A conceptual physics class where students found meaning in calculations

Michael M. Hull, Andrew Elby

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Open Source Tutorials*

Guided worksheets that students complete in groups
- Draws upon student experiences to learn physics concepts
- **Minimal calculations; mathematical reasoning not stressed**

Translated into Japanese in 2011

Tokyo Gakugei University**
10 minute lecture ; 80 minutes on Tutorial

Interviews of 28 students

How does OSTs compare with prior physics classes?
Did you think "is this new class even **physics**?!"
- 11 of 14 evidenced a shift in physics epistemology

CASE STUDY: TADAO

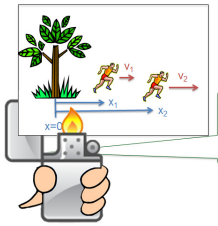
He thought physics could only be learned by rote…

Last year's physics class

Tadao

It was one-way teaching from the teacher. The teacher would write on the blackboard and we would memorize it - that was the nature of that class.

He used to solve problems by substituting into equations…



That's why he hated physics

There were a lot of calculations for distance, for example… calculations that use pictures… **I hated that kind of thing …**

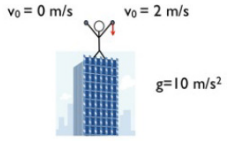
Through Tutorial

… and discovered it can be learned with one's own ideas too

Open Source Tutorials

It's the kind of class where you think in a group and the things that you yourself are thinking, just as they are you can write them down and organize them.

…and now he solves by using his own ideas



What's the difference in speed after 5 seconds?

Given $v = v_0 + at$

Since the accelerating is the same from the time of the initial speed, they go and become faster by exactly the same speed… so the difference is still the same.

Surprise! Sophisticated view of calculations

[When asked to evaluate the plug and chug solution] Right away you can put out an answer, and it's easier for it to really click I think: "No matter what numbers you put in, the difference becomes 2". Between people who understand, this way of thinking is easier to transfer to the other person. If it's a kid who doesn't know physics, he would absolutely not understand this – zero percent. But if it is between people who know physics, both would understand it 100%. With my answer, even a kid would understand it 50-60%.

Tadao sees the advantage of the more calculation-based solution for faciliting communication with experts *about the problem's conceptual conclusion,* but thinks his more conceptual solution is better for communicating this with novices.

"Plug and Chug Solution"

(Written by interviewer)

$V = V_0 + at$

① $V = 2 + 10 \times 5$

$50 = 52$

② $V = 0 + 10 \times 5 = 50$

m/s

Students besides Tadao integrated calculations with conceptual reasoning

Rina

So, once, just solve the problem. But it's not "get out that answer, write it and be done." Rather, look to see if it's different than what you were thinking initially and if so, think why - that will make it easier to understand.

Miu

First, to some degree you have an image, and, and then you write [the equation and substitutions]. But, if you just substitute… "since there is this equation, substitute and go, the answer comes out, the difference comes out, so, wow, it's two meters/second faster" … it is not very good

Conclusion

Surprisingly, Japanese students who took a conceptual physics class developed a more sophisticated epistemology towards mathematics in the context of physics.

How this happened remains an open question that would be interesting to pursue

References
*A. Elby, R. E. Scherr, T. L. McCaskey, R. Hodges, E. F. Redish, D. M. Hammer, and T. Bing, Open Source Tutorials in Physics Sense-making: Suite I (2007).
** H. Uematsu, Physics Education in University 17, 129–132 (2011). (Details of the implementation of Open Source Tutorials at Tokyo Gakugei University, written in Japanese)

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