AC 2007-1706: ASSESSING REFLECTIVE JUDGMENT THINKING IN UNDERGRADUATE MULTIDISCIPLINARY TEAMS

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Abstract – Our University has a project-based interprofessional learning program (IPRO) designed to improve competencies in project management, teamwork, communications, and ethics among the undergraduate students. An emerging goal is to increase the level of "reflective judgment thinking" among the IPRO students, indicating that they can deal effectively with complex, ambiguous, not clearly-structured problems. All undergraduate students are required to participate in two, 3 credit hour, IPRO projects; most do so during their junior and senior years. Every semester 35-40 teams are established, each with 7-15 students. The foci of projects vary, including service-learning, entrepreneurial (ENPRO), product development and others. All projects include unstructured problems. In order to ultimately increase reflective thinking in the student body, we have included a reflections process in a sample of the interprofessional teams that include service-learning and entrepreneurial teams. A reflections pilot with 11 of our 33 project teams was conducted during the fall 2005 and spring 2006 semesters and examination of the spring 2006 data revealed that our students in the pilot did not exhibit high levels of reflective thinking. We evaluated reflective thinking by rating responses to reflective questions from students that participated in the pilot. Responses were categorized into 4 levels of reflective thinking based on the Reflective Judgment Model[7]. In the fall 2006 semester, we again ran a reflections pilot that included redesigned questions that we expected to elicit more reflective answers to the problems that students face in the project. We collected demographic data from students compared the level of reflective thinking by school year. Juniors in our sample exhibited the greatest level of reflective judgment. We also examined if the changes made to the questions in fall 2006 versus spring 2006 generate more reflective thinking. We found our changes did not generate more reflective judgment as hoped. Finally, we compared service-learning teams and non service-learning teams in terms of reflective and found there were no significant differences between the two types of teams.

Introduction

Our university has a program that emphasizes the development of effective teamwork skills called the Interprofessional Projects Program (IPRO). IPRO is an open-ended project-based course through which all undergraduate students are expected to develop competencies in multidisciplinary teamwork, communication, project management and problem solving skills, and ethical issues.

All undergraduate students at our university are required to participate in at least two IPRO projects. Each semester we offer 35-40 team projects, with 7-15 students and one (or more) faculty supervisors. The projects vary, including service- learning, international, and entrepreneurial experiences. IPRO projects that include entrepreneurial experiences are referred to as EnPROs. The majority of students are enrolled in engineering or science programs, with significant numbers of architecture students, and smaller numbers of liberal arts, psychology, and business students. Teams are expected to

include students from at least three different disciplines; students select teams rather than apply for or accept assignment.

The Accreditation Board for Engineering and Technology (ABET) has outlined required program outcomes that include "an ability to function on multidisciplinary teams," (teamwork) "an understanding of professional and ethical responsibility," (ethics) and "an ability to communicate effectively[1]," (communications). The IPRO program currently addresses each of these desired ABET outcomes and the reflections pilot is designed to measure if reflective judgment can be increased for IPRO students.

The IPRO Program is designed to prepare students for the practical challenges they will face in the changing workplace, emulating a cross-functional team operating environment and grappling with complex multifaceted issues.

Reflections as a Component of Experiential Education

The concept of "reflective thinking" is primarily evident in discussions of service learning, where the assumption is that students need to understand why they are being asked to dedicate their intellectual and personal skills, and time, to projects that are designed to benefit people unlike themselves. The assumption is that if students stop and think about (e.g. "reflect") what they are doing and why they are doing it, they will gain more from the experience, be more committed to the project, and all involved will benefit. There are many assertions that such processes are beneficial. For example, Eyler, Giles and Schmiede assert that reflections in service-learning projects "forces students to observe and analyze what they observe and to article it"[2] and are a documented and critical aspect that develops critical thinking skills[3]. Reflections also can create an analysis of the process, experience, and results of a project[3]. In some studies, reflection and coaching have been found to be necessary to increase the ability of students to use what is learned in applied and service-learning settings[4].

