Using web-based Interactive Video-Enhanced Tutorials to improve students’ problem-solving skills

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Helping students develop problem-solving skills is a common learning outcome of many science courses, but one which may be challenging to achieve, particularly in large-enrollment courses. There is a vast research literature on development of expertise in problem solving which can be used to design effective learning materials that would work in diverse settings. In the past few years, we have been engaged in a project to create web-based Interactive Video-Enhanced Tutorials (IVETs) which incorporate prior research on problem solving in their design and can be used with large numbers of students. IVETs include mini-lectures by a narrator interspersed with branching multiple choice questions that include feedback, allowing students who require less guidance to navigate the tutorials quickly, while students who struggle receive more support according to their needs. In this presentation, we will showcase one of our IVETs and provide details about its design features. We will also discuss results from using our IVETs in large-enrollment introductory physics courses. Lastly, we will provide resources for those interested in creating a similar product for their own classes.

NSF IUSE DUE-1821396
NSF IUSE DUE-
Problem solving: Background

- Problem solving definition (Newell, Simon, Larkin, Reif)
  - Novel activity, specific goal, limited time

- Prior research
  - Metacognitive skills, effective problem-solving heuristics, use of representations
  - Knowledge organization
  - Information processing and cognitive load
Problem solving: Background
Metacognition, problem solving heuristics, use of representations

- Metacognition: Self-regulation of learning: planning, monitoring, evaluation
- Problem solving heuristics/strategies: step-by-step process
- Early research: expert/novice differences; computer programs
- Lots of specific strategies, step-by-step procedures
  - Polya *How to Solve it* (1945)
  - Van Heuvelen Active Learning Problem Sheets (ALPS)
  - The Hierarchical Analysis Tool (HAT) (Dufresne, Gerace, Mestre)
  - Personal Assistant for Learning (PAL) (Scott & Reif)
  - GOAL oriented problem solving (Biechner)
  - Etc.
- Conceptual start, representations, specific rules for generating useful representations, working forward, being systematic, monitoring progress, evaluating answer
Metacognition, problem solving heuristics, use of representations

- Metacognition: Self-regulation of learning: planning, monitoring, evaluation
- Problem solving heuristics/strategies: step by step process
- Early research: eye tracking (泪川, Tsukiyama et al., 1995)
- Lots of specific strategies:
  - Separate system
  - Mass
  - Motion (velocity & acceleration)
  - All forces
    - Long-range (e.g., gravity)
    - Interacting objects?
    - Forces on system
  - Contact
    - Touching objects? (Mark & label contacts)
    - Forces on system
  - Components
- Conceptual start for generating useful representations, working forward, being systematic, monitoring progress, evaluating answer
Metacognition, problem solving heuristics, use of representations

**VISUAL REPRESENTATION**

1. **BIG PICTURE** of the situation
   - Gravity = mg
   - Points of contact
   - At least one force at each point

2. FBD for each object of interest
   - FBD for each object of interest

3. Choose an xy coordinate system
   - Break up all forces along the x and y directions chosen

**MATHEMATICAL REPRESENTATION**

4. Use FBD to write Newton's 2nd law
   - $F_{net,x} = ma_x$
   - $F_{net,y} = ma_y$
   - Either $a_x = 0$, or $a_y = 0$

5. Knowns/unknowns + other relevant equations (e.g., $f_k = \mu_k N$)

6. Make a plan using equations and knowns identified in steps 4 and 5
Knowledge organization

- Network organization vs. hierarchical
  (Reif, Eylon & Reif, Chi et al.)
- Differences in problem solving depending on instruction (Eylon & Reif)
  - “A hierarchical organization should facilitate performance on complex tasks involving appreciable information retrieval”
- Efficiency (Sweller)
Knowledge organization (Chi et al., 1981)
Knowledge organization (Chi et al., 1981)
Cognitive load

