Work in Progress: Does Practice Make Perfect? How First Year Students Develop Reflective Learning Skills

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Abstract

The U.S. Department of Labor and the American Association of Engineering Societies developed the Engineering Competency Model in 2015, which contains specific competencies in Adaptability and Flexibility, Lifelong Learning, Critical Thinking, and Creative Thinking. We promote critical thinking skills through reflection in the form of five graded journal assignments during our 15-week semester course in introductory engineering design. Students identify what they learned, why it is important and in what other context they could use this knowledge. Our goal is to measure individual progress over the course of a semester by using a repeatable and internally developed rubric for grading the assignments, and comparing participants' responses over time to the intellectual development scales found in the Perry Model and in the Reflective Judgement Stages of King and Kitchener.

Introduction

The Engineering Competency Model contains five tiers of competence: Personal Effectiveness, Academic Competencies, Workplace Competencies, Industry-Wide Technical Competencies, and Industry-Sector Functional Areas. [1] We assert that specific competencies in Adaptability and Flexibility, Lifelong Learning, Critical Thinking, Creative Thinking and Engineering Ethics are enhanced through practice in reflective thinking and judgement.

Reflective learning skills are metacognitive, and first year engineering students are already involved with metacognition as they consider and evaluate their own place in the engineering community through engineering identity and self-efficacy. [2] [3] We apply reflection in order to contribute to our students' intellectual development for critical thinking skills to whatever extent is possible during the first year. Our research goal is to measure individual progress in reflection over the course of a semester in two ways:

- By using the same rubric for all assignments, do students' grades improve over time?
- How do participants' responses compare to the intellectual development scales found in the Perry Model [4] and the Reflective Judgement Stages of King and Kitchener? [5]

Theoretical Framework

Our theoretical framework consists of the Perry model of intellectual development, first formed during the 1960's, and the King and Kitchener Reflective Judgement Model, beginning in 1994.[4] [5] [6] Both models are forms of epistemic cognition, involving the role of uncertainty and context in the acquisition of knowledge, and its effects on the development of beliefs about specific types of knowledge. It appears that the higher levels require the use of critical thinking.

Perry originally identified nine levels of cognitive skills leading to knowledge from a state of "right" vs. "wrong" to a state of awareness that knowledge is relativistic and context-bound, i.e., there can be many "rights "and many "wrongs." [6] According to King and Kitchener, knowledge is uncertain, depends on context and, at higher reflective judgement stages,

incorporates the changeable nature of existing and emerging evidence, along with recognition of the legitimacy of alternative beliefs. In our course, the appearance of evidence is evidence of reflection.

Study Context

This study involves the second of two one-semester introductory engineering courses, in which students pursue a design project in teams, coupled with individual development in engineering graphics, computer programming, teamwork, and critical thinking skills through reflective learning exercises. Graded homework assignments provide guided practice in these engineering skills. The participants are first year engineering students in their second semester of college.

Data Collection

Participants' responses will be compiled and de-identified in accordance with Institutional Review Board policy. Each participant answered these questions five times over the course of the semester:

1. What was the most important item of knowledge that you learned in this course over the past three weeks?
2. Why was it important to you to learn it? Please use a specific example, except for an immediate need to use it in our design project or to pass this course.
3. How could you use this knowledge somewhere outside of this course, such as in another course, a job, at home, etc.? Please be specific and tell me something that I am not yet likely to know.

Data Analysis

Participants' responses to questions #2 and #3 will be analyzed according to the intellectual development and reflective judgment stages identified in Table 1. Grading rubric criteria, which were common for all five of each participant's responses, appear in this table next to their corresponding stages. In addition to open coding of the responses, the grades for each response will be compared over the course of the semester. By comparing the response codes to grade behavior, we can determine whether a student's reflective judgement ability has improved with repeated practice. Using two forms of measurement provides triangulation, which improves validity.

Implications of Practice

Our results will inform our course content and delivery by indicating whether feedback through a repeated rubric is sufficient for students to progress beyond a superficial level of reflective judgement, indicating little or no intellectual growth, or whether additional guided practice in reflective learning could be beneficial. In addition, our results may also provide some indication of whether today's engineering students could progress any farther in their intellectual development than those studied by Pavelich and Moore in the early 1990's. [1]

Table 1: Intellectual Development and Reflective Judgement Stages Compared to Our Reflective Learning Journal Rubric

Stage	***Perry Model of Intellectual Development Regarding Knowledge***	***King and Kitchener's Reflective Judgement Stages Regarding Knowledge***	***Course Grading Rubric Criterion for "Importance of This Item of Knowledge"***	***Course's Grading Rubric Criterion for "Where Else Could You Use It?"***
1	Is right or wrong, a collection of facts obtained from authority	Is absolutely certain and concrete, based on observation	N/A	N/A
2	Is generally right or wrong. Authority gives us the right answer or give us problems to solve in order to find it.	Is absolutely certain but not immediately available, based on either observation or authority figure	N/A	N/A
3	Is right or wrong, but some of it may be unknown. Authority gives the answers or the means by which to find them.	Is absolutely certain (from authority figures) or temporarily uncertain (beliefs serve as substitute until absolute knowledge is available)	Identifies a non-specific benefit or consequence (e.g., " I can use this in my job as an engineer.") (1 point)	Names a non-specific use (e.g., " I can use this in my job as an engineer.") (1 point)
4	Some of it is right or wrong, but most of it is unknown. If authority does not know, then everyone can have their own opinion.	Is uncertain because knowing always involves some ambiguity; data are not always reliable and may be subject to error. Idiosyncratic beliefs may exist.	N/A	N/A
5	Most of it is contextual and can be judged qualitatively or subjectively.	Is based on context, and is subjective because it depends on individual perception and criteria for judgement	Identifies a specific benefit gained or consequence avoided (3 points)	Identifies a specific use outside of this course (3 points)
6	Is not absolute. Student accepts responsibility for making judgements and commitments based on their values.	Is constructed as a series of individual conclusions about ill-structured problems; information comes from a variety of sources. Conclusions are based on evaluations of evidence across contexts and can be derived from the opinions of well reputed others.	Identifies a specific benefit gained or consequence avoided clearly and convincingly (5 points)	Identifies a specific use outside of this course clearly and completely (5 points)
7	Is relative. Judgements are made among alternative views, and doubt is recognized and accepted.	Is constructed as a series of individual conclusions about ill-structured problems; is re-evaluated based on new evidence or perspectives, or the availability of new tools of inquiry	N/A	N/A

Note: the students receive a common grading rubric for each of five assignments. Each assignment has a total of 15 points, of which 5 points maximum are given for each of three questions: 1) "What was the most important item of knowledge that you learned?" 2)"Why is it important to you to learn it? "3) "Where else can you use this item of knowledge?" We also ask students to identify what they still find difficult to learn (not graded) and use their feedback for course improvement.

References

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