Experience does not necessarily prompt the desired learning outcomes, as all instructors know. It appears that learning often is a result of a reflective component "explicitly designed to foster learning and development. The goal of reflection is to promote learning about the larger social issues behind the needs in which [student] service is responding. This includes the social, cultural, economic, and political contexts of the needs or issues being addressed"[5]. Reflections are necessary for students to step back and examine what they are doing and why they are doing it. Critical reflection "provides the transformative link between the action of serving and the ideas and understanding of learning"[2]. Reflection should be done before the experience, during the experience, and after the experience[2].

Thus, the first sense of "reflections" is to step back and consider what you are doing and why you are doing it. This seems to be an important process, as reported anecdotally, but we have not found convincing empirical evidence that this makes any substantial difference in learning or performance.

Reflections traditionally have been used in service-learning projects[6]; the applicability to other kinds of experiential, team-based learning programs has not been assessed. We have adopted the process of reflections to be included in multidisciplinary project teams found in the IPRO program where some, but not all, are service-learning teams. Other IPRO teams include business planning, design, and process improvement projects.

Reflections used in the Purdue EPICS program have focused expanding the use of reflective judgment skill to include team dynamics, the design process, and ethics. Purdue has outlined a model that includes learning objectives into reflection activities and has a focus on critical thinking[6]. Adopting the design at Purdue and including suggestions found in[2], we developed our reflections to include the learning objectives of the IPRO program: teamwork, communication, project management and ethics. We also added questions to prompt and evaluate reflective judgment as defined by King and Kitchener[7] by including questions about possible ill-structured problems. The goal was for the students to identify ill-structured problems that occur while working on the project (for example, how to deal with difficult team members) as well as the issues involved with the problem the project was designed to solve (for example, finding ways to decrease world hunger).

Reflective Judgment and Thinking about Ill-Structured Problems

A second approach to "reflections" is to use this process to assess and promote a certain kind of thinking – known as reflective judgment thinking. This is not exactly the same as contemplating what you are doing and why you are doing it, though they are (probably) linked. Reflective judgment is used to "bring closure to situations that are uncertain… and requires the continual evaluation of beliefs, assumptions, and hypotheses against existing data and against other plausible interpretation"[7]. Reflective judgment involves rationally defended insights and is often used to solve ill-structured problems. Overpopulation, hunger, and pollution are examples of ill-structured problems that require reflective judgment.

Ill-structured problems generally have more than one plausible solution. Students should be able to justify why he or she reached a particular solution[8]; reflections questions must ask students to justify their reasoning. Reflecting on the process of getting to the solution is important for solving ill-structured problems and becomes "part of the mental model that is stored along with the problem and its solution,"[8]. One of the main difficulties with ill-structured problems and reflective judgment is recognizing that an ill-structured problem exists. If a person does not recognize a problem as ill-structured, reflective judgment is not possible.

Reflective judgments are formed by evaluating opinions, relevant information, and available explanations followed by constructing plausible solutions for the problem and the recognition that the solution may need continual evaluation[7]. Students that use reflective thinking can recognize that some problems do not have clear or absolute solutions and evaluation of alternate solutions is a skill that can be developed. All IPRO

projects have at least one central problem that the student team attempts to solve, most of which require reflective thinking. Also, while working on the project, problems often arise that do not have a definite solution, like those involving ethical behavior.

King and Kitchener developed a model of the stages of reflective thinking called the Reflective Judgment Model (RJ model)[7]. The model focuses on the progression of reflective thinking beginning with pre-reflective thinking to quasi-reflective thinking, and ending with reflective thinking. It is our intention to measure all levels of the King and Kitchener analytical model through our reflection pilots, with the desired goal of increasing reflective thinking in our students.

