A Longitudinal and Cross-Sectional Study of Engineering Student Intellectual Development as Measured by the Perry Model

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Introduction

Industry leaders tell us that today's successful engineers need excellent communication, problem solving, and life-long learning skills in addition to the technical content engineering educators have traditionally focused on (Augustine, 1997; Barr & Tagg, 1995). In response, colleges are reforming their curricula to introduce more hands-on, active-learning techniques into many courses. Such experiences are intended to produce in our students the skills just described. While anecdotal evidence may exist to support the effectiveness of these types of changes, strong quantitative evidence is also needed. This study examines the effects of recent curricular changes in Penn State's College of Engineering on first-year students' intellectual development as measured by the Perry Model (Perry, 1970). These results are part of a larger study which is described in the *Method* section.

The Perry model suggests that studentsí cognitive processes develop over time from simple black/white thinking to a more complex evaluation of alternatives. Students' cognitive levels are assessed by a structured interview which asks them to reflect on the ways they think about ambiguous intellectual problems. This paper reports on the results of the *initial* phase of longitudinal and cross-sectional study of intellectual development of engineering students. In the first year of a four-year data collection plan (1996-97), semi-structured interviews were conducted with a randomly selected cohort of 53 entering first-year students. While results from the larger study will provide us with both longitudinal and cross-sectional data on the issues described, this paper reports only on the first round of interviews with the freshman cohort of 53 students. Thus, this paper examines the following research questions.

- Where do first-year engineering students begin on a scale measuring intellectual development?
- How do first-year students' Perry ratings at our institution compare to freshman engineering student ratings at other institutions?
- How do first-year studentsí comments about knowledge and learning vary based on student Perry ratings?
- How do men and women engineering students score relative to one another on the Perry scheme?
- What are the implications of the subjects' Perry ratings for teaching?

Literature Review

This section provides the line of reasoning for the studyís research questions as well as for the tools chosen to address these questions. We begin with an overview of the trends in changes in engineering education and then examine the Perry Model of Intellectual Development as a means of measuring student intelectual growth specifically analyzing the data for affects of the curricular changes these students are experiencing. In our discussion of the Perry Model, we provide background on how the model was developed, and also briefly summarize relevant prior research associated with the model.

Curricular Changes in Engineering Education

Science classrooms, along with other academic disciplines, have been the target of criticisms centering around students' ability to perform satisfactorily in the workplace. A recent report from the National Science Foundation (1996) indicates that teaching and learning methods in undergraduate science, math, and engineering courses do not adequately address the rapid changes that these students face in their industrial careers. Specifically in engineering, the Accreditation Board for Engineering and Technology (ABET)— which is the only agency responsible for accreditation of education programs leading to degrees in engineering — has recently published new standards which increases the focus on students' ability to perform real-world job tasks (PRISM, 1997).

Augustine (Augustine, 1997) tells us that ABET is correctly responding to fundamental changes in the engineering profession that push us to accredit programs on more than simply profieciencies in traditional engineering skills. Because of these changes, todays engineer must be able to

- continually re-educate him/herself
- operate effectively within the policital, ethical and economic forces of the world
- apply his or her skills to practical, real-world, complex problem situations.

The ABET 2000 criteria require engineering educators to examine their entire curriculum — from freshman to senior level courses. The current study, however, sampled only entering engineering students, so in this paper we focus our discussion of engineering education change to the first-year. Even before ABET 2000, many engineering colleges began to revamp the first-year engineering experience to include increased hands-on design, technical writing, oral presentations, and team-based projects (Dally & Zhang, 1993; Dym, 1994; Augustine, 1997; Olds, Pavelich, & Yeatts, 1990). Curricular changes, such as those implemented in Penn Stateís first-year engineering design course are designed to begin to meet the demands of ABETís new criteria in the entering engineering studentís first course.

We, as well as other researchers (see Section Related Research, below) have chosen the Perry model of intellectual development as one means of examining how such curricular changes are affecting our student populations. The next sections provide an overview of this model as well as a review of relevant research using the model in engineering and the sciences.

Perry Model Overview

William G. Perry (Perry, 1970) developed a quantifiable measure of intellectual development from clinical studies of Harvard college students in the late 1960's . The Perry Model has a range of "positions" from 1 to 9, where each level represents an increasingly complex and mature level of intellectual development. Table 1 summarizes the Perry positions. College freshman tend to be somewhere between Positions 2 and 3 on the Perry scale. This means they are strongly dualistic thinkers who tend to rely heavily on authority when making decisions. A typical entry level professional should be at Perry Position 6. At position 6, individuals use evidence and logic to make decisions in ambiguous real–world situations. Thus an implied goal of any collegiate education should be to help learners move from Position 2 to Position 6.

Engineering educators from a variety of institutions have adopted the Perry Model (Culver & Hackos, 1982; Pavelich & Moore, 1993) as a framework for evaluating the cognitive development of their students. At the Colorado School of Mines, educators have tested engineering and science students to determine how students develop along the Perry Scale during their four year undergraduate education. Early results showed that seniors were still averaging below Position 5. These educators will now use these results to initiate curricular changes in an effort increase the intellectual development of their students as measured by the Perry scale. At Penn State, we will integrate our measurement of the intellectual development of Engineering students with their discussions of how they approach open-ended design problems.

