Clickers in an introductory physics classroom

Presentation given to eight SMU physics faculty

Pavel Nadolsky
Department of Physics
Southern Methodist University
March 15, 2010

Introducing clickers at SMU Department of Physics

•Student response systems (clickers) are electronic devices for rapid feedback from the audience to the instructor

•Our department purchased a set of 100 clickers from TurningPoint Technologies using the funds of the Provost's Instructional Technology grant

• I am using clickers in most lectures of the PHYS 1304 course, Introductory Electricity and Magnetism, taught in Fall 2009 and Spring 2010 to 70+ students

In today's presentation, I will…

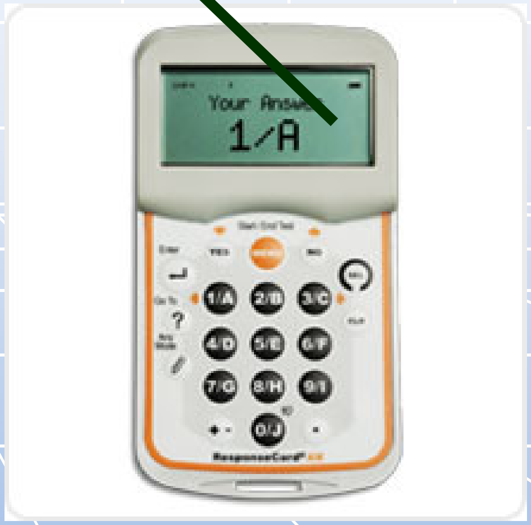
- share my experience with TurningPoint clickers
- give a tutorial on setting up clickers
- discuss the role of clickers, and novel instructional technology in general, in advancing physics instruction
    - **Recent research in physics education**: what is relevant for SMU?
    - **Interactive instruction vs. a traditional lecture**: does it make a difference?
    - **Learning outcomes for SMU undergraduates**: what do we want them to learn in the introductory physics courses?

Clickers:
basic applications

TEST YOUR CLICKER NOW

Press 0-9 from your seat

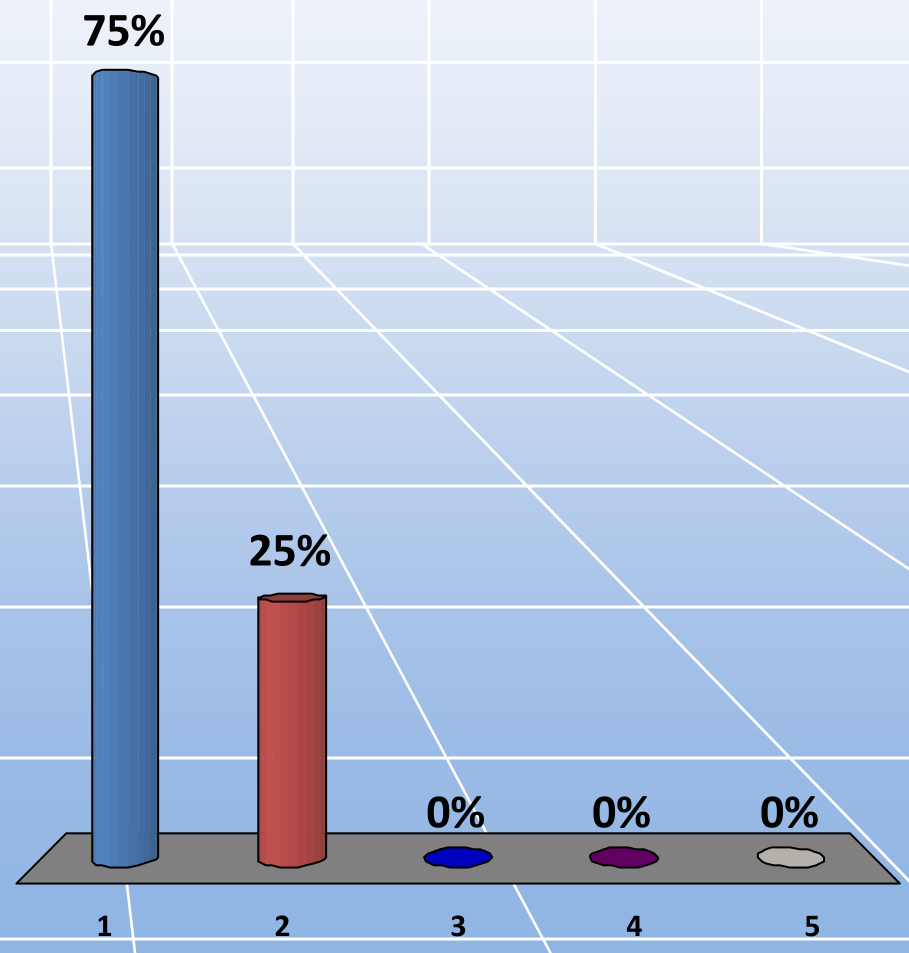
A checkmark appears on the right-hand side if your answer is received



A temporary ID of your clicker flickers in the table

Have you used clickers before?

