

Overview and comparison of basic teaching techniques that promote conceptual change in students

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Why is conceptual change important?

- students hold many alternative conceptions regarding physics phenomena
- it is important to help students make transition from their existing viewpoints toward the science view

Cognitive conflict (Posner et al., 1982)

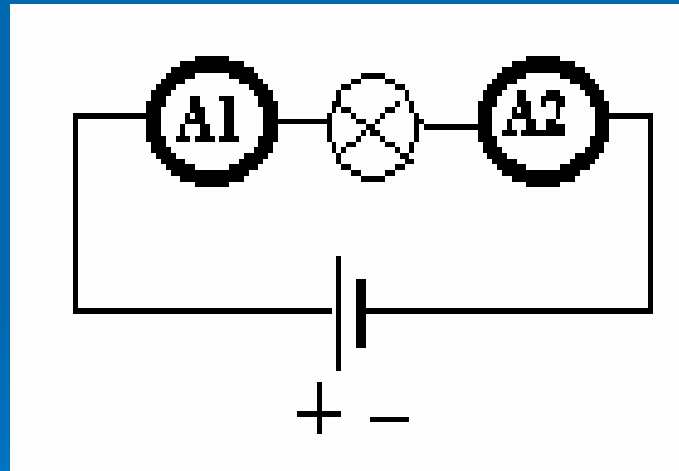
- student's existing ideas about some phenomenon are made explicit and then directly challenged
- the discrepancy between student's prediction and the outcome of the experiment creates cognitive conflict
- to resolve the conflict, student replaces the alternative conception with the scientific one

Problems:

- success depends strongly on the will and ability of each individual student to recognize and resolve the conflict
- students are unwilling to give up their ideas
- frustration is created in some students

Example

Is electric current used up in the circuit?



Concept substitution (Grayson, 2004)

- the essence of some student ideas is correct, but the idea is applied to the wrong concept
- if the concept is substituted with another concept, the idea becomes correct

Example

- something is used up in the electric circuit, but that is not the current
- substitution of current with energy
- the essence of the idea is preserved
- students can easily accept the conservation of current

Anchoring conceptions and bridging analogies (Clement, Brown & Zeitsman, 1989)

- anchoring conceptions are students' ideas that are roughly correct from physics point of view
- they can serve as analogies with counterintuitive target conceptions
- additional bridging analogies can be introduced if necessary

Example

A book is at rest on the table. Does the table exert a force on the book?



- Target: The table exerts a normal force on the book directed upward.
- Anchor: If the book is supported by hand, the hand exerts a force on the book in the upward direction.
- Bridge: If a book is placed on an elastic spring, the spring is deformed and exerts a force on the book in the upward direction.

Socratic dialogue (Hake, 1992)

- Socratic dialogue involves questioning students in such a way that they are led to express their ideas and figure things out for themselves
- instead of providing the correct answer, the teacher leads the student slowly to his/her own conclusion

Example

Teacher: The Earth attracts a falling apple with gravitational force. Is there a force of the apple on the Earth?

Student: Yes, but it is much smaller than the force of the Earth on the apple.

T: Why do you think that it is smaller?

S: Because the apple falls and the Earth is at rest.

T: Could Newton's third law be applied to this case?

S: Well, according to Newton's third law the forces would have to be equal ... but I don't see how that could be true...

T: What would happen if the forces were equal?

S: I guess the apple and the Earth would have equal velocities.

T: What about the masses, do they influence the velocities?

S: The masses are very different..

T: If equal forces act on objects of different masses, will the effects of the forces on the objects be equal?

(Here the student uses Newton's second law to determine the accelerations that the objects will acquire.)

S: No, the effect will be larger on the object with smaller mass.

T: So, if forces on the apple and on the Earth were equal, what would happen?

S: The acceleration of the apple would be larger... Oh, I see, that means the forces can actually be of equal magnitude...

T: Yes, it is important to distinguish between forces and the effects that they produce. Equal forces can produce different effects.

Conclusion

- Cognitive conflict presents a significant intellectual challenge for students. It can be motivating, but sometimes also frustrating.
- Concept substitution and analogies are easier for students to accept, but not applicable to all alternative conceptions.
- Socratic dialogue is efficient in improving students' reasoning, but time consuming.

Solution

- Using a combination of strategies
- Being attentive to intellectual demands that each strategy puts on students
- Being attentive to students' reactions to different strategies

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