Table 1. Explanation of Perry Positions Relative to Knowledge and Learning

Perry Position	Knowledge	Learning
2 (Dualism)	Knowledge is right or wrong, a collection of facts	Receive right answers from authority
3 (Multiplicity)	Knowledge is right or wrong, but some knowledge unknown	Authority is the source to find the answers
4 (Multiplicity)	Some knowledge is right or wrong, but most is not yet known	Authorities are the source of ways to think
5 (Contextual Relativism)	Most knowledge is contextual and can be judged qualitatively	Authority are sources of expertise in defined realms of knowledge
6 (Contextual Relativism)	Knowledge is not absolute but student accepts responsibility for making judgments	Learns methods and criteria of their discipline
7, 8 and 9 (Commitment within Relativism)	Commitments made within a relativistic world as an affirmation of oneís own identity	Choices made in the face of legitimate alternatives and after experiencing genuine doubt. Multiple commitments necessary. No real answers, but a willingness to struggle with the process.

Three Perry Positions are particularly relevant to college student development. Position two reasoning, called dualism, is represented by a view of the world that is bifurcated. Students at position two see things as "us versus them", right versus wrong and good versus bad. Everything that is right, is determined absolutely by authority, and faculty members are seen as examples of this absolute authority. Thus there is no need for evidence beyond simply quoting an authority who knows what is "right". Freshman, who are often at this level, do recognize that multiple points of view regarding an issue may exist (even from authorities) but generally chalk this up as a short coming in the authority. Freshman at this level who are working on an open–ended design project may be disturbed or shocked that neither the client nor the professor has a definite answer to the problem at hand.

Position four, called multiplicity, is represented by students accepting that multiple points of view and lack of concrete answers is a common state. Knowledge and values are still seen in bifurcated terms, but more complex ones than at position two. Knowledge is divided into two realms: (a) things that are definitely known as right or wrong, and (b) things that are uncertain or that are represented by a multiplicity of views. Students are also more adept at using evidence, but still do not see evidence as a consequence of knowledge and its sources, but rather as an exercise in "how we should think". These students begin to demand more justification of authority's action and can be very suspicious of the truth of any evidence. They also feel that everyone's opinion is equally valid, and therefore, a commitment to any decision is easily changed. In terms of projects, Pavelich and Moore suggest that this position is represented by a project team who develops a good case for one solution, but does not explore other alternatives (Pavelich & Moore, 1993).

By position six, students’ view of knowledge as uncertain is now seen as the norm. Persons at position six can see how multiple opinions are the natural way of things when persons of many backgrounds and values are placed in a situation. The use of evidence that was once seen as just an exercise in thinking is now seen as necessary for approaching real–world open ended problems. Persons at position six are also more committed to a course of action. Everyone's opinion is no longer viewed as equal and thus a particular course of action or decision may be seen as having more validity and rightness than another — although this is nothing like the dualism expressed at position two.

There are several means of determining a person's Perry Position: (a) structured interviews, (b) written essays focusing on decision making and problem solving processes (Measure of Intellectual Development), and (c) an objective, recognition measure of the Perry Scheme called the Learning Environment Preferences (Baxter Magolda, 1987b; Stonewater, Stonewater, & Hadley, 1986). Interviews focus not so much on the specific stands or views a student holds, but rather how that student reaches those views and the way the student justifies the stand. This study uses the interview form only. The interview format has been shown to allow students the most opportunities to express their ideas and thus achieve their maximum Perry rating (Pavelich & Moore, 1993). Some sample interview questions are shown in Figure 1.

- What is your view of the ideal college education?
- How would you define knowledge?
- What is the relationship between knowledge and truth?

The interviewer may probe further with questions such as:

- How did you arrive at that view?
- Can you remember a time when you didn't think this way?
- What kind of experiences or situations might have produced the changes in your thinking?

Figure 1. Sample Perry interview questions.

Perry Model Research Review

Since the original study of Harvard men in the late 1960's **(**Perry, 1970) the Perry scheme has been used in many research studies. For purposes of brevity, this review focuses primarily on the use of the Perry scheme in research associated with classroom interventions and curricular changes. For a more complete review of Perry literature, refer to Hofer and Pintrich (1997).

Perhaps the most noted study from engineering education using the Perry model was conducted at the Colorado School of Mines (Pavelich & Moore, 1993; Pavelich & Moore, 1996). Researchers at the Colorado School of Mines (CSM) wanted to determine what intellectual development actually does occur for their undergraduate students as they progress through their four years of study. Their purposes, beyond the important one of attaining this benchmarking data, were several. First, CSM wished to determine if graduating seniors have attained Perry position 6 — because employers would like to have entry-level workers functioning at Perry position 6, a goal of a college education should be to move students from their typical freshman starting point of 2, to position 6. If position 6 were not being achieved, the data would help to drive subsequent curricular reform and be used to measure the effects of such curricular changes.

