Undergraduate Students Experience in Using Simulations and Remote Web-based Science Labs in Physics

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NANSLO Webinar 9/19/14

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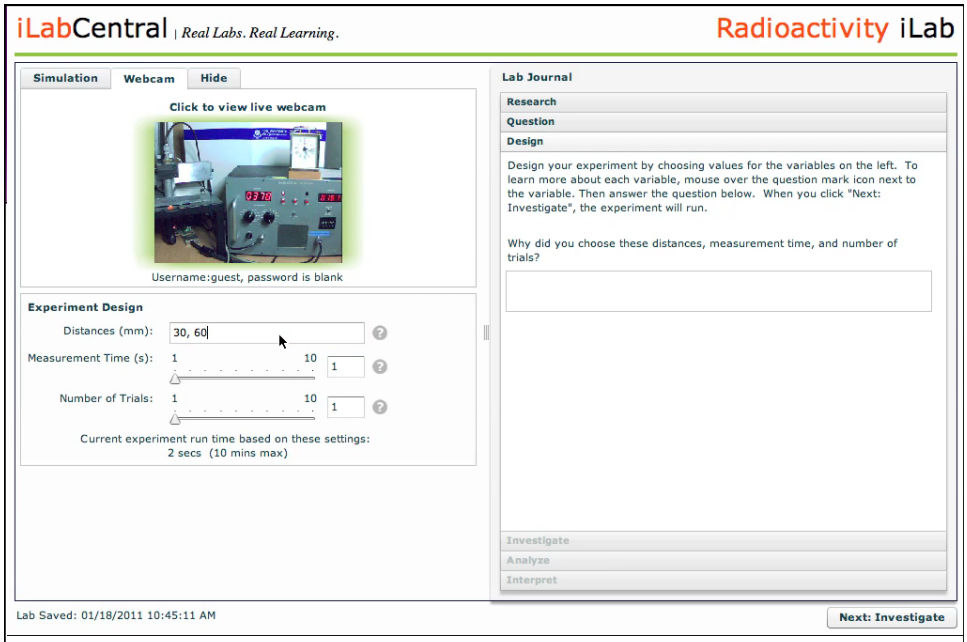
WHAT ARE REMOTE LABS?



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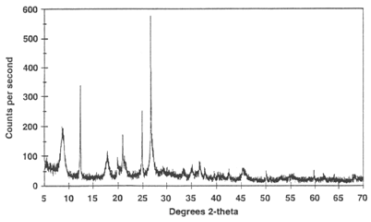
Northwestern X-ray powder diffraction iLab

- Identification of unknown crystalline materials
- Measurement of sample purity



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Thompsons River University Shimadzu TOC/TN Total Organic Carbon/Nitrogen Analysis