Pre-reflective thinking is characterized by simply accepting knowledge from an authority figure as absolutely certain and not recognizing there may be more than one solution to a problem. Knowledge at this stage is absolutely certain and correct. This type of thinking is typically found with grade school and high school students. Pre-reflective thinking includes stages 1-3 of the Reflective Judgment model as described in King and Kitchener[7].

Quasi-reflective thinking is characterized by the recognition that sometimes problems do have uncertain solutions and are ill-structured but individuals have difficulty resolving the ambiguity implied in this recognition. Making judgments about situations that contain uncertainty is difficult for those in this stage. This type of thinking is typically found in college students and includes stages 4 and 5 of the RJ model[7].

Reflective thinking is the most advanced type of reasoning to use when uncertainty in problems arise. Individuals that use reflective judgment evaluate all possible solutions and choose the best solution available but recognize other solutions are possible. Individuals who use reflective judgment recognize that no answer is the absolute truth. This type of thinking is often found in advanced doctoral level students and includes stages 6 and 7 of the RJ model[7].

Reflective judgment is usually assessed through hour long interviews which are done by trained interviewers and are transcribed and evaluated. These interviews tend to be costly in terms of time and money, costing roughly 6-8 hours and $150 per interview[9]. Participants are presented with a problem followed by probing questions. An example of standard problem for the Reflective Judgment Interview follows:

"There have been frequent reports about the relationship between chemicals that are added to foods and the safety of these food. Some studies indicate that such chemicals can cause cancer, making these food unsafe to eat. Other studies, however, show that chemical additives are not harmful, and actually make the foods containing them more safe to eat,"[7].

The probing questions that follow are used to evaluate how a person thinks about the issue, not on their level on knowledge on the topic. This method produces the best

reflective judgment results but is not possible to use on full IPRO teams or the entire IPRO program.

Paper based instruments have been developed to assess reflective judgment in the past but have shown relatively low correlations, usually around .4 and .3[9]. Pavelich, Miller, and Olds [9] were able to develop an instrument, Cogito, that reached a correlation of .5 based on pre-determined topics and questions. For example, on of the scenarios Pavelich, Miller, and Olds[9] used in Cogito involved overpopulation.

"Some people believe that overpopulation is one of the greatest dangers facing humans today. They argue that if population growth rates are not substantially reduced within the next few years, the earth faces widespread starvation, resource depletion, and massive environmental degradation by the year 2020. Other people contend that the problem has been exaggerated. They say that humans are distinguished by their resourcefulness and that we will be able to contend with population growth just as we have dealt with other challenges. Supporters of this view point out that past "Doomsday" predictions have been unfounded and argue that this one is likely to be also"[9].

Following the scenario were 5 statements about overpopulation from people that believed it was a problem that needs to be currently addressed. Participants were asked to mark how much they agree or disagree with each statement using a 5-point likert scale. We wanted to develop an instrument which could be IPRO specific and evaluate reflective judgment at the same time. The inherent problem with this approach is that not all IPRO projects are the same and all projects do not necessarily contain a problem in which reflective thinking is necessary. However, we felt the benefit of having reflective judgment questions related to the IPRO project the students were working on outweighed this potential problem. Similar to the previous models, we tried to develop questions that would emphasize how they reasoned and evaluated the issues rather than the knowledge of the issue itself.

The IPRO Reflections Pilot

Over the past 3 semesters we have implemented and continuously improved the reflection questions/ protocol used in the IPRO program. The main goals of the reflections include student identification of the IPRO program learning objectives (project management, teamwork, communication, and ethics) and the recognition of ill-structured problem with an emphasis on reflective judgment. Some questions targeted the plan of the team (project management), how students were working together (teamwork) and communicating progress with each other (communication) and what ethical issues had occurred either within the team or with the project itself (ethics), for example, having access to confidential information. In the spring 2006 semester we added questions to our set of reflections questions to specifically pull for reflective judgment so that we could evaluate the reflective judgment levels of students in the reflections pilot. However, many responses were brief and made evaluation difficult. In the fall 2006 semester we updated the questions to probe for the reasoning behind the students' solutions to ill-structured problems they face with the hope of receiving more and better information

