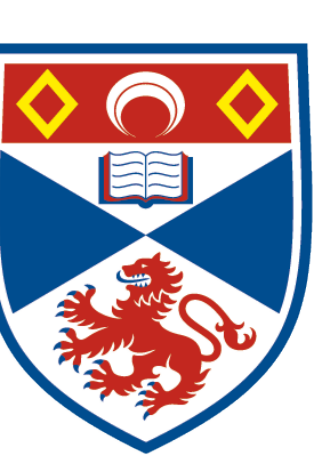# Evaluation Work For QuVis: The Quantum Mechanics Visualization Project

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600 YEARS

INTRODUCTION

Animations and simulations can help students build mental representations of physics concepts through high levels of interactivity, prompt feedback and multiple representations of physics concepts, including microscopic processes that cannot be directly observed. By choosing particular interactive elements and limiting their ranges, students can be implicitly guided in their exploration [1-3].

Since 2009 we have been developing and evaluating visualizations and animations (collectively called animations in what follows) for the teaching and learning of quantum mechanics concepts at university level [4,5]. This resource builds on existing education research as well as our teaching experience. The animations are in many ways complementary to other resources: Each animation shows a situation aimed at clarifying a particular concept and includes a step-by-step exploration that explains key points in detail. Many animations include instructor resources consisting of worksheets with full solutions. Animations and instructor resources are freely available at www.st-andrews.ac.uk/~qmanim, and can be played or downloaded from this site. Animations are available on a wide range of topics from introductory to advanced quantum mechanics.

EVALUATION METHODS

Animations are used at St Andrews in the PH2012 Quantum Physics course taken by physics majors in their first or second year of study and the PH3061 Quantum Mechanics 1 course taken in their second or third year of study. We have used the following methods to evaluate the QuVis animations:

• Student questionnaires assessing student attitudes towards and use of the animations.

• A diagnostic survey to evaluate learning gains. The survey is multiple-choice, but asks students to explain their reasoning and rate their confidence on each question.

• Observation sessions with a small number of student volunteers. In these sessions, students were asked to think aloud while interacting freely with an animation not yet encountered.