- Working memory: Limited processing capacity (Miller, Chrystal & Kyllonen)
- Chunking (Simon)
- Cognitive load theory (Sweller, Paas & Merrienboer)
  - Intrinsic/germane, extraneous
- Multimedia learning principles (Mayer)
Development of expertise

- Deliberate practice (Ericsson)
  - What matters for learning problem solving isn’t the number of problems solved, but the strategies practiced when solving them (Byun et al., Kim & Pak)

- Cognitive apprenticeship model (Collins, Brown, Newman)
  - Importance of coaching and scaffolding
  - Reducing support to encourage self-reliance
Other important factors

- Cognitive task analysis (Chipman)
- Misconception research (Clement, U of Washington group, Van Heuvelen, Arons, Reif, McDermott, etc.)
  - Pedagogical content knowledge (Shulman)
- Motivation and emotion (DeVore et al., D’Mello & Graser)
Other important factors

\[\text{'an Heuvelen,}\]
IVET design

- Takes all this background into account
- Carefully selected problems that incorporate important aspects of problem solving for that topic
- Core: Cognitive task analysis and prior research on problem solving heuristics for that particular topic
  - The path students follow encourages a hierarchical organization of knowledge (always starting from the core concepts/principles)
  - Cognitive load -> multimedia learning principles
    - Breaking problems up, focusing attention on just a few things at a time, use of representations to offload cognitive load etc.
IVET design

- Misconceptions included in incorrect answers
- Motivation and emotional aspects:
  - Use of a real person
  - Encouraging feedback
  - Respond to student affective states found to be important by prior research (confusion, frustration, boredom, anxiety)
  - Control-Value Theory
    - Content has high appeal (value), aligned with coursework (intrinsic value)
    - Cognitively demanding activities with appropriate balance between skill and challenge, so feel some control over the outcome of the activity
- Think-aloud interviews with students
### How are you feeling right now?

- I feel fine.
- I feel confused.
- I feel frustrated.
- I feel worried.
- None of the choices apply.
- I prefer not to answer.

Please choose the most appropriate response from this list.

- The tutorial is moving too quickly.
- I am having trouble staying focused so I’m not getting the most out of this tutorial.
- This tutorial uses terms that I do not understand.
- The problem-solving approach used here is different from what I learned in class.
Emotion

Angular Momentum Tutorial 1
Interactive Video-Enhanced Tutorials

How are you feeling right now?

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  - Please choose the most appropriate response from this list:
    - The tutorial is moving too quickly.
    - I am having trouble staying focused so I’m not getting the most out of this tutorial.
    - This tutorial uses terms that I do not understand.
    - The problem-solving approach used here is different from what I learned in class.
- I feel bored.
- I feel worried.

- None of the choices apply.
- I prefer not to answer.

Students can opt out; focus on those who may benefit from additional support.
Emotion

- Main goal is to help motivate students to engage properly with tutorial
- Emotions are always validated first, then:
  - Confused: provided advice and more support
  - Frustrated/worried: emotional support and advice where appropriate
  - Bored: reminded that tutorial provides a problem solving strategy applicable to many problems
Emotion

- Confused because tutorial is moving too quickly:
  - Yes, this problem certainly can be confusing and it has many different parts (validation)
  - Here are some things you can do to slow the problem down and regain focus:
    - Reread the problem statement. That will help you remember the end goal of the problem as well as keep the big picture in mind
    - You can also make sure that you are taking clear notes every step of the way; look over them
    - Sometimes, it’s also helpful to just take a short break
    - On the next page, we’re going to give you the option to watch a summary of what we’ve done so far. This will help recap the big picture of what we are doing and you should definitely choose that option.
Emotion

Confused because tutorial is moving too quickly:

- Yes, this problem certainly can be confusing and it has many different parts (validation).

Similar approach for other affective states.

Content of the feedback (exact words) as well as the demeanor (tone, posture, facial expressions) developed in consultation with the expert in computational models of emotion.

