Interactive Learning Platforms for Upper Level Electrical Engineering Courses

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Introduction and Objectives

This project encompasses an interactive homework system that provides realtime feedback on student conceptual understanding and learning.

- Plenty of tech to support delivering more content to more people
- Some tools for delivering homework content to students
  - Potential for personalized learning
- Lack of technology to support interactive upper-level material in engineering
- Challenge: Students in upper-level classes have different competencies
- Potential: identify missing concepts

History of Innovation

- Implemented for EE324 in Fall 2012
  - Fundamentals of semiconductors
  - Class of 77 students, no grader
  - Implemented towards the middle
  - Agile process: revised and redeployed often based on student feedback
  - Reviews: none negative, most said they learned a lot from it
- Maintained a client-server architecture
  - Record as much data as possible as students solve questions for potentially building better learning models later
  - Employed a Google Web Toolkit (gwt) frontend for cross-platform
  - Employed a schema-less database (MongoDB) for extendability
- Currently teaching EE 326
  - 2nd semester microelectronics
  - Class of 58 students
  - Innovating circuit design tools for Q/A and student interaction
  - Added in-class anonymization for shy students (from student request)

Learning Activities

Week lecture series progression:

- System online at the beginning
- Students log in and start problems
  - Problems asked based on competence in concept areas
- Each question contains a reference to relevant material (lectures, book, etc) to learn how to do the problem
- Students can get the question wrong
  - Question will be asked again
  - Dynamic questions ask different questions each time and computer correct answers.
- Students can chat with others

Example:

Dynamically compute question to ask and correctly render mathematical expressions

Silicon at room temperature (300K) is doped with arsenic atoms to a concentration of $N_d^+ = 8.1e16\ cm^{-3}$. Silicon has an intrinsic carrier density of $1.5e10\ cm^{-3}$ and a bandgap of 1.12 eV.

Quickly access learning material for problem

For a description of Fermi energy levels please refer to lecture and this section of the book.

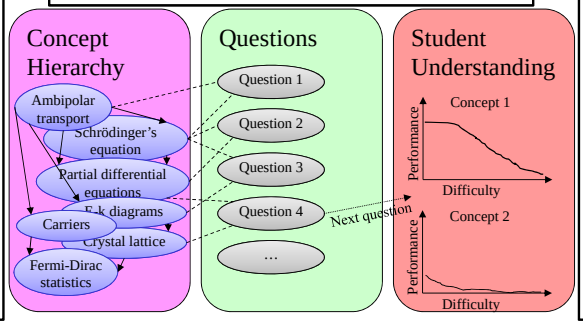
Concepts involved in this problem

Concepts: quantum behavior in solids, crystals, bandgaps, Fermi-Dirac statistics, holes, electrons, semiconductors

Part 1: What is the hole concentration?
Answer: _____ cm^{-3} **Recognize range of values (+/-10%)**

Part 2: What is the Fermi level wrt the intrinsic Fermi level?
Answer: _____ eV **Multipart questions calculated**

Chat: **Chat allows students to teach each other, especially when instructor unavailable.**
Me: Does an increase in donor atoms raise the Fermi level?
Tom: Yes, you should see an increase. Check the link for a plot.



Execution

- It is best if the system is always available and reliable
  - Tells student where they are at on understanding material concepts
  - Gives student directions on where to focus studying
  - Provides comparison with class
- Goes hand-in-hand with a flipped classroom where students can accelerate if they want to
- The more possible questions for each concept, the better the experience

Issues

Problems:

- Students wanted to ask questions and communicate with others
  - Result: implemented an integrated chat program that became popular
- How do we correctly render mathematics and circuits – and flexibly allow input of those
  - Result: Common javascript libraries coming available, MathJax; for circuits, I had to implement my own

Issues remaining:

- How can we create a recommender system that suggests the next best topics to discuss in class or with a subgroup of the students?
  - Most benefit from least effort
- Personalized gap-finding and concept proficiency
- Accurately building concept

Discussion

Benefits:

- Precisely measure student learning
- Improve utility of homework
- Prevent cheating
- Improve tailoring to students

Approaches to improved teaching:

- Assessment of fundamental conceptual understanding and rate of understanding current material
- Improved dynamics and adapatability in lecturing and providing pre-recorded lecture material

Spinoffs:

- Improved learning models
- Interactive learning sites for people not taking a course (wiki teaching)

Recommendations:

- Provide an open source environment
- Maintain central repository of results
- Encourage adoption and sharing

Potential NSF proposal submission:

- Research on Education and Learning

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