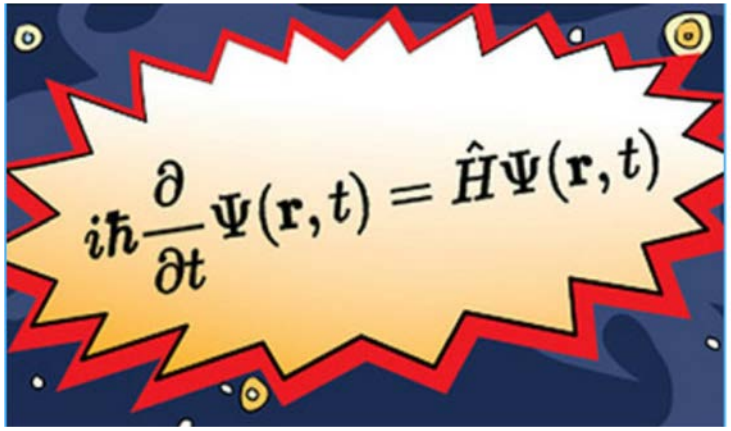
Electronic, Optical, and Magnetic Properties of Materials: A Comic-Based MOOC

J. Sandland, E. Vargo, J. Paras, G. Varnavides, S. Warkander, P. Anikeeva
Dept. of Materials Science and Engineering
Massachusetts Institute of Technology

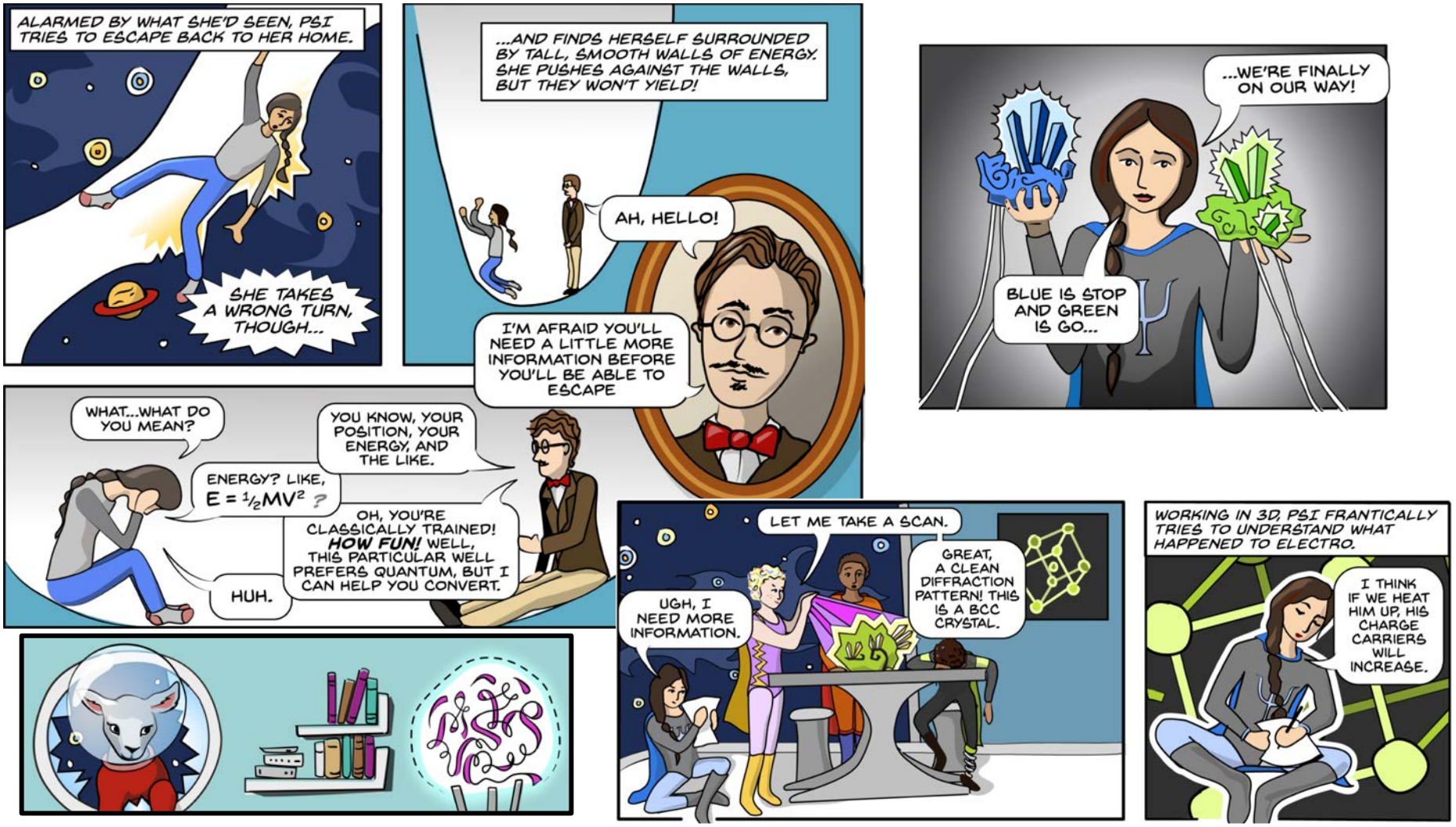
3.024x: Electronic, Optical and Magnetic Properties of Materials