- Sometimes, it’s also helpful to just take a short break

- On the next page, we’re going to give you the option to watch a summary of what we’ve done so far. This will help recap the big picture of what we are doing and you should definitely choose that option.
See an IVET in action

1D kinematics: https://ivet.rit.edu/KM1/2533
Identify Essential Steps (decision points)

1. Be able to identify and draw the initial and final conditions for solving the problem.

2. Identify what “catch” means (i.e. recognize $x_{i,t} = x_{f,p}$ at time $t_f$ which is same for both).

3. Use Kinematic equations to determine an expression for $x_{f,T}$ at time $t_f$.

4. Use Kinematic equations to determine an expression for $x_{i,p}$ at time $t_i$.

5. Recognize need to set expressions equal to one another (i.e. set $x_{i,t} = x_{i,p}$) to solve for $t_i$.

6. Use quadratic eqn to solve for $t_i$ and choose the appropriate $t_i$ solution.

7. Use the calculated $t_i$ to find $x_i$ for one vehicles. Recognize $x_i$ is same for both vehicles.
A more complex IVET

Static equilibrium: https://ivet.rit.edu/SEc/2533
Introductory Physics at UC

- **Algebra-based Physics**
  - primarily health science majors
  - 13 sections of 135 each/yr (~1500 students)
  - Lab taught by graduate TAs

- **Calculus-based Physics**
  - primarily engineering majors
  - 16 sections of 135 each/yr (~2000 students)
  - Lab and recitation taught by graduate TAs

Wide variation in students’ academic preparation
Wide variation in approaches to teaching
Methodology for evaluating IVETs

- Two sections of algebra- or calculus-based physics course with same homework and exams
  - Instructors sometimes the same, other times different
- One section watched video summary (Video group)
- One section worked through IVET (IVET group)
- Paired problem given as quiz at the beginning of the next class
- Treatment and control alternated
- The IVETs/Video summaries were often advertised as providing help with the weekly quiz
- Rubric used to grade problem-solving performance
Results: 1D kinematics

A motorcycle is moving at a constant velocity of 10 m/s to the East (right). A car is moving towards the motorcycle, and the car is moving at a constant velocity of 25 m/s to the West (left). When they are at a distance of 2,000 m apart, the motorcycle begins to speed up at a constant rate of 1.0 m/s².

a. Where do the two vehicles pass each other

b. What is the speed of the motorcycle when this happens.
Results: 1D kinematics

1. Be able to identify and draw the initial and final conditions for solving the problem.
2. Identify what “pass” means (i.e. recognize $x_{f,M} = x_{f,C}$ at time $t_f$ which is same for both).
3. Use Kinematic equations to determine an expressions for $x_{f,M}$ and $x_{f,C}$ at time $t_i$.
4. Recognize need to set expressions equal to one another (i.e. set $x_{f,M} = x_{f,C}$) to solve for $t_f$.
5. Use quadratic eqn to solve for $t_f$ and choose the appropriate $t_f$ solution.
6. Use calculated $t_f$ to find $x_f$ for where vehicles pass.
7. Use calculated $t_f$ or $x_{f,m}$ to determine $v_{f,m}$. 
Results: 1D kinematics

Impact of IVET and Video Treatments

Exams 1 Avg IVET group = 75.2%  p < 0.001
Exams 1 Avg Video group = 84.5%  Eff Size = -0.602 (favors Video group)
# Results: 1D kinematics

<table>
<thead>
<tr>
<th>IVET</th>
<th>Video</th>
<th>Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>32%</td>
<td>Correct (includes minor math errors)</td>
</tr>
<tr>
<td>95%</td>
<td>93%</td>
<td>Drew/indicated initial state for problem</td>
</tr>
<tr>
<td>31%</td>
<td>4%</td>
<td>Drew/indicated final state for problem</td>
</tr>
<tr>
<td>93%</td>
<td>98%</td>
<td>Recognized $x(t,m) = x(t,car)$</td>
</tr>
<tr>
<td>5%</td>
<td>19%</td>
<td>Selected kinematic equation w/too many unknowns</td>
</tr>
<tr>
<td>8%</td>
<td>15%</td>
<td>Appeared to have no idea (not included in line above)</td>
</tr>
</tbody>
</table>
Results: Linear momentum and energy

Two small spheres of putty, A and B, of equal mass \( m \), hang from the ceiling on massless strings of equal length. Sphere A is raised to a height \( h_0 \) as shown below and released. It collides with sphere B (which is initially at rest). The two spheres stick and swing together to a maximum height \( h_f \). (Assume a completely inelastic collision with the two spheres sticking together after the collision.)