• Facilitation of the Quantum Physics workshop session in which students interact with animations.
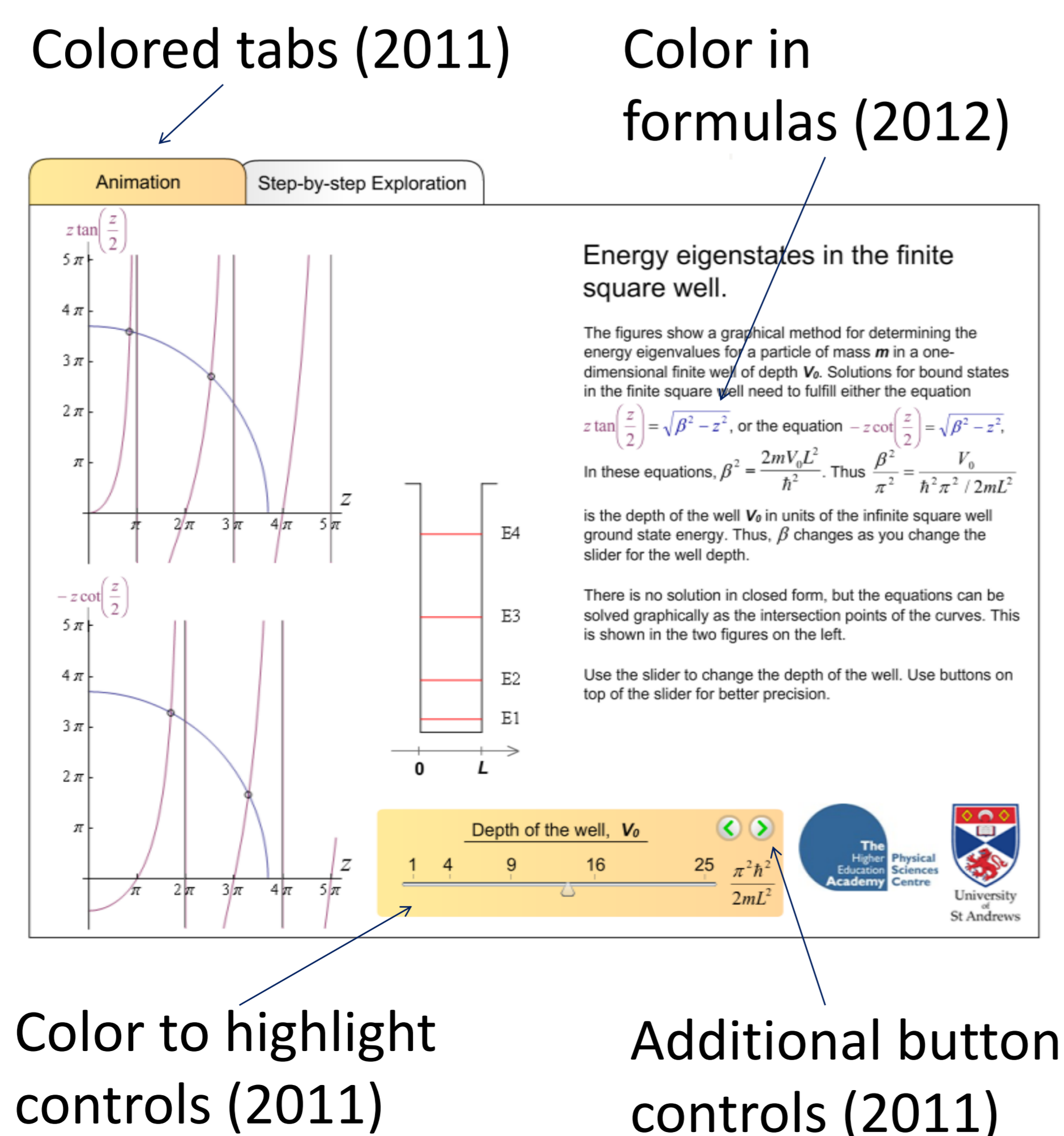
DIAGNOSTIC SURVEY OUTCOMES