- 3.024 describes the origins of the electronic, optical, and magnetic properties of materials, and considers how these properties can be tailored for particular applications

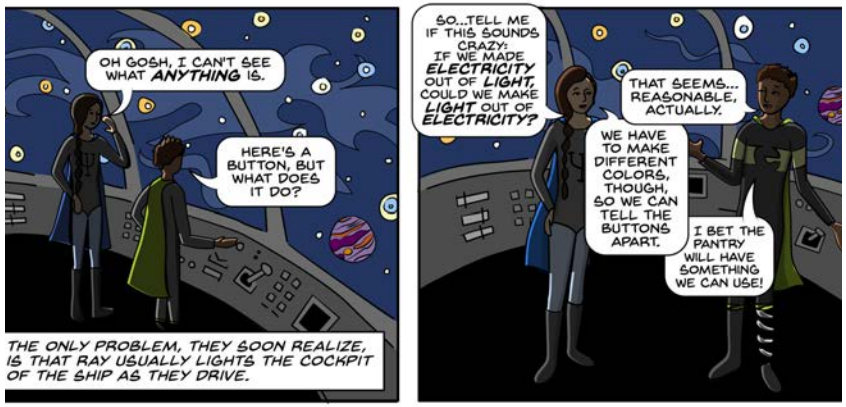


- A sophomore-level core course in the Department of Materials Science and Engineering. All MS&E undergraduates must complete this course
- Online lectures, interactive tools, and problem sets have been developed and used with residential students since 2017:
- Desire to reduce the time residential students spend working on problem sets, maximize the time that they spend working on design projects
  - Online problem sets insure that students have the background required to undertake the design projects
- Course offered on edX in Spring 2018 as a single 16-week long MOOC

Superheroes!



Sample Homework Problem



Useful properties of GaN:

- Band gap: $E_g = 3.28eV$
- Electron effective mass: $m_c^* = 0.13m_e$
- Hole effective mass: $m_v^* = 1.4m_e$
- Electron mobility: $\mu_n = 400cm^2V^{-1}s^{-1}$
- Hole mobility: $\mu_p = 150cm^2V^{-1}s^{-1}$
- Effective DOS for conduction band: $N_c = 2.3 * 10^{14}T^{3/2}\frac{cm^{-3}}{K^{3/2}}$
- Effective DOS for valence band: $P_v = 8.0 * 10^{15}T^{3/2}\frac{cm^{-3}}{K^{3/2}}$

The heroes decide to make lights for the controls in their ship's cockpit. They plan to make light-emitting devices (LEDs) with emission wavelengths from blue ($450\ nm$) to green ($550\ nm$).

They used-up the silicon-like meteoroid to make the solar cell, but luckily Ferro has quite a collection of meteoroids! He selects a different meteoroid composed of gallium nitride (GaN).

With a direct bandgap of $3.28\ eV$ GaN is an excellent UV emitter. Ferro knows that is possible to add other Group III metals to GaN to make $Ga_XMe_{1-X}N$ alloys. These metals do not act as dopants, but rather as substitutions to Ga. Consequently, they influence the band gap.

Consider the material to be at room temperature ($T = 300K$), unless stated otherwise.

Humor in the Classroom

- We hope that the inclusion of comics will help increase both student motivation and student performance
- There is some promising research in this field, though results in the literature are mixed:
  - Student attitudes, enjoyment, and opinions of their instruction have been shown to increase when content-related humor is introduced [1,2].
  - Secondary school students who were presented with comics demonstrated better scores on a creativity test designed to measure fluency, flexibility, and originality of thought [3].
  - Several studies have shown an improvement in final exam and post-test performance when content-related comics or humor were used in the mathematics, engineering technology, and psychology classrooms [2, 4, 5, 6].

