Measuring the Effect of Experiential Education Using the Perry Model

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ABSTRACT

This paper reports data on how well one engineering curriculum with extensive experiential components helps students mature toward more complex thinking; toward being better able to make good decisions on ambiguous, real-world, engineering problems. Hour-long, structured interviews were used to assess students' thinking based on William Perry's Model of Intellectual Development. These cross-sectional data show Colorado School of Mines students progressing an average of 1.0 Positions during their undergraduate years. This may be an unusually high achievement. If so, the data speak to the value of experiential education in a curriculum. However, the data are disturbing in that only one quarter of graduating seniors show progression to the level needed in their professions (above Position 5), while one third of them still fall below Position 4. We argue that, to get more students to progress above Position 5, professors teaching experiential engineering courses need to be knowledgeable about developmental models like Perry's and need to use those insights proactively in mentoring their students.

I. INTRODUCTION

A primary goal of collegiate education is to help students mature into skilled and responsible open-ended problem solvers. For example, our graduates need to be able to design a durable, low-cost process to prevent runoff of acidic, heavy-metal waters from an inactive mine rather than to simply calculate the flow of water through a hypothetical system. This complex, real-world problem solving requires a wealth of skills including technical competence, teamwork, self-education, creativity, and evaluation of alternatives. These all feed into the most important ability, being able to make reasoned decisions in an ambiguous situation and taking responsibility for the consequences.[1]

Many engineering schools have programs designed explicitly to help students develop these open-ended problem solving skills.[2,3,4] At the Colorado School of Mines (CSM), most undergraduates complete what we call projects courses in six of their eight semesters, beginning with the first semester of their freshman year and ending with senior design.[5,6] A projects course is one where students work in teams on an open-ended problem given to them by an industrial or government agency client. The idea is to help students develop these complex thinking skills by repeatedly putting them in situations where those skills are called for and then mentoring them through the experience. The clienteed-projects program at CSM is a decade old and has yielded some very satisfying results.[7] However, there is one important aspect of student development which is still disquieting to us. That aspect is the advanced thinking that enables students to "make defensible judgments about vexing problems"[8] or, as stated above, their ability to make reasoned decisions in an ambiguous situation and to take ownership of the consequences.

College educators face a fundamental difficulty in teaching open-ended problem solving. There is ample evidence that freshmen do not understand these problems as a professional does; furthermore, neither do sophomores nor many seniors. It is not simply what they don't know; rather, it is that their knowledge reflects deeply held beliefs that are at odds with the situation. For example, many freshmen sincerely believe that all problems have known answers. When given an open-ended problem for their team to work on, they search the readings for "the answer" believing that the professor has hidden it somewhere. Many freshmen also do not understand why evidence has to be used in justifying a decision. To them recommendations can be justified by blindly citing an authority in the field. Most sophomores and seniors do use evidence well, but see no need to devise and evaluate alternative solutions to a problem; one well argued possibility is considered sufficient.

To help us understand and work with these student perceptions, we have found William Perry's model of intellectual development in the college years most useful. The model directly analyzes the understandings needed for open-ended problem solving and identifies stages that students go through as they approach this understanding. In this paper we present the model, illustrating its stages with excerpts from hour-long interviews of CSM students. We next discuss this interview method as a measuring device and present data, based on these interviews, on how students progress through the stages over the undergraduate years. The results are compared to those from other investigations, and conclusions about the need for further reform of engineering education are argued.

II. THE PERRY MODEL

Based on a series of open-ended interviews conducted primarily with Harvard undergraduates during the 1950's and 1960's, and since replicated with a wide variety of students and institutions, the Perry Model provides an extensive qualitative analysis of the ways in which the students perceive their experiences and transformations over their college years.[9] The model reflects the critical inter-

twining of cognitive and interpersonal skills at the heart of a college education—a difficult journey toward more complex forms of thought about the world, one's discipline, and how one uses knowledge. Perry's work underscores the notion that the most powerful learning, the learning most faculty really want to see students achieve, involves significant qualitative changes in the way students approach their learning and the subject matter. As one student describes her best class:

> "The class transformed my attitudes of myself as a student. I no longer played the role of a recorder of my prof's knowledge. I had the ability to go out on my own and seek knowledge although many times I needed guidance from the prof.. The professor encouraged us not only to learn the material but to think it over and integrate it into our lives."[10]

Perry identified nine distinct "positions" (or "stages") in the students' common paths through the college experience. The sequence of positions can be described in four major categories: dualism, multiplicity, contextual relativism, and commitment within relativism. These categories are illuminated below using quotations drawn from interviews with students at the Colorado School of Mines.