At CSM, a cross-sectional study was conducted using student volunteers at the freshman, late sophomore and graduating senior levels. These subjects were measured on the Perry scheme via one-hour structured video-taped interviews which were then viewed by expert evaluators who determined where each student's thinking placed them on the Perry scale. CSM students showed a growth of one position over their undergraduate years. While this does not attain the goal of most seniors graduating at or near Perry position 6 (only one quarter of seniors tested above position 5), it does stand up well when compared to a study using a similar developmental. This latter study, which used measured undergraduate students over a 15 year period in a wide variety of schools, used the Reflective Judgement Model of King and Kitchener and found that students moved only one-half position at best (King & Kitchener, 1994). Examining freshman, the focus of the current study, CSM first-year students averaged a 3.27 Perry rating (Pavelich & Moore, 1996).

Pascarella and Terenzini (1991) summarize several other studies based upon the Perry scheme. Stephenson and Hunt (1977) specifically developed a course-based intervention around Perry's scheme of intellectual development to encourage movement from their freshman students' dualist position to a more relativistic stage on the Perry scheme (see Table 1). To accomplish this, the course emphasized content that challenged students' values, while doing so in a supportive teaching enviroment. On pre and post tests on the Perry scale, the students in this experimental course section showed substantially greater movement than their counterparts in the control (mean change of +.85 versus +.25).

Pascarella and Terenzini (1991) describe other studies that also sought to examine whether developing course interventions specifically aimed at the students' initial Perry stage could encourage and facilitate student advancement on the scale. (Widick, Knefelkamp, & Parker, 1975; Widick & Simpson, 1978; Knefelkamp, 1974) One of these studies, which did not have a control group, showed via pre and post test course measures a Perry gain of slightly more than .75. A second study included a classroom intervention which intentionally exposed students to cognitive development instruction. A greater percentage of the students in this experimental section showed growth on the Perry scale than those in the control (63% versus 51.5%). To see Perry gains of .75 to .85 during one semester is of particular signficiance relative to the expected Perry gains during a four or five-year college undergraduate education. Recall from our earlier description of the Perry model that desired growth in Perry ratings over the college years is a total of four positions. If one course can help students progress nearly a full position of the desired total of four, this is certainly a significant contribution.

The research summarized in this section shows that the Perry scheme is a useful tool for both analyzing curricular reforms as well as shaping them. The purposes of this study embrace both of these goals. Early results from the overall longitudinal and cross-sectional study, such as those reported in this paper, will provide benchmarking data for engineering faculty and administrators. The second set of studies cited show that this benchmarking data can then specifically and effectively inform overall curricular reforms.

Method

Research Design. The data collection for this study is part of a larger research study in the College of Engineering at the Pennsylvania State University. The data reported here is from the first of a four year study of the intellectual development of engineering students. The following items summarize the collection plan and our current status.

- First year of study: 53 first-year students (cohort AAA from Table 2), 27 fourth-year students (BBB) were interviewed.
- Second (current) year: 29 third (junior) year (CCC), and 53 first-year (DDD), and approximately 25 fourth-year (EEE) students interviewed.
- Third year: reinterview original cohort AAA, now as third-year students; and sample a new first-year cohort (FFF), and so on as depicted in Table 2. The data collection will continue in this fashion, both adding new cohorts and following initial cohorts over time. In this way, we will construct a sample that can be analyzed both cross-sectionally and longitudinally.

Table 2: Data Collection Plan. Staggered Freshman, Junior, Senior, and Alumni Cohorts.

Academic Year	**Semester**	**Cohort**			
		End of Freshman	**Beginning of Junior**	**End of Senior**	**Alumni /5th yr**
	Sum/Fall				

1996-97 (completed)	1996				
	Spr 1997	AAA (53)		BBB (27)	
1997-98 (in progress)	Sum/Fall 1997		CCC (29)		
	Spr 1998	DDD (53)		EEE (~25)	
1998-99	Sum/Fall 1998		AAA (53)		BBB (27)
	Spr 1999	FFF (~50)		CCC	
1999-2000	Sum/Fall 1999		DDD		EEE
	Spr 2000	GGG (~50)		AAA	
Final Follow-up	Sum/Fall 2000		FFF	DDD	CCC

As the data are collected, we will be able to analyze differences between various groups of students, for example those student who are retained in the College of Engineering versus those students who leave. As we collect the interview data, we will also collect transcript information from students. In this way, we can connect the cognitive levels of students to their retention and achievement.

Population, Sample and Data Collection. Fifty-three students were randomly selected from the 900 pre-engineering first-year students at the Unviersity Park campus of the Pennsylvania State University. Sixteen students were female (30.2%) and 37 students were male (69.8%). The students in the sample were predominantly white American (87.5%), a proportion which is slightly lower than the proportion of white first-year students in the college as a whole. The average Math SAT score for the sample was 652 and the average Verbal SAT score for the sample was 607. During their first semester of college, the students in the sample earned an average GPA of 3.15 on a 4.0 scale.