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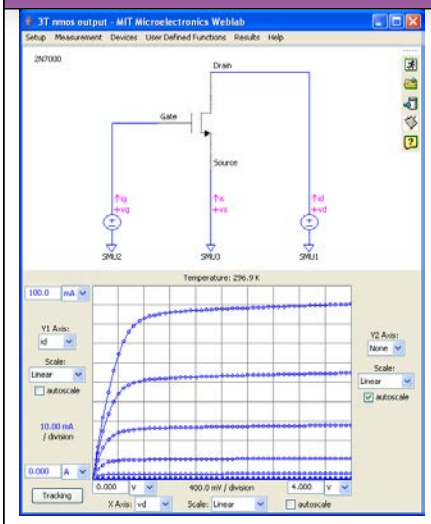
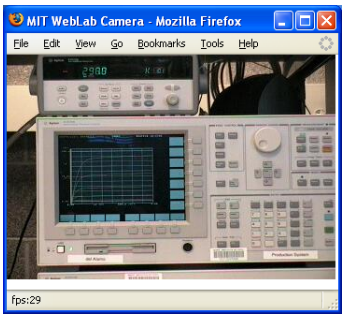
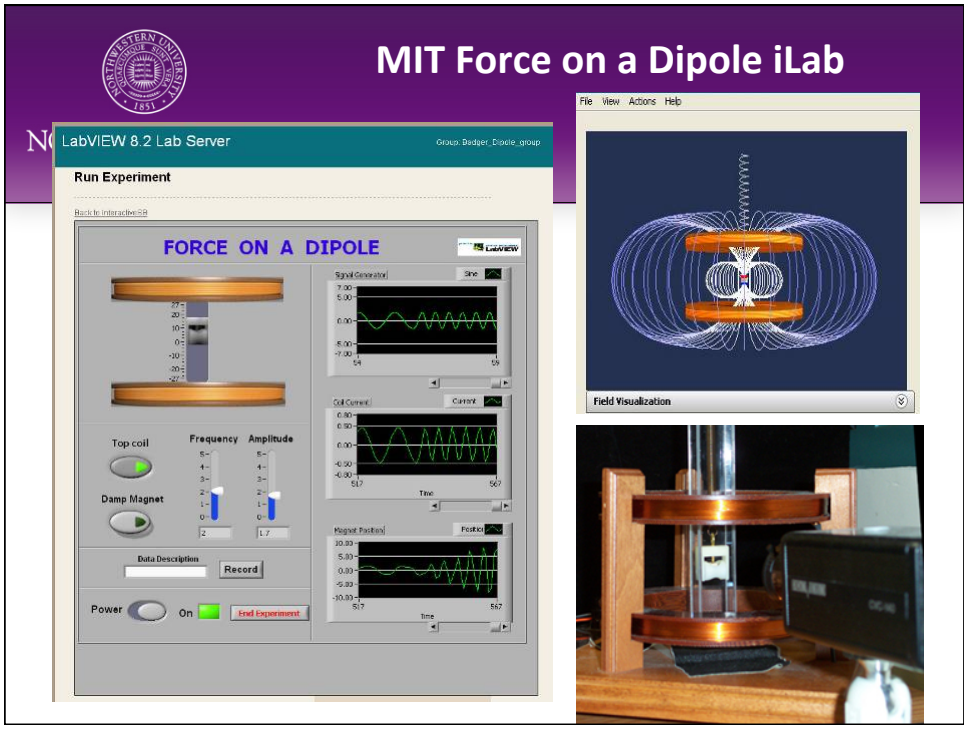
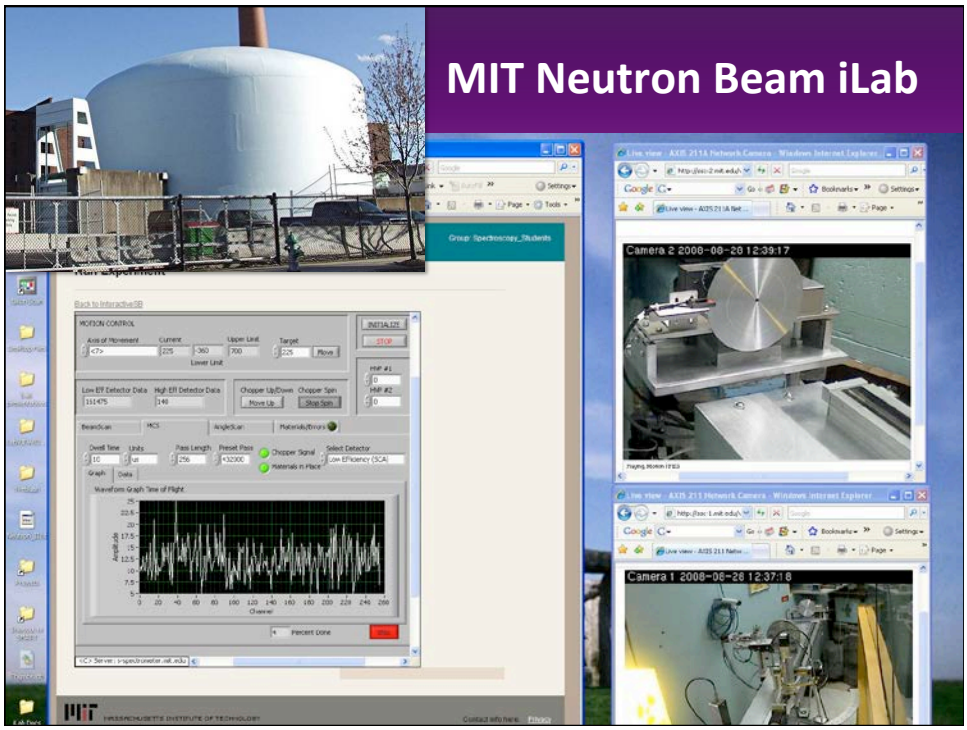
MIT Microelectronics Device Characterization iLab