1. Never
2. Rarely
3. Occasionally
4. Often
5. Very often



Some applications of clickers

- Support interactivity in large classes
- Evaluate students' progress on a frequent basis
- Quantitatively assess the quality of instruction to large groups of students
- Track attendance
- Carry out surveys and demographic studies
- Vote

Overview of clicker technology

Clicker systems are sold by several manufacturers (**Turning Technologies**, **eInstruction, iClicker,…**) at the price of $25-50 per device

Pros and cons of various brands are compared at http://www.uwec.edu/evansmm/SRS/clickerDecision.pdf

Our clickers…

- are bought from Turning Technologies (*www.**turningtechnologies**.com*)
- are supported by the SMU Office of Instructional Technology
- in my experience, are quite reliable; the manufacturer provides helpful support
- come with two **free** Windows programs:
  - **TurningPoint** – versatile, fully integrated with PowerPoint 2007
  - **TurningPoint Anywhere** – standalone, simple, limited

Interactive lectures with clickers

- Clickers are generally incompatible with the "traditional format" of the lecture, delivered "one-way" from the instructor to the audience
- They are well-suited for "active learning" lectures, such as **peer instruction** developed by E. Mazur
- With clickers, structure and pace of the lectures, as well as the curriculum must be reconsidered

Active learning in physics education

- According to a variety of studies, lectures with **active learning components** (collective discussions; hands-on activities;…) are **more efficient** in teaching the sci-tech undergrads than **the traditional combination** of one-way lectures + problem-solving recitations + labs + homework assignments

- Efficiency of active learning varies depending on its specific setup; but active involvement appears to be beneficial in most cases

See e.g., M. Prince, *Does Active Learning Work? A Review of the Research,* J. Engr. Education, 93(3), 223-231 (2004)

Active learning in physics education

Benefits of active learning are claimed to be enhanced by…

…changing the role of the instructor from being "just a lecturer" (source of **all** information delivered to **passive** listeners) to a facilitator of practical learning **by** students, who spends most time on elucidating essential points and targeting students' alternative conceptions

Active learning in physics education

Benefits of active learning are claimed to be enhanced by...

… allowing more time for in-class activities and discussions of physics phenomena and demos (at the expense of reduced discussion of abstract laws)

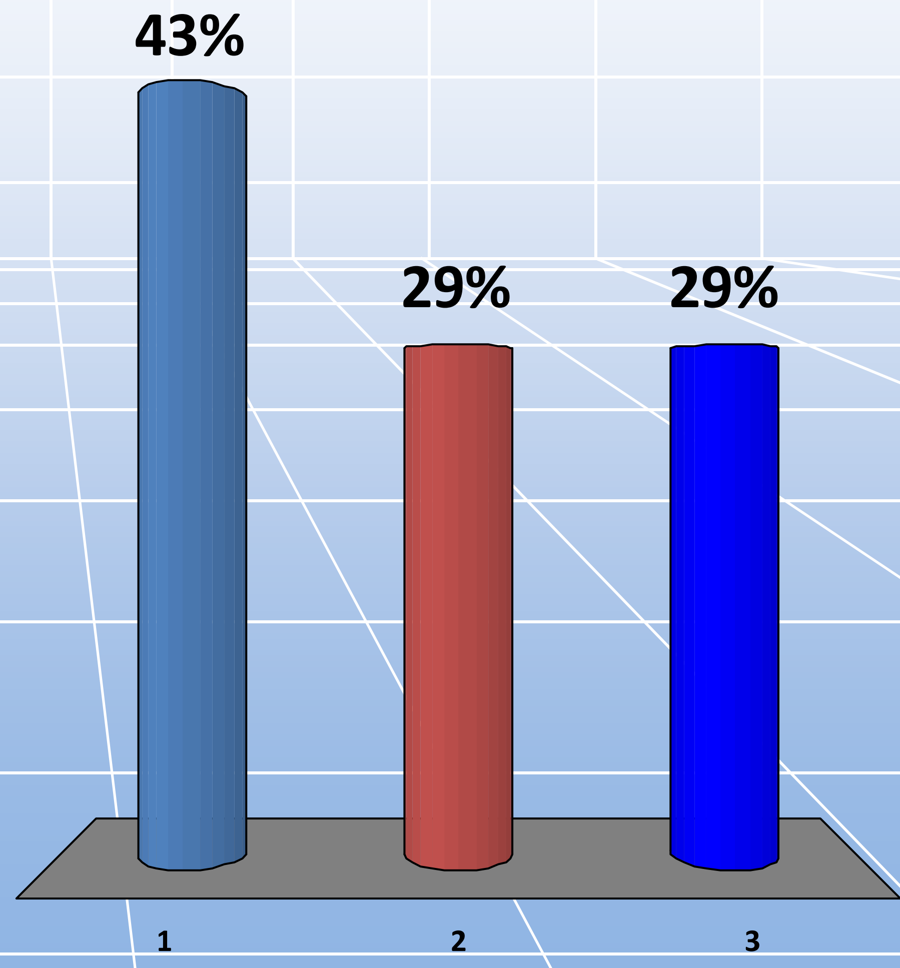
…changing expectations for learning outcomes

…changing the curriculum

…evaluating students' progress based on standard tests developed by statistical studies at a variety of colleges

