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Getting Hooked on Physics!

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A number of papers in this journal have dealt with the idea of using hooks in physics instruction.[1,2] A hook, as the name suggests, engages[1,3] students in learning by triggering their attention[4] and interest.[2] Hooks can be any type of pedagogical approach—a question, a demonstration, a puzzle or video. They are generally short and center on the most interesting aspects of a topic.[4] Here we focus on using Conceptual Change (CC) teacher-led demonstrations as the pedagogical hook approach. Conceptual Change is an instructional method mentioned by a number of authors to stimulate interest among learners.[5,6] This is where an educator presents an issue or topic that has associated misconceptions. As the teacher explains the truth behind the concept, cognitive conflict occurs and the students' initial perceptions are challenged and ideas start to change.[5] However, the instruction used in association with the demonstrations must provide intelligible, plausible, relevant explanations so that students are convinced by the new ideas.[7] The gap between prior knowledge and new knowledge has the potential to provide a strong stimulus for augmenting interest, engagement, and attention among students.[8] Thus, CC can act as a hook in itself.

Hook examples

Teaching to elicit cognitive conflict requires a discrepant event through instruction. That is, teachers must incorporate an anomaly into their teaching.[7] There are four phases to cognitive change and they are as follows:

- **A)** The student recognizes an anomaly in her instruction.
- **B)** She expresses some form of interest in the anomaly.
- **C)** The student becomes anxious and wants to resolve her cognitive conflict.
- **D)** She engages with a cognitive reappraisal of the situation by thinking about the problem for a longer period of time or actively seek out an explanation.[7]

Below, the authors outline three hooks that employ a CC methodology. It should be noted that some of the hooks demonstrate a discrepant event that attempts to create (or reveal) student misconceptions. The following illustrations are simple, short, and easily replicated in class. The suggested teaching methods have been recommended so that students can achieve a reappraisal of their initial misconception and assimilate the correct cognitive model.

• Hook 1: Gravity hand trick

Subject: *Gravity and forces*
Materials: *Coin*

Background: As we move our body, we place a milieu of forces on our blood circulation. One force our body withstands on a daily basis is gravity. If you hold one of your hands above your head for one minute and then return it beside your other hand (Fig. 1), the hand that was in the air appears lighter and less defined than the one held by your waist. Based on a person's physiology, this will work better for some people than others. For instance, students with darker skin tones can expect to see more definition of the veins in the hand held by their waist and not as obvious a color change. The blood does not flow as easily to the hand in the air due to the force of gravity. A practical application is elevating a swollen limb. The force of gravity helps drain and disperse fluid from the swelling around the rest of the body.

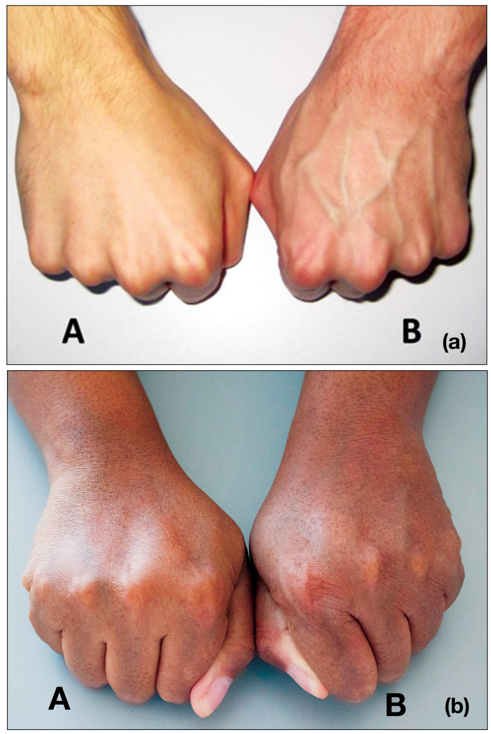

Fig. 1. Shows the difference between a hand held in the air for one minute (A) and one held at the waist (B). In (b) the effect is less pronounced in students with darker complexions, but still sometimes apparent, especially in the definition of the veins

Teaching method: This hook takes the form of a trick. Give the coin to a student. The student places it in one of his hands. The student stands out of sight from the teacher, but in sight of the class. He places the hand with the coin in the air, with the other hand by his waist. He must do this for one minute. Then, without the teacher seeing, the student holding the coin returns his hands together as per Fig. 1. By visually assessing the hands, the teacher will be able to find the coin. In terms of pedagogy, the teacher should tell the student who takes part in the experiment that if the wrong hand is selected, he can keep the coin. Otherwise, the student who can explain through scientific reasoning how the teacher performed the trick should be awarded the coin. A teacher can also develop student interest through questioning and assessing various rival explanations. Students with different explanations can be placed into groups to debate their points of view.

Explanation: This demonstration will work as a hook since it is presented as a trick and students have the chance to use their knowledge for (small) monetary gain. Cognitive Change should be initiated as the student is expectant of an anomaly. After the hook, students will want to resolve the cognitive conflict and engage in cognitive reappraisal. This is when the teacher has generated interest and can use whatever pedagogy she deems fit with the class. After this, the teacher should explain the actual science behind the coin trick. At the end the students should have attained the correct cognitive model behind the demonstration. Once explained, this hook has the potential to make a topic like the force of gravity relatable to most students.