Students were contacted by phone early in Spring semester and asked to come in for an interview about their academic experiences in the College of Engineering. The researchers conducted a semi-structured interview with each student that lasted approximately one hour. Interviewers asked students about their opinions on the ideal college education, their preferences for learning, their definitions of knowledge, how they solve open-ended problems, and their encounters with people who held views different from themselves. Fifty-one inteviews were videotaped and two interviews were recorded on audio-tape (at the students' request). Each interview was then independently rated by an expert rater at the Center for the Study of Intellectual Development. Fifty-two of the 53 interviews provided a reliable indication of a specifc Perry stage of development. One student interview (male, international) was not consistently rateable due to language and cultural barriers.

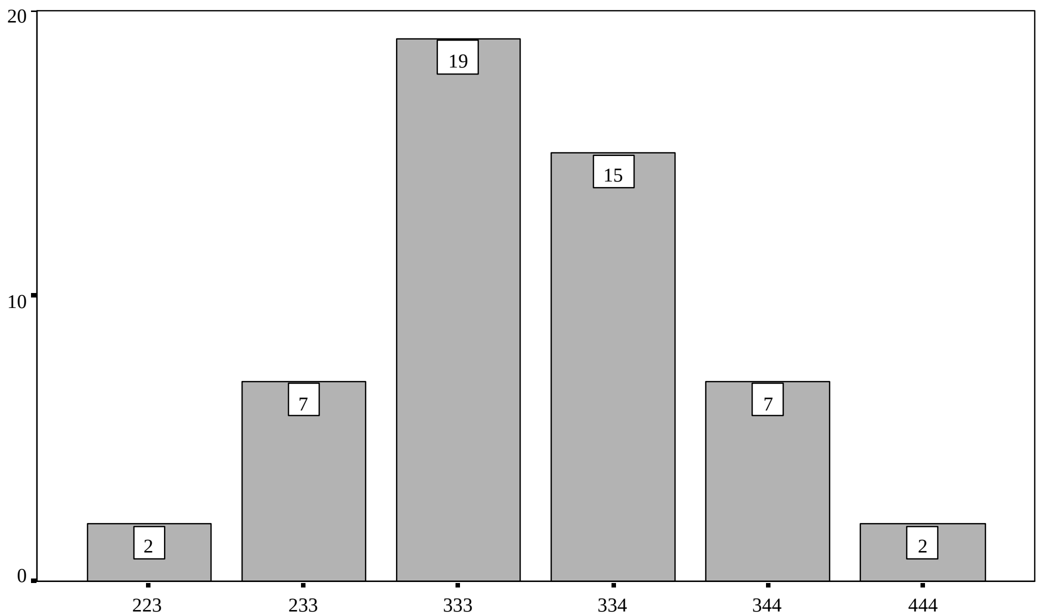
Method of Analysis. Data on students' pre-college test scores and semester GPA were collected from the University student database. Additional demographic data was collected from each student after the interview. Perry model ratings were translated into a numerical scale and entered into this same dataset. This quantitative data was then analyzed using SPSS. Qualitative data (summarized in Tables 3 and 4) were transcribed from individuals who were judged by the independent Perry rater to be representative of the comments of a particular Perry model stage of intellectual development.

Results

Four percent of the first-year sample were rated below Perry level 3. These students were still consistently dualistic thinkers, seeing knowledge as a collection of facts. They expect their teachers to be authorities and the source for right and wrong answers. The majoritiy of the students in the first-year sample were at Perry level 3 and 4 (multiplicity). To varying degrees, these students are willing to consider multiple answers but expect their teachers to be a source for finding the right answer from the various possibilities. None of the students in the first-year sample were rated above Perry level 4. The average rating for the sample was 3.15 with a standard deviation of only .38 points.

In addition to the single digit Perry rating just reported, our independent rater has devised a system (which has been used in prior research (Pavelich & Moore, 1993)) that results in a three-digit rating, such as 3,3,4. This rating system, which is an extension of Perry's original single numerical rating, provides an assessment of the continuum of the ratee's cognitive development (Pavelich & Moore, 1996). In other words, while a student may be primarily at Perry position 3, they may show strong evidence of beginning to move to position 4. Ratings such as 333 indicate a "stable" position. Then, there are two steps of transitional ratings between each stable position. For instance, a 334, indicates a dominant position 3 but with some opening to position 4. A 344 indicates a dominant position 4, with a trailing position 3. Thus, the middle digit indicates the dominant rating (as reported in the prior paragraph), the first digit the ìtrailingî position and the last digit the ìopeningî position. Figure 1 shows these ratings for the sample.

Figure 2: Distribution of Perry Ratings for First-Year Engineering Students



Control Variables. Students' Perry ratings were not significantly correlated to Math SAT score (r=-.039, n.s.) or first semester college GPA (r=.083, n.s.). The correlation between Perry rating and Verbal SAT approaches statistical significance (r=.224, p=.110). Given the verbal nature of the interview task, it is not surprising that students with better verbal skills would achieve higher Perry ratings.

Gender Differences. There were no significant differences in rating between males and females in the sample (F=.8104, df = 1,51, p=.3723). Similarly, men and women did not differ significantly on the control variables of Math SAT scores, Verbal SAT scores, or first semester college GPA.

