Investigation of Computational and Visual Modules to Enhance learning in Undergraduate Heat Transfer

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CIRTL @ Vanderbilt/CFT
Nashville, TN, USA, January 19, 2010

Motivation

Many science and engineering concepts are difficult to understand from lectures and text books.

- Problems
  - lack of relation of concepts to real world
  - lack of motivation
  - lack of interaction
  - difficult to visualize
- Possible solutions
  - more real world problems
  - more interactive components - experiments and simulations
  - use of visualizations

Interactive components to lectures can be beneficial to student learning by involving students in ways typical lectures do not.

- Hands-on experiments
  - Pros: students physically involved and in control, learn about equipment, easy to monitor participation
  - Limitations: must be a smaller class, no access to experiment outside of class, require equipment
- Web-based simulations
  - Pros: no equipment required, students can continue to use the simulations outside of class, students in control, learn about simulation techniques, any class size
  - Limitations: less knowledge of participation, not physically involved

Approach

The current study consisted of the following phases to determine specifically if and how students utilized the tools.

- Phase 1
  - in-class demo of hotSPICE tool in lecture
  - optional use of tool for homework
- Phase 2
  - in-class demo 1DFDM and Analytic Conduction Solutions tools in lecture and a class discussion
  - questions on the final exam
- Phase 3
  - brief tutorial of NTU-effectiveness tool in class
  - require and optional use on homework
  - optional use on design project

This study consisted of 58 junior/senior level students of mechanical engineering in the undergraduate heat transfer class.

thermalHUB.org

ThermalHUB.org is thermal science cyberinfrastructure comprised of community-contributed resources designed for educational applications, professional networking and research simulation tools for heat transfer funded by the NSF.

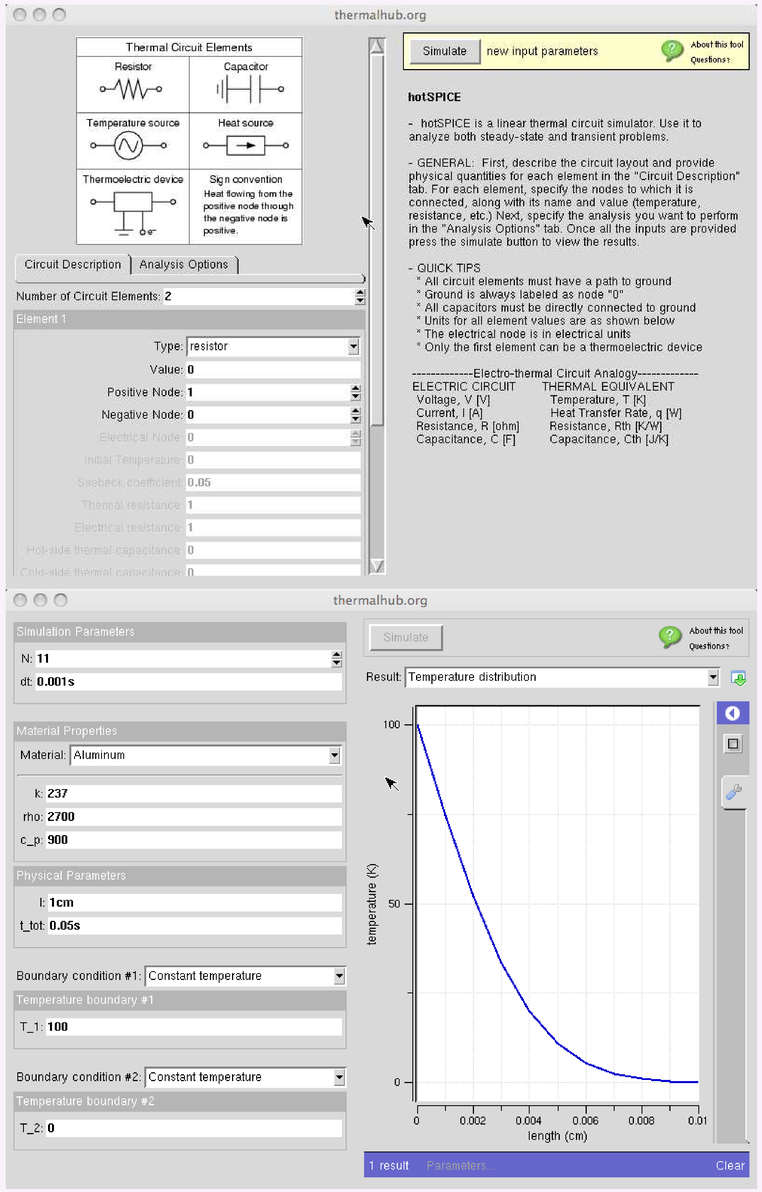

Figure 1: Examples of tools available on thermalHUB.org.

Results

- Phase 1
  - students felt the in-class demo was helpful for understanding the concept of equivalent thermal resistance circuits
  - 0.0% of the students that responded to the survey used the tool - many felt the homework was not complex enough to require the use of the tool
- Phase 2
  - students felt the demos and discussion were helpful for understanding the finite difference method and temperature profiles in systems with varying initial and boundary conditions, heat generation and material properties
  - student performance on the final exam is shown in Figure 2 where questions 1, 2, 4 and 5 were on topics related to the tools and question 3 was a control question
  - 29.5%, 71.4%, 12.5%, 860.0% and 97.3% improvement on questions 1-5, respectively
- Phase 3
  - 10.3% of students used the tool on problems that they were not required to use it on
  - 58.3% of groups used the tool on the design project - groups that used the tool had an average of 3.5 initial design ideas while groups that did not had an average of 1.5 initial design ideas

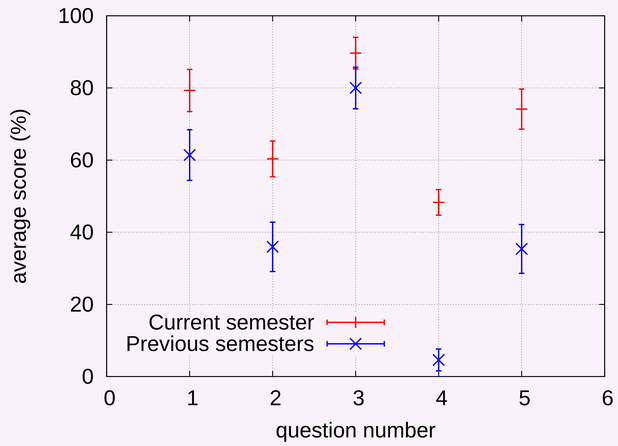

Figure 2: Comparison of question performance from previous semesters with current. Questions 1, 2, 4 and 5 are related to topics in which tools were used. Question 3 was the baseline question.

Overall students felt the demos were useful, but could be improved with respect to the tutorial portion. Students also felt that the homework assignments could be designed to better match the function of the tools.

Conclusions

- tools were effective for improving interaction in class during discussion and demonstrations and improved student performance on questions related to those topics.
- current tools were not very effective for use on homework assignments, but were useful when assignments were designed for use with the tools.
- students rarely used the tools outside of class.
- tools need to be improved for future courses.

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