Interactive Usage of Demonstration Videos: An Experimental Evaluation

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Abstract for DBER Group Discussion on 2014-11-13

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Title:
Interactive Usage of Demonstration Videos: An Experimental Evaluation

Abstract:
Crouch et al (2004) posit that students will be more engaged by and learn more from classroom demonstrations when asked to predict the outcome of the demonstration and discuss it with peers. We tested this hypothesis in an experiment involving 116 students enrolled in an undergraduate astronomy class using an online survey and five video demonstrations. Students were randomly assigned to one of four conditions, including watching a set of videos (about convection, sun spots, and buoyancy) under one of Crouch’s three modes of presentation (observe, predict, and discuss) and a control condition which involved viewing different videos (about differentiation and phase changes). Students were asked to report their levels of engagement with each video immediately after viewing it and to answer knowledge questions related to the videos at the end of the survey. These knowledge questions were repeated in a follow-up survey administered one week later to test how well knowledge was retained. Results indicated no significant differences in the engagement between conditions except for social engagement, which as expected was highest in the discussion condition. Significant differences were found only for the knowledge questions related to convection, with significant differences between high and control conditions but not between control and low or medium conditions. This difference between the high and control condition remained in the one-week follow-up measure of knowledge for convection. Control students had watched a video pertaining to differentiation and knowledge of differentiation was highest in control condition at both time points.
Interactive Usage of Demonstration Videos*

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Background

• Classroom demonstrations can
  – Increase student enjoyment
  – Illustrate complex concepts
Background

• But demonstrations aren’t always effective

  – Students may remember what they expected to see, not what actually happened\(^1\)

  – Concept may still be confusing

\(^1\) Milner-Bolotin, Kotlicki and Riger (2007)
Background

- Video demonstrations are easy to replicate
  - But are they effective?
Background

• Crouch et al (2004):
  – Learning improves as students interact more with the demonstration

  – 3 increasing levels of engagement:
    • Observe
    • Predict
    • Discuss
Observe

• View demonstration in traditional fashion

“The students in the observe group display no greater understanding of the underlying concepts than those who did not view the demonstration at all.”

-Crouch et al. (2004)
Predict

• Students predict the demonstration’s outcome
Discuss

• Students discuss the demonstration with peers
Previous Findings

- Significant improvements for predict/discuss
Our Study

- Apply Crouch’s design with a few differences
  - Laboratory setting
  - Pairs of students, instead of small groups

- Test UNL Astronomy’s suite of demonstration videos
  - What are the effects of high, medium, low engagement conditions?
Recruitment

• Extra credit in Introductory Astronomy
  – 3 sections total

• 115 students volunteered to
  – Complete initial online survey, supervised
  – Complete follow-up survey one week later
Design

- Selected 6 video demonstrations from UNL Astronomy
  - 3 for the experimental conditions

Convection

Solar Tube

Sunspots
Design

- Selected 5 video demonstrations from UNL Astronomy
  - 3 for the control condition

Differentiation

Phase Changes (x2)
Design

- Students randomly assigned to 1 of 4 conditions

Control  Observe  Predict  Discuss
Design

• Students randomly assigned to 1 of 4 conditions

Control | Observe | Predict | Discuss

• Viewed videos on Differentiation and Phase Changes (order of presentation randomized)
Design

- Students randomly assigned to 1 of 4 conditions

  - Control
  - Observe
  - Predict
  - Discuss

- Viewed videos on Convection, Sunspots, and Solar Tube (order of presentation randomized)
Design

- Students randomly assigned to 1 of 4 conditions
  - Control
  - Observe
  - Predict
  - Discuss

- Same videos as Observe Condition

- Halfway through demonstration, asked to predict the outcome
Design

• Students randomly assigned to 1 of 4 conditions

  Control   Observe   Predict   Discuss

• Paired in groups of two

• Same videos/prediction activities as Predict condition

• Before making final prediction, see hypothetical peer responses and discuss with partner
Measures - Engagement

