CONCEPT INVENTORIES: TEACHING INFORMATION LITERACY LIKE A PHYSICIST

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INTRODUCTION

How does a physicist teach? While there are a variety of answers to this question, since 1992 it is increasingly likely that introductory college physics courses involve interactive engagement (Hake, 1998) aided in part the Force Concept Inventory (FCI). The FCI is a multiple-choice test used to diagnose or assess students’ understanding of and misconceptions about foundational elements of Newtonian physics (Hestenes, Wells & Swackhamer 1992). Like the rest of their work, physics educators take a research-based approach to instructional activities. Not limited to physics, concept inventories are used in many scientific and technical fields including astronomy, biology, and geosciences (Libarkin, 2008).

Given the prevalence of concept inventories in the sciences, one wonders: could the concept inventory approach inform the work of librarians teaching information literacy? In order to investigate this, the LOEX workshop facilitator shared an example from the FCI, compared concept inventory elements to Meyer and Land’s (2003) threshold concept theory, and asked participants to share enduring misconceptions in information literacy. Then, working in groups, the participants accepted the challenge of writing information literacy concept inventory questions based on the ACRL Framework for Information Literacy for Higher Education (2015). A slide presentation used in the workshop is available at the following URL: http://bit.ly/tillap.

FORCE CONCEPT INVENTORY AND ENDURING MISCONCEPTIONS

In order to understand the idea behind concept inventories, it is helpful to examine the composition of one and investigate how it is used. The Force Concept Inventory provides an excellent model as it has been the subject of two decades of scrutiny and revision by the physics education community. In reviewing a sample item from the FCI, it is clear that though multiple-choice, the questions require application of concepts, not simple memorization of formulas or facts. A typical question presents a scenario, then asks a question or set of questions related to the scenario. Of course the correct answer is included amongst the answer choices. The incorrect answers are common sense alternatives derived from students’ real answers to open ended versions of the same questions (Halloun & Hestenes, 1985; Hestenes, Wells, & Swackhamer, 1992). Using the FCI, physics educators can diagnose specific areas where students have misconceptions, thereby identifying a focus for subsequent learning activities.

Harvard physics professor Mazur (2009) recounts his surprise at how poorly his students performed on the FCI while his own assessment of it was that it seemed trivial. The sudden realization that his lectures were not effective led to a transformation of his approach to teaching. Mazur, like others (Hake, 1998), discovered that enduring misconceptions cannot just be explained away. When an explanation of a concept fails, explaining it better or in another way is not the fix. Unlike basic facts (e.g., that Mars is a planet), misconceptions need to be addressed by well-designed learning experiences based on research of effective instructional practices. Mazur, for instance, uses problem sets that compel students to confront their misconceptions in combination with peer instruction where students learn from each other.

A demonstration of the enduring nature of misconceptions can be found in the short video documentary, A Private Universe (Harvard-Smithsonian Center for Astrophysics, 1987). In the introduction Harvard students, faculty and alumni are interviewed immediately after a graduation ceremony. They are asked to explain either the phases of the moon or how the seasons occur. Despite years of education, in 21 out of 23 interviews, the students, faculty and alumni fail to accurately explain these basic concepts. Later in
the video the scene is a 9th grade classroom. The teacher describes one student as being “very bright” and expects that she will know the answers to these same questions. Despite the teacher’s prior assessment, the student’s explanations of the earth’s orbit and phases of the moon are wildly inaccurate. The student is interviewed again later, after the teacher attempted to address the misconceptions in the class. Despite her ability to initially provide a valid explanation for both concepts, the student still held onto a misconception about “bouncing” light. From the narrator, “Her own personal theory is so deeply ingrained that despite our attempts she never abandons it” (17:54).

