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Work in Progress - Virtual Facilitation and Procedural Knowledge Education

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Abstract – **Engineering students acquire both conceptual and procedural knowledge as part of their education. While conceptual knowledge, such as understanding why certain design practices are required or having knowledge of the general principles of engineering development, is essential, procedural knowledge to enact specific engineering practices is also needed. This kind of knowledge, such as balancing chemical equations, solving calculus problems, or finding Thevenin-Norton equivalents, is usually taught through rote problem solving, sometimes with the guidance of teaching assistants or aid from the instructor if students find themselves "stuck". However, a Virtual Facilitator, designed to help students develop team skills, can also be used to guide students through the solution of specific problems. This Work In Process paper describes the process for developing the needed procedural rules using an example problem from electrical engineering – finding a Thevenin equivalent circuit.**

Index Terms – Virtual Facilitation, Procedural Knowledge, Computer-Aided Instruction.

INTRODUCTION

Much of the basic knowledge that is at the center of an engineering degree is procedural as opposed to conceptual knowledge. From solving calculus problems to balancing chemical equations or finding Thevenin-Norton equivalents; engineering problem solving often involves a series of well-defined steps toward a solution.

Generally the approach taken to teaching this kind of procedural knowledge involves demonstration in a classroom followed by a series of problems that are to be solved independently or in small groups, supported by a textbook. However, the development of a "Virtual Facilitator" provides another approach. It models specific behaviors and guides students through inquiries and observations as they interact with it through widely available online systems. A web-based "Rule Editor" allows instructors or others to input detailed rules for facilitating the actions of an individual or team. The development of procedural rules incorporated into the Virtual Facilitator provides a way to guide students through step-by-step procedures such as those required to solve basic engineering problems. This approach enables independent and individual coaching on engineering problem solving that is available anytime and everywhere.

BACKGROUND

Engineering students gain both procedural and conceptual knowledge as part of their studies. Procedural knowledge involves skills (the steps to accomplish a task or operation) while conceptual (semantic or theoretic) knowledge involves an understanding of the "why". While there is much to be learned about the ways that students gain these different aspects of knowledge and how they build on and influence one another [1-3], the gaining of procedural knowledge is a major focus of engineering studies.

Many tools and approaches have been used to help students acquire procedural knowledge from, for example, using HyperCard to teach students to balance chemistry equations [4], to the use of an intelligent modeling and tutoring system to aid in learning mechanics [5].

The Virtual Facilitator is one tool that is being developed to aid students in learning procedural skills having to do with team communication [6]. The goal of the Virtual Facilitator is to provide ubiquitous coaching and facilitation that is available 24/7 and can be easily modified by anyone through a crowdsourcing approach. It allows the development of "rulesets" for intervention into group communication based on expert knowledge. In previous studies [7] these rulesets have consisted of "state-less" boolean phrase matching rules. (For example, IF((("You must") OR ("You need to")) AND NOT(because)) THEN ("It sounds like you are advocating a position. Please give your reasoning and inquire into the other person's reasoning."). However, the capability of "state-ful" rules (embedded in flowcharts) has been added recently and an easy to use editor is being developed.

METHODOLOGY

I. Coaching using the Virtual Facilitation System

The instrument is well suited for problems involving procedural knowledge since it reinforces the procedural steps and steps for different problems will be nearly identical. It currently allows coaching procedures to be entered into its state machine. It can then enact these procedures through student interaction. The system is currently text-based and operates in a widely available chat environment, though a voice-enabled system is under development. Because a computer system's "knowledge" is relatively limited, the procedures must be aimed at solving a specific problem.

II. Thevenin Equivalent Circuit Example

A basic skill in electrical engineering involves finding Thevenin equivalent circuits. The problem chosen to illustrate coaching is in Figure 1, with directions "Determine the Thevenin resistance R_{TH} and the Thevenin voltage v_{TH} for the circuit shown with respect to the terminals ab."

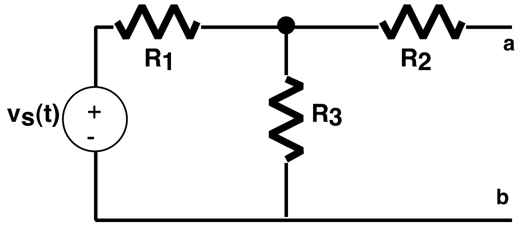

FIGURE 1
THEVENIN CIRCUIT EXAMPLE.

The steps to completion are:

I. Determine the Thevenin Resistance R_{TH}.
II. Determine the Thevenin Voltage v_{TH}.

Rules to assist the student by asking questions are developed for each step of the procedure along with explanatory text, e.g.:

I. Determine the Thevenin Resistance R_{TH}.

Q1. How is the circuit changed to determine R_{TH}?

"Kill" the (independent) sources. **Correct**

(Other answers). **Incorrect, what must be done to the voltage source?**

"Kill" or short the (independent) voltage source. **Correct**

Replace the source with an open (or other answer). **Incorrect, an independent current source is replaced with an open, but an independent voltage source is replaced with a short.**

Q2. How is an independent voltage source "killed"?

Replace the source with a short. **Correct**

Replace the source with an open (or other answer). **Incorrect, what must be done to the voltage source?**

"Kill" or short the (independent) voltage source. **Correct**

Replace the source with an open (or other answer). **Incorrect, an independent current source is replaced with an open, but an independent voltage source is replaced with a short.**

Q3. The new circuit contains only resistors; which two resistors should be combined first?

R_1 and R_3. **Correct**

R_1 and R_2 or *R_2 and R_3. (or other answer).* **Incorrect, which two resistors share either a common voltage or a common current?**

R_1 and R_3 share a common voltage. **Correct**

R_1 and R_2 do not share a common voltage or current. OR R_2 and R_3 do not share a common voltage or current. (or other answer) **Incorrect, consider the shared node and the reference node.**

Q4. How can R_1 and R_3 be combined (series or parallel combination)?

CONCLUSION

Virtual Facilitation has the potential of providing a new approach to educating engineers in procedural knowledge that is specific to engineering. Its use of existing social media encourages wide dissemination. The demonstration of its application to engineering circuits concepts provides a glimpse of possibilities for future use.

The implementation plan includes testing the example with engineering students in a circuits class. The system will be access for ease of use and effectiveness in coaching.

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