Qualitative Results. While the numerical results provide an accurate picture of how the sample distributed itself over the Perry positions, actual quotations from the student interviews afford a sense of what comments about topics such as knowledge and learning indicate particular Perry ratings. These data were transcribed from individuals who were judged by the independent Perry rater to be representative of the comments of a particular Perry model stage of intellectual development. We begin with quotations that address the topic of knowledge (see Table 3), and then examine subject thoughts on learning (Table 4). Regarding knowledge, subjects were asked to define knowledge and its relationship to truth. The reader will note that subjects with higher Perry ratings are more capable of articulating their thoughts about knowledge, and their comments become more sophisticated. For Tables 3 and 4, a set of astericks in the student comments columns indicates that the next paragraph represents a different student's remarks (e.g. Perry rating row 444 in Table 3).

Table 3: Transcript excerpts on knowledge representing Perry positions.

Perry Rating	Student Comments About Knowledge
223	I guess memorizing something and then being able to apply it. It involves like reading, letís say reading, you have to be able to read it, like know all the letters, and what the words mean. Thatís the memorization part, and then you have to be able to apply it to see what the sense says. Well, the college has to teach you how to apply the knowledge. Itís your job to memorize stuff, like to learn it by reading the book and college shows you how to apply what you know. I donít think thereís a relationship [between truth and knowledge], or very little. I think you can have knowledge of something, it could be wrong, but you think you have knowledge of it....Yes, I think truth is absolute.
233	Being more intelligent than just smart. Knowing, not just factual information but everything about human beings and nature -- their ideas and feelings. Having an imagination. They have to be really rounded, itís not just memorizing encyclopedias or something like that..... I think, if you have knowledge on the subject, it might not be the truth. Just because you know, or you think you know something But if you know the truth, you definitely have knowledge on the subject. Just because you know about it, doesnít mean you know the truth about it. If you havenít really studied it, you might know it, but what you might have heard could be a rumor or could be something else..... Teachers should definitely teach you the truth. You should be able to get knowledge from that. Just by knowing, trusting the teacher is going to give you the right information.
333	Itís just information that you apply. Like you take stuff that you know and apply it and then you have knowledge. Itís experiences, and the more experiences you have the more knowledge you have. Itís just something that you accumulate throughout your life. And gain more and more of as you experience things........ Well just because you have knowledge doesnít mean you know the truth all the time. Truth can be hard to find some times. But the more knowledge you have, the better tools you have for seeking out the truth.
334	Well knowledge like I said about applying what you learn. So thatís like all knowledge your experiences and from what you learn. And truth, Iím not really sure how truth fits in. Truth is...thatís tough. I think that itís just from what you learn in experiences, like I said before , it fits in because people form opinions about things through college, cause I know a lot of ideas are shooted out because there are so many people in college and youíre exposed to so many different things I think people hold different values and stuff form where youíre raised. And college just brings that out even more. So I think truth is further developed in college, knowledge is a bigger part I think, but Iím not really sure. Iím sure Iíll find out eventually. I think that people might be closeminded or open-minded and if youíre if you understand, if you donít, if you feel that you can experience other stuff, if youíre just open to other things, and your values have taught you that you should be openminded, and you should consider what others have to say, then that adds to your learning, your knowledege. It allows you to seek different aspects of college. If youíre, like, closed, if you donít have good values, you might not be openminded, you might not want to experience other things, you might not want to go out and actually learn this stuff and go out and get hands on experience. But if you have good values you’re willing to talk to others. If you have bad values you might not be willing to talk to other students of different backgrounds and that might come into play. But if you have good values you will go out and talk to them and youíll learn so much more.
344	Yes, actually, one of the things Iíve learned from this class is that, at least in engineering, there is no one exact answer. Because even exact answers have assumptions built into them. And as long as your answer is within established bounds for your error, itís a correct answer.

444	Truth is like, for me at least, it would be the best answer possible, the one that makes the most sense. *** Wow thatís a good question. Knowledge is a way of thinking about problems, perhaps. Almost an intuitive sense of where to begin something, how to go about thinking about it....... I donít think there is an absolute truth. So I guess knowledge would be a way of trying to come to a truth in your mind. But I mean, there are so many alternatives that itís hard to say if there is a real truth, but knowledge would be a way of trying to get to a truth...... Iíd say that, like, scientifically, yes, [there is an absolute truth] with facts. But no, not really, I donít want to get too philosophical here, but perhaps there is one truth, but we can never get to it because of our own human problems and imperfections....... But I think even with facts there is room for change because you can take facts and expand upon them. As long as you are using what has been proven before to prove something new. I guess with Einsteinís theory he took Newtonian mechanics and he just expanded it to higher level. So itís not like he disproved it, but he kind of took it and said that was good but this is better...... And I guess thatís why you say there are no one absolute answer because you keep learning and finding more things out..