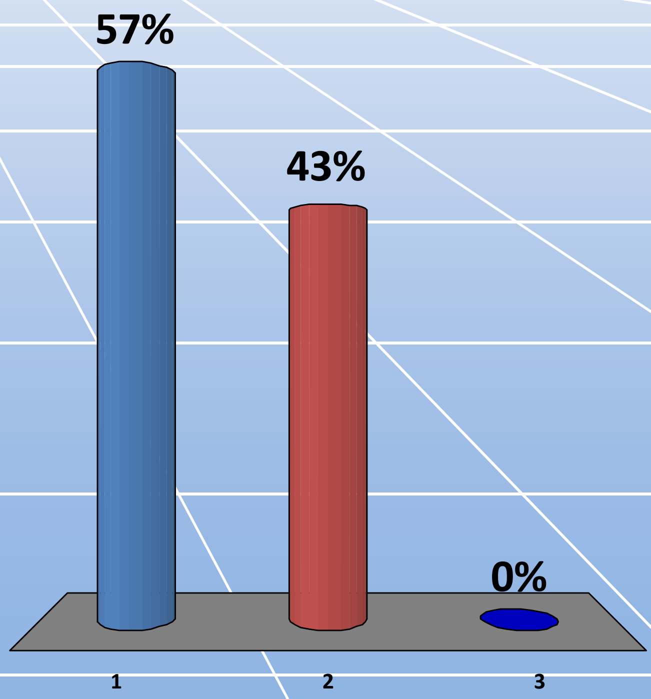
How closely are you following recent developments in physics education?

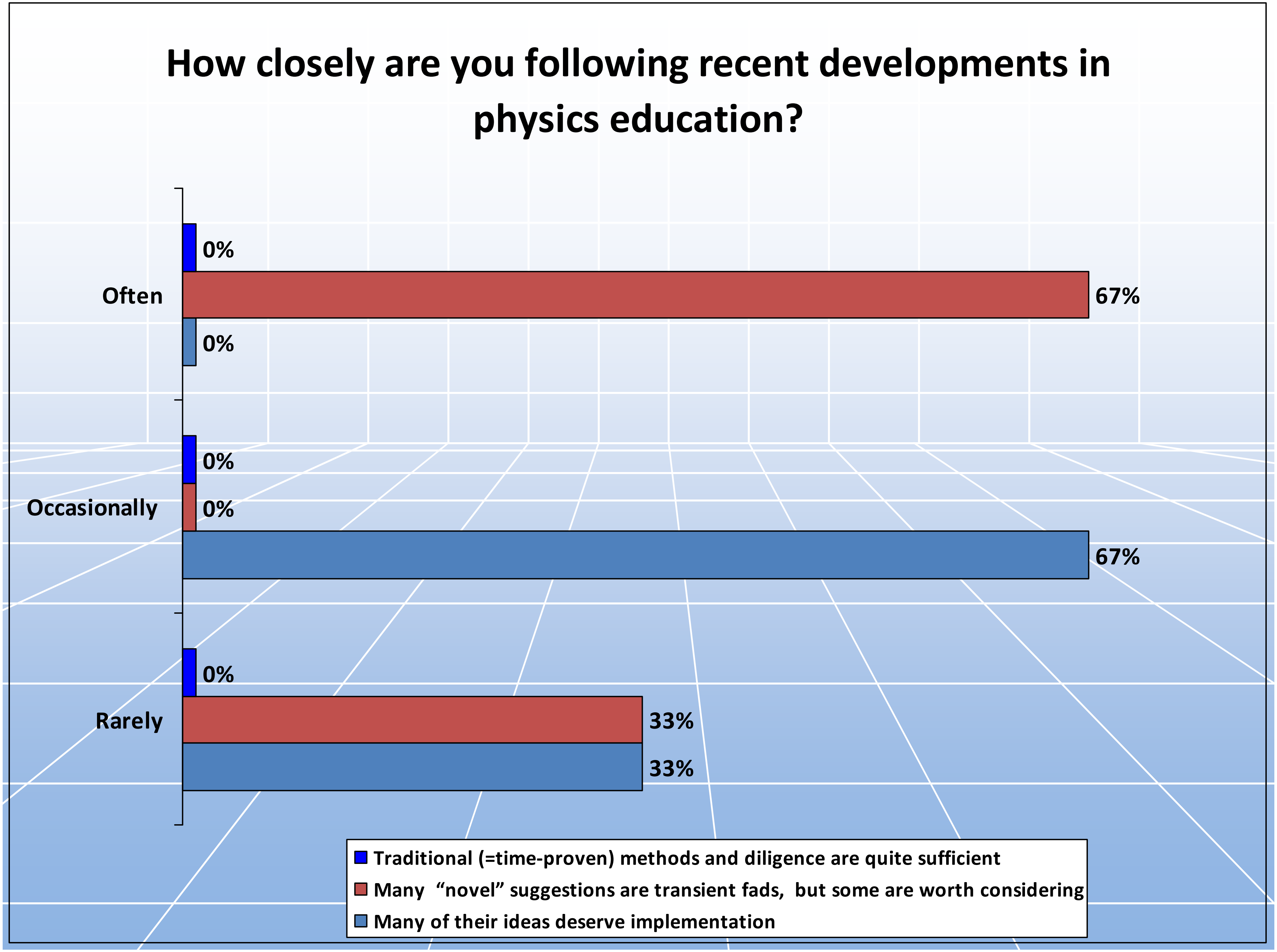
1. Often
2. Occasionally
3. Rarely



How enthusiastic are you about new approaches proposed by physics education papers?