Humor in the Classroom

- [1] James, D. (2004), A Need for Humor in Online Courses. *College Teaching* 52(3):93-4.
- [2] Garner, R.L. (2006), Humor in Pedagogy: How Ha-ha Can Lead to Aha! *College Teaching* 54(1): 177-80.
- [3] Ziv, A. (1983), The Influence of Humorous Atmosphere on Divergent Thinking. *Contemporary Educational Psychology* 8:68-75.
- [4] Ziv, A. (1988), Teaching and Learning with Humor: Experiment and Replication. The Journal of Experimental Education 57(1): 5-15.
- [5] Hackathorn, J., Garczynski, A., Blankmeyer, K, and Tennial, R. (2011) All kidding aside: Humor increases learning at knowledge and comprehension levels. *Journal of the Scholarship of Teaching and Learning* 11(4):116-23.
- [6] Matthews, M.L.M. (2011), *A Funny Thing Happened on the Way to the Hippocampus: The Effects of Humor on Student Achievement and Memory Retention*, Doctoral Dissertation, Arizona State University.

3.024x A/B Test

- We divided the edX students in half.
- In the first unit, half of the students received 3.024x comics and superhero-themed problem sets.
- The other half of the students didn't see the comics, and superhero themes until the second week of the course.
- After the first unit, all students could see the comics
- Residential version of 3.024 only included comics

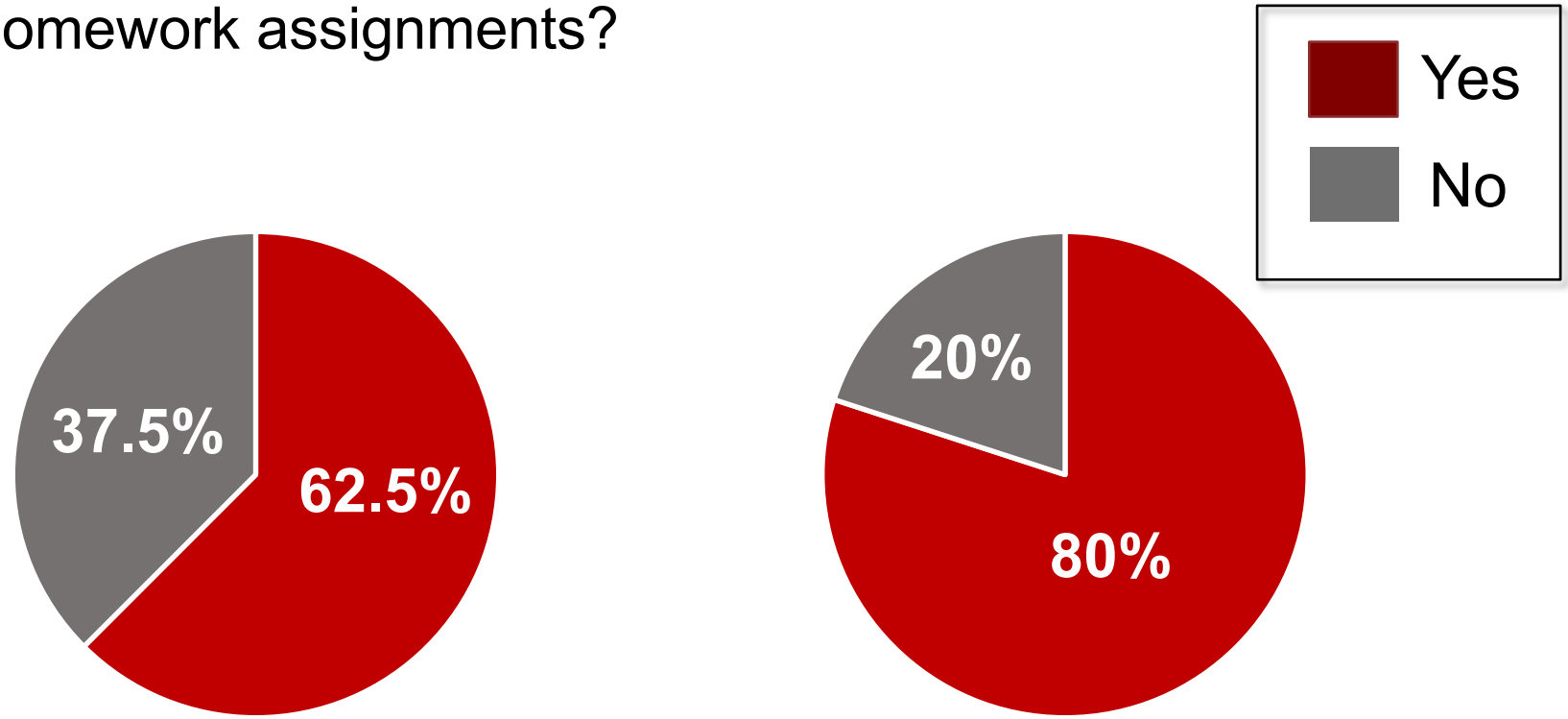
Problem Set Performance

	Comic Group	Traditional Group
Number of learners who attempted PSet	148	145
Average score	56.2%	55.4%

