Workshop: Using Inquiry-Based Learning Activities in Engineering Courses to Promote Conceptual Understanding

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Have you wondered how to make your students curious about your content, how to get them discussing the important concepts in your class? We have found that presenting them with a physical situation and having them predict the outcome – especially when they predict that outcome incorrectly – can create a engaging learning environment. Our work centers on Inquiry-Based Learning Activities (IBLA), which follow the general cycle shown in Figure 1.

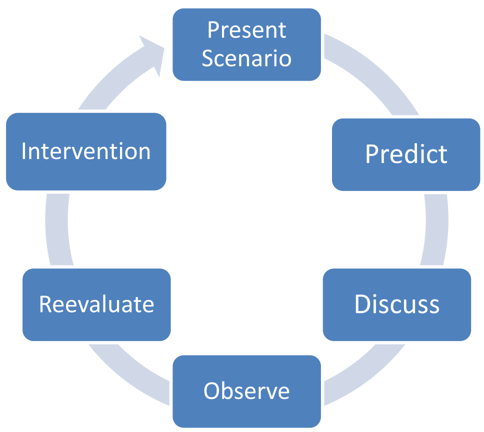

Figure 1. Learning cycle for IBLAs.

We first present students with a physical scenario. For example, a solid cylinder and a pipe, each with the same outer radius and mass, are placed at the top of a ramp. Which will reach the bottom first (or will they reach it at the same time)? Students must first submit an individual prediction, which forces them to confront their own conceptual understanding. After this prediction, students discuss the scenario with their teammates (promoting collaborative learning). Following this, the students conduct the experiment, allowing the physical world to be the authority instead of the instructor. After team discussion of the results, the instructor may intervene and provide some guidance or explanation, or may simply present an additional scenario to help students investigate the relevant concepts. An IBLA team worksheet is used to help guide student discussion and to record their explanations. At the end of the multi-cycle IBLA, we typically have a follow-on discussion and/or homework problems to reinforce the relevant engineering principles.

Although the exact definition of inquiry-based instruction varies somewhat between different investigators, we will use the defining features offered by Laws et al.[1] and highlighted by Prince and Vigeant[2] (see Table 1).

Table 1. Elements of Inquiry-Based Learning Activities.

(a) Use peer instruction and collaborative work
(b) Use activity-based guided-inquiry curricular materials
(c) Use a learning cycle beginning with predictions
(d) Emphasize conceptual understanding
(e) Let the physical world be the authority
(f) Evaluate student understanding
(g) Make appropriate use of technology
(h) Begin with the specific and move to the general

Our team has developed and tested five different IBLAs for use in introductory dynamics[3]. The IBLA name and targeted concepts are provided in Table 2.

Table 2. Targeted concepts for IBLAs.

	Targeted Concepts
Pulley IBLA	System mass, net force, and acceleration (particles)
Pendulum IBLA	Linear momentum, work-energy, impact (particles)
Spool IBLA	Force, moments, linear and angular acceleration, rolling friction (rigid bodies)
Rolling Cylinders IBLA	Mass distribution, angular acceleration, translational and rotational kinetic energy, potential energy (rigid body)
Gyroscope IBLA	Angular momentum, applied moment, change in angular momentum direction, gyroscopic motion (rigid body)

As shown in Figure 2, the Pulley IBLA consists of two Atwood machines placed side by side. The masses on each side of the pulley are varied for each case (see Figure 3), and students are asked to predict what will happen when the system is released from rest. Although a very simple application of Newton's second law, students still struggle with overall system mass, identifying and applying net force, and transferring their knowledge to a final case involving an applied load, Case (d). Our group has conducted several think-aloud protocols to further help us improve the IBLA and to investigate student conceptual

Figure 2. The Pulley IBLA.

understanding[4].

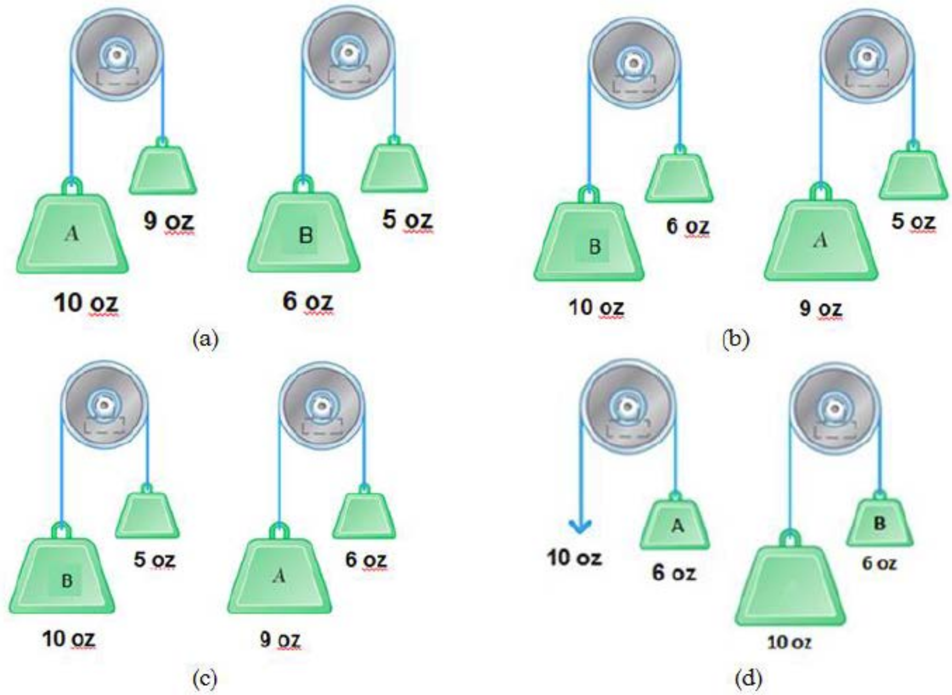

Figure 3. Four cases of the Pulley IBLA.

During the workshop, participants will conduct an IBLA, acting as if they were the student. After discussing the basic principles of developing and implementing IBLAs, attendees will be given the opportunity to work on developing an IBLA for their own class. At the end of the workshop, participants will present their new IBLAs to the group for feedback.

Inquiry-Based Learning Activities have been very successful in the physics educational community[5], and we think they provide great promise for many engineering topics as well. By first developing conceptual understanding, students can build a framework for attacking more complex problems later in their coursework. The hands-on activities provide a memorable learning experience for students, promote a collaborative learning environment, and should be incorporated into a wide variety of engineering classrooms.

Acknowledgments
This work was funded in part by the National Science Foundation, NSF #1044282, "Using Inquiry-Based Activities to Repair Student Misconceptions in Engineering Dynamics."

References

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