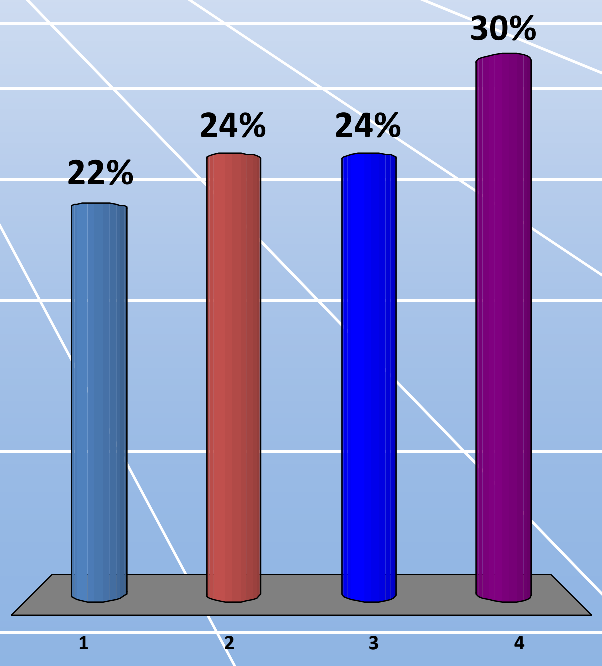
1. Many of their ideas deserve implementation
2. Many "novel" suggestions are transient fads, but some are worth considering
3. Traditional (=time-proven) methods and diligence are quite sufficient




How closely are you following recent developments in physics education?
Often
0%
67%
0%
Occasionally
0%
0%
67%
Rarely
0%
33%
33%
Traditional (=time-proven) methods and diligence are quite sufficient
Many "novel" suggestions are transient fads, but some are worth considering
Many of their ideas deserve implementation

Rank learning outcomes expected from SMU undergraduate students according to their importance. (1st response – most important outcome; 4th response – least important outcome)

1. Familiarity with essential physics phenomena shown in demos
2. Knowledge of basic concepts and "expert shortcuts and skills" applicable in a variety of situations
3. Familiarity with profound, even though challenging, ideas essential for systematic learning of physics (e.g. Gauss and Ampere's laws)
4. Ability to solve typical physics problems encountered in practical applications



Normalized gain G

A commonly used figure of merit to characterize "the teaching efficiency" is the normalized gain,

$$g = \frac{P_{post} - P_{pre}}{100\% - P_{pre}}$$

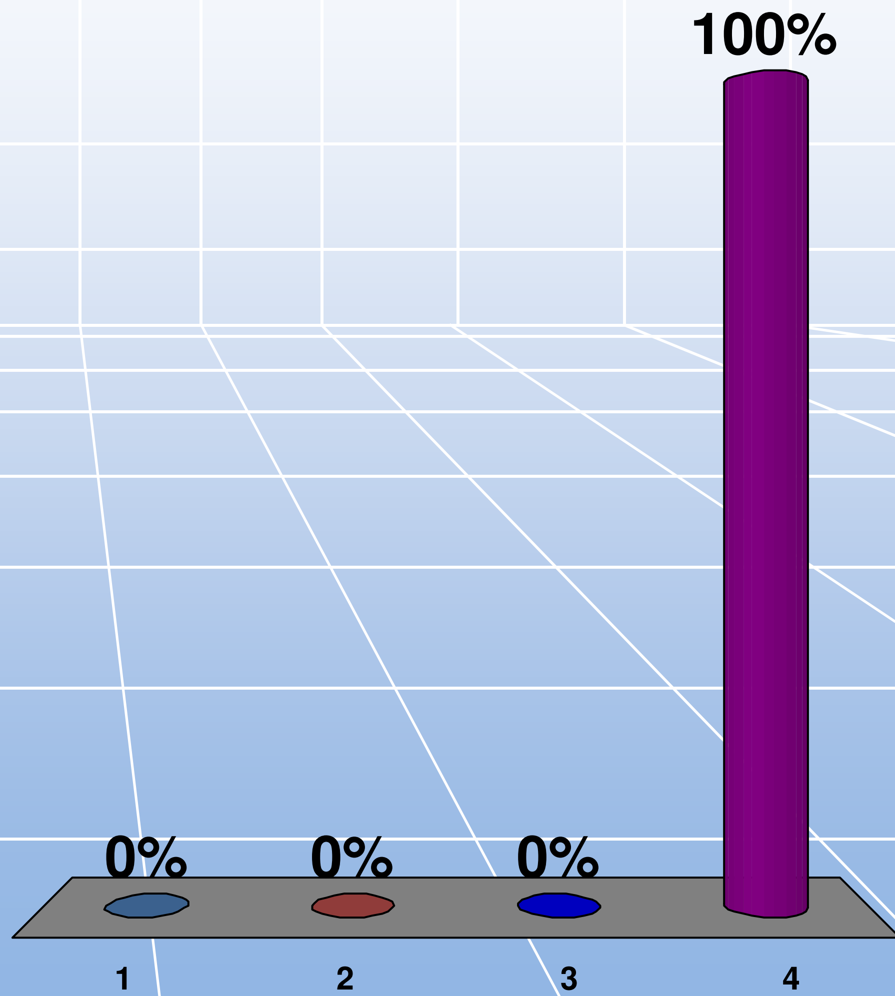
$P_{pre}(P_{post})$ is the average class score before (after) the instruction, as a percentage of the maximal score

$$0 < g < 1$$

Better instructional methods presumably have *g* values with (a) a higher average and (b) smaller variance due to circumstantial factors like initial preparation of students, instructor's personality, etc.

