New ways of thinking about university physics teaching: A discussion of discursive representations using South African examples

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Outline of presentation

• Grounding of interest
• What is meant by representations
• Question of relevance
• Ways that lectures think about representations in their teaching practice, and ways that lectures think about dealing with their students’ representational competence
~280 staff:
40 prof’s +33 lecturers +67 researchers +15 postdocs + 83 graduate students + 44 support staff: technical + administration

~318 MSEK budget:
58 MSEK for teaching
133 MSEK faculty funding for research
128 MSEK external funding for research

Physics & Astronomy at Uppsala Ångström Laboratory
Physics Department, UWC

Small staff number and small budget but a long sustaining history of enormous teaching effort
Review of Physics Education in South Africa (CHE-SAIP Report, 2014)

In light of the concerns expressed by the Heads of Physics Departments regarding student competence, to consider the extent to which teaching and learning delivers graduates with the knowledge and skills which would maximize their potential to pursue postgraduate studies and other employment careers.
Education experience is a complex system
Representations are taken to be the collection of semiotic resources that make up the “text” of all communication.
Physics ways of knowing and doing get shared through Physics Discourse, which is made up of Representations (semiotic resources). These include Working practices, Spoken language, Written language, Diagrams, Gestures, Pictures, Apparatus, Mathematics, and Etc...

After Airey & Linder 2009
Examples

\[ F_g = G \frac{m_1 m_2}{r^2} \]
Examples

Haroche's arrangement for manipulation of photons and atoms in Rydberg state
Examples

\[ F_g = G \frac{m_1 m_2}{r^2} \]

Decoherence process measured for two different strongly intertwined states.
"Oh, if only it were so simple."
NOTHING SUCKS LIKE AN ELECTROLUX

The most powerful vacs you can buy are in the new 2000 series.
Different representations have different disciplinary affordances, that is different possibilities to share critical aspects of physics knowing and doing
Physics Concept

After Airey & Linder 2009
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Now the inverse sine was the sigma, but left-to-right reflected so that it started with the horizontal line with the value underneath, and then the sigma. That was the inverse sine, NOT $\sin^{-1} f$—that was crazy! They had that in books! To me, $\sin^{-1}$ meant $1/\text{sine}$, the reciprocal. So my symbols were better.

I didn’t like $f(x)$—that looked to me like $f$ times $x$. I also didn’t like $dy/dx$—you have a tendency to cancel the d’s—so I made a different sign, something like an & sign. For logarithms it was a big L extended to the right, with the thing you take the log of inside, and so on.

I thought my symbols were just as good, if not better, than the regular symbols—it doesn’t make any difference what symbols you use—but I discovered later that it does make a difference. Once when I was explaining something to another kid in high school, without thinking I started to make these symbols, and he said, “What the hell are those?” I realized then that if I’m going to talk to anybody else, I’ll have to use the standard symbols, so I eventually gave up my own symbols.

(From Surely you’re joking Mr Feynman)
(a) Words
A parachutist whose parachute did not open landed in a snow bank and stopped after sinking 1.0 m into the snow. Just before hitting the snow, the person was falling at a speed of 54 m/s. Determine the average force of the snow on the 80-kg person while sinking into the snow.

(b) Pictorial Representation

(c) Physical Representation

(d) Math Representation

\[ 2a(y - y_0) = v^2 - v_0^2 \]
\[ \sum F_y = N - w = m \ddot{a} \]
SA example #1

How relevant and prevalent today?

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Algebraic signs are not applied in vector-kinematics</td>
</tr>
<tr>
<td>B</td>
<td>Algebraic signs are applied as magnitude only</td>
</tr>
<tr>
<td>C</td>
<td>Algebraic signs are applied as changing magnitude</td>
</tr>
<tr>
<td>D</td>
<td>Algebraic signs are applied as both magnitude and direction</td>
</tr>
<tr>
<td>E</td>
<td>Algebraic signs are applied as directions</td>
</tr>
</tbody>
</table>

Govender (1999)
Method and Setting

- Govender’s categories
- Pilot studies
- Questionnaire
- Categorization
- Interviews

65 Swedish students
30 South African students

Moa Eriksson
Summary of Results

• No differences found between the Swedish and South African students.
• Four of the original five categories were identified.
• Students were inconsistent when using signs
• Students had limited appreciation of the significance of using signs

Algebraic signs are not applied in vector-kinematics
Algebraic signs are applied as magnitude only
Algebraic signs are applied as changing magnitude
Algebraic signs are applied as both magnitude and direction
Algebraic signs are applied as directions
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SA example #2

Part 1: How teachers think about the representations that they use in their teaching?

Part 2: How teachers respond to a lack of representational competence in their students?

Anne Linder  Susanne Wickman  Nokhanyo Mayaba  John Airey  Paul Webb
How teachers think about the representations that they use in their teaching?

Semi-structured interviews (30-45 mins)

15 lecturers from four SA physics departments.

Categories constructed in terms of what guided their thinking
Teachers’ reflective narratives on the role that disciplinary representations play in the crafting of teaching practice

- John Dewey on the nature of experience
- Donald Schön’s work on reflective practice
- Michael Connelly and Jean Clandinin's work on personal practical knowledge
- Generative metaphors
- Images

Narrative case study

Guiding principles
Results

How teachers think about the representations that they use in their teaching?

[i] Guided by a taken-for-granted tool-box of disciplinary style
[ii] Guided by insight into personal learning experience
This category builds on insight into students’ reactions, knowing where students are coming from, and their learning difficulties. The storylines contain a strong practical reasoning component with a growing theoretical base.

[iii] Guided by perceived student learning-needs
This category builds on choice of actions that are tested against both outcomes and conceptualizations of educational value. The storylines contain a much stronger blending of practical and theoretical reasoning.

[iv] Guided by efforts to contextually extend the possibility of learning for students
Part 2: The study setting

How teachers respond to a lack of representational competence in their students?

Semi-structured interviews (approx 1 hr)

20 lecturers from five very different* SA physics departments.

*The student intake for these 5 departments represent a cross-section of different linguistic and socio-cultural backgrounds
All the physics lecturers recognized a lack of representational competence in their students.

Six-level system of response strategies:

1. Not relevant
2. Relevant, but not my job
3. Encourage translation to alternative representations
4. Offer passive support
5. Actively engage with the challenge
Discussion

Not relevant
Relevant but not my job
Avoid problematic representations

Encourage translation to alternative representations
Offer passive support
Actively engage
Attempts to develop language competence was only done for English

Lecturers did not appear to think that students would have problems “translating” their (English language) physics knowledge into settings where other languages may be called for (society and workplace).
Representational-Competency Questions

• Which representations do students need?
• Which type of representational competence is needed (interpret or use)?
• Competence for where? Society, Workplace or just Physics?
• Whose job is it to teach students this?
• What about languages other than English?
Conclusion

To address the concerns in the CHE-SAIP report lectures need to better understand what is critical about the representations they use in their teaching ....

and to craft that understanding into their teaching practice in a positive and productive way.
Thank you!

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