

# Investigating Inquiry-Based Learning in an Introductory Course on Semiconductor Devices

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## Abstract

- Problem Statement:** Engaging students is challenging for courses where subject matter is abstract (such as semiconductor physics)
- Hypothesis:** Student learning and interest in courses with abstract concepts will be improved by the incorporation of inquiry-based learning methods
- Study Objective:** Introduce inquiry-based learning methods to EECS 320, assess student performance and interest in course material.

## Definitions

- Inquiry based learning:** teaching method where students and the instructor together explore conceptual principles via inquiry, linking concepts to knowledge already familiar to the student.
- Just-in-time teaching:** introducing or reviewing a concept just prior to teaching. The intent is to encourage students to think about the concepts prior to the formal introduction, and to provide feedback on student background to the instructor.
- EECS 320:** junior-level introductory course on semiconductor devices for electrical and computer engineering students. Topics include semiconductor physics, diodes, and transistors.

## Methods

**Inquiry-based learning:** Introduce four in-class inquiry-based activities to introduce concepts.

- "Top down" introduction to electron motion in semiconductors
- "Act out" electron motion in doped semiconductor material
- "Act out" formation of p-n junction diode
- "Act out" operation of field effect transistors

**Just-in-time teaching:** Introduce online quizzes (Ctools) as "warm-up" exercises to prepare students for new concepts.

- Electromagnetics/electrostatics review
- P-N junction diode
- Metal-Oxide-Semiconductor band diagrams

**Assessment:** Student performance and response

- Focus groups
- Surveys on behavior, confidence, and interest
- Class performance

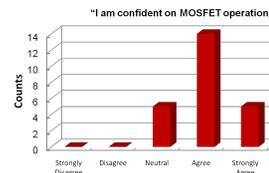
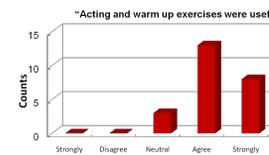
## Student Learning

### Inquiry-Based Learning Activities

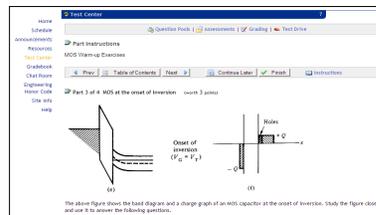


Focus groups indicate that students benefit from visualizing the concept and seeing the complete picture:

- "It all came together and clicked when we acted out the MOSFET."
- "Acting out the transistor helped me visualize the MOSFET operation, and understand it thoroughly."
- "I got in the head of an electron."

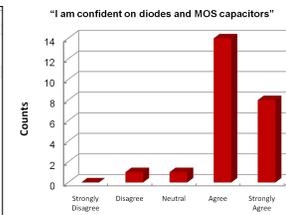


### JiTT / Warm-Up Exercises

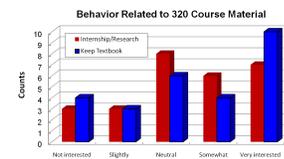
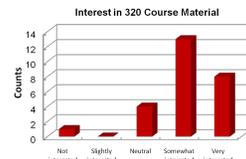


Focus groups indicated that students used the exercises to get in the proper mindset before lectures and to correct misconceptions:

- "I was ready to learn, and somewhat curious when I arrived in lecture following a warm up quiz."
- "I understood the material better when I was initially wrong in my guess."



## Student Behavior



- Student interest partially determines their subsequent plans
- Focus groups suggest discrepancies often come from scheduling EECS 320 late in the undergraduate curriculum

## Discussion

- Focus group interview with former students suggest that most students were "turned off" after EECS 320
- Previous perception of semiconductors was that it is a standalone esoteric field of study. Students felt concepts from EECS 320 remained unclear in future classes.
- weak correlation observed between motivation and performance
- Interest in 320 high for current class, but does not appear to have a direct translation to further study of semiconductors
- Interest and confidence correlates closely with how useful students found the inquiry based approach

## Conclusions

- Student motivation matters for near-term recruitment and retention in the semiconductors field
- Inquiry based (acting) exercises improved student learning and motivation by helping students visualize otherwise abstract concepts
- JiTT (warm up) exercises improved student learning by preparing them for upcoming concepts. Concepts were put in context, and linked to previous classes/concepts
- Advising students to take EECS 320 earlier in their studies will allow them to explore semiconductors further
- Performance of students in this 320 class was strong, though improved methods of evaluating the effect of JiTT and inquiry based learning need to be studied further



## Acknowledgments

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