Making iPad Videos to Learn Physics

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Abstract

We describe the iPad video physics project at SUNY Buffalo State College, in which we used a class set of iPads to support student learning of introductory physics content both in traditional undergraduate courses and graduate level courses for physics teacher preparation. The iPads were used both for traditional video capture and model fitting via Vernier Video Physics, and video editing and voiceover for the production of student physics content multimedia presentations similar to YouTube's Minute Physics or Veritasium videos. We report student feedback, some pre- and post- standardized student conceptual learning scores (BEMA, TUG-K and FCME) for the courses, instructor comments and lessons learned. This work was supported by the NSF, SUNY IITG and the University of Cologne as well as SUNY Buffalo State Physics.

iPad as a Measurement Device

Two of the most common physics apps for the iPad are Vernier's *Video Physics* and *Graphical Analysis*. *Video Physics* allows students to capture and analyze video footage by using motion-tracking technology. With *Graphical Analysis*, the video data can be easily analyzed and fit with mathematical models. Thus, on a single device students are able to go from the raw video footage to the data analysis in minutes time.

A screenshot from *Vernier Video Physics* is shown.

iPad as a Multimedia Device

The multi-tasking capabilities of the iPad far exceed those of any past multimedia tool. On a single device, students can capture photos and video, use motion-tracking software, edit raw footage, piece together video clips, add sound effects, create voice-over, and produce YouTube style videos. This is made possible by the *iMovie* app that Apple provides on every iPad free of charge. Another free app for multimedia production is *iMotion*, which allows the user to film stop-motion videos. Stop motion has become a staple of YouTube science videos, particularly those created by Henry Reich on his minutephysics Youtube channel. Combined, these apps allow for the production of science videos by almost anyone.

A screenshot from *iMovie* .

A screenshot from *iMotion*.

Physics Content Multimedia Presentations

By combining the measurement and multimedia capabilities of the iPad, it is possible to produce the types of science videos popularized by minutephysics and Veritasium. These are not slide presentations, lab reports, or compilations of raw experimental footage. Instead, they explain physical phenomena with narration, scripted scenes, experiments, illustration, and animation.

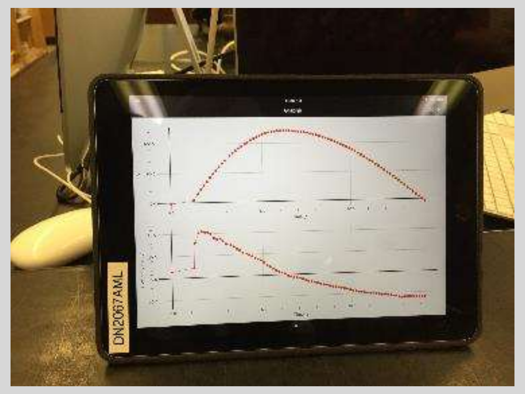
At the University of Cologne, Germany, physics students are assigned group projects in which they use iPads to create multimedia presentations. The purpose of the assignment is not for students to contribute new or improved science videos to the YouTube community. Instead, they are expected to learn about a physical phenomenon through the process of video production.

The assignment promotes a high level of engagement by allowing students to use the familiar technology of handheld devices. More importantly, all students must gain a firm conceptual understanding in order to create an effective video. The project is a much better learning tool than the resulting video, making it an appropriate assignment in college and university settings.

iPads in Undergraduate Courses

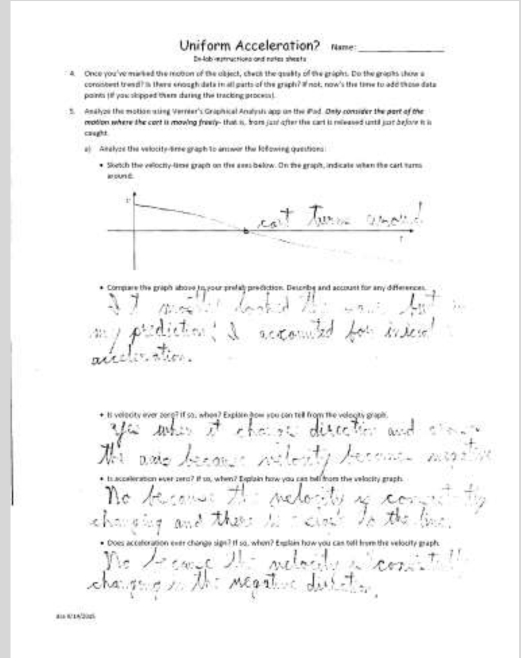
The physics department at Buffalo State College successfully applied for a technology grant from SUNY IITG in the spring of 2015. This grant allowed the department to purchase eleven iPads for instructional use and the development of laboratory experiments in mechanics. Three such experiments were created during the fall semester, and were employed in an introductory calculus-based mechanics course at the college, PHY 111. Each lab utilized the iPads to take data via Vernier's *Video Physics* and *Graphical Analysis* apps. Photos from these experiments and an image of a student handout are shown below.