**ENDURING MISCONCEPTIONS IN INFORMATION LITERACY AND THE ACRL FRAMEWORK**

A necessary first step in the investigation of a concept inventory for information literacy is the creation of a misconceptions inventory. Using an Ink-Pair-Share activity, the workshop facilitator asked the audience to brainstorm enduring misconceptions in information literacy. What ideas are difficult for our students? What misconceptions do students seem to hold onto despite our best instructional efforts? After writing and discussing with a partner, participants shared various information literacy misconceptions, many of which are included in Appendix A: Worksheet Responses.

On a much smaller scale, this activity has a similar aim as the Delphi study by Townsend, Lin, Hanick, and Brunetti (2016), which contributed to the development of the ACRL Framework for Information Literacy for Higher Education. While that study identified threshold concepts, not misconceptions, there is much in common between the concept inventory approach and threshold concepts theory. Meyer and Land (2003) assign five criteria to threshold concepts:

- **Transformative** – provokes a new way of thinking
- **Integrative** – exposes the interrelations amongst a variety of ideas or concepts
- **Irreversible** – when learned, cannot be unlearned
- **Troublesome** – knowledge that is difficult to grasp, confusing
- **Bounded** – defines or establishes a frontier or limit for a concept

The table below uses language from both Hestenes, Wells, and Swackhammer (1992) and Meyer and Land (2003) that respectively describes concept inventories and threshold concept theory. Three of the threshold concept criteria - Troublesome, Bounded, and Transformative - can easily be applied to concept inventories. For the Integrative and Irreversible criteria, the link is not as evident, but worthy of future investigation.

<table>
<thead>
<tr>
<th>Table 1: Concept inventory and threshold concept comparison</th>
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<tbody>
<tr>
<td><strong>Concept Inventory</strong></td>
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<tr>
<td>“...used to identify and classify misconceptions” (Hestenes, Wells and Swackhammer, 1992, p.150)</td>
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<td>“Without this concept the rest of mechanics is useless, if not meaningless.” (p. 150)</td>
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<tr>
<td>“...not a test of intelligence, it is a probe of belief systems” (p. 142)</td>
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**AN INFORMATION LITERACY CONCEPT INVENTORY**

The connection between these two ideas make a compelling case for further exploration. Since the ACRL Framework is derived from a threshold concept Delphi study (Townsend, Lin, Hanick, & Brunetti, 2016), it provides a convenient structure for the creation of information literacy concept inventory questions. For reference, the workshop facilitator provided each table a handout with one of the six frames from the framework including the frame title, definition, knowledge practices, and dispositions. Attendees sat at only four tables, so only four of the frames were used:

- **Authority is Constructed and Contextual**
- **Scholarship as Conversation**
- **Information has Value**
- **Searching as Strategic Exploration**

Table participants were asked to examine their assigned frame to identify areas of enduring misconception within the frame and agree as a table on one misconception. Secondly, the participants were tasked with the challenge of writing an application-based concept inventory question that addressed the misconception and developing a scenario or example if necessary. Results of the activity were reported by table reporter and are summarized in Appendix B.

**CONCLUSION**

While the stated aim of creating information literacy concept inventory questions was achieved on a limited basis, the activity successfully encouraged spirited and engaging
discussions about information literacy misconceptions, the ACRL framework and the potential for an information literacy concept inventory. To conclude the workshop, the facilitator summed up ongoing challenges and considerations with the following questions and observations:

- Is information literacy a ‘coherent conceptual system’ like Newtonian physics?
- Would all librarians score 100% on our own concept inventory? Some questions that we might ask do not have a single correct answer. Much of information literacy is dispositional.
- Does our content change too rapidly? Newtonian physics is not changing much, if at all, but information literacy is evolving, changing and growing.
- Philosophically, is this a subtractive model, rather than an additive one? Does it focus too much on what the student doesn’t know?

The workshop attendees clearly expressed interest in this novel idea of creating an information literacy concept inventory. Despite the many challenges involved, the success of the workshop provided confirmation that it is an idea worthy of further investigation.