The interview protocol also contains several questions related to learning. We examined subject quotes from the following query: describe a course that would represent the ideal learning environment for you. We further probed by asking what the role of the student and the faculty member would be in this environment. Transcriptions on these questions show a similar trend as those for knowledge. Subjects that were rated higher on the Perry model, once again, show evidence of deeper thinking in their comments about learning (see Table 4).

Table 4: Transcript excerpts on learning representing Perry positions.

Perry Rating	Student Comments on Learning
223	It was just a open lecture course, but I was able to pick up a lot of stuff in there. She went at a good pace. And it just lecture. I have trouble sometimes in a class where there is a lot of class participation I like being lectured to, I find I just learn stuff better that way. just drill it into you.
233	I had English 15 last semester. and that was good because the teacher was really interested in getting everyone to see that other people had different opinions. To get us to work in groups to evaluate, like student evaluation, to point out things that were wrong or right, and showing why. Kind of like helpful criticism. Not like putting someone down. She helped us to see a lot of different views that way. So it was a really good class. Iím trying to think what else I have.... I had one other class I had this summer, a comparative literature course. Where again it was more opinion-based, of what you were reading and what you saw. And that was helpful, because you would read the texts and see something maybe totally different than what other people saw. And then they would come to class and you would all talk about it and they would be ìMan, I didnít even see that.î So that was helpful too.
333	I think that they [faculty] need to stimulate your thinking, not just tell you what the answer is but stimulate your thinking to try and solve it yourself. But to help you along with that, I think thatís the best thing.
334	The teacher? I use him as a resource, like my textbook. Like I, if I read the book and I donít understand it, make office hours, go to an appointment. Use him as another way of learning the material. .... But I feel thatës what the teacher is there, to make you understand whatís going on. And as long as you a have the will to access the information, itís there.. And I like to use the professor or the teacher as another means of information to help me learn the material.

	** I think theyíre [faculty] more there just to present the concepts to you, and if you have trouble to help you along. Theyíre not really there to do the work for you or , I donít really know, they show examples but I think its more up to you to hands-on on learning. They are more there as like an overseer. I think thatís a good role to have as a teacher in that kind of setting......The role of the student I think is to do the actual work and to apply what theyíve learned. It probably, itís more work for the student. And thatís probably the way it should be. The student learns, applies what theyíve learned. I canít think of many different ways to put it. The student is the more active person in the class and thatís the way it should be. The teacher is there to guide you along and help if you have problems.
344	The role of the faculty member? Definitely to provide the direction for the class. Establish the content. Make sure things donít stray from the topic. But not necessarily just to say ìhereís the information, memorize this and on the test repeat it back to me. And if you memorize it all you get 100%, an A.î ....Not that they donít present everything, but that you should be required to think and not just memorize answers. I guess related to Engineering. Iím in my first Chemical Engineering course right now. The problems that we do. We havenít really talked about that specific problem in class, but just general principles that you use to solve the problems. And you work through that process. Heís taught us the process but we have to work through the problems on our own. Because thatís how weíre going to learn. He canít just stand there and say ìokay, this is how do this problemî Because that problemís already been solved. You have to solve new problems now. Well, in addition to being there for clarification of the problem, there are times where you come to a certain point where youíre just like ìI donít know, Iím stuckî And itís not so much his [the facultyís] job to give you an answer as it is to kind of kick you back along again. And give you something that you can work with, maybe lead you in the direction you need go. Not necessarily carry you around on a leash, but just kind of guide you in the right direction. And thatís kind of objective because everyone needs a different amount of guiding and some people will feel dragged, and others will be like ìhey, I still donít know what heís talking about, I still donít know what to do.î ..... itís the students job to, well, use everything within his means to figure out the problem and, of course, that includes the instructor and his teammates or whatever. But also, itís the studentís job to be able to realize that although they would like to have the answer given to them , itís their job to find it themselves.
444	I think the main thing is to make him think for himself. Thatís what college is for basically, problem solving You got to learn how to do that stuff, thatís why you come here. You learn how to think for yourself, put your ideas, state your ideas clearly and coherently. Just basic communication skills as well I think that is really important in any field you might go into...... [The role of the faculty is] to promote this kind of behavior from the student. To sort of be a mediator To look over everybody, Make sure everything is progressing as it should be. I think that their main job is, they should be available as a resource. To help the student out if they are having any problems. To help them develop their thinking style along the way.

Discussion

To guide our discussion of these results, we recall the research questions posed earlier in the paper. Specifically:

- Where do first-year engineering students begin on a scale measuring intellectual development?
- How do first-year students' Perry ratings at our institution compare to freshman engineering student ratings at other institutions?

- How do first-year studentsí comments about knowledge and learning vary based on student Perry ratings?
- How do men and women engineering students score relative to one another on the Perry scheme?
- What are the implications of the subjects' Perry ratings on teaching?

Overview of Sample Perry Ratings

Figure 2 summarized our findings to the first research question. From Figure 2, we can see that 52 first-year engineering student subjects distributed themselves in almost a “normal” or “bell” curve. The leading and trailing ends of the curve both contain 2 students; two at Perry rating 223, and two at Perry rating 444. This symmetric picture continues with two more sets of 7 students; seven at Perry position 233 and seven at positon 344. The remaining 34 students are distibuted across positions 333 an 334.

