Extended Abstract – Exploration of Cognitive Apprenticeship Practices in a First Year Engineering Course

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***Abstract* - The cognitive apprenticeship approach is a pedagogical method that extends the methods used in a traditional apprenticeship to cognitive tasks. The study described in this paper is a follow up on a previous project, in which we found evidence that instructors who are not explicitly trained in teaching using a cognitive apprenticeship approach still might use techniques that fit that model. In this study, we conduct interviews with instructors in order to determine the extent to which the teaching methods they report employing in the classroom fit the cognitive apprenticeship model. We then survey students in the course to determine how well their experience of teaching methods used in the course compares to both the reported methods from the instructor interviews and the cognitive apprenticeship model. Initial results from the study will be shared at the conference.**

Index Terms – Cognitive Apprenticeship, First-year Engineering, Pedagogy

INTRODUCTION

Cognitive Apprenticeship is a pedagogical approach that we believe has significant applications in the education of engineering students. Using the Cognitive Apprenticeship framework, instructors model expert practices for students, making explicit the approach they take towards solving complex problems in their domain and coaching students towards use of a more expert-like approach. Students are supported through scaffolding, and encouraged to articulate and reflect upon their own problem-solving process. In the year preceding this study, a subset of instructors in our first-year program were trained to use a Problem-Based Learning / Cognitive Apprenticeship approach in their classes. We found that students in classes taught by the trained instructors felt a sense of empowerment and increased motivation compared to students in classes taught by untrained instructors. Additionally, we found students in these classes had higher domain identification with engineering, which correlates highly with intention to pursue an engineering career.

While we expected students in classes taught by the trained instructors to report experiences fitting the Cognitive Apprenticeship model, students in classes taught by one untrained instructor also reported that the instructor demonstrated practices associated with cognitive apprenticeship. However, we still needed to determine how widely untrained instructors enact these practices. The goal of the study described in this paper is to investigate the extent to which cognitive apprenticeship practices are used by instructors in our first-year program on a broader scale. In this study, we seek to answer the following research questions:

1) How broadly is cognitive apprenticeship employed by course instructors?
2) How broadly is cognitive apprenticeship experienced (or not experienced) by students?

THEORETICAL FRAMEWORK

Before formalized schooling became the norm, most people learned new skills through an apprenticeship model. In a traditional apprenticeship, the apprentice observes the master demonstrating the completion of a physical task such as farming or carpentry. Because the task to be learned generally involves the manipulation of physical objects, the apprentice can easily observe the process by which the master completes the task and attempt to do it themselves. Likewise, the master can observe the apprentice completing a task and identify and help them to correct problems and hone their skills.

Of course, apprenticeship goes beyond the apprentices simply mimicking the master. Collins, Brown, and Holum [1] identify four basic components of a traditional apprenticeship: modeling, scaffolding, fading, and coaching. Modeling is the process described above, where the master demonstrates and apprentice observes a task. In scaffolding, the master gives the apprentice support while allowing them to complete the task autonomously. The level of support slowly fades over time until the apprentice can work independently. Throughout the apprenticeship, the master acts in a coaching capacity by evaluating, encouraging, and challenging the apprentice, thereby overseeing their learning process [1], [2].

The contrast with traditional schooling methods is stark; while apprenticeship focuses on the process of production, schooling tends to focus much more heavily on the product. For example, even the most well read student may be at a loss when it comes to writing. It is not at all obvious from the product of knowledge, the final document, the process by which the author produced it. Even observation of the author writing would likely be insufficient because in cognitive tasks, much of the process is invisible and takes place in the mind of the expert. Additionally, many tasks students learn to complete in schooling are decontextualized and it is non-obvious to students how a task they are learning fits into a larger goal.

The aim of the cognitive apprenticeship model is to apply the same techniques that are used in a traditional apprenticeship to learning more abstract tasks: "In apprenticeship, the processes of the activity are visible. In schooling, the processes of thinking are often invisible to both the students and the teacher. Cognitive apprenticeship is a model of instruction that works to make thinking visible" [1]. Additionally, it is important that the instructor situate classroom tasks in a context that makes them meaningful to students as well as using the same skill in multiple contexts in order to foster transferability of that skill outside the context it was learned in [1], [3].

DESCRIPTION OF STUDY

This study was conducted within the setting of a second-semester first-year engineering design course with an enrollment of approximately 1,000 students. The course is divided into a large lecture and small workshop sections, with approximately 30 students per workshop section. There are four faculty members that teach the large lecture, and 13 workshop leaders consisting of a mix of three faculty members and 10 graduate teaching assistants.

To address the first research question, we conducted semi-structured interviews with faculty lecture instructors and workshop leaders and conducted a semi-structured focus group with graduate teaching assistant workshop leaders.

We expect that the majority of instruction that will align with the cognitive apprenticeship model will take place in the workshop sections of the course due to their small size and high level of interaction between teacher and student. Therefore, we focus on the workshop leaders rather than the lecture instructors in this paper. In the interview and focus group questions for workshop leaders, we ask questions such as:

1. How do you view your role in the classroom?
2. Describe your approach to interacting with students in your workshop.
3. How do you help students understand what they are supposed to do?
4. Do you do anything to help students know whether they've been successful, to know what they've learned?

These interviews and focus groups were then transcribed and coded using the cognitive apprenticeship behaviors described in the previous section as *a priori* (pre-defined based on the model) codes. We also coded the interviews for descriptions of classroom approaches that seemed to go against the principles of the cognitive apprenticeship model. For example, one workshop leader indicated that they look up answers to student questions during class, but hide the fact they are doing so from the students, clearly contradictory to the principle of modeling; several workshop leaders mentioned having students demonstrate their solutions to the class, a clear example of both reflection and articulation.

To address the second research question, we developed a survey that was administered to students in the course. Survey questions were designed to uncover student experiences that fit the cognitive apprenticeship model and were based both on the model itself and on the techniques that the workshop leaders reported using. Example Likert-style survey questions used include:

1. My workshop leader demonstrates how they approach and work through engineering problems.
2. My workshop leader asks guiding questions without giving an explicit answer or instruction.
3. My workshop leader encourages me to experiment and explore the results.
4. My workshop leader demonstrates how they find relevant information to complete a task.
5. My workshop leader asks students to demonstrate their solution or process to other students.

The survey included space to elaborate on the Likert-scale questions, as well as two open-ended questions:

1. What were the most useful things your workshop leader did this week to help you with your design project?
2. What other things could your workshop leader do that would be helpful to you?

Surveys were administered electronically during four consecutive weeks during the completion of a design project. At the time of writing, the interviews, focus groups, and surveys have been completed and we are in the analysis phase. If the need for deeper understanding of student experiences is indicated by the survey results, we plan to conduct one or more focus groups with students in the next semester. Initial results from the study will be shared at the conference, and we will publish a complete analysis in the future.

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REFERENCES

[1] A. Collins, J. S. Brown, and A. Holum, "Cognitive apprenticeship: Making thinking visible," *American Educator*, vol. 6, no. 11, pp. 38–46, 1991.

[2] A. Collins, J. S. Brown, and S. Newman, "Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics," in *Knowing, Learning, and instruction: Essays in Honor of Robert Glaser*, L. Resnick, Ed. Routledge, 1989.

[3] A. Collins, "Cognitive Apprenticeship," in *The Cambridge Handbook of the Learning Sciences*, 1st ed., R. K. Sawyer, Ed. Cambridge University Press, 2006.

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