There was no significant difference between the performance of the traditional group and the comic group.

Student Response to Comics

- Do you enjoy the comics that are embedded in the homework assignments?

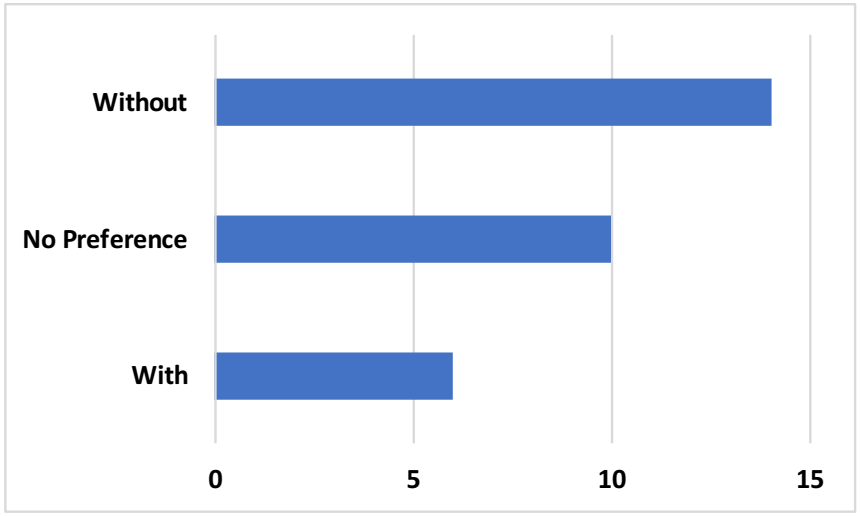


edX Learners (n = 48)

MIT Students (n = 15)

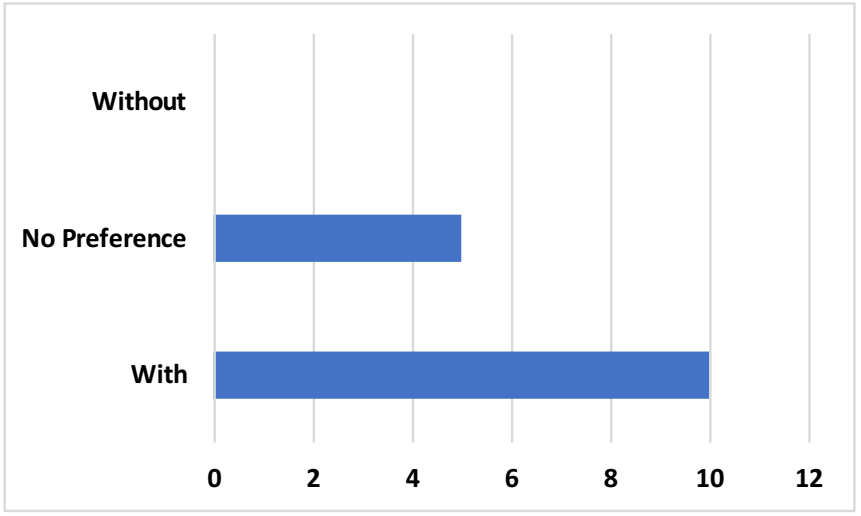
Student Response to Comics

Did you prefer assignments with or without comic strips?



edX Learners (Control Group)

Would you prefer assignments with or without comic strips?



MIT Students

Problem Set Performance

	Comic Group	Traditional Group
Number of learners who attempted PSet	148	145
Average score	56.2%	55.4%

There was no significant difference between the performance of the traditional group and the comic group.

The 3.024x Team

- Prof. Polina Anikeeva, Lead Faculty
- Emma Vargo, Comic Design
- Jane Holland, Graphic Artist

<u>Course Development Team:</u>
George Varnavides
Sarah Warkander
Jonathan Paras

<u>Course Support Team:</u>
Maddie Sutula
Emma Vargo