Find the height \( h_f \) in terms of \( h_0 \).

Assume that the lowest point in the path is the point of zero gravitational potential energy.
Results: Linear momentum and energy

- Three-step problem
- Prior research: students use either conservation of energy or conservation of momentum, but not both
- Very difficult problem forintroductory students
Results: Linear momentum and energy

A 2000 kg truck starts at rest 15 m above the bottom of a hill. It rolls down the hill and at the bottom the truck collides and locks bumpers with (sticks to) a 1500 kg car which is at rest at the bottom of the hill in a completely inelastic collision. The two vehicles then roll together up a second hill. Assuming that both vehicles are in neutral and roll without energy loss due to friction or air resistance, how high up the second hill will the two vehicles travel before stopping?
Results: Linear momentum and energy

- Watched Video Solution (n=124)
  - Avg: 6.33
- Completed IVET (n=105)
  - Avg: 8.83

p < 0.001
Eff Size = 0.91

Exam 2 Avg IVET group = 68.2%
p = 0.012
Exam 2 Avg Video group = 74.8%
Eff Size = -0.338 (favors Video group)
Results: Linear momentum and energy

Watched Video Solution (n=124)  Completed IVET (n=105)

Correct (or with simple math error):
43%  77%

Exam 2 Avg IVET group = 68.2%  p = 0.012
Exam 2 Avg Video group = 74.8%  Eff Size = -0.338 (favors Video group)
Results: Linear momentum and energy

What did you think of the guidance in the tutorial?

<table>
<thead>
<tr>
<th>Opinion</th>
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<td>25%</td>
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<td>39%</td>
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<td>18%</td>
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Results: Linear momentum and energy

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Results: Linear momentum and energy

- “I learned to separate into sections and work on each one, one by one. This allows for a more clear way to set up problems.”
- “I learned how to integrate different formulas together to solve 1 problem.”
Results: Linear momentum and energy

- “I learned to separate into sections and work on each one, one by one. This allows for a more clear way to set up problems.”
- “I learned how to integrate different formulas together to solve 1 problem.”
- “This activity was extremely easy to follow and I finally followed a physics problem all the way through.”
- “Very good at explaining how to obtain equations. Related concepts to solving the problem.”
- “I really enjoyed the tutorial. Very well made and easy to follow.”
Results: Angular momentum

It's going to strike the wheel horizontally at the rim,
Results: Angular momentum

A 20 kg boy stands at the edge of a small stationary (at rest) merry-go-round of radius 2.0 m. The total moment of inertia of the system of merry-go-round with the boy on it about the center is 120 kg m\(^2\). The boy jumps off the merry-go-round in a tangential direction with a linear speed of 1.5 m/s. What is the angular speed of the merry-go-round after the boy leaves it?
Results: Angular momentum

Exam 3 Avg IVET group = 68.7%  p = 0.020
Exam 3 Avg Video group = 75.3%  Eff Size = -0.319 (favors Video group)
Results: Angular momentum

Correct (or with relatively minor errors, e.g., sign, math, using Rmv for Li):

15%
44%
p < 0.001

Exam 3 Avg IVET group = 68.7%  p = 0.020
Exam 3 Avg Video group = 75.3%  Eff Size = -0.319 (favors Video group)
Results: Angular momentum

Separated by gender: IVET group

Women Average: 7.51
Men Average: 6.94

P-Value: 0.120
Effect Size: -0.315
(Favors women)

Exam 3 Avg Men = 75.0%
Exam 3 Avg Women = 64.8%

p = 0.016
Eff Size = 0.789 (favors men)
Results: Angular momentum

Separated by gender: Video group

Men Average: 6.13
Women Average: 5.89

P-Value: 0.747
Effect Size: 0.116 (Favors Men)

Exam 3 Avg Men = 78.4%
Exam 3 Avg Women = 76.5%
p = 0.6
Eff Size = 0.117 (favors Men)
Repeated analysis in 2021 with a different group – similar, but not as drastic results.

