Designing self-diagnostic tools for students in large intro classes

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Why student self-diagnosis?

Students’ common attitudes in large intro science classes:
• Expectation of ‘receiving’ knowledge -- not constructing it
• Search for ‘recipes’ detached from conceptual understanding
• Reluctance to admit weaknesses to others (socially)

I cannot learn unless teacher explains things well in class.

- Agree: 76%
- Neutral: 11%
- Disagree: 13%

When solving problems, I look for formulas to plug in values into.

- Agree: 82%
- Neutral: 15%
- Disagree: 3%
Why student *self*-diagnosis?

**Instructor’s** common problems in large intro science classes:
- Lack of opportunities for giving personalized *feedback*
- Difficulty of ‘tuning in’ on a *heterogeneous* audience
- Manifestations of expert *blindspot*

**ZPD**: Difference between what a learner can do without help and what he/she can do with help.

**Effective instruction only occurs in the ZPD of learners** (*Vygotsky*)

Oops: Learners are not all the same, and there is a natural **distribution of all cognitive variables** (*Redish*)

In large intro classes, there is a **broad distribution of ZPDs**!
Learning objectives and skills

**Learning objectives** *(content-specific)*

“You should be able to...” (apply/compare/rank/analyze...)

**“Competencies”** *(cross-content skills)*

Mathematical proficiency* (algebra, graphing, calculus, etc)
Translation between representations (verbal, graphical, math, etc)
Strategic planning
Dimensional analysis
Making estimates
Use of jargon
...

*Note: Mathematical proficiency may include specific areas like algebra, graphing, and calculus.
Example: basic test of scientific reasoning

Average: 17/24 (≈71%)

proportional reasoning; control variables; probability; cause/effect
Modes of developing skills

**Group** practice of *single* skill

**Group** practice of *multiple* skills

**Individual** practice of *single* skill

**Individual** practice of *multiple* skills

Homework
Modes of developing skills

**Group** practice of *single* skill

**Group** practice of *multiple* skills

**Individual** practice of *single* skill

**Individual** practice of *multiple* skills

Homework after peer instruction
Modes of developing skills

Group practice of *single* skill

Group practice of *multiple* skills

Individual practice of *single* skill

Individual practice of *multiple* skills

Homework after *self-diagnosis* and *peer instruction*
Beta version

Competency 1

**Self-diagnostic** (prelecture)

Correct/incorrect feedback

**Pair discussion** (lecture)

Instructor feedback

**Group problem solving** (recitation)

Instructor feedback

... Competency n

**Self-diagnostic** (prelecture)

Correct/incorrect feedback

**Pair discussion** (lecture)

Instructor feedback

Instructor feedback
Sample self-diagnostic (prelecture)

An ant is at $2u\hat{x} + 6u\hat{y}$ and a beetle is at $-4u\hat{x} - 4u\hat{y}$. Locate the ant (A) and the beetle (B) in the graph and without using a calculator, find their mutual distance as accurately as possible.

Note: units of both axes are $u$.

[Answer given at end of lecture preview]
Version 1.0?

Competency 1

Self-diagnostic (prelecture)

“Personalized” feedback

Pair discussion (lecture)

Instructor feedback

Group problem solving (recitation)

Instructor feedback

... Competency n

Self-diagnostic (prelecture)

“Personalized” feedback

Pair discussion (lecture)

Instructor feedback
Sample self-diagnostic

You drag a box across a wooden floor at constant speed, by pulling it at a positive angle $\theta$ with the floor. Which is the qualitatively correct free body diagram for the box?

(A) HorP
(B) NF=W
(C) noNF
(D) correct

(E) None of the above diagrams is correct.

(A): HorP  
(B): NF=W  
(C): noNF  
(D): correct

Participation: 80%
Sample self-diagnostic

You drag a box across a wooden floor at constant speed, by pulling it at a positive angle $\theta$ with the floor. Which is the qualitatively correct free body diagram for the box?

(A): HorP  
(B): NF=W  
(C): noNF  
(D): correct  
(E) None of the above diagrams is correct.
During an apartment move, Tom drags a \( m \)-kg chest at constant speed across a carpeted floor. To move the chest, he pulls with \( P \) N a rope that forms an angle \( \theta = 30.0^\circ \) with the floor. What is the coefficient of kinetic friction between the chest and the carpet?

A) \{option\} (HorP)
B) \{option\} (NF=W)
C) \{option\}
D) \{option\}
E) \{option\} (Correct)

Sample assessment (midterm exam)

Time lag: 1 week
Participation: 100%
During an apartment move, Tom drags a \( m \)-kg chest at constant speed across a carpeted floor. To move the chest, he pulls with \( P \) N a rope that forms an angle \( \theta = 30.0^\circ \) with the floor. What is the coefficient of kinetic friction between the chest and the carpet?
P(NW_a|NW_d) = 0.564
P(NW_a|noN_d) = 0.400
P(Cor_a|Cor_d) = 0.137
P(HP_a|HP_d) = 0.053