Del Alamo, J. A., Brooks, L., McLean, C., Hardison, J., Mishuris, G., Chang, V., & Hui, L. (2002, May). The MIT microelectronics weblab: A web-enabled remote laboratory for microelectronic device characterization. In World Congress on Networked Learning in a Global Environment, Berlin (Germany).


MIT Force on a Dipole iLab
LabVIEW 8.2 Lab Server
Run Experiment
FORCE ON A DIPOLE
Top coil
Frequency
Amplitude
Damp Magnet
Data Description
Record
Power
On
End Experiment
File View Actions Help
Field Visualization


MIT Neutron Beam iLab
Camera 2 2008-08-26 12:39:17
Camera 1 2008-08-26 12:37:18

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University of Technology Sydney Remote Lab Facility

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Conventional, remote, and simulation labs

"The debate over different technologies is confounded by the use of different educational objectives as criteria for judging the laboratories: Hands-on advocates emphasize design skills, while remote lab advocates focus on conceptual understanding. We observe that the boundaries among the three labs are blurred in the sense that most laboratories are mediated by computers, and that *the psychology of presence may be as important as technology*."

Ma, J. & Nickerson, J. V. (2006). Hands-on, simulated, and remote laboratories: A comparative literature review. *ACM Computing Survey, 38*(3), p. 7. My emphasis.

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What are the learning goals?

Table III. Educational Goals for Labora

Lab Goals	Description
Conceptual understanding	Extent to which laboratory activities help students understand and solve problems related to key concepts taught in the classroom.
Design skills	Extent to which laboratory activities increases student's ability to solve open-ended problems through the design and construction of new artifacts or processes.
Social skills	Extent to which students learn how to productively perform engineering-related activities in groups.
Professional skills	Extent to which students become familiar with the technical skills they will be expected to have when practicing in the profession

Ma, J. & Nickerson, J. V. (2006). Hands-on, simulated, and remote laboratories: A comparative literature review. *ACM Computing Survey, 38*(3), p. 8

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Goals of each lab type

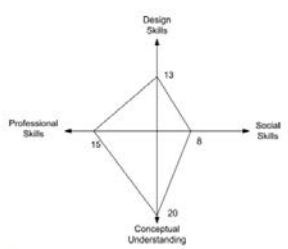

Fig. 1. Educational goals of hands-on labs.

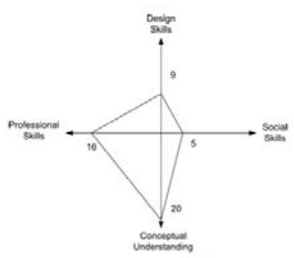

Fig. 2. Educational goals of simulated labs.

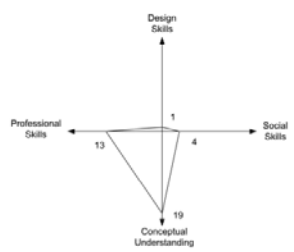

Fig. 3. Educational goals of remote labs.

Ma, J. & Nickerson, J. V. (2006). Hands-on, simulated, and remote laboratories: A comparative literature review. *ACM Computing Survey, 38*(3), p. 7.

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HOW DO REMOTE LABS COMPARE WITH SIMULATIONS?

Sauter, M,. Uttal, D., Rapp, D., Downing, M., & Jona, K. (2013). Getting real: The authenticity of remote labs and simulations for science learning. *Distance Education Journal, 34*(1), 37-47.

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Study design

	Visualization Condition	
Lab type	Remote lab + photo	Remote lab + live webcam
	Simulation + photo	Simulation + prerecorded video

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Subjects

- 123 undergraduate students
  - Freshmen (N=83)
  - sophomores (N=19)
  - juniors (N = 10)
  - seniors (N = 11)
- Previous physics coursework (avg = 1 course)
  - 13 had no previous physics experience
  - 56 had taken high school introductory physics
  - 33 had taken AP physics in high school
  - 21 had taken physics at the college level.

