

Research Designs to Test and Refine the Pathway Active Learning Environment

Christopher M. Nakamura, Sytil K. Murphy, Dean Zollman
Kansas State University Physics Department



Michael Christel and Scott Stevens
Carnegie Mellon University Entertainment Technology Center



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Project Overview



Pathway Active Learning Environment

- Develop an interactive online synthetic tutor
 - Targeted at high school & intro college physics students
 - For supplemental instruction at home
 - To study student learning processes
- Seek to exploit benefits of human tutoring¹
 - Interaction is mostly student-centered²
 - Students must self-explain²
 - Students must challenge their constructed explanations²

¹Bloom (1984)

²Chi et. al (2004)

Active Learning Environment



Two Components

- Guiding Lessons

- Synthetic Tutor (SI)

The screenshot displays a user interface for an Active Learning Environment. It is divided into several sections:

- Lesson 1, Exploration 1:** Contains directions: "Directions: Use the accompanying materials to answer these questions. Explain your reasoning as completely and clearly as possible." and a question: "1. What is the speed of the ball near the beginning of the portion of the track marked off by the ruler?". Below the question is a text input field and a "Done with Question 1" button.
- Video:** A video player showing a male tutor named Chris. The video title is "Answering: What is force?". The tutor is speaking, and the video progress is at 00:36 / 01:05. Below the video is a "Tutor: Chris" label with a star rating and a "More..." button.
- Force Diagrams:** Two diagrams illustrating force. The first, titled "A Push", shows a blue block on a grey surface with an orange arrow labeled "5 N" pointing to the right. The second, titled "Or a Pull", shows the same blue block on the grey surface with an orange arrow labeled "5 N" pointing to the right.
- Input and Navigation:** A text input field with the text "What is force?" and an "Ask" button. Below this are two dropdown menus: "Related questions: Select related question:" and "Your past questions: Select question answered earlier:".
- Video Player:** A video player at the bottom showing a close-up of a ruler on a red surface, with a ball at the end. The video has a play button and a progress bar.

Active Learning Environment



Two Components

- Guiding Lessons

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The screenshot displays a user interface for an Active Learning Environment. It is divided into several sections:

- Lesson 1, Exploration 1:** Contains directions: "Directions: Use the accompanying materials to answer these questions. Explain your reasoning as completely and clearly as possible." and a question: "1. What is the speed of the ball near the beginning of the portion of the track marked off by the ruler?". Below the question is a text input field and a "Done with Question 1" button.
- Video Player:** Shows a video of a man (Tutor Chris) speaking. The video title is "Answering: What is force?". It includes a play button, a progress bar (00:36 / 01:05), a star rating (5 stars), and a "More..." button.
- Force Diagrams:** Two diagrams illustrating force. The first, titled "A Push", shows a blue block on a grey surface with an orange arrow labeled "5 N" pointing to the right. The second, titled "Or a Pull", shows a blue block on a grey surface with an orange arrow labeled "5 N" pointing to the right.
- Input and Navigation:** Below the video, there is a text input field with the placeholder "What is force?", an "Ask" button, and two dropdown menus: "Related questions: Select related question:" and "Your past questions: Select question answered earlier:".
- Video Player (Bottom):** A smaller video player at the bottom shows a close-up of a ruler on a red surface.

Active Learning Environment



Two Components

• Guiding Lessons

• Synthetic Tutor (SI)

The screenshot displays the interface of an Active Learning Environment. It is divided into several sections:

- Lesson 1, Exploration 1:** Contains directions: "Use the accompanying materials to answer these questions. Explain your reasoning as completely and clearly as possible." and a question: "1. What is the speed of the ball near the beginning of the portion of the track marked off by the ruler?". Below the question is a text input field and a "Done with Question 1" button.
- Video Player:** Shows a video of a tutor named Chris. The video title is "Answering: What is force?". The tutor's name is "Tutor: Chris" with a star rating and a "More..." button. Below the video is a text input field for "What is force?" and an "Ask" button. There are also dropdown menus for "Related questions:" and "Your past questions:".
- Force Diagram:** Titled "Force", it shows two diagrams. The first, "A Push", shows a blue block on a grey surface with an orange arrow pointing right labeled "5 N". The second, "Or a Pull", shows a blue block on a grey surface with an orange arrow pointing right labeled "5 N".
- Video Player (Bottom):** Shows a video of a ruler on a red surface, likely related to the lesson's content.

Active Learning Environment



- Three lessons cover Newton's Laws
- Can be thought of as “problems in video contexts”
- Can involve textbook-style problems & questions, observation & measurement, or both
- Connects to the real-world
- Uses established pedagogy³

The screenshot displays a user interface for an Active Learning Environment. On the left, a text box titled "Lesson 1, Exploration 1" contains directions: "Directions: Use the accompanying materials to answer these questions. Explain your reasoning as completely and clearly as possible." Below this, a question asks: "1. What is the speed of the ball near the beginning of the portion of the track marked off by the ruler?" A "Done with Question 1" button is visible. A second question asks: "2. How did you calculate the speed of the ball?"

In the center, a video player shows a tutor named Chris, with a progress bar at 00:36 / 01:05. Below the video, the text "Answering: What is force?" is displayed. A question input field contains "What is force?" and an "Ask" button. Below this are sections for "Related questions:" and "Your past questions:", each with a "Select related question:" and "Select question answered earlier:" dropdown menu.