Comparison to Similar Study

Proceding to the next research question, we compare our first-year students' Perry ratings with those of a similar sample — that from the Colorado School of Mines (CSM). Table 5 summarizes the two studies comparatively. While the CSM data shows a slightly higher average Perry rating than PSU's (3.27 versus 3.15), the PSU data shows a lower standard deviation. Because of the differences in sample sizes and other methodological differences, a formal statisitcal analysis was not performed on these data. A couple of comments regarding this comparison are in order. Recall that while the CSM subjects were chosen from the entire institution (and not from a specific course of study such as engineering), that CSM is entirely an engineering and sciences institution — thus both samples deal with students of somewhat similar intellectual interests. Another difference to note between the two studies is the sampling method. Subjects from CSM were volunteers while PSU subjects were randomly generated. It is possible that this difference in sampling methodology together with the relatively small sample sizes from both populations, could account for the differences in ratings. Regardless, the ratings are similar enough to provide mutual support for both sets of data.

Table 5: Comparison of Colorado School of Mines (CSM) and Penn State (PSU) Results

Institution	**Sample Size for First-Year Students**	**Mean Perry Rating**	**Standard Deviation**
CSM	45	3.27	0.44
PSU	52	3.15	0.38

Comments on Knowledge and Learning Relative to the Perry Ratings

To examine how first-year studentsí comments about knowledge and learning vary based on student Perry ratings we turn to the qualitative data presented in Tables 3 and 4. Essentially, students at lower Perry positions are less sophisticated in their descriptions of knowledge, and its relationship to truth, as well as learning, than students at higher Perry postions. For instance, the student at Perry postion 223 describes knowledge as

> I guess memorizing something and then being able to apply it. It involves like reading, letís say reading, you have to be able to read it, like know all the letters, and what the words mean.

This description of knowledge is in stark contrast to the Perry position 444 student's comments:

> Knowledge is a way of thinking about problems, perhaps. Almost an intuitive sense of where to begin something, how to go about thinking about it....... I doní think there is an absolute truth. So I guess knowledge would be a way of trying to come to a truth in your mind.

While all subjects struggle with these questions, subjects with higher Perry ratings indicate a view of knowledge that is beyond the black and white, or dualistic view, of simplying memorizing something. The 444 student characterizes knowledge in tehrms of the thinking process and searching for truth as compared to the foacu on memorization taken by the 223 student. In general, for students with higher Perry ratings, knowledge is portrayed as more intuitive, developmental, and a way of thinking about something. Note also the clearly relativistic statement from the second quotation indicating the there is "no absolute truth".

Regarding learning, subjects were queried about their preferred learning environment and what role the student and the faculty member take in this environment. As with the subjects' comments about knowledge, we see a similar progression in their comments about learning. The subject at position 223 as quoted in Table 4 says the following about a specific course that represented his/her ideal learning environment.

> It was just a open lecture course, but I was able to pick up a lot of stuff in there.
> She went at a good pace.

The student at 223 describes an ideal learning situation in terms such things as the course format (lecture), being able to learn a lot of stuff (one might read "facts"), and the pace of the course. While these are all certainly characteristics of a learning environment, they are fairly broad and shallow in terms of their treatment compared to how the student at position 444 talks about learning.

> I think the main thing is to make him think for himself. Thatís what college is for basically, problem solving You got to learn how to do that stuff, thatís why you come here. You learn how to think for yourself, put your ideas, state your ideas clearly and coherently.

The two quotations, while both in response to the same query, are qualitatively different. The 223 student examined learning in terms of very specific course characteristics (lecture, learning "stuff", and pace). In contrast, the 444 student discusses how the ideal learning environment should affect his thinking, his knowledge organization, and his ability to act effectively and independently. More specifically, the 223 student's thoughts on learning focus on external activities (mostly those of the teacher), while the 444 student considers how the experience will change how he approaches and views the world.

Gender Differences in Perry Ratings

Given the overall interest in recruiting and retaining women in engineering colleges, we posed a research question regarding gender differences in the Perry ratings for our sample. We find it notable that there were no statistically significant gender differences in the sample (F=.8104, p=.3723). This is interesting for a number of reasons. First, the Perry model is reputed to be male-biased (Belenky, Clinchy, Goldberger, & Tarule, 1986) — that is, because the original Perry sample was nearly entirely male, the instrument does not afford the women the opportunity to score as well as men. Because of this reputed bias, we might expect to see that men would be rated higher than women on the Perry scale. This, as the data shows, is not the case. Table 6 shows how the sample distributed itself by gender and Perry ratings.

Table 6. Sample Displayed by Gender and Perry Ratings (N=52)

Gender	Count (Percentage)	Average Perry Rating
Male	36 (69.2)	3.185
Female	16 (30.8)	3.083

Another reason this finding is interesting has to do with retention of women in engineering. University data that follows first-year cohorts until their undergraduate matriculation, shows that women who begin in engineering graduate at a lower rate in engineering than their male counterparts (Marra & Palmer, 1997). So, while retention of women in engineering is definitely a problem that our faculty and administration continue to address, given the data shown above, we can conclude that women's relative intellectual development ratings are not negatively contributing to women's retention in engineering during the first-year.

