What Can we Learn From Student Writing in Physics?

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**Context: Explorations in Physics**

- activity-based course developed for non-science majors (Jackson, Laws, and Franklin)
- emphasizes study of natural phenomena (rainbows, clouds, snowflakes) to motivate physics concepts
- 2/3 activity guide on 2 topics, 1/3 student-directed projects
- at RIT, class filled with information technology, imaging arts, economics, and computer science
Why Writing: Writing in the Disciplines

• Hermsen: 2003 Provost’s Learning Innovations Grant to incorporate formal writing into disciplinary classes

• *Writing in the Disciplines* (WID) and *Writing Across the Curriculum* (WAC) claim that:
  * students can master discipline-specific conventions best through assignments in disciplinary courses
  * understanding these conventions leads to an improved understanding of content.

• If we relate these conventions with epistemologies (what constitutes acceptable proof, logic, etc.) then these claims may be supported by current PER (Hammer, Elby, et al.)
Writing in \textit{EiP}

- Students wrote weekly journals
  - describe weekly activities and connect them with bigger picture
  - revise previous entries and integrate revision with new entry into one coherent essay
  - 3 revisions per topic

- provided examples of good/bad writing, grading schema

- asked to write at tone of Scientific American article, interested non-scientist reader
Previous Attempts at Using Writing in Physics Courses

- Leonard & Mullin incorporated writing into introductory and upper level physics courses, cited as model WAC courses. Assessment was anecdotal.

- Joyner & Larkin linked intro physics course with writing course (for motivation). Looked for impact on FCI.

- Etkina et al. studied student epistemologies with written responses to very specific questions. Coded sentence types based on level of sophistication of ideas.

- Our attempts at rubrics, correlating writing with standard concept & epistemology (EBAPS) tests inconclusive. *We can’t know what students are thinking without asking them.*
Rhetorical Discourse Analysis

- papers put into .pdf form, annotations “untainted”
- focused on grammar, style, detail, coherence
- often drawn to same area for different reasons

- **Rhetorical Discourse Analysis**: analyzing how they write (analogous to word choice and gestures)
Student writing changes appreciably from paragraph to paragraph. Consider the following fragments from successive paragraphs (floating & unbalanced forces):

However the water can push or force the object up therefore keeping it afloat. Both objects that sink or float have similar forces from both gravity and the water in order to keep them in one position either at the bottom or top of the water. This was shown by the objects that sink staying at the bottom or staying at the top of the water and floating once they had been placed into the water.

However, then the forces are unbalanced and one force is acting greater than the other the object will begin to move. For example if I push right on a cart then it will begin to move towards the right, or if I pull it from the left it will begin to move to the left, as long as the force that I am pushing or pulling with is greater then the forces acting on it in the opposite direction.
Local Variations in Student Writing

• Student writing changes appreciably from paragraph to paragraph (comfort with the material). Consider the following fragments from successive paragraphs:

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Contrasting use of “However”

Transition sophistication

Generalization beyond specific activities

Illogical sentence structure
Paragraph Level Variations

- In the next paragraph, the student returns to simplistic writing
- Note lack of transitions, chronological reporting of activities, complete lack of any generalizations

Also in order to measure pressure and buoyant forces we used a force sensor. The force sensor was able to help us determine the amount of buoyant force on and object by initially determining the force in Newtons when the object is suspended from the force sensor in the air, and the force measured in Newton’s when the object is being lowered into the water. The difference between these two forces was the amount (in Newtons) of buoyant force that was exerted on the object. Using the force sensor also showed how the forces on the object changed as it was lowered into the water and only part of it was submerged.

- Similar features seen in other essays more casually inspected
Session Level Variation

- Sometimes a student suddenly “gets it,” and later essays show significant improvement
  - Student did not revise; early entries unchanged in later drafts
  - Dramatic shift in writing between early and later entry

Under a continuous model, the layer of a soap might be able to spread out indefinitely, but that does not fit the observation that, at some point, the soap will stop spreading over the surface of the water. (Poor use of commas.)

If the soap is made of atoms, then the soap could spread until the height of the layer of the soap is equal to the height of a soap atom, which would mean at a certain point, the soap could not spread anymore.

The sugar crystals were generally smooth with a few bumps and were relatively clear, which was much different from the salt crystals, which generally looked very rough, cloudy, and had an uneven...

- Many ideas jammed into single sentence; He’s lost control of his sentences
Session Level Variation

- He’s regained control of his sentences, connecting experiments, making generalizations.

Fracturing other solids in different ways ends up having similar results to the tearing of paper, such as when a silicon wafer is broken. Breaking the silicon, with the edge of the table perpendicular to the flat edge of the wafer, ended up making very uniform cracks with straight edges, and it appears to be easiest to break it this way. . . . The fact that the solids that were examined so far broke in very specific ways under certain conditions suggests that there might be an underlying structure contained within them that determines how these breaks form.

- Indication that EiP’s cyclical learning structure is succeeding?
Rhetorical Indicators of Simplistic Vision

● Even the best students struggled to write a coherent paper that integrated activities with larger themes.

● Seen in certain rhetorical ways:
  * Introductions often “course-centered” (In class we...). Some tried to appeal to an external reader, but very clumsily.
  * Very few (2/25) had conclusions. Not seeing this document as something to be summarized.
  * Sentence transitions mostly chronological or non-existent

● Project reports significantly different
  * All had conclusions, more introductions were concept-centered
  * Transitions were more synthesizing
Conclusions and Implications for Pedagogy

- student writing — sophistication, style, grammar — changes appreciably from paragraph to paragraph, essay to essay
  - hypothesize this correlates with content mastery MUST TEST!
  - perhaps students more receptive to suggestions on better written paragraphs where comfort with content is greater

- Most students do not know how to revise
  - writing improvement in successive essays may indicate that series of writing assignments are necessary
  - consistent with research and common practice in rhetoric and writing communities

- Students can write coherently and holistically when they own the topic. With projects they can’t assume the reader (me) knows the relevant questions or procedure; they must explain.
Future Work

- Extend rhetorical discourse analysis to more student papers
- Novel form of student interview to investigate *non-invasively* what students think while they write
  - students compose on laptop on which key-capturing software has been installed
  - interview includes “playing back” the writing process