A positive electric charge is placed at rest near a north pole of a magnet. The charge will…

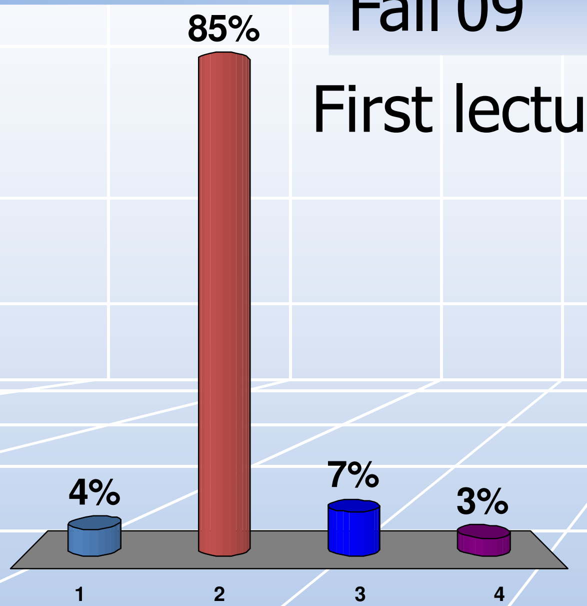
1. Be attracted to the magnet
2. Be repelled away from the magnet
3. Move according to the right-hand rule
4. Stay at rest



Students' responses

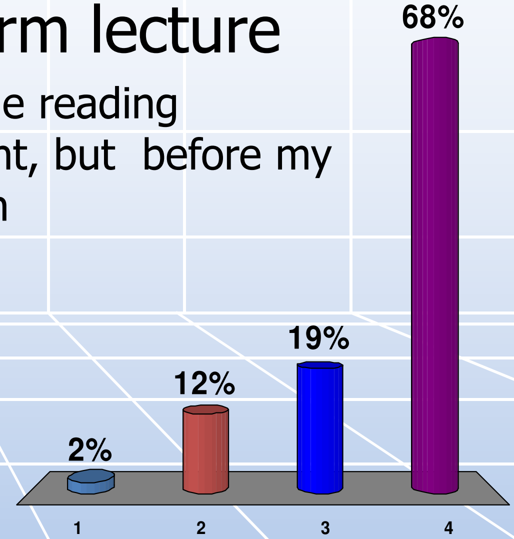
Fall'09

First lecture

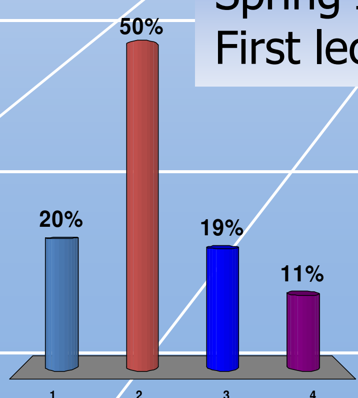


Midterm lecture

After the home reading assignment, but before my instruction



Spring'10
First lecture



Final exam

36% of correct answers (#4)

Types of clicker sessions

- Quick one-time polls
  - easy to set up (a few minutes)
  - can be anonymous or not
- Recurrent quizzes / in-class discussions/ attendance monitoring /advanced slides
  - require more careful settings to keep the list of participants, record scores, and backup the results

Setting up a quick poll

- Open TurningPoint (starts PowerPoint automatically)
- Open the "TurningPoint 2008" menu at the top of PowerPoint; use it to
  - insert and configure interactive slides (in the menu "Insert slide->…")
  - Choose settings for your session (in "Settings")
  - Reset the session, save the session, or continue a prior session (in the corresponding menus)
  - Insert special TurningPoint objects (like counters of time or responses)

A quick poll (continued)

- Run the slide show
- Poll the audience
- Save the results into a session file (“Save session”) or as a report in the Excel format (“Tools->Reports”)

Important: In Fondren lecture rooms, all local user files are deleted when the computer is rebooted

Restore the TurningPoint configuration files and save all your results to the NFS drive (U:) at the beginning and end of each session

Lists of participants

- **Anonymous response mode**: TurningPoint records only the total tally of answers
- **Auto/individualized response mode:** TurningPoint records a table of individual answers, by associating hex IDs of clickers with the names in the participant's list (created using the "Participants" wizard)

Efficiency of interactive instruction

Can be assessed with a standardized test tried on a large group of students

Several standardized tests are available to evaluate learning of introductory mechanics (e.g. Force Concept Inventory)