Exam 3 Avg Men = 78.4%
Exam 3 Avg Women = 76.5%
p = 0.6
Eff Size = 0.117 (favors Men)
Results: Angular momentum

What did you think of the guidance in the tutorial?

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Results: Others

- Generally positive results, perhaps not always this stark (single ~10 min intervention)
- Practical issues: recitations, in-class practices, timing, etc.
- Gender comparison: generally smaller or reversed gender gaps on paired problem compared to exams
- Survey comments generally positive
Survey results after one semester

- Algebra-based class
- Assigned six IVETs over the course of a semester
  - Week 2: 1D kinematics
  - Week 4: Newton’s laws
  - Week 7: Linear momentum
  - Week 8: Static equilibrium
  - Week 9: Torque and rotation
  - Week 13: Thermal equilibrium
- For each, turned in a solution to the IVET problem and a solution to the paired problem
  - Were told the IVET should help with the paired problem
- Survey at end of semester
Survey results after one semester

Whenever you answered a question incorrectly, the tutorial provided you with feedback. What did you think of this feedback, which sometimes included hints?

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<td>The feedback was mostly helpful, but sometimes the hints didn’t help me much.</td>
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<td>The feedback was only helpful about half the time</td>
<td>7%</td>
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<tr>
<td>The feedback was rarely helpful and most of the time the hints didn’t help me much</td>
<td>3%</td>
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<td>I didn’t pay much attention to the hints and went back to the question and tried again.</td>
<td>13%</td>
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<td>I didn’t find the problems in the tutorial difficult, so I often didn’t use the hints.</td>
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Survey results after one semester

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Survey results after one semester

Why is feedback helpful?

68% Help put on the right track/help guide/help figure out error/correct wrong thinking
37% Help make sense of the right answer
8% Liked/that it made it easy to able to try again
Survey results after one semester

Why is feedback helpful?

“I felt the feedback and hints helpful because they always put me on the right track to solve the problem when I either made a small error or was confused.”

“I feel the hints were helpful because they usually guided me into getting the question right and helped me realize what I did wrong.”

“The guided hints were helpful because if I were to get one wrong or if I was between two, the lady would make me think a way I didn't before so I was able to make sense of the correct answer instead of just getting it wrong.

I also liked how it gave me multiple chances to answer the questions again because since we are newly learning it, we obviously did not know exactly how to do the problems.”
Survey results after one semester

Why is feedback not helpful? (Sometimes yes, sometimes no)

46% Little vague, confusing, didn’t understand hints

27% Hints were helpful. No reason given for not being helpful.

27% Not helpful if I was really lost. Only helpful when I had an idea
Survey results after one semester

Why is feedback not helpful? (Sometimes yes, sometimes no)

“Sometimes it would vaguely mention concepts and I couldn’t figure out what they meant. Most of the time the hints were helpful and I understood where I went wrong after they pointed me in the right direction.”

“I felt that the hints took too long and I just wanted to understand what the correct answer was and have it explained to me.”

“Every now and then, I would get feedback that did not make much sense to me until the question was debriefed by the professor in the video after I selected the correct answer choice. This means when I didn’t understand the feedback, I would end up guessing and checking until I got the question right. From there, I would watch the professor break the question down, which really helped clear my confusion.”
## Survey results after one semester

When you worked on the tutorials, how mentally engaged were you?