• All items answered for each video

• Primarily interested in:
  – Active engagement (Cronbach’s $\alpha$ range: .53 – .77)
  – Disinterested engagement (Cronbach’s $\alpha$ range: .68 – .80)
  – Creative engagement ($\alpha$ range: .80 – .89)
  – Social engagement ($\alpha$ range: .93 – .96)
  – Transformative engagement (follow-up, $\alpha = .89$)

• Other engagement scales:
  – Open-minded, conscientious, angry, close-minded, disinterested, anxious
Measures - Knowledge

• Prior Knowledge (assessed at pre)
  – 4 items, 2 each from the Force Concept Inventory and the Light and Spectroscopy Concept Inventory

• Video Knowledge (assessed at post and follow-up)
  – Research team wrote knowledge questions with expert advice
  – One set of items answered at two times: immediately after seeing all videos and one-week following the initial survey
  – Topics covered in each video except for Phase Change
Measures - Knowledge

- **Video Knowledge** – 22 Questions Total:
  - 6 for Differentiation Video
  - 5 for Sunspots Video
  - 6 for Convection Video
  - 5 for Solar Tube Video
Example – Prior Knowledge

Prior Knowledge

The following questions are intended to test your current understanding of fundamental concepts in astronomy and physics.

Don't worry if you do not know the answers! (Most people do not know the answers!)

Please do answer all the questions to the best of your ability. If you do not know the answer, please guess. You will not be graded on the accuracy of your responses.

Which of the following travels slowest through space?

- Infrared photons
- Visible light
- X-rays
- Radio waves
- They all travel at the same speed

An empty office chair is resting on a floor. Consider the following forces:

A. a downward force of gravity.
B. an upward force exerted by the floor.
C. a not force exerted by the floor.

Which of the forces is (are) acting on the office chair?

- A only
Example – Background Information

Video Demonstrations

Next you will watch three short videos (2-3 minutes long each) designed to illustrate fundamental concepts in astronomy and physics. Please watch each video and then answer the questions that follow.

Note that some of the videos may have some activities to do as you watch them.

After you’ve watched all three videos, you will be asked to answer some questions over the concepts they cover.

Background Information

First, please read the following background information. It will provide you with some basic vocabulary that will help you understand the videos.

The following are basic concepts that may be discussed in the videos.

Modes of Thermal Transport

Conduction: Conduction is a mode of thermal transport (heat transfer) by microscopic collisions of particles within a body or between bodies, due to temperature difference. For example, a metal pot becomes hot upon contact with a hot stove burner.

Convection: Convection is a mode of thermal transport through the collective rising and falling of groups or aggregates of molecules within fluids (including gases & plasmas). For example, the water inside the pot atop the stove burner, redistributes heat and comes to a boil via convection. Other examples of convection are natural phenomenon such as wind and ocean currents.
Example – First Half of Video and Prediction

Which of the following pictures best shows how the mixture will look after it has been heating for a few minutes?
Please Stop and Discuss with your partner.

Next, please discuss your predictions with your partner, especially discussing why you predicted what you did.

Also discuss with your partner whether you agree with the peer responses below, or not, and why you disagree or agree.

Peer responses

Here are the answers that your peers from UNL provided in a prior version of this study, when we asked students which answer they would choose, and why they chose it.

The graph below shows how many students chose each of the answers. Below the graph are sample explanations for each choice.

![Graph showing percentage of students choosing different answers]
Example – Second Half of Video

Watch the video above. Was your final prediction correct?
- Yes, completely
- Yes, partly
- No
## Example - Engagement

### Video Activity Experience

Please indicate the extent to which the following phrases describe your experience with the activity you just completed while watching the video.

Don't think too much about your answers, simply respond with your first "gut" response.