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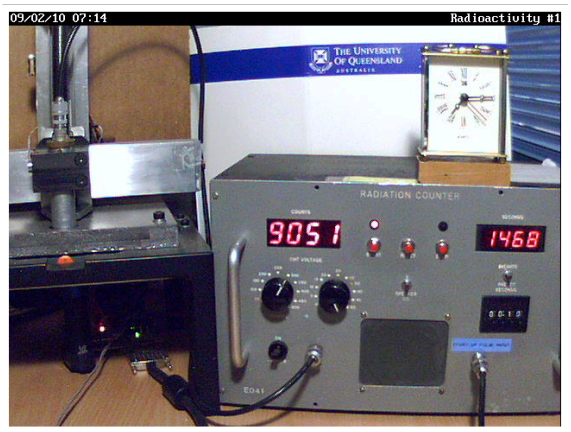
Still photo condition



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Identical display of resulting data (simulated or real)

Results Export Results

Experiment Design

Distances (mm): 15, 17, 20, 25, 30, 45, 60

Measurement Time (s): 5

Number of Trials: 5

Trial 2 (particle	Trial 3 (particle	Trial 4 (particle	Trial 5 (particle counts)
293	313	301	319
214	233	240	215
165	166	176	162
110	91	107	86
44	53	59	38

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RESULTS

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Presence

- The remote lab group rated their experience as more like a real lab.
- Remote lab users more strongly believed that they had done a real experiment than simulation users did $F(1, 117) = 5.14$, $p = <.05$.
- Simulation users who saw the video reported feeling more like they completed an experiment than did simulation users who just saw a photo, $F(1, 58) = 6.22$, $p = <.05$, with no analogous difference for remote users, $F(1, 59) = .45$, p = ns.

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Preference for lab type

- Participants preferred the remote lab over the simulation, particularly if they had completed the remote lab, $\chi2(1, N = 116) = 13.511$, $p = <0.01$. Few remote lab users preferred the simulation.
- This preference did not vary as a function of viewing a picture or video within either the remote lab ($\chi2$ (1, N = 56) = .012, p = ns) or simulation ($\chi2$ (1, N = 54) = .313, p = ns).
- This means that the lab type exerted a greater influence on participants' lab preferences than the visual features did.

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Prompting "scientific thinking"

- Remote lab users tended to expect variability in their data more often than simulation users did, F(1, 116) = 4.09, p p=0.053.
- Remote lab users more likely to want to run lab again, F(1114) = 4.24, p = <.05.
- Remote users who saw a video more likely to want to rerun the lab as compared to users who saw a photo, F (1, 57) = 5.23, p = <.05.
- Simulation users showed no such pattern, F(1, 57) = 0.04, p=ns.
- Participants' reasons for wanting to rerun the lab included a desire to confirm or replicate their original data and to try different settings or methods.

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Remote Lab vs. Simulation

- **Key results**
  - Participants who used the remote lab wrote higher-quality research questions [$F(1, 121) = 15.99$, $p < .01$]
  - Remote lab users who saw a video of the device wrote higher-quality questions than did users who saw only a photo [$F(1, 60) = 12.04$, $p < .01$], but simulation users did not show this difference [$F(1, 59) = .258$, p = N.S.]
- **Implications**
  - Remote lab users seemed more invested in the actual experiment– they crafted better research questions, considered how their experiment limited human error while also evaluating other possible sources of variability in their data, and wanted to run their experiment multiple times
  - Remote users who watched the video felt most engaged with the task

Sauter, M,. Uttal, D., Rapp, D., Downing, M., & Jona, K. (2013). Getting real: The authenticity of remote labs and simulations for science learning. *Distance Education Journal, 34*(1), 37-47.

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Learning differences: Conceptual understanding

- Within the remote group, participants who saw a video were better at explaining the relation between distance and intensity of radiation than those who only saw a photo, $F(1, 58) = 8.38$, $p = <.01$, with no comparable difference for simulation users, $F(1, 58) = 2.29$, p=ns.
- By viewing the video, participants saw the relation between distance and radiation in action: The particle counts decreased as the Geiger sensor moved away from the source.

