

Work in Progress - Use of Guided Inquiry as an Active Learning Technique in Engineering

Elliot P. Douglas and Chu-Chuan Chiu
University of Florida, edoug@mse.ufl.edu, chchch@ufl.edu

Abstract - The purpose of this study is to examine the effectiveness of using guided inquiry in an Introduction to Materials class at a large research university. Throughout the course, the instructor, as a facilitator, guided students by providing an active learning environment and probing students with questions. A comparison was made between lecture and guided inquiry sections, both taught by the same instructor. The Materials Concept Inventory was used as a pre-test/post-test to measure students' learning; student satisfaction and self-assessment of learning was measured by the Student Assessment of Learning Gains. Measures of learning showed no significant difference between these two sections. The preliminary findings from surveys and interview data indicated that students did recognize the benefits of being active learners, but they felt uncomfortable without having an authority figure provide the "correct" answers. More detailed analysis of qualitative data is ongoing in order to gain more insights into using guided inquiry in engineering.

Index Terms – Active learning, Guided inquiry, Introduction to materials

INTRODUCTION

Active learning techniques are being used with increasing frequency as a means to engage students in their own learning. The use of active learning in the classroom spans a continuum, ranging from the occasional use of problems for students to solve, to the extensive use of discussions, problems, or other activities in a class[1]-[5]. Guided inquiry falls at the extreme end of this continuum. In a traditional class, students acquire knowledge by coming to the classroom, listening to instructors' lectures, and taking notes. In a guided inquiry class, the instructor does not lecture but instead creates an active learning environment where students can explore and construct knowledge through the interaction with their peers and instructor[6]. This approach replaces a traditional teacher-centered model with a new student-centered model.

In our study, we implemented guided inquiry in an Introduction to Materials course at a large research university. Students were given opportunities to become more cognitively engaged in their own learning with the instructor and their peers instead of passively receiving knowledge from the instructor.

IMPLEMENTATION OF GUIDED INQUIRY

The Introduction to Materials class is an introductory level course offered to both Materials Science and Engineering (MSE) majors and students in other engineering majors. The course covers a broad range of materials; topics can be broken down into the categories of materials structure and defects, diffusion, phase diagrams, phase transformations, mechanical properties, composites, corrosion, and electrical properties. There were 98 undergraduate engineering students enrolled in this guided inquiry class. Throughout the semester, students, as active learners, worked in teams of typically four students to complete worksheets. The worksheets contained three components: 1) Data or information as background material; 2) Critical thinking questions that were designed to lead the students to understand the fundamental concepts represented by the data, and 3) Application exercises that provided the students with practice in solving problems using the concepts they derived. During the group work time, students were encouraged to ask questions, and making mistakes were treated as part of the learning process.

The instructor guided students by providing an active learning environment, promoting group discussion, and probing students with questions. When students did not know how to proceed on a question, instead of being told the correct answers immediately the instructor asked probing questions that would guide the students into solving the problem. Through this mutual interaction, the instructor also gained feedback from students' questions and understood the challenges posed to students before the exams. Based on the students' progress on the worksheet, the instructor would stop the class and hold an open discussion. The teams were changed after each of the three exams. Thus, students had opportunities to work with other peers from different disciplines and hear voices from different perspectives.

DATA COLLECTION

In order to determine the effectiveness of this approach, a comparison was made between lecture class sections and guided inquiry class sections, both taught by the same instructor. The Materials Concept Inventory (MCI) [7] was used in a pre-test/post-test design to measure students' learning. The MCI is a thirty item, multiple choice instrument designed by Krause et al. to assess students' level of conceptual knowledge in an introductory materials science class. In order to assess students' beliefs about their

learning, student satisfaction and self-assessment of learning were measured using the Student Assessment of Learning Gains (SALG) [8]. The SALG is an online instrument designed to focus on how the pedagogy of the class affected students' learning gains, as opposed to issues of teacher performance or the extent to which students "liked" the class. The total sample consisted of 217 students in the control group, in which students were taught in a traditional lecture format, and 98 students in the treatment group, in which guided inquiry was applied.

In order to better understand the ways in which learning occurs within a guided inquiry classroom, a qualitative study was also conducted. Three randomly-chosen student groups were audio recorded while working in the classroom, followed by individual semi-structured interviews with students from those groups. The interview questions were mainly focused on revealing how students were working in groups and developing their knowledge. After the course finished, additional theoretical sampling [9] was conducted by interviewing more students in order to gain additional insight. Interviewees were selected based on their SALG surveys. Qualitative data analysis is still ongoing.

PRELIMINARY FINDINGS

From the quantitative analysis, the measures of learning showed either no difference between the two groups or a larger improvement for the control group (all significance testing was conducted at $p < .05$): there was no significant difference between the two groups on MCI post-test score, final course average, or course letter grade. While the control group did show a higher gain in MCI scores, the gain was minimal (1.3 points). On the SALG, students in the control group tended to rate the use of various class activities as more beneficial than the treatment group, and tended to be more confident in the extent of their learning. The only areas in which the treatment group scored higher were in questions related to the benefits of the worksheets and in working with their peers. In contrast, implementation of guided inquiry in other settings has found improved performance over lecture [6].

Preliminary examination of the transcripts for the interviews conducted so far suggests that students did recognize the benefits of working in groups, such as establishing critical thinking, learning cooperative skills, and retaining the content knowledge. However, the use of guided inquiry in this setting had minimal benefit due to the expectations of the students and the dynamics of group work. Some students felt uncomfortable with not being told the answers to the worksheet questions and suggested that the instructor offer the answers to all the questions, so they know they are getting them correct. Even though the instructor provided an active learning environment, students still expected to be fed knowledge by their instructor.

The other reason may result from the dynamics of the group work. Some interviewees reflected that their peers did not talk much during the teamwork time. Thus, the quality of

discussion was influenced by the characteristics of some of the team members.

It was also noted that course attendance dropped to approximately 50% by the middle of the semester, which is typical for this course. However, this may have differentially impacted the guided inquiry course, which relies on class attendance. To make guided inquiry work effectively, this study suggests that it is important for students to develop confidence in their own abilities and to be aware that they can not rely strictly on instructors to learn.

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AUTHOR INFORMATION

Elliot P. Douglas, Associate Professor of Materials Science and Engineering, College of Engineering, University of Florida, edoug@mse.ufl.edu

Chu-Chuan Chiu, Graduate Student, School of Teaching and Learning, College of Education, University of Florida, chchch@ufl.edu