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<td>37%</td>
</tr>
<tr>
<td>I usually did the tutorials without interruption and was <strong>mentally engaged about half the time</strong></td>
<td>25%</td>
</tr>
<tr>
<td>I usually did the tutorials without interruption but <strong>didn’t really engage mentally</strong> (that is, I depended on the narrator to do the thinking for me)</td>
<td>14%</td>
</tr>
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<td>I usually did the tutorials <strong>with some interruption</strong> (e.g., texting), but I was mentally engaged most of the time.</td>
<td>7%</td>
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Survey results after one semester

I was mentally engaged most of the time

“I was always mentally engaged because I knew how helpful the tutorials would be for me in learning each new problem. I always thought the tutorials were the best way for me to complete my understanding of how to attack each part of the different problems.”

“I generally engaged with the tutorials since they were pretty short, informative, and helpful. I also felt like I could do the problem on my own when done.”

“I usually tried to fully engage in the tutorial because often I knew we had to do another problem for homework that was basically the same as the tutorial so I wanted to make sure I understood the tutorial so I was able to complete the homework problem without much struggle.”
Survey results after one semester

I was mentally engaged half the time

“Sometimes the videos got boring if I understood it generally for the most part. If I didn’t know much about it, then I would have paid a lot more attention to it. So I did engage more in those scenarios.”

“Some days I was just tired and rushed through the tutorials just to finish them and get a general idea of what to do. Other days I was mentally engaged and wrote notes as I was going along with the tutorial.”

“If I understood the topic prior, and this tutorial enhanced my knowledge it was easier to keep engaged.”

“I am usually mentally engaged when I set aside time for me to do my homework but sometimes I get distracted by someone asking me a question or getting a text”
Survey results after one semester

Overall, how would you rate the tutorials with regards to helping you learn how to apply specific problem-solving strategies to homework problems?

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tutorials were very helpful in teaching me how to use specific problem solving strategies</td>
<td>50</td>
</tr>
<tr>
<td>The tutorials were only somewhat helpful in teaching me how to use specific problem solving strategies</td>
<td>34</td>
</tr>
<tr>
<td>The tutorials were only a little helpful in teaching me how to use specific problem solving strategies</td>
<td>9</td>
</tr>
<tr>
<td>Given that we learned similar problem solving strategies in class, the tutorials didn’t necessarily teach me the strategies, but rather provided additional practice</td>
<td>8</td>
</tr>
</tbody>
</table>
Survey results after one semester

The tutorials were very helpful:

“I found the tutorials helpful because they showed how to solve the problems piece by piece, so when I made a small error during a single step I was able to correct myself with the feedback and make notes for future problems.”

“I think the nature of clear explanation and the fact I could take my time in answering the problem and learn at my speed was very beneficial to me.”

“Since the tutorials were slow they made more sense to me. In class, the professor would go too fast for me because everyone in the class was at different levels, so when I watched the videos it made more sense in my head and allowed me to slowly understand the steps of the problem.”
Survey results after one semester

The tutorials were very only somewhat helpful;

““The tutorials were very helpful in explaining the material, however I was still a little confused on a couple of the homework assignments, as they seemed to be more challenging then the problem done in the video.”

“Some of the time I felt like I gained a much better grasp on the material while other times I was simply just a little to lost to learn the way I would have hoped to.”

“The way she explains it helped a lot. Even the way she problem solves in a step by step manner contributes to it being more clear and concise. However, sometimes I found the problem a little difficult and wouldn't understand it. I wouldn't necessarily blame that on the tutorial though. I guess I need extra practice when it comes to some things but the tutorial did help a lot. I generally did the tutorials because they were assigned as homework, but I believe it’s a really good way to study in the future!”
Survey results after one semester

Halfway through each tutorial, you were asked a question about how you were feeling about the problem solution up to this point (see the provided screen shot). Based on your response to this question, the narrator followed up with a video response, such as advice on what to do if you were confused in solving the problem or worried about your understanding moving forward.