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Research question quality

- Participants who used the remote lab wrote higher-quality questions than did participants who used the simulation, $F(1, 121) = 15.99$, $p = <.01$.
- And, remote lab users who saw a video wrote higher-quality questions than did users who saw a photo, $F(1, 60) = 12.04$, $p = <.01$
- Simulation users did not show this difference, $F(1, 59) = 0.258$, p = ns).

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Experimental design quality

- Participants' experimental designs did not differ according to condition.

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Improved Experimental Designs & Research Questions

For students conducting more than one run of the experiment

N=352

Experiment Design Parameter	First Run	Second Run	Significance
Average number of distances	5.8	7.7	$p < 0.001$
Average measurement time	5.5	5.8	$p < 0.001$
Average number of trials	5.0	5.5	$p < 0.01$
Research question quality	1.47	1.54	$p < 0.05$

Jona, K. & Vondracek, M. (2013, January). A Remote Radioactivity Experiment. *The Physics Teacher, 51,* 25-27.

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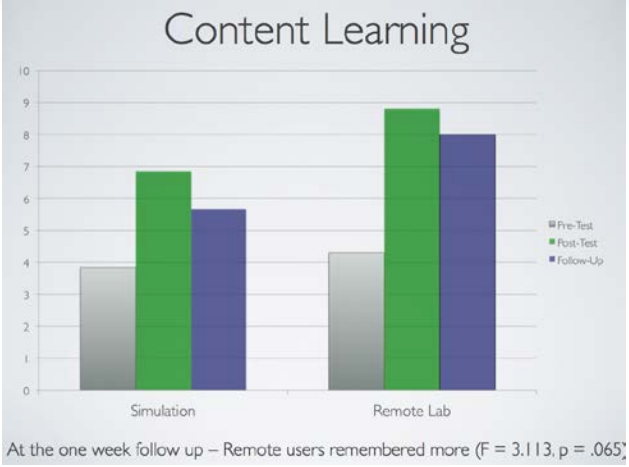
Better retention



Source: Michael Downing (2012), Undergraduate Thesis, Northwestern University Dept. of Psychology

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Flexibility of access = greater opportunity to engage in scientific inquiry

First Run of Experiment	N	Distances	Measurement Time	Trials
In Class	238	5.04	5.10	4.50
Out of Class	342	7.21	6.17	6.31

✓ Experimental designs were of higher quality when used out of class time

Jona, K. & Vondracek, M. (2013, January). A Remote Radioactivity Experiment. *The Physics Teacher, 51,* 25-27.

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Flexibility of access = greater opportunity to engage in scientific inquiry

	In class	Out of Class	Significance
Students conducting 3 or more experimental runs	4.6%	12%	$p < 0.0001$

✓ When used out of class time, 3X students *voluntarily* did more experiments than required

Jona, K. & Vondracek, M. (2013, January). A Remote Radioactivity Experiment. *The Physics Teacher, 51*, 25-27.

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Conclusions

- An important difference between the remote lab and simulation conditions involved beliefs about the data source
- Remote lab users are able to gather real data from a real device whereas simulation users use computationally derived data -- which did not feel as realistic or scientifically authentic.
- Even though the remote lab and the simulation looked the same on the screen, the remote lab's connection to a real device was integral to fostering an engaging and realistic lab experience.

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Conclusions

- The authenticity of the data was important because it encouraged student engagement with the experimental task (e.g., higher-quality research questions and wanting to run the lab again).
- Earlier study showed that running the lab multiple times significantly increased experimental design and research question quality
- Also showed that given chance out of class, students do in fact voluntarily run lab more than required

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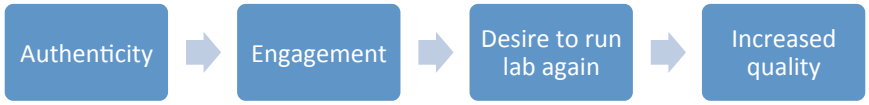
Logic model



Thank you!

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