A. Dualism: Positions 1-2.

The thinking defined by Positions 1 and 2 is characterized by dichotomies and dualisms, i.e., We-Right-Good vs. They-Wrong-Bad or some variation. Teachers are seen as absolute authorities rather than as knowledgeable resources. Discrepancies among teachers are generally explained in this dichotomous framework: "Oh, I see, this teacher is not teaching the truth—s/he is a bad authority." The world thus consists essentially of two boxes—rights and wrongs—and there is seldom trouble in distinguishing between the two. The learning emphasis is on facts and right answers, and particularly in an engineering context, on specific facts that relate to one's future career.

> J. is a freshman, who says "all the social skills I need in life I've already developed ... [The purpose of college is for me to] learn everything I need to know to do my job correctly." J. is highly critical of any required coursework outside of his intended major; referring to a particular general education requirement, he says, ". . I learned a few facts about a few philosophers, but it didn't teach me anything I need to know for mechanical engineering."

The need for and the use of evidence in decision making is not understood. In this perspective the answer alone is important and one justifies a position by simply citing an authority.

> S., a freshman, speaks of how his views of a social science treatise on auto pollution was affected by studying several chemical research reports: "I still agree with [the author]. The last few weeks of studying the chemistry of photochemical smog and the arguments for and against global warming have had no effect on my view. It helped me understand the intricacies of the chemistry involved, but I knew that many people already did. [The author] based her [treatise] on the knowledge of these people."

B. Multiplicity: Positions 3-4.

The worldview of Position 2 begins to break down in a number of different ways, perhaps most frequently through the confrontation with several authorities, already established as good authorities, who happen to disagree. The modification in Position 3 represents the first acknowledgment of legitimate uncertainty in the world; instead of two boxes or categories, right and wrong, there are now three: right, wrong, and "not yet known." For now, if good authorities disagree, obviously they are dealing with an area in which the answers have not yet been found. This acceptance of uncertainty as legitimate, albeit temporary, is a profound departure from the dualistic perspective, and for many students an exciting one. In position 3 the problem of uncertainty is handled as "there are obviously right ways, or methods, to find the right answers," and learning focuses more on process and methodology. Thus the use of evidence is practiced.

Identifying notions in the Position 3 view of the world are that hard work should pay off in good grades and an argument is more sound if there is more evidence on its side. The transition from Position 3 to Position 4 is often triggered by the growing realization that hard work is not sufficient in and of itself. More broadly, the area of classroom evaluation is frequently critical as the student begins to understand issues of quality vs. quantity and the application of criteria. The Position 4 solution to these evaluation concerns becomes a focus on how to think—independent thinking as a means for making some sense of things, especially in the classroom.

> For S., a sophomore, the purpose of college is to get "a broader education, more than math and science—you should learn about yourself, your ethics, your leadership abilities—techniques you need as well as basics for the workplace." Students should be "open-minded, and learn as much as they can;" teachers should "be willing to help students, try and understand their problems and difficulties with the material."

While self-processing and a sense of the ownership of ideas increases, knowledge is still seen as essentially existing in two areas: a small area of "Rights/Wrongs," and a generally much larger one of "No one knows." However, the "not yet known" of Position 3 changes more toward a "we'll never know for sure" view. This frequently results in a stance at Position 4 that there is simply no nonarbitrary basis for determining what is right; hence an attitude of "do your own thing" or "anything goes" often prevails.

> Talking about a decision to be reached in a hypothetical mountain town that could gain economic health at the cost of some pollution, P. a sophomore, gives her reasoning. "I would vote to not let them build the plant because it might effect the beauty of the town, but I see [the other] point too. It is not really a question of right or wrong. It's what you think is best for the community and that comes down to your personal preference."