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I typically selected “fine” so this question was not useful to me</td>
<td>80%</td>
</tr>
<tr>
<td>I typically selected “Prefer not to answer” so this question was not useful to me.</td>
<td>0%</td>
</tr>
<tr>
<td>I occasionally chose something other than “fine” and the response from the narrator was useful to me.</td>
<td>6%</td>
</tr>
<tr>
<td>I occasionally chose something other than “fine” but the response from the narrator was not useful to me.</td>
<td>7%</td>
</tr>
<tr>
<td>I often chose something other than “fine” and the response from the narrator was useful to me.</td>
<td>3%</td>
</tr>
<tr>
<td>I often chose something other than “fine” but the response from the narrator was not useful to me.</td>
<td>5%</td>
</tr>
</tbody>
</table>
Emotion (~1,000 responses)

How are you feeling right now?

81%  I feel fine.
1.6%  I feel confused.
1.6%  I feel frustrated.
4.4%  I feel bored.
3.9%  I feel worried.
3.0%  None of the choices apply to me.
4.5%  I prefer not to answer.
## Emotion (~1,000 responses)

### How are you feeling right now?

<table>
<thead>
<tr>
<th>Feeling</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel fine.</td>
<td>81%</td>
</tr>
<tr>
<td>I feel confused.</td>
<td>1.6%</td>
</tr>
<tr>
<td>I feel frustrated.</td>
<td>1.6%</td>
</tr>
<tr>
<td>I feel bored.</td>
<td>4.4%</td>
</tr>
<tr>
<td>I feel worried.</td>
<td>3.9%</td>
</tr>
<tr>
<td>None of the choices apply to me.</td>
<td>3.0%</td>
</tr>
<tr>
<td>I prefer not to answer.</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

### How are you feeling right?

- I feel fine.
- I feel confused.
- I feel frustrated.
- I feel bored.
- I feel worried.
- I feel confident. I already knew how to do the problem so I find this easy.
- I feel confident. This tutorial has been easy to follow and understand.
- I’m engaged with the problem and feeling good.
- I’m feeling OK.
Create your own IVETs!

- Vignette Studio II software with detailed guidance, both in text and video: https://www.compadre.org/IVET/
Create your own IVETs!

- Vignette Studio II software with detailed guidance, both in text and video: https://www.compadre.org/IVET/
- Involves primarily dragging and dropping slides; requires just basic familiarity with HTML
- Easy to use if you know a little about HTML
- Activities you make with Vignette Studio II can be uploaded to most Learning Management Systems (Blackboard, Canvas, Moodle...)
### Instructional suggestions

<table>
<thead>
<tr>
<th>Resource</th>
<th>Spring 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google (ex. Chegg.com)</td>
<td>47%</td>
</tr>
<tr>
<td>Other students</td>
<td>23%</td>
</tr>
<tr>
<td>Khan or other online videos</td>
<td>15%</td>
</tr>
<tr>
<td>Textbook</td>
<td>8%</td>
</tr>
<tr>
<td>Physics Learning Center</td>
<td>2%</td>
</tr>
<tr>
<td>Office hours</td>
<td>1%</td>
</tr>
<tr>
<td>Supplemental Instruction Sessions</td>
<td>1%</td>
</tr>
<tr>
<td>Didn’t seek help or other</td>
<td>3%</td>
</tr>
</tbody>
</table>
Instructional suggestions

- Preparatory materials for regular homework
- A significant proportion of students seem to want it
- Individual accountability (student quotes)
- Integrate in course; do you agree with the strategies? Use them in class!
Conclusion

- Created a set of 28 IVETs (soon 30); roughly one per chapter
- Problem solving is a common goal in science courses; students come in with a wide range of preparation
- Prior research can provide information about how to design effective learning tools that can be used online; adaptable to student pace
- Need to take into account many things, but your expertise (PCK) and intuition is very helpful
- Students like being guided and learning strategies for problem solving
  - Helps with motivation, engagement, and learning
- Can create your own IVETs; just need to make a script and film videos, then upload them to youtube or vimeo
- Would be happy to keep the conversation going: mariesau@ucmail.uc.edu

Questions/comments?