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Backwards By Design Mini-Assessment (2015-2016)

Circling Back to Guiding Questions

My participation in the Backwards by Design workshop last Summer inspired me to think deeply about the nature of writing experiences afforded to our students in the physical sciences. One of the courses I teach is SCED 201: Matter and Energy in Physical Systems. This is a 4 credit-hour, inquiry-based, physics course for prospective primary (elementary) school educators. It utilizes a well-researched curriculum known as "Physics in Everyday Thinking," which allows students to investigate various physical phenomena through activities.[1]These activities begin by eliciting students' initial ideas, which are often shared during whole-class whiteboarding sessions. The students then proceed through the activity in small groups and, finally, whiteboard summarizing questions that focus in on the main "takeaways" from the activity. A homework assignment typically follows.

During the Winter 2016 quarter, I reflected upon my experience in Backwards by Design when I noticed students having some difficulty addressing the main purpose of each activity, in a holistic sense, once the class finished one. I suddenly remembered that the activities all begin with a guiding question. Students, effectively, are expected to address this question by completing the activities, the summarizing questions, and the homework assignments. However, there are few instances within the curriculum in which students are given the opportunity to actually revisit this question and think on an individual basis about how they would address this question given their particular experiences with the activity (e.g. data collection, interactions with peers, insights from whole group and small group discussions). This reflection led to my spontaneous assignment of a short reflection on an activity. The following is the exact text from the first time I gave such an assignment:

"Write a paragraph addressing the guiding questions for C1A4 (found on p. 55) "Why do moving objects tend to slow down and stop? Where does the energy go?" Address this in the context of what you've discussed in class (both within small group discussions and based on whiteboard discussions) and the evidence you've gathered and analyzed to support your response."

Upon receiving the first of these paragraphs, I scored them for completion and provided feedback to students based on the degree to which they contextualized their response in alignment with what I asked for in the prompt. From the very first set of paragraphs, the vast majority of students appeared to take full advantage of the opportunity to "circle back" to this guiding question. It also afforded me some additional student writing to assess for various misconceptions that can emerge when learners are wrestling with relatively abstract concepts such as energy transfer or force. The form of feedback I would often need to give, either directly (verbally to the student in class) or in written form when I handed back the assignment, was the need to include evidence from their experience in the activity itself. This led me conceptualize the following threshold concept:

Scientific inquiry is driven by asking questions about the natural world; addressing such questions requires the analysis of evidence obtained from experimentation, and the dissemination of this analysis in clear, concise language.

Certainly, this threshold concept has been alluded to in many publications concerning the nature of science, and S.T.E.M. education in general. In fact, a report by the National Research Council identifies "asking questions" as well as "obtaining, evaluating, and communicating information" as two of eight science and engineering practices that are essential for inquiry in these domains.[2] Though it is certainly at a large grain size and is, by no means, novel, I feel that it was an important one to address in the class. The inquiry-oriented curriculum around which this class is structured provided, and continues to provide, a platform for assessing and improving how students engage in the scientific practices alluded to above.

I gave this assignment for each activity during the remainder of the Winter 2016 term, as well as throughout the entirety of the current (Spring 2016) quarter. It became quite evident that, as students gained more practice writing about and reflecting on their experiences with each activity, they were better able to address the pertinent guiding question or questions. In the current term, I instituted consensus ideas discussions: whole-class discussions in which the groups decide what the main "takeaways" were from a cluster of activities focused on a particular "big idea." I found that the students organized their thoughts with a relatively high level of ease, and were able to draw upon content in their earlier writings to support their claims in such discussions. While I am very much unable to rigorously determine a causal link between the writing assignments and this impressive level of reflection and organization of thoughts, I hypothesize that it helped students meaningfully contribute to the consensus ideas discussions. The best evidence I have for this so far is the alignment of the reflections in the paragraphs with the nature of student discourse in class.

Another observation I made is that students became increasingly attentive to important details when constructing scientific explanations on their exams. Scientific explanations in SCED 201 couple a diagram of the phenomenon under study with a scientific narrative, which serves to give a detailed description of the components of a system and how they are interacting. Evidence from experience and experimentation must be carefully incorporated into the scientific narrative in order for the student to receive full credit. A high level of clarity in the language used is also essential. Throughout both quarters (Winter 2016 and Spring 2016), students were better able to invoke the relevant "big ideas" and associated experiences from the activities. While I must reiterate that I do not have sufficient data to establish a causal link, I would certainly submit that the students' reflections on the guiding questions throughout the quarter improved their ability to create strong scientific explanations.

I have at least two plans for future work (thus far) concerning improving writing insruction in my classes:

1. Develop a sufficient, and reliable, method for assessing the efficacy of the series of small writing assignments for SCED 201 (which I have described in this reflection)
2. Explicitly address, and assess, the threshold concept alluded to above for the laboratory experiments in my Chem 464: Physical/Inorganic chemistry laboratory class next winter (I taught the course this past winter, but did not yet implement a revised structure for the writing of reports)

I look forward to the continual development of students' writing in both the chemistry and SCED courses I teach here at Western. I also look forward to reconnecting with colleagues from across disciplines, such as those I met at Backwards by Design last summer, to bounce new and different ideas off of.

References:

1. Otero, V. K.; Gray, K. E. Attitudinal gains across multiple universities using the Physics and Everyday Thinking Curriculum *Phys. Rev. ST Phys. Educ. Res.* **2008,** *4,* 020104.
2. Committee on Conceptual Framework for the New Ke-12 Science Education Standards, National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas;* The National Academies Press: Washington, DC, 2012.