• Hook 2: Metal plate with circular hole

Subject: *Thermodynamics/material science*
Materials: *Picture of question*

Background: Consider a metal rectangle with a hole in it (Fig. 2). When the plate is uniformly heated, the diameter of the hole will

A) increase.
B) decrease.
C) stay the same size.

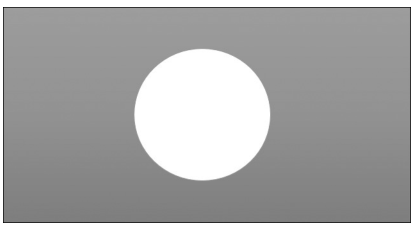

Fig. 2. Illustration of a metal plate with a hole in the center.

This is an example of a question that can promote CC based upon thermodynamics. The answer is A. When heat is applied, the entire object expands and thus the hole gets bigger. Generally students are given the example of an iron ball increasing in size from heating. That is, solids expand when heated. However, in the above question, students are asked about the hole. The hole represents an empty space that is unaffected by heating, making the problem more abstract, and students will think twice about their previous assumptions. The cognitive conflict escalates student interest.[9] The result can be proven to students by conducting the experiment in class with spanners and washers.

Teaching Method: Students are posed the question at the start of class. It should be noted that for this hook to be effective, students should have prior or experiential knowledge of thermodynamics.

Explanation: To recognize the anomaly and initiate CC, students must be familiar with the rule of thermodynamics that solids expand when heated. Students look at the picture of the metal plate and often think of it as akin to a sponge and water, which would expand in all directions, hence making the hole smaller. This provides the anomaly and a source for cognitive conflict. This is an example taken from Watkins and Mazur,[9] in which peer instruction is advised as a complementary teaching method. Peer instruction would allow for cognitive reappraisal by the students and the completion of CC. However, the teacher must again make sure that students have attained the correct mental model before moving on with the lesson.

• Hook 3: Are two straws better than one?

Subject: *Air pressure*
Materials: *Cup/beaker, two straws, water, tape*

Background: A common expression used by people to describe or explain the movement of a fluid in a straw by air pressure is that it is being "sucked up." This implies that the person is applying all of the pulling force to drink from a straw. However, the movement of water is caused by a pressure differential. Air moves from areas of higher pressure to areas of lower pressure. When you suck on a straw in a glass of water, the air pressure in your mouth decreases. At this point, there is no air pressure in the straw; however, there is still air pressure acting on the rest of the liquid in the glass. This pressure then causes the liquid to push up into the straw. Due to the notion that a person applies all of the force to operate a straw, this allows for the creation of a discrepant event in relation to the two straws as set up in Fig. 3. Students are asked whether or not they could suck up any of the liquid while using both straws simultaneously. In general, the students think they can; however, when the student inhales, air will move through the straw placed outside the container and into the mouth. This means that there is no pressure differential between the mouth and the outside environment, and the student will fail at sucking up any of the liquid. This is a good example of a discrepant event that can be the focus of a unit on pressure and the behavior of fluids.[9] It works as a CC hook because people do not sense atmospheric pressure around them. This demonstration displays that atmospheric pressure is relevant and a relatively strong force.

Fig. 3. Beaker with two straws taped together.

Teaching method: Before conducting this demonstration, ask students their opinion on whether the new straw will work. This is a 50/50 question, meaning that a lot of students will guess the correct answer but perhaps without the correct scientific reasoning. This is also good for differentiated learning as all students can make a prediction on what will happen with little to no prior knowledge. Predictions made pre- and post-demonstrations can be teased out by teachers. Students who make pre-demonstration predictions garner a greater understanding of the content than students who do not and also show higher levels of engagement. After this, place students with opposing opinions in pairs or groups and ask them to convince the others of their argument for one minute. Assess if any of the students have changed their opinions based upon the think-pair-share time. At this point, place one straw inside the glass with the water and one outside. Instruct one volunteer to use slow and steady draws of breath to test the straw.

Explanation: This works as a hook as every student can make a prediction as to what will happen. To achieve CC, the above method must be followed in a way that students are asked to think and develop the science behind their ideas before observing the demonstration. Placing students in pairs allows for cognitive reappraisal. Upon conducting the demonstration, they will be proven correct or incorrect. At this point, to complete CC effectively, the teacher must explain the correct science behind the demonstration and ensure a complete level of understanding among the class.

Conclusion

As noted previously, a hook can take any form. This article advocates the utilization of CC as the hook method. Presenting students with an anomalous situation as per the examples in this article has the potential to provide the grounding for the development of increased attention, interest, and engagement in physics. The hook examples are combined with student-centered interactive instructional methodologies. It is positioned that using the correct pedagogy in association with the hook will augment its impact in the classroom. The hope is that this article will help educators at all levels to create and share simple, short, and replicable hooks to provide a school-based solution to improving physics instruction.

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