REFERENCES


NOTES

1. A sample item from the Force Concept Inventory was shared during the workshop, however it has been removed from the online presentation slides in order to preserve the security and validity of the FCI. For those that are interested, the full FCI is available to registered high school or college faculty users at the PhysPort website. A different public sample is also available at the site. https://www.physport.org/assessments/assessment.cf m?A=FCI

2. Ink-Pair-Share is a variation of the Think-Pair-Share active learning strategy. To accommodate introverted learners the ‘think’ portion of the activity is renamed ‘ink’ to emphasize the solitary nature of that portion of the activity. Only after everyone has had sufficient time to quietly consider the question does the ‘pair’ portion of the activity occur.
APPENDIX A

Worksheet Responses

1. What concepts described in this frame are the subject of enduring misconceptions? Be sure to focus on misconceptions or alternative conceptions vs. “stuff they just don’t know”. Please read the frame handout and circle or highlight areas for consideration. Agree on ONE and write it below.
   - Searching as Strategic Exploration: “There is one perfect search. If a well-constructed search doesn’t work, the information doesn’t exist.”
   - Scholarship as Conversation: “That a published article has a “right answer”
   - Information has Value: “Libraries are free”, “Give credit to the original ideas of others…”, “That students must cite to avoid getting in trouble”
   - Authority is Constructed and Contextual: “All scholarly info is equal and is valid. (3rd bullet from Framework)

2. Write a concept inventory question(s) based on an authentic, real-life example/scenario. Focus on application, not knowledge.
   - Searching as Strategic Exploration:
     a. Your professor gives you a citation,. You search e-discover by author and title and get no results. This means...
     b. You search for “children of immigrants and educational attainment” and get few results. The results for this are...
     c. You’ve been to a party and heard a great new song. Your friend suggest, but it not sure, the song was recorded by the band “Rose and Ash”. Consider the following: 1. “Rose and Ash” may not be the name of the band., 2. The song may not be new. You want to find the song online.
   - Scholarship as Conversation:
     a. Scientist A and B found x (the earth’s warming is naturally caused by the rhythms...) Scientist C and D found y (humans contribute...). Which articles would you use? Why or why not?
• Information Has Value:
  a. Johnny remembers an article he found on JSTOR during his senior year of college and mentions its relevance in a conversation he has with his new boss. His boss wants to see it, but Johnny can no longer find the full text online. Why could he access it before but not now?
  b. A group of students is creating a PowerPoint presentation for a class. They have used multiple sources of information. Why (or why not?) should they cite sources?

• Authority is Constructed and Contextual:
  a. My family member has a child with epilepsy. I heard that medical marijuana might help with her condition. How can I tell if this would help?
APPENDIX B

Table Participants

- Authority is Constructed and Contextual: Dianna Sachs, Western Michigan University; Sue O’Dell, Bowdoin College; Laura Harris, SUNY Owego; Barbara Benisch Sisolak, University of Wisconsin-Madison; Raymond Maxwell, American University; Quetzcilli Barrientos, American University.

- Information Has Value: Brandy Whitlock, Anne Arundel Community College; Stephanie Taylor-Davis, Indiana University of Pennsylvania; Rachel Callison, Carnegie Mellon University; Nancy Dewald, Penn State – Berks; Joel Burkholder, Penn State – York; Victoria Raish, Kimberly Feilmeyer, Hamline University; Ximena Chrisagis, Wright State University; Eleanor Goldberg, Delaware County Community College.

- Scholarship as Conversation: Amy White, Penn State; Erin Burns, Penn State – Shenango; Chelsea DeGlopper, Touro College; Pamela Mann, St. Mary’s College of Maryland; Nancy Bellafonte, Delaware County Community College; Valerie Beech, Marquetter University

- Searching as Strategic Exploration: Kate Ganski, University of Wisconsin-Milwaukee, Katie Harding, Dartmouth College, Veronica Arellano Douglas, St. Mary’s College of Maryland; Anne Deutsch, SUNY New Paltz; Faith Rusk, University of Maryland, Sheila Corral, University of Pittsburgh, Suzie Roth, Embry-Riddle Aeronautical University; Steve Black, College of Saint Rose.