Only a few existing tests were developed to assess learning of E & M

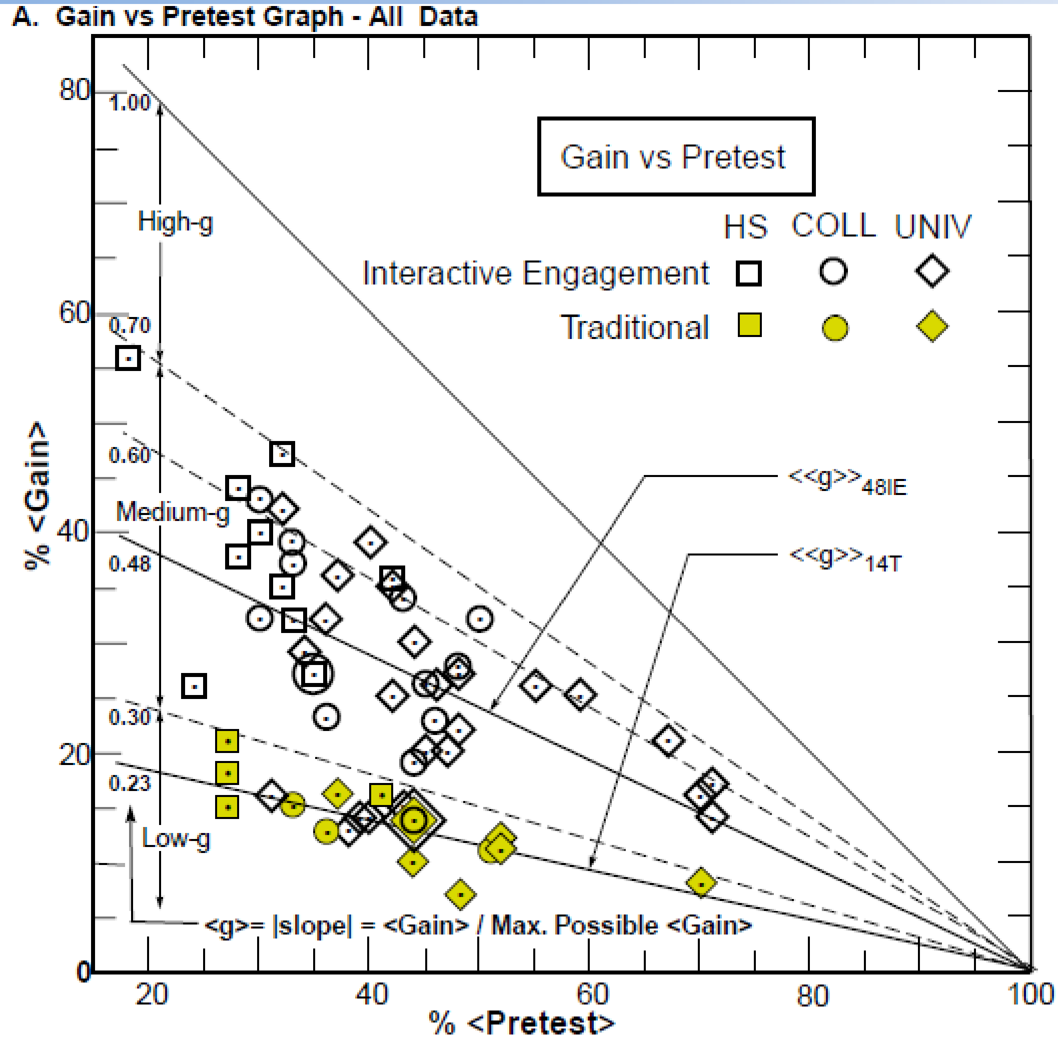


Fig. 1. %<Gain> vs %<Pretest> score on the conceptual Mechanics Diagnostic (MD) or Force Concept Inventory (FCI) tests for 62 courses enrolling a total N = 6542 students: 14 traditional (T) courses (N = 2084) which made little or no use of interactive engagement (IE) methods, and 48 IE courses (N = 4458) which made considerable use of IE methods. Slope lines for the average of the 14 T courses $\langle\langle g\rangle\rangle_{14T}$ and 48 IE courses $\langle\langle g\rangle\rangle_{48IE}$ are shown, as explained in the text.

Hake, R.R. 1998a. "Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," Am. J. Phys. 66(1): 64-74