C. Contextual Relativism: Positions 5-6

The transition beyond Position 4 is perhaps the most significant movement within the Perry scheme because it represents the most profound transformation of perspective: from a vision of the world as essentially dualistic, with a growing number of exceptions to the rule in certain specific situations, to the exact opposite vision of a world as essentially relativistic and context-bound with a few right/wrong exceptions. This transition transforms the student's attitudes about learning and his/her role as a learner in dramatic fashion; the self is finally understood to be a legitimate source of knowledge along with the authorities (teacher or textbook) and the discipline. The most significant distinction between the pseudo-relativism of Position 4 and the contextual relativism of Position 5 is the self-consciousness of being an active maker of meaning.

One's task in life is finally understood fully as intellectual and ethical, a question of identity in a world of multiple contexts.

> M., a senior, has come to view college as "a period of growing up, basically from adolescent to adult. A lot of the ideas I had coming out of high school aren't at all the same that I have now ... [My goals have shifted from] 'making as much money as I can' in my field to 'doing something I want to do,' becoming a well-rounded person," specialized in an area but who can "function in a bigger world." As a senior, the college experience makes a lot more sense to him now: "I'm taking a lot of design classes now, and finally seeing how they all fit together with the courses I took as a freshmen and [at that time] thought, 'this is ridiculous!'"

Open-ended problem solving, making judgments, using evidence, and evaluating alternatives are finally seen as the natural and necessary approaches to our world. With Position 6 comes a sense of responsibility to be more than just a technical expert on a professional problem.

> R., a senior, talks about decisions he will be a part of as a civil engineer. "A good decision makes sense technically, but also makes sense politically, economically and socially. A bad decision considers only the technical aspect or only the political aspect." .... "You don't just build a technical project and it doesn't just function in a technical world. It functions in a broader world of political and social values. If you concentrate on any single [aspect], it is not as good a decision as if you concentrate on all aspects and try to come to some agreement where all your needs are met to the best of your ability."

D. Commitment within Relativism: Positions 7-9.

Little work has been done on these upper positions beyond the original Perry study, partly because of their complexity and the necessity of researching them through qualitative interviews. Also work with both the Perry scheme[11] and the related Reflective Judgment Model[8] suggests that few, if any, students reach these levels during their undergraduate careers. According to the Perry scheme, these positions reflect elaborations of identity commitments in a relativistic world, characterized by three crucial features:

- chosen in the face of legitimate alternatives,
- chosen after experiencing genuine doubt,
- chosen as a clear affirmation of one's self or identity.

Where Position 6 represents the awareness of the need for commitment, Position 7 is identified by the actual making of a major commitment in one's life. Positions 8 and 9 focus on the person coping with and synthesizing solutions to the consequences of his/her commitments. Initially assuming that making a commitment will take care of everything, one soon discovers that multiple commitments are necessary (career, partner, lifestyle) and that rather than being always complementary they are sometimes competing or even contradictory. Position 9 finds the individual coming to terms with this complexity in a tentative way, acknowledging that there is no real "answer" but only a willingness to struggle with the process.

III. The Interview Measurement Method

Measurements were made by conducting structured, hour-long interviews of CSM students. A videotape of each interview was viewed by expert evaluators who assessed that student's thinking based on the Perry scheme. We chose the interview method, even though it is costly and time consuming, because it yields data whose accuracy is least in doubt. The interview gives the evaluator a clearer, richer view of the student's thinking process; also, it directly models how Perry obtained his original data.

Less open-ended instruments, the Measure of Intellectual Development (MID) and the Learning Environment Preferences (LEP),[12] are available and are used in many studies. These instruments allow the testing of larger populations fairly quickly and at a lower cost than interviews. However, there is some limited research suggesting that such measures correlate only moderately (R's typical of about 0.5) with interviews.[13,14,15] Furthermore, they tend to yield conservative scores, sometimes as much as one to two Perry Positions lower than that obtained by interviews.[13] Given these concerns, and our desire to stimulate faculty discussion about curricula with our data, we chose to use the interview approach so that fewer questions about the data's meaning would arise.

The students tested were volunteers. Announcements were made in selected classes inviting students to sign up for the interviews as an aid to the college in understanding students' perceptions of decision making and the role of a college education. They were promised a $10 stipend for sitting for the interview. Students were signed up on a first come basis until the available interview times were filled. Normally we conducted twenty interviews per semester, doing new freshmen in October and late sophomores and/or seniors in April. Data were collected from 1990 to 1994 as money and time allowed. The selection by volunteering did not limit us to students of a particular academic success; the volunteers show a range in GPA consistent with the entire student body. Given the selection process, the data are cross-sectional rather than longitudinal.

The protocols for the interviews were established by co-author W. S. Moore. These consisted of questions leading into general areas of inquiry and follow-up questions (probes) meant to encourage the student to elaborate on his/her thinking. The leading questions were of the type given below.

- What is your view of an ideal college education?
- In a situation where information is not clear-cut, how do you go about making a decision?

A few questions such as these stretched into an intense hour of student talking as the interviewer probed with further questions such as:

- How did you arrive at that view? Have you always felt that way?
- You said ___. What do you mean by that?
- If someone else decided differently, are they wrong? How would you view that person?
- What do you see as the relationship between knowledge and truth?

Thus the interviewer's focus was not so much on the specific stands the student espoused, but rather on the thinking processes that lead to that conclusion and the ways the student justified his/her point of view.

Co-author M. J. Pavelich and colleagues organized and conducted the interviews; W. S. Moore and his colleagues at CSID (see reference 10) evaluated them by viewing the video tapes. Each student was given a three part rating, such as 3,3,4. This rating represents an overall assessment of the cognitive complexity displayed in the interview reflecting the primary and, if necessary, the secondary positions seen in the interview. This system extends the Perry scale to more of a continuum for scoring purposes. Solid rat-

ings, like 3,3,3, reflect a "stable position" perspective; the two steps between each stable position indicate "transitional" ratings. In the example, 3,3,4 represents a dominant position 3 opening to position 4, whereas a 3,4,4 rating indicates a dominant position 4 with trailing position 3. For data handling purposes the three number rating was then reduced to an average; thus, a rating of 3,3,4 becomes a 3.3. Given the statistical goals of the study,[16] data were collected until over 40 students had been interviewed in each of the critical populations: freshmen and seniors.

IV. Results and Discussion

Perry Model data were collected as one useful measure of CSM's current curriculum, especially its extensive use of experiential education methods. The "projects" classes that most students encounter in six of their eight semesters should, theoretically, enhance the kind of maturation described in the Perry Model.[17] Dealing with real-world, open-ended problems challenges the student's view of vagaries of information and decision making. Repeated challenges of this type should accelerate movement from Position 3, where students see open-ended problems as a game set up by authority, toward Position 6, where the reality and consequences of open-ended problems are understood.

We will discuss the results of our interview data from two perspectives: a numerical, statistical view and a more anecdotal, "voice of the student" view. Both perspectives lead to the same conclusions about curricula, but they give different insights.

The data on the Perry positions of CSM students are presented in bar chart form in Figures 1 and 2. Figure 1 shows the distribution of Perry positions for first month freshmen versus those for last month sophomores who have had four semesters of cliented project team work.[5] Figure 2 compares the distribution for these same freshmen to that of last month seniors who have completed those four lower division projects courses plus two more semesters of open-ended team problem solving in their senior design courses.[6] Table 1 presents the statistics of these data. Applying an F-test to these data reveals that the averages between freshmen and sophomores, sophomores and seniors, freshmen and seniors are all significantly different at the 0.1% (1/1000) level.

Drawing meaning from our distributions and averages, we end up heartened, and yet concerned. On the heartening side, over one quarter of the CSM seniors tested above Position 5, which, when compared to the Freshmen distribution, indicates a substantial maturation for these people. It also represents a satisfying position from which to enter their professions. Another positive aspect is the average difference of one Position between CSM freshmen and seniors. This seems small; however, it may indicate unusual achievement.

We arrive at this possibility by comparing, semi-quantitatively, with data collected using the Reflective Judgment (RJ) Model of King and Kitchener.[8] The RJ and Perry Models are essentially identical, at least through Position 4. Above Position 4, they do look for slightly different attributes in complex thinking. Moreover, published RJ Model data come from probing, structured interviews of students, making such data a good methodological match to those obtained in our study. Data collected in over twenty studies using the RJ Model show an average gain of only one-third of a position by students over the undergraduate years.[8] Thus the One Position gain by CSM students may be unusual. If it is, it would indicate that the extensive exposure of students to ambiguity, as inherently occurs in their experiential courses, had a real effect.

Our concern also stems from the CSM change being One Posi-

Students' Year	Average Position	Standard Deviation	N
Freshmen	3.27	0.44	45
Sophomores	3.71	0.53	34
Seniors	4.28	0.70	46

Table 1. Results of CSM students' Perry positions.

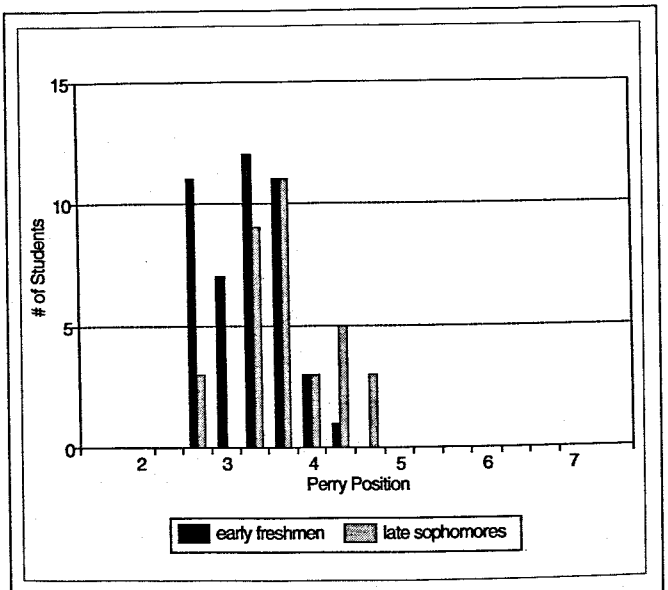

Figure 1. CMS students' Perry positions - freshmen vs. sophomores.

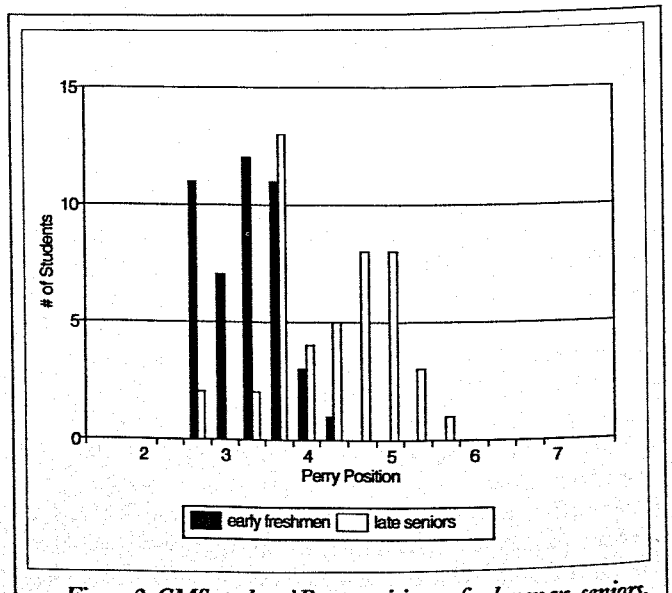

Figure 2. CMS students' Perry positions - freshmen vs. seniors.

tion. We had hoped for more students achieving higher levels given the consistent exposure to complex decision making built into the curriculum. Of more concern than averages is the Senior distribution. While one quarter of our seniors tested above Position 5, almost a third tested below Position 4. This bimodal pattern is also seen in a longitudinal studies at Evergreen College[18] and at Fairhaven College[19] using the MID as a measure. For example, student progress over the undergraduate years using Evergreen's collaborative education methods is substantial compared to standard curricula results. However, a substantial number of seniors still test below Position 4. This is not a satisfying result. One would prefer to graduate seniors more in tune with the kinds of perceptions (above Position 5) expected of them in their professions.

We come to the same conclusions when we look at what individual students are saying in the interviews as we do when we look at the numeric results. We are heartened by the quality of thought and excitement shown by the many seniors testing at or above Position 5.

> M. passionately talks about the effect of college "College is supposed to teach you how to learn, give you the ability to take information, synthesize it and come up with a decision....especially in engineering, given a problem that you may never have done anything with...the challenge you have to meet is to gather information and make your own decision ..... you learn that things aren't black and white; there are an awful lot of shades of gray...[you need to be able to] make the best decision possible."

We are further heartened by their spontaneous and almost unanimous praise of the projects classes for showing them what their profession is like and giving them confidence in doing the work. However, the seniors who are not yet able to work at Perry's higher levels, those below Position 4 in Figure 2, do give one pause. Some struggle with decision making in their profession.

> R., a senior who rated a 3.7, readily acknowledged grayness in most life decisions, but when asked if a lot of grayness exists in mechanical engineering answers "It really shouldn't.....given all those courses....but normally it seems there is..... There should be one best solution, but usually there is not enough difference between that solution and another, so you can make a choice between economics, ease of manufacture, strength." How do you choose among these? "....you...I don't know...you prioritize them...and go down the list". He goes on to give a reasonable analysis, but seems to be thinking at this depth for the first time.

Other seniors rated below Position 4 acknowledge the multitude of possible answers to an open-ended problem in their profession, but see themselves as having no responsibility for, or legitimate input into, deciding the direction of the problem's solution. Their answer to the question of how one operates when there are multiple demands on a design is "You tell me what to optimize and I'll optimize it for you." They really see themselves simply as technicians awaiting the decisions of others.

V. The Next Step

These Perry Model data show that the CSM curriculum has a significant positive effect on students' maturation towards more complex thinking. However, much more needs to be done. We would like the majority of our students to be able to achieve Position 5 thinking before graduation. More importantly, we would like to not have so many students testing at Position 3.7 as seniors. That college faculty purposefully work toward such goals is critical. Studies indicate that development is less a function of age than of educational experience.[8]

The next step in achieving better results seems to be refining our teaching methods rather than changing our curriculum. Theoreticians in student development[8,17,20,21] agree that students should progress most readily through teaching that balances challenge and support. By challenge they mean teaching that is not dualist, teaching that repeatedly exposes students to the legitimate vagaries of knowledge and requires them to deal with them. The CSM curriculum has these challenges in abundance, especially in its projects courses. By support, the theoreticians mean actions by faculty that help students deal with the mismatch, the discontinuity, between the students' perception and the professor's. This support requires an affirming of the students in their struggles while helping them to see a step or two beyond their current perception. This requires professors to understand the students' perceptions, to be patient with their misperceptions, and to be skilled at getting students to think beyond them. Developing this support, this high quality mentoring by faculty, is what we feel is the necessary next step.

Two groups of CSM faculty experienced at teaching projects courses have been meeting to address this issue. They have been studying the Perry Model, discussing how it fits with what they see in the classroom, and experimenting with ways to more effectively mentor students in their freshman and senior projects classes. These faculty are developing formats that encourage students to reveal their perceptions about project work and are developing specific suggestions for responding to student misperceptions and problems. An example of the latter that occurred last semester is:

> A freshman team, when asked by the Prof if they were having any difficulties, responded: "Things are in a mess. We talked to the client last week and he says that [solution X] is the way to go. Thus we have to scrap all the information we've gathered on [solutions Y and Z]. All that work is down the drain." This misperception arises from the Position 3 students seeing the client as the authority, having the right to dictate the problem's solution. The team sees its role as acceding to that authority. The Prof began by saying: "I understand your frustration. Situations like this often arise in consulting, especially when the client has some knowledge of the field. You have done good work to this point and need not throw it out. Let's discuss what you might do by focusing on what value you can be to such a client."
>
> The Prof then asked what the team thought about all three possible solutions. They said that all seemed viable to them. The Prof complimented them on their work and then pointed out that their value to this client, in fact their responsibility to him, was to help him break out of his mindset, to get him to look seriously at alternatives. The team should continue developing Y and Z, but must be aware that they will need stronger evidence to convince the client than if they were to propose solution X. The team bought into this approach, but were skeptical. Twice more in the semester they wanted to talk it through again with the professor, to voice their concerns.

Such insights and examples will be shared with other faculty working in projects courses each year. We will also continue discussion groups for these faculty each year. In effect, we will be bootstrapping ourselves into a more consistent, knowledgeable form of mentoring our students.

A few years into this effort, we will test students again using the Perry Model interviews. The educational goal is to determine if these refined teaching approaches can significantly improve students' movement to higher levels of problem solving abilities, toward more complex and realistic views of knowledge.

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