

An Interactive Video-Enhanced Tutorial (IVET) is a web-based activity that leads students through a solution using expert-like problem-solving approaches.

Theoretical background

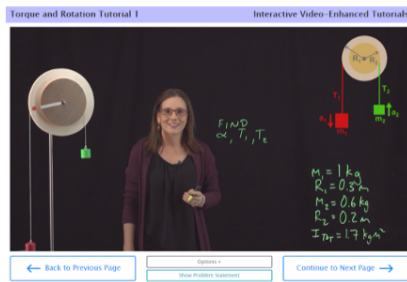
Even students who have learned problem-solving techniques often have not developed the necessary strategies for applying this knowledge. Research indicates that mastery is developed through *deliberate practice*. This involves completing many effortful activities with feedback specifically designed to improve the level of performance, explicitly highlighting how decisions are made for using specific principles, concepts, and procedures. Deliberate practice in an IVET includes supporting students with guidance and targeted feedback throughout the entire problem-solving process. Another important part of the IVET design is the application of multimedia learning principles that are based on research in human learning and memory. For example, students are given control over the pace and mode of presentation (either text or video), which motivates students' engagement and impacts learning.

IVET design

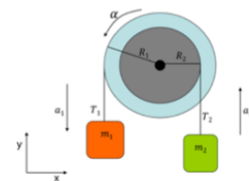
IVETs are web-based, self-paced, and short, often taking less than ten minutes to complete. Each is focused on a challenging introductory-physics problem that exemplifies an important concept or principle. They include videos of mini-lectures interspersed with multiple-choice or multiple-select questions, where students must choose the correct answer before moving to the next video segment. Feedback is provided whenever an answer is chosen (either correct or incorrect). The questions and feedback are designed to carefully step students through each stage of an expert-like problem-solving process, while emphasizing the reasoning behind each step. Students who require less guidance can navigate through quickly by selecting text instead of video for the questions and feedback, while students who need more support can choose video summaries that provide extra guidance. Most IVETs are also affect-adaptive, meaning that students are asked how they feel midway through the activity and are then given targeted feedback to encourage and help them if they are struggling.

Flow of an IVET

Each IVET begins with a **description of the problem** by a narrator (left below). Students can also choose to see the problem in text form (right below) and return to it at any time using a button on the bottom of each screen. Before continuing, students are asked to sketch out a possible solution, or approach to solving the problem, and summarize it in a text box.

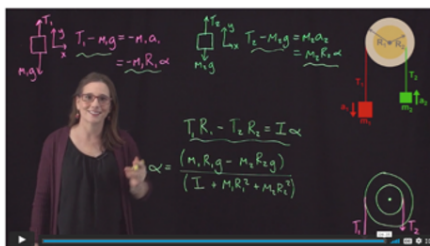


Problem Statement
Two blocks ($m_1 = 1.0 \text{ kg}$, $m_2 = 0.6 \text{ kg}$) are hanging from a pulley as shown in the figure below. The moment of inertia through the axis of rotation passing through the center of the pulley is $I = 1.70 \text{ kgm}^2$. The ropes are attached at two different distances from the center of the pulley ($R_1 = 30 \text{ cm}$ and $R_2 = 20 \text{ cm}$). Find the angular acceleration α of the pulley system and the tensions T_1 and T_2 .



Multiple choice questions (below left) guide students through an expert-like problem-solving process, starting with an understanding of what principles are involved. Occasional multi-select questions dissuade students from guessing. Each question gives feedback for correct and incorrect answers. Hints are often provided as part of the feedback.

- Q1: Which physics principle(s) should you use to solve this problem? Choose all that apply. If necessary, scroll down to see all four choices.
- A. Newton's 2nd Law for translations: $\Sigma F = ma$
 - B. Conservation of Mechanical Energy
 - C. Conservation of Linear Momentum
 - D. Newton's 2nd Law for rotations: $\Sigma \tau = I\alpha$ where τ is the torque about a chosen point

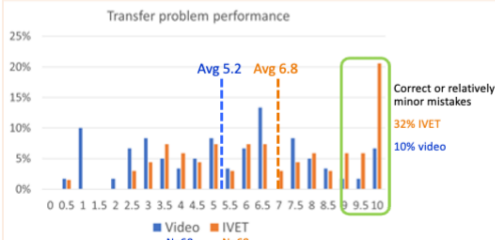


Each IVET ends with a short video summary, with emphasis on the problem-solving strategies applied. This is followed by the narrator posing another problem students can work through on their own without guidance. Here, the narrator may provide hints for how the new problem differs from the one just solved in order to help students transfer what they just learned to the new scenario. The last page of the IVET is a completion certificate, which students can print and submit to their instructor.

Does an IVET impact student problem solving ability?

One study on the Torque and Rotation IVET:

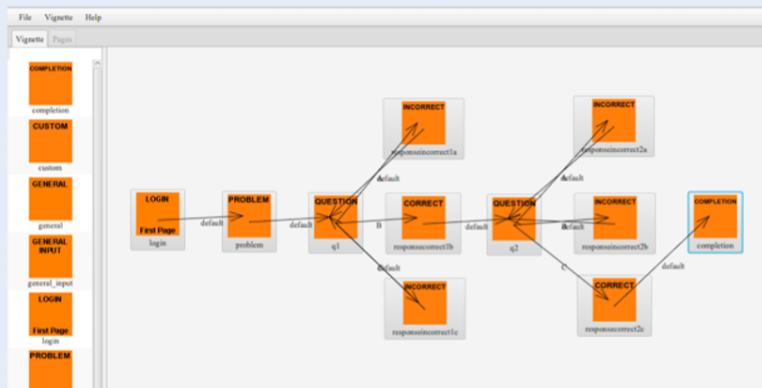
- Two sections of calculus-based physics included in study
- Same instructor, materials, homework, exams (Traditional instruction)
- Instruction related to torque and rotation, but no problems which included both Newton's laws and torque were done in class
- One was section given the Torque and Rotation IVET to complete at home
- The other section was given a ~9 minute solution video to watch at home
- Given before the lecture on the topic
- Both sections given a transfer problem to complete in class (as a quiz) on the day the assignment was due.



- Ten IVETs have been studied. Six had positive results comparable to the above. Two were indeterminate. Two are still being analyzed.

Vignette Studio II

We developed free open-source software that you can use to make your own IVETs!



Use the drag-and-drop interface to create the pages in your IVET, then add text, video links and images to each page. Link pages together to create a path for your students to follow through the activity. You can include multiple-choice and multiple-select questions that branch to other pages.

When you are finished you can upload your IVET to an LMS (Learning Management System: Blackboard, Canvas, Moodle, etc.) or upload it to a standard website. An IVET can be connected to a grade item in an LMS, so students will get course credit when they complete the IVET.



Preliminary website:

<https://ivet.rit.edu>

A permanent site will be established on ComPADRE.org later this year.



The 30 IVETs we created can be uploaded to most Learning Management Systems (Blackboard, Canvas, Moodle, etc.) or they can be put on a standard website. You will be able to download them from ComPADRE.org.