http://www.physics.indiana.edu/~sdi/ajpv3i.pdf

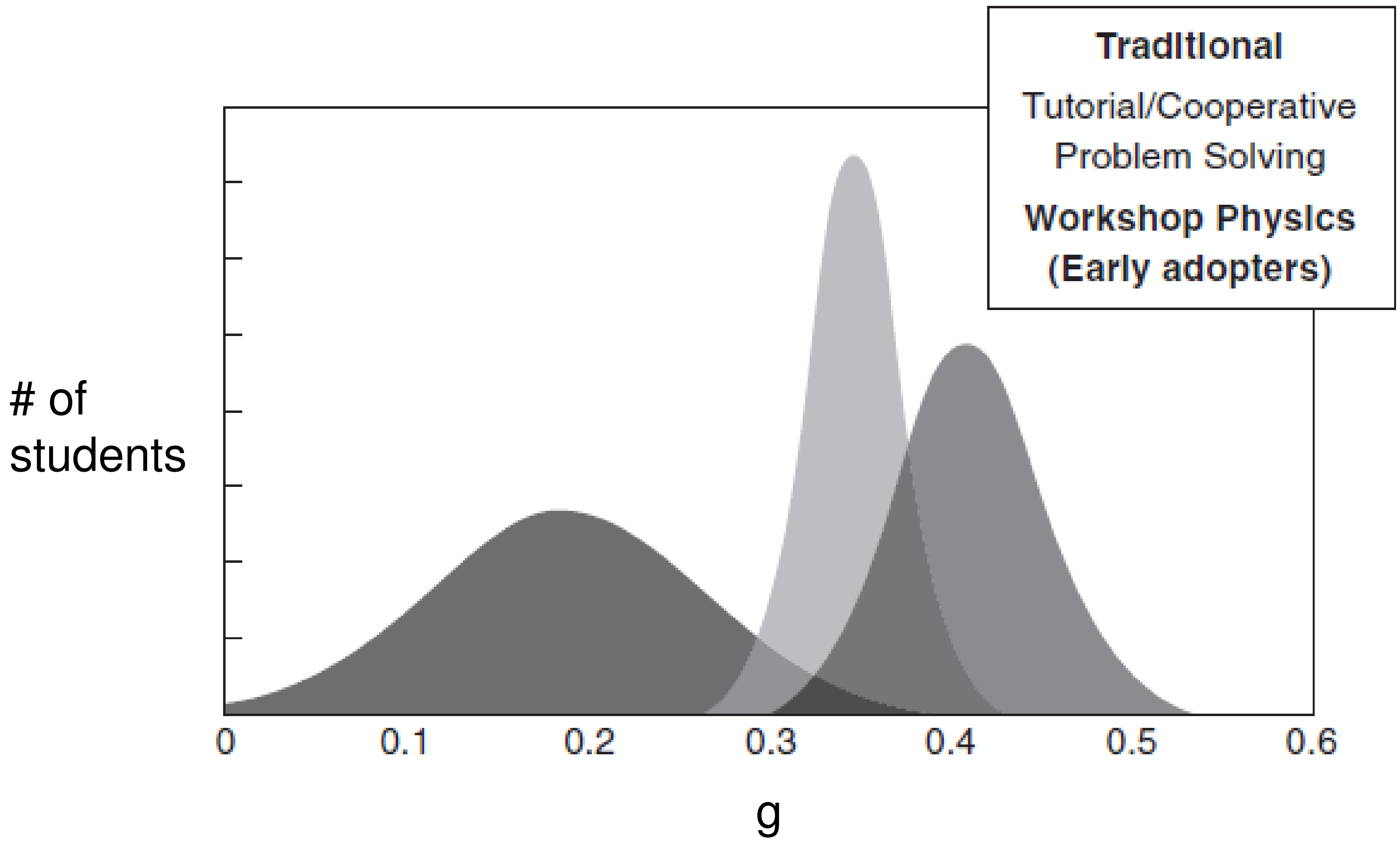


Figure 5.3 A plot of the fractional FCI gain achieved in three types of classes: traditional, moderate active engagement (tutorial/group problem solving), and strong active engagement (early adopters of workshop physics). Histograms are constructed for each group and fit with a Gaussian, which is then normalized [Saul 1997].

J. M. Saul and E. F. Redish, "Final Evaluation Report for FIPSE Grant #P116P50026:Evaluation of the Workshop Physics Dissemination Project," U. of Maryland preprint, 1997.

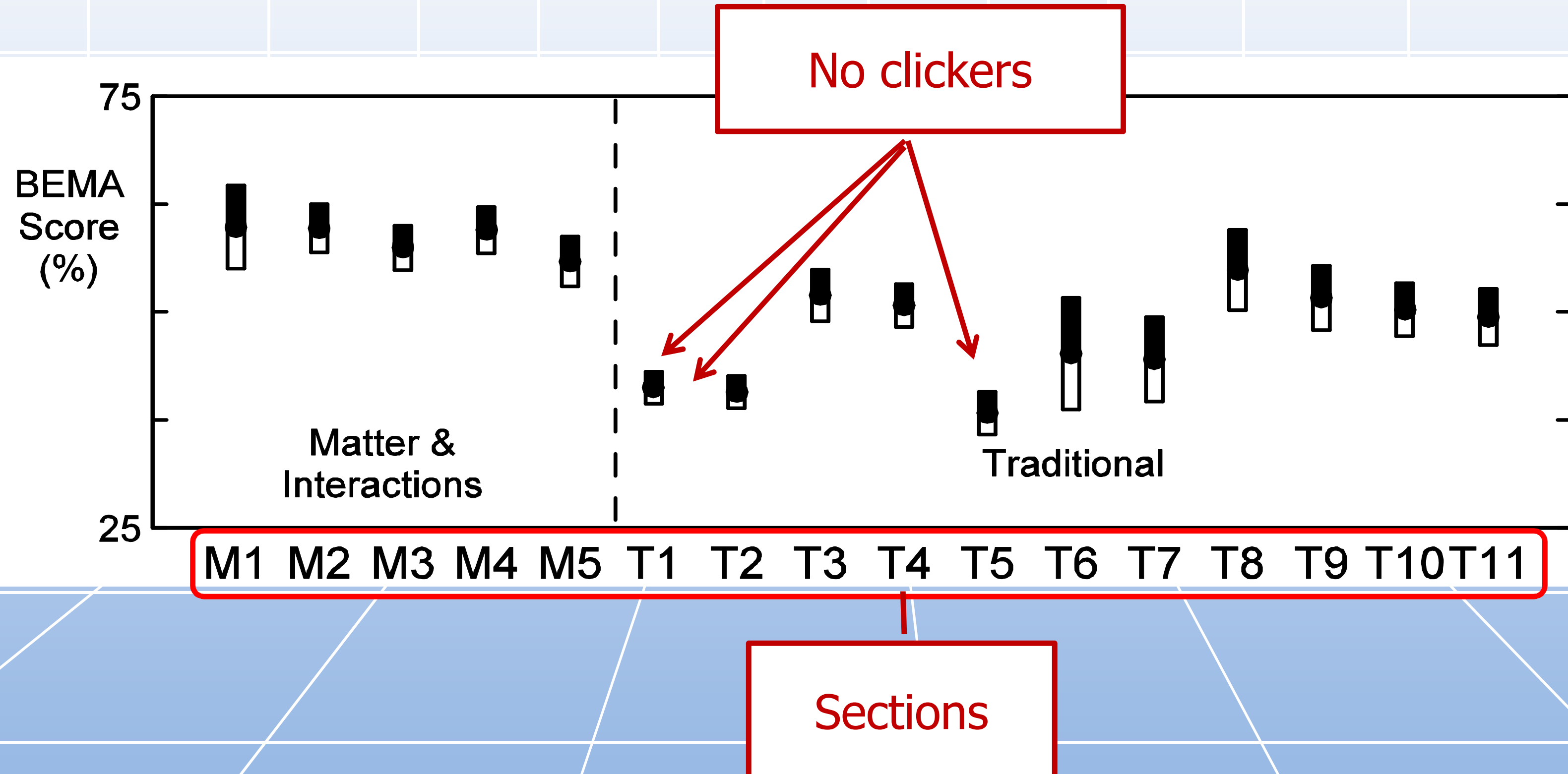
Brief Electricity and Magnetism Assessment (BEMA)