#### During this video activity, I...

<table>
<thead>
<tr>
<th>Activity Description</th>
<th>Not at all</th>
<th>Slightly</th>
<th>Somewhat</th>
<th>Moderately</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asked others what they thought about the topics and issues.</td>
<td></td>
<td></td>
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<tr>
<td>Talked to others about the topics to get their opinions.</td>
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<tr>
<td>Felt creative.</td>
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<td>Felt open-minded.</td>
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<tr>
<td>Felt like my mind was already made up.</td>
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<tr>
<td>Checked myself to see how well I understood the issues related to the topics I was learning about.</td>
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<tr>
<td>Thought about how the topics related to other things I know.</td>
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<tr>
<td>Tried hard to understand a new perspective on the topics.</td>
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<tr>
<td>Used my imagination.</td>
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<tr>
<td>Discussed my ideas about the topics with others.</td>
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<tr>
<td>Was thorough in my consideration of the issues.</td>
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<tr>
<td>Felt angry</td>
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</tbody>
</table>
Repeat for Additional Videos
Please answer these to the best of your ability.

PLEASE NOTE: Please do not worry if you do not know all the answers! Some of the questions may have been answered by the videos, but some may NOT have been answered by the videos. You are not expected to know all of the answers.

Thunderstorms are due to the movement of air: as the warmer and moist air moves up, then cool down and become more dense, finally dropping down as water droplets form. What main thermal transfer mechanism does this weather phenomenon represent?

☐ Radiation
☐ Conduction
☐ Convection
☐ Advection

The density of the material making up the earth changes systematically as one moves from the Earth's outer crust to its innermost core. What process is most likely to explain this pattern?

☐ Differentiation
☐ Radiation
☐ Buoyancy
☐ Convection
Engagement
Means of Scales

- Expected experimental conditions to be increasingly more engaging
ANOVA results indicated that social engagement was significantly higher in the discuss condition (robust $F=15.709 \ p<.01$), but no statistical differences in active, creative or disinterested engagement.
• Although upward trends were observed, there were no significant differences in other types of engagement.
Post Knowledge
Percentage of Correct Answers From Video-Specific Questions

Hypothesized results:
- Differentiation video only viewed in control condition
- Experimental conditions expected to aid learning for all other videos
• **Convection** video: significant difference between **Discuss** and **Control** ($\beta = .24$)
• Prior-knowledge only correlated with knowledge from **Solar Tube** video ($r = .23$)
Post Knowledge
Percentage of Correct Answers From Video-Specific Questions
(now looking at differentiation too)

- Significantly higher percentage of correct answers in Control than observe ($\beta = -.46$), predict ($\beta = -.62$), and discuss ($\beta = -.30$) conditions for Differentiation video
Follow-up Engagement

Means of transformative engagement

No significant difference between conditions

Transformative

control  observe  predict  discuss
Follow-Up (Delayed) Knowledge
Percentage of Correct Answers From Video-Specific Questions
(now looking at differentiation, too)

- **Convection**: Significantly higher percentage of correct answers in discuss ($\beta = .23$) than in control condition

Graph showing percentage of correct answers over different conditions:
- Sunspots
- Convection
- Solar Tube
- Total of convection, sunspots, and solar tube
Follow-Up (Delayed) Knowledge
Percentage of Correct Answers From Video-Specific Questions
(now looking at differentiation, too)

- Significantly higher percentage of correct answers in control than observe ($\beta = -0.37$) and predict ($\beta = -0.28$) but not discussion conditions for differentiation video.

![Graph showing percentage of correct answers across different conditions.](image-url)
For active engagement, solar tube was higher than other videos.

For creative engagement, phase change part 1 was lower than other videos except convection, and phase change part 2 was lower than differentiation.

For disinterested engagement, differentiation was higher than other videos.
Other types of engagement also showed video effects
Discussion

• Discuss conditions learned significantly more for convection video, but no significant learning or engagement effect between conditions for other videos

• Video specific effects were only slightly more apparent than condition effects

• Implied:
  – May need better knowledge questions
  – Videos/topic differ in level of difficulty
  – Students may be less engaged in contrived lab setting
  – Experimental design may have emphasized differences between videos over differences between conditions.