In 2011 and 2012, we administered the diagnostic survey to Quantum Physics students in a lecture slot at a time when part of the class had interacted with two animations (The Finite Well, The Potential Step) in an hour-long workshop, whereas the other part of the class had not yet used animations. The survey covered topics from the Quantum Physics course. Two questions on the survey, question 5 on the finite well and question 7 (from the QMVI [6,7]) on the potential step, covered the topics of the animations used in the workshop. All students had worked on tutorial problems on these topics. One can see that students who had used the animations outperformed students who had not on questions 5 and 7 in both years.
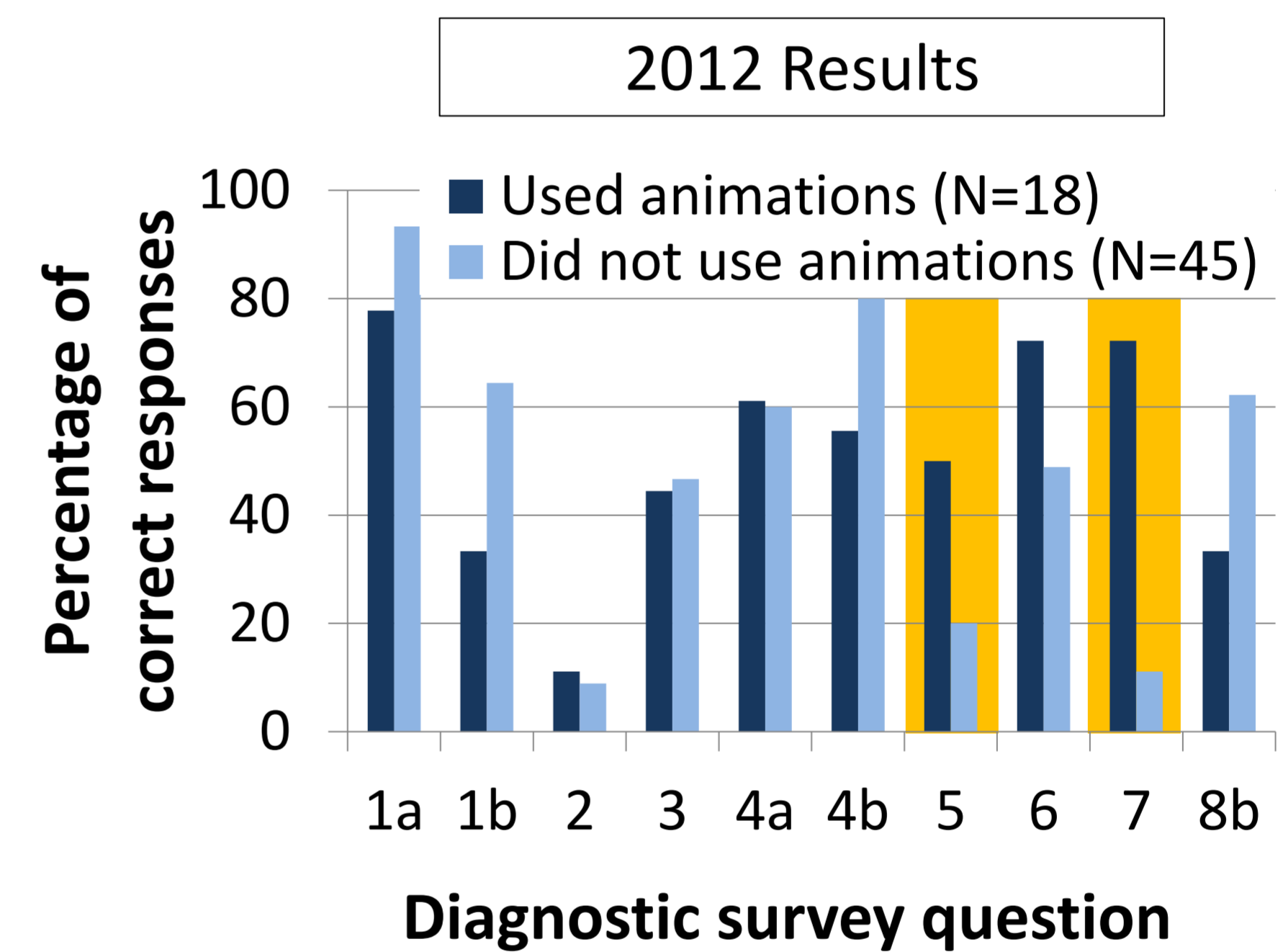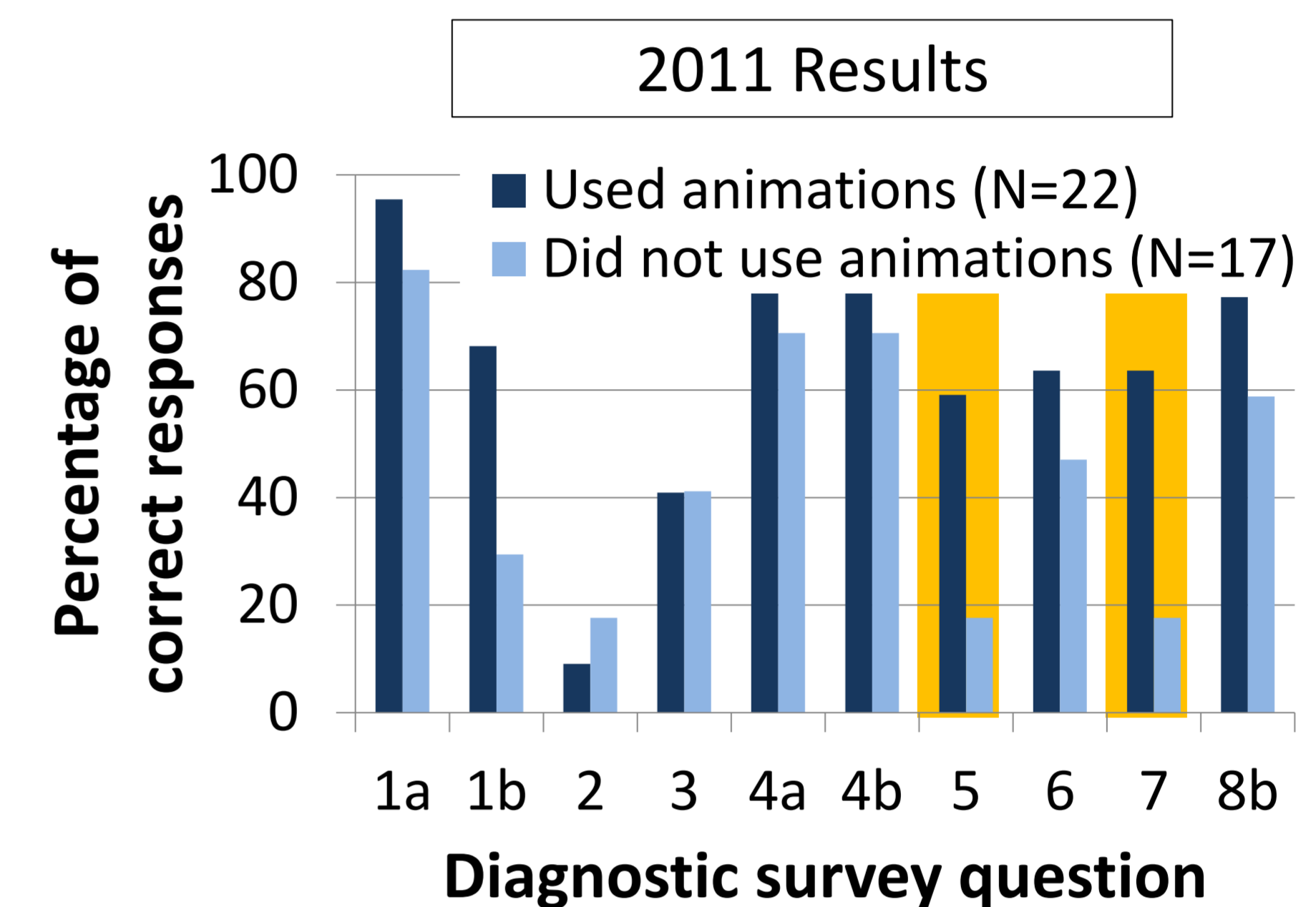
The students who had used the animations were also more confident that their answer was correct for these two questions. Explanations of reasoning showed that students that had used the animations were justifying their choices using physical arguments and not just remembering the shapes of curves.

EXAMPLE: REVISIONS TO THE FINITE WELL ANIMATION DUE TO EVALUATION OUTCOMES

The Finite Well animation was developed in summer 2010. In summer 2011, we revised all animations as a result of student observation sessions. We also considered research outcomes of the PhET team in these revisions [1-3]. In summer 2012, further revisions addressed student difficulties during the Quantum Physics workshop.

Colored tabs (2011)

Color in formulas (2012)

Improved graphics, using colored curves (2011)

Color to highlight controls (2011)

Additional button controls (2011)

Additional animated steps explaining relation between intersection points and energy levels (2012)

Step counter and clearer step controls (2011)

Steps with user interactivity (not shown, 2012)

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