A 30-question test administered to 2000 students at Georgia Tech, Carnegie Mellon, North Carolina, and Purdue, with the goal to compare

- traditional and interactive instruction techniques
- learning outcomes based on the traditional curriculum (textbooks by Tipler, Giancoli, Young & Freedman…) and "physics-education"-driven curriculum (Matter & Interactions by Chabay and Sherwood)

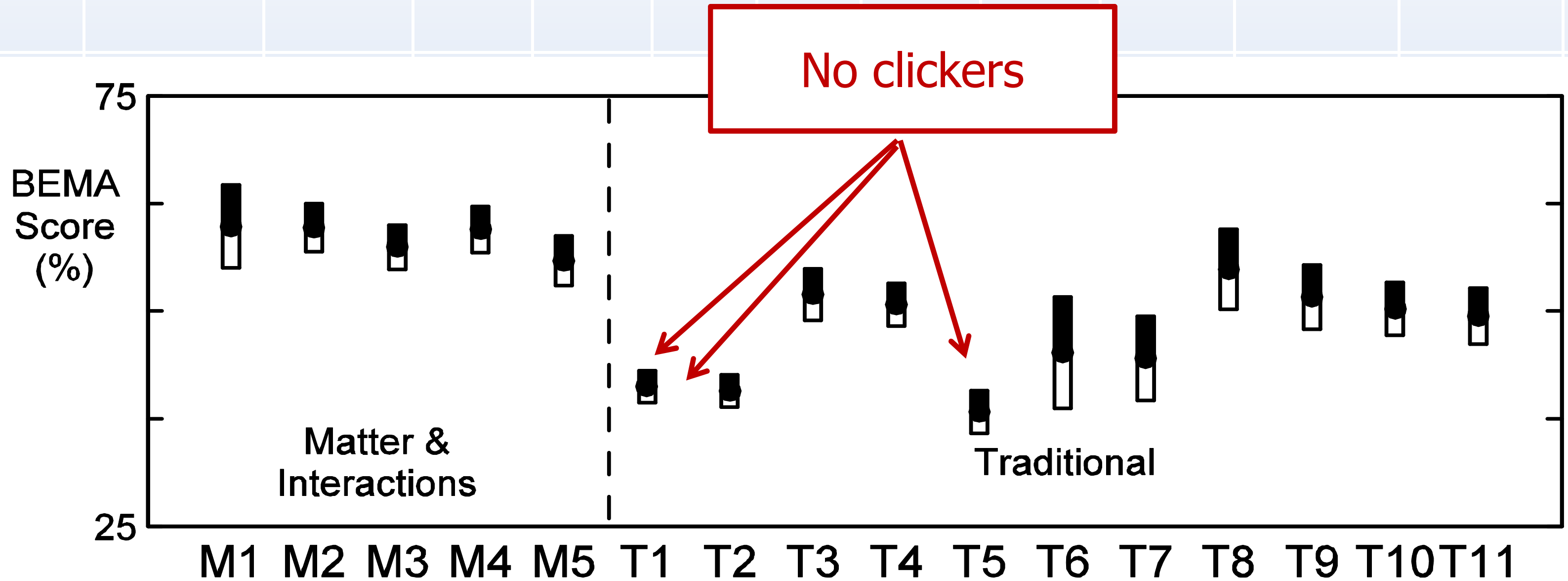
Detailed results are published in M. Kohlmyer, 8 more authors, Phys. Rev. ST Physics Ed. Research 5, 020105 (2009), arXiv:0906.0022

BEMA results at Georgia Institute of Technology (1700+ students)



9 different instructors; instructors in Sections T3, T4, T8, and T9 have a reputation for excellent teaching

BEMA results at Georgia Institute of Technology (1700+ students)



Comparable improvements in the score result from
- personal skill and experience of the instructor
- introduction of clickers
- revision of the curicullum

Comparison with PHYS1304 in Fall'2009

- Average normalized gain on questions similar to BEMA: g=42%

Structure of interactive physics lectures

Structure of PHYS 1304 lectures

- Students must do some preparation **before the class** by
  - reading the textbook assignment
  - watching free video lectures available on the web
  - reading supplementary material
- 2 clicker questions at the beginning of the class (2-3 minutes, graded individually) to check the students' preparation and attendance
- 1-3 learning units (lecture + demos) with a clicker-based discussion in each unit
- Discussion questions are moderately difficult; a collective grade is assigned to all participants based on the final percentage of correct answers

MIT OpenCourseWare

Before each PHYS 1304 lecture, students are encouraged to watch YouTube videos with MIT lectures by Walter Lewin – a fantastic introductory course in the traditional format

MIT OpenCourseWare

…For each one of my lectures, I dry-run them three times. Once about 10 days before I give the lecture. Then about three or four days before. Then I dry-run at 6 in the morning of the day that I give the lecture. So it is like a performance, whereby I cannot even go wrong [with the demonstrations] anymore, even if I tried.

Lewin's interview
to US News & World Report

Purpose of PHYS 1304 lectures

PHYS 1304 lectures are supposed to cover what students cannot learn on their own from reading or watching videos:

- reinforcement of most essential concepts and skills
- resolution of typical difficulties
- a variety of interactive demonstrations
- in-class activities and discussions
- learning of problem-solving skills