Implications for Instruction

A central reason for collecting these data is to inform future curricular reforms as well as to provide individual faculty with information that can improve the impact they have on their students. Several of the studies reviewed previously (Pascarella et al, 1991; Stephenson et al, 1977) address how knowledge about the typical students' Perry positions can positively affect course interventions and curriculuar innovations. For instance Stephenson and Hunt (1977) were able to include course activities that challenged students absolute beliefs in authority and helped them to see the value of multiple perspectives.

A specific suggestion for course structure based both upon this prior research as well as the underlying implications of the different Perry positions has to do with moving from lecture-centered, so called "chalk and talk" courses, to ones where students are actively participating in discussions and problem-solving activities. In thse suggested learning activities, the instructor moves away from a position of absolute control to a more facilitator-like role. We suggest this because we believe that lecturing to students reinforces the underlying dualistic precepts of first-year students. Dualistic learners see authority figures as purveyors of absolute truth and knowledge. The instructor who “transmits” knowledge to students for 50 or 75 minutes strengthens the dualistic idea that he/she knows what is right and wrong and that students have no input or influence on this knowledge. Exposing students to, coaching them into, and requiring them to participate in more open-ended discussions and problem solving activities is a way to begin to challenge their dualism. While this may look great on paper, it may not be easy. Some dualistic students in our sample seem to prefer lectures. For instance, a predominantly dualistic learner at position 223 says:

> I like being lectured to, . . . I find I just learn stuff better that way. . . just drill it into you.

We can see a change from this position as we examine a quote about the faculty’s role in the learning environment from a student at position 344.

> But not necessarily just to say ìhereís the information, memorize this and on the test repeat it back to me. And if you memorize it all you get 100%, an A.î . . . Not that they donít present everything, but that you should be required to think and not just memorize answers.

From this student at position 444, we see yet another view on the faculty member’s role in the learning environment.

> [The role of the faculty is] to promote this kind of behavior from the student. To sort of be a mediator To look over everybody. Make sure everything is progressing as it should be. I think that their main job is, they should be available as a resource. To help the student out if they are having any problems. To help them develop their thinking style along the way.

From these quotes, we can see that the dualist learner clearly states his/her preference for lecture. The learner at position 344, while not clearly addressing a preference or an aversion to straight lecture, indicates that a faculty member should not “present everything”and that students should be required to do more than simply memorize. Finally at position 444 we see the student clearly defining the faculty member’s role as something other than a lecturer. The faculty member should act as a “mediator” and a “resource” and should strive to help learners develop their own thinking style along the way.

These ideas are supported by Baxter Magolda’s research on student relationships with faculty members and intellectual development (Baxter Magolda, 1987a). This study showed that students at higher Perry positions preferred more colleagial relationships with faculty while students atht the lowest level wanted the relationships to be comfortable but not too close or personal. The faculty-member-as-student-colleague maps directly to a faculty member who is more likely to facilitate discussions, and encourage student-to-student learning, and avoid lecture. Thus we strongly suggest that using active learning strategies (e.g. in-class discussions), challenging students in class to express their own opinions, introducing multiple perspectives, acting as a coach/facilitator rather than a transmitter of knowledge, and in general moving away from lecture classes will help students grow intellectually.

We aren’t naive; we recognize that these activities may initially be more work for the faculty member and perhaps may be equally uncomfortable and unfamiliar for both them and their students. However, if it is a goal to move the predominantly dualistic first-year student towards relativism, these activities would appear to be most effective.

Conclusion

This paper has presented a study of intellectual development of 53 first-year engineering students using the Perry scheme. This study, which is part of a larger longitudinal and cross-sectional study of intellectual development of engineering students, examined several research questions.

- Where do first-year engineering students begin on a scale measuring intellectual development?
- How do first-year students' Perry ratings at our institution compare to freshman engineering student ratings at other institutions?
- How do first-year studentsí comments about knowledge and learning vary based on student Perry ratings?
- How do men and women engineering students score relative to one another on the Perry scheme?
- What are the implications of the subjects' Perry ratings for teaching?

While the numerical results, which showed that our first-year sample compared similarly to a study at the Colorado School of Mines which also used the Perry scheme (means were 3.15 and 3.27 respectively; see Table 5), perhaps the most interesting results are found in the qualitative data concerning how how students at different Perry positions discuss knowledge and learning. This qualitative data (see Tables 3 an 4) clearly shows that students at high Perry positions think and discuss these topics in more sophisticated ways.

Although these results are preliminary in terms of our overall five-year research plan, we anticipate they will effectively inform the ever-evolving engineering curriculum. At this writing, the authors are planning activities to disseminate this data at our institution. These initial data will thus serve as a specific framework for discussing desired intellectual growth for our students, and how to achieve maximal growth via curricular changes and specific course interventions. Future results from this longitudinal study may then shed light on the effectiveness of these continual curricular reform efforts.

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