Based upon the Eyler, Giles, and Schmiede[2] suggestion of reflections occurring before during and end of the semester, three reflections were distributed throughout the semester, at the beginning, middle, and end of the semester. Each set of reflections questions contained 7-10 questions, although individual questions often contained more than 1 question. For example, question 1 in reflections 1 contained 3 questions. All questions can be found in the appendix. We distributed the reflections to the students at week 4, week 9 and week 15. Most reflections were returned the following, however, some students did not return until 2 weeks later and others simply did not turn them in at all. We also returned feedback to the students on reflections 1 and reflections 2.

Each set of reflection questions were designed to target at least one of the learning objectives of the IPRO program. Reflections 1, given at week 4, had an emphasis on project management. Reflections 2, given at week 9, had an emphasis on teamwork and communication, and reflections 3, given at week 15, had an emphasis on ethics. Each set of reflections questions also had at least 1 question that targeted reflective thinking. Reflections 1 contained 2 reflective judgment questions, reflections 2 contained 1 reflective judgment question, and reflections 3 contained 3 reflective judgment questions.

Questions used to evaluate reflective judgment:

Reflections 1

1. Why is this IPRO project important? How can this project be used to benefit the community outside of IIT? How can this project benefit society? How confident are you in your assessment of the potential benefits? What other information or types of information do you need to fully assess the benefits of the project?

2. Is there more than one way to solve the problem your IPRO faces? What are other possible solutions? How do you know which one is best? Can you ever be completely sure that solution is the one that should be implemented?

Reflections 2

1. Has your view of the importance of the IPRO project changed since the beginning of the semester? Why did it change? Has your view of the benefits to the community and society outside of IIT of this IPRO project changed since the beginning of the semester? Why or why not? What might be the counter argument to your view of the overall importance of the IPRO (i.e. the IPRO has no importance outside of IIT)? Can you be sure either argument is correct? How or why not?

Reflections 3

1. Ethical issues in IPRO are of two types: those involving behaviors within the IPRO team and those involving the eventual application of IPRO output to the larger society. Please outline the most important ethical problems the team has encountered over the entire semester. What was the issue and what was the outcome? From your experience(s) this semester please explain the best course of action the team could or should have taken to produce the optimal resolution to its ethical dilemma. How did you contribute? If you did not contribute, how could you have contributed?

2. What other possible solutions are there to the ethical problem? Which solution to the ethical problem do you think is best and why? How confident are you in the solution? Include the method used to resolve the differences of opinion and the level of agreement on your final assessment.

3. Has your view of the importance of the IPRO project changed since the beginning of the semester? Has your view of the benefits to the community and society outside of IIT of this IPRO project changed since the beginning of the semester? Why or why not?

Other questions on the reflections were used to evaluate student progress and any problems occurring within the team. These questions asked about aspects of the project like the project plan, necessary steps that needed to be taken, and individual contributions. Such questions could only be evaluated by the members of the team or faculty sponsors as they had the knowledge of the correct answer. For example, one question that was continually repeated on each reflection asked about what progress was made and what next steps need to be taken to reach the team's goal. Only a person directly associated with the team could evaluate the accuracy of the answers. These questions were not focused on how a person evaluates an issue, but whether they are on track with the rest of the team. The reflective judgment questions were designed to gain information on the thought process and could be effectively evaluated by a person not directly involved with the IPRO project.

Responses from 71 students that were involved in eight IPRO projects,four of which were service-learning, were evaluated for reflective judgment. Reflective judgment was determined based on the RJ model proposed by King and Kitchener[7]. Responses were marked in 4 categories; pre-reflective, 2 levels or quasi-reflective, and reflective. The first category contained stages 1-3 of the Reflective Judgment model; the pre-reflective thinking stage. In this stage, knowledge is reported as certain and based on opinion rather than facