working for them.*

How and why are students motivated to "lean into difficult work"?

- *I think students are motivated to lean into difficult work when they are interested and passionate about the subject they are learning about. I know from personal experience that if I want to understand something, I will find ways to do so, no matter how difficult it is of a subject. For example, one student asked you in class during week 2 about what a gradient is and also when she'd ever need to use the term in her life. Questions about the point of learning something are so common amongst students and all too often, teachers are quick to dismiss these questions. I've had teachers say that I just have to learn it and to stop asking questions. How we would use what we learned in class in real life is such an important question to ask. We always want to know why we're learning what we're learning.*

- *For mid-semester feedback I know that students definitely felt the need to let you know that group work was not the method they preferred or that they just didn't quite understand something. They found you to be approachable and came to you for office hours. If they're willing to visit you during office hours and ask these clarification questions, it's clear that they want to understand this difficult work.*

When a threshold is crossed, what becomes possible? What does it do for motivation?

- *Threshold concepts are described as "akin to a portal, opening up a new and previously inaccessible way of thinking about something" (Meyer & Land, 2005, p. 3). Students will be more likely to take risks in an academic setting and be in a troublesome learning state, which is a good thing because learning should be*

about challenging oneself. If one doesn't take risks and instead only takes in the same information over and over again, then that isn't real learning.

- *I've also learned that maybe threshold concepts aren't easy to recognize right away – I spent this whole semester waiting for one to happen in class. I think it's more of an internal thing and if it did happen, I suspect it would've happened during Liz's office hours. I know what it feels like to experience crossing this threshold but I don't know if I could recognize it happening to another person. It's a very personal experience.*

Conclusion:

What I (Liz) learned from my experience in the seminar and my consultation with Chandrea was the importance of educating on two levels. First, helping students become aware of their learning and revealing the choices and rewards involved. And second doing that in the context of a rich and connected set of ideas and insights about the human and physical world around us. Beyond such content matter much of what a successful teacher does is to frame and support the development of a students' ability to foster, manage and excel at their own learning. It is a deeply enriching process for both teacher and learner.

What I (Chandrea) learned from my experience was that I didn't necessarily have to understand the subject of Physics to be able to detect troublesome learning. In fact, my lack of experience in Physics may have helped me observe the classroom learning more objectively. I appreciated Liz's openness to trying new teaching techniques, such as having students listen to the podcast lectures and then doing problems in class, even though it may not have worked out and she had to readjust her teaching plans. Students felt comfortable enough to approach Liz when they had suggestions about her teaching methods and she was always willing to try them out. Finally, I learned that students' crossing of thresholds may not be so obviously visible in a classroom, despite how baffling and exciting the experience can be.

References:

(1) Myer, J.H.F., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. *Higher Education, 49*, 373–388.

(2) Leslie, I. (2012). The Uses of Difficulty. *Intelligent Life*, The Economist, December 8-14.