On the right, a diagram titled "Force" shows a blue block on a grey surface. The top part is labeled "A Push" and shows an orange arrow pointing right with "5 N" above it. The bottom part is labeled "Or a Pull" and shows an orange arrow pointing right with "5 N" above it.

At the bottom of the interface, a video player shows a close-up of a ruler on a red surface.

³Karplus & Butts (1977)

Active Learning Environment



- Can answer natural language questions
- “Quickstart” menus enable selection of questions
- Multimedia can support tutors’ verbal responses
- Attempts to develop a synthetic social interaction⁴
- Currently offers two tutors
- 7 different experiences total

⁴. Okita et al. 2008

The screenshot displays a web-based learning interface. On the left, a text box contains a question: "1. What is the speed of the ball near the beginning of the portion of the track marked off by the ruler?" Below the question is a "Done with Question 1" button. In the center, a video player shows a man (the tutor) speaking. Below the video is a progress bar and a text input field with the question "What is force?". To the right, a diagram titled "Force" shows a blue block on a grey surface. An orange arrow labeled "5 N" points to the right, labeled "A Push". Below this, another diagram shows the same block with an orange arrow labeled "5 N" pointing to the right, labeled "Or a Pull". At the bottom of the interface, there is a video player showing a ruler on a red background.

Factors in Testing the PALE



- PALE logs (through student accounts):
 - student responses
 - changes to responses
 - queries to SI tutor
 - several other types of actions
- PALE logs these with a time stamp for time-resolved analysis
- PALE does not log facial expressions, thoughts, feelings, or mutterings

Three-modes of Testing



- One-on-one interview setting



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- In-classroom setting



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- At-home setting



Photo: ©2011 Chris Nakamura,
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Three-modes of Testing



- One-on-one interview setting
 - Observe details of use that the log would miss
 - Get student's immediate feedback
 - Cross-check on physics knowledge
- In-classroom setting
 - Access the student population in a controlled environment and encourage completion
 - Teacher can observe and cite difficulties
- At-home setting
 - Test under ultimate design condition: This is a system that is to be used at home

One-on-one Interview Mode



Testing PALE Fall 2010

- Algebra-based college physics students (N = 22)
- All 7 PALE experiences were used
- Volunteers were solicited for modest compensation
- One session per week for three weeks.
- Worked on a lesson for 1 hr. and discussed the lesson and their work for ~30 min.
- Interviews were conducted by SI tutors

In-class Mode



Testing PALE Fall 2010

- Five classes of highschool physics students ($n = 12, 13, 10, 8, 16$; $N = 59$)
- Students completed the lessons in-class under the supervision of the classroom teacher.
- 4 of the PALE experiences were used (One tutor was eliminated)

At-home Usage Mode



Testing PALE Fall 2010

- Concept-based college physics students, mostly elementary ed. majors in a large enrollment class (N = 107)
- Students were assigned the completion of one lesson per week for a homework grade
- 4 of the PALE experiences were used (One tutor was eliminated)

Data Analysis



Schematic of a data set

| | | | | | | | | | | | | |
|-----------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Student 1 | Q ₁ | A ₁ | A ₂ | Q ₂ | | A ₃ | Q ₃ | A ₄ | A ₅ | | | |
| Student 2 | A ₁ | A ₂ | A ₃ | Q ₁ | Q ₂ | | A ₄ | Q ₃ | A ₅ | | | |
| Student 3 | A ₁ | Q ₁ | A ₂ | Q ₂ | Q ₃ | Q ₄ | A ₃ | Q ₅ | A ₄ | A ₅ | | |
| Student 4 | A ₁ | A ₂ | A ₃ | Q ₁ | Q ₂ | Q ₃ | A ₄ | A ₅ | | | | |
| Student 5 | A ₁ | Q ₁ | | Q ₂ | | A ₂ | Q ₃ | Q ₄ | A ₃ | Q ₅ | Q ₆ | Q ₇ |
| Student 6 | A ₁ | A ₂ | A ₃ | A ₄ | A ₅ | | | | | | | |



Additionally we have

- Video recordings of algebra-based students' usage
- Transcripts of algebra-based students' interviews
- Teachers' comments and observations

Data Analysis



Multi-faceted analysis procedure is needed

- Quantitative analysis & data-mining of PALE log
- Phenomenographic analysis of interview data
- Integrative procedure to obtain a complete picture
- This is an ongoing effort

Summary & Future Work



Summary

- Collected three complimentary data sets with PALE
- Each addresses different but related aspects of PALE testing
- Multi-faceted analysis techniques will likely be needed to extract a clear picture of PALE's efficacy

On-going Efforts

- Continue data analysis efforts
- Continue acquiring data in different settings with different student populations

References



1. Bloom, B. S. (1984). "The 2-sigma problem: The search for methods of group instruction as effective as one-to-one tutoring," *Educational Researcher*, 13(6), 4-16.
2. Chi, M. T. H., Siler, S. A., and Jeong, H., (2004). "Can tutors monitor students' understanding accurately?," *Cognition and Instruction*, 22(3), 363-38.
3. Karplus, R, and Butts, D. P. (1977). "Science teaching and the development of reasoning," *Journal of Research in Science Teaching*, 14(2), 169-17.
4. S. Y. Okita, J. Bailenson, and D. L. Schwartz in *Proceedings of the 8th International Conference for the Learning Sciences*, (Lawrence Erlbaum and Associates, Utrecht, Netherlands, 2008), pp. 132-139.

The End



Thank you

Contact Information:
cnakamur@phys.ksu.edu