Dr. Dave Ettestad assists students in using an iPad.



A shot of the graphing capabilities of *Graphical Analysis.*

Students are shown filming an experiment to determine the coefficient of kinetic Friction between a block of wood and a metal track.

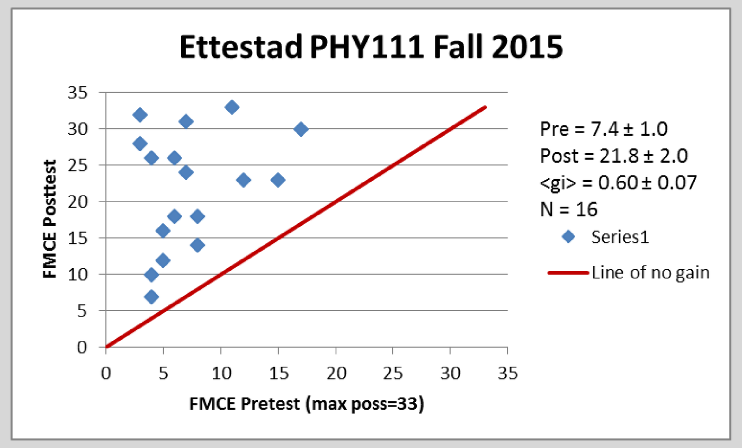


An example of a student lab handout is shown.

Data

The Force and Motion Conceptual Evaluation (FMCE) was used to obtain a quantitative measure of conceptual learning outcomes. Pre- and Post- assessment scores, as well as gain scores are reported for PHY 111 classes taught by Dr. Dave Ettestad over the past few years at Buffalo State. The most recent results are in bold.

Test	Course	Instructor (Term)	N	Max	Pre	Post	<gi>
FMCE	**PHY111**	**Ettestad (F15)**	**16**	**33**	**7.4 (1.0)**	**21.8 (2.0)**	**0.60 (0.07)**
FMCE	PHY111	Ettestad (S14)	20	33	8.1 (1.3)	21.4 (1.5)	0.55 (0.05)
FMCE	PHY111	Ettestad (F13)	18	33	10.1 (1.2)	21.0 (2.4)	0.46 (0.11)
FMCE	PHY111	Ettestad (F12)	25	33	10.2 (1.6)	20.4 (1.6)	0.52 (0.05)

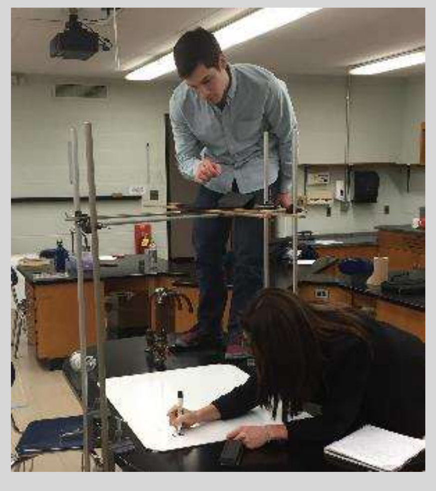


Pre- and Post- scores on the FMCE are shown above.

iPads in Graduate Courses

During the months of July and August 2015, Buffalo State held two of its annual summer courses for physics teachers: PHY 510 Physics for High School Teachers: Content & Pedagogy, and PHY 622 Powerful Ideas and Quantitative Modeling: Electricity and Magnetism. For the first time, both courses included a physics content media presentation as a group project. Students were provided iPads for use on the project and were provided guidance and support by instructors from the University of Cologne.

Two students from PHY 622 are shown working on their physics content media presentations.



Two students from PHY 520 are shown working on an iPad video.

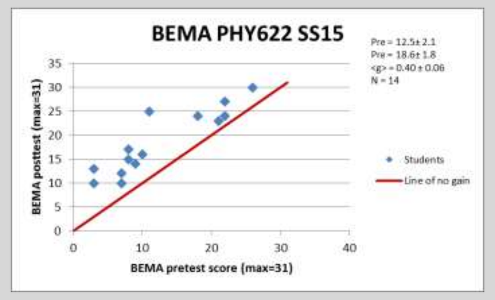
During the Fall 2015 semester at Buffalo State, two students from PHY 520, Modern Physics, also completed an iPad physics content media presentation. They created a video as a resource for educators teaching about radioactive decay.

Videos created at Buffalo State are available on Dan MacIsaac's Youtube channel. (Simply search Dan MacIsaac on the homepage of Youtube.)

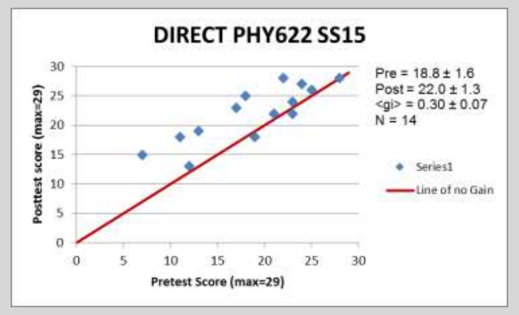
Data

Two assessments are typically used in PHY 622 to measure student learning outcomes: the Brief Electricity and Magnetism Assessment (BEMA) and the Determining and Interpreting Resistive Electric Circuit Concepts Test (DIRECT). As before, the most recent class results are in bold.

Test	Course	Instructor (Term)	N	Max	Pre	Post	<gi>
BEMA	**PHY622**	**MacIsaac et al. (SS15)**	**14**	**31**	**12.5 (2.1)**	**22.6 (1.6)**	**0.40 (0.06)**
BEMA	PHY622	MacIsaac et al. (SS13)	17	31	13.4 (1.5)	19.0 (1.0)	0.30 (0.05)
BEMA	PHY622	MacIsaac et al. (SS11)	11	31	14.2 (2.2)	19.2 (2.2)	0.29 (0.09)
BEMA	PHY622	MacIsaac et al. (SS10)	8	31	13.6 (2.8)	19.6 (1.9)	0.35 (0.12)
DIRECT	**PHY622**	**MacIsaac et al. (SS15)**	**14**	**29**	**18.8 (1.6)**	**22.0 (1.3)**	**0.30 (0.07)**
DIRECT	PHY622	MacIsaac et al. (SS13)	17	29	15.8 (1.1)	21.4 (1.1)	0.41 (0.06)
DIRECT	PHY622	MacIsaac et al. (SS11)	11	29	19.2 (1.6)	21.6 (1.6)	0.29 (0.10)
DIRECT	PHY622	MacIsaac et al. (SS10)	8	29	19.8 (1.5)	24.5 (1.4)	0.52 (0.08)



Pre- and Post- assessments scores on BEMA are shown on the left.



Pre- and Post- assessments scores on DIRECT are shown on the right.

Discussion & Lessons Learned

From the Undergraduate Course (digitized video in calculus-based mechanics)

The iPad video motion labs developed for PHY 111 were fairly successful. The experiments went smoothly and students clearly learned something from each lab. The iPads and the apps we used (Vernier's Video Physics and Graphical Analysis) worked well – our campus Information Technology support folk got the apps on the iPads, and both students and instructors adopted the technology seamlessly.

Discussion & Lessons Learned (continued)

Our data suggest no correlation between the use of iPad technology and conceptual learning outcomes in the physics classroom. Scores on standard assessments (FMCE) for PHY 111 are in line with the norm for this course and instructor. *We believe this shows the use of iPads did no harm to student learning.* The data will be used as a baseline for future implementations of iPad activities in introductory courses. In the coming semester, we hope to tweak the existing labs for improved understanding and to develop new labs for other courses.

From the Graduate Course (teachers learning physics by making media presentations)

See Muller's ***YouTube Veritasium*** video "Khan Academy and the Effectiveness of Science Videos" for a cogent discussion of the limits of clear explanation. Our takeaway insight is *"Watching a clear and correct explanation is NOT learning; but creating and refining your own clear and correct presentation fosters learning."*

Making quality videos is hard work, and almost certainly an inappropriate goal for physics content courses for students who are becoming physics teachers. However, the fun, professionalism and attention to detail required of making quality physics videos – especially a final draft video with accompanying notes for improvement does seem appropriate for future physics teachers. While making a video, future physics teachers learn simple video planning, shooting, editing and voiceover skills that call upon their abilities to research physics content and prepare a clear, concise and appropriate presentation order, visualizations, footage, language and mathematics. This serious, enlightening and intense attention to detail and deliberate refined practice is similar to Japanese lesson study and not at all typical of North American STEM teacher preparation. As part of the process future teachers improve their own subject matter knowledge and refine rigorous articulate language, clarity of thought and representation skills they can call upon to guide student discourse in their own classrooms. The participant's physics videos (while highly motivational) are almost an afterthought to the process, and *we strongly believe that attempting to follow through to produce a professional grade video is best left to a follow up project, independent study or capstone project.*

Our Advice: Have students start as early as possible with multiple researched topic explanations (including critiques of other literature and videos), a storyboard and checked mathematics. Students have not generally been exposed to professional-level outcome expectations and usually strive to produce a last minute highly imperfect school-level draft outcome that most classroom instructors accept. *For a physics course final product, we suggest you plan on a solid draft video with extensive guidelines for improvement as an acceptable outcome. Expect much student humor, creativity and lots of "inside jokes" along the way.*

References & Links

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Acknowledgements

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The iPad labs and this poster are available from:
http://physicsed.buffalostate.edu/pubs/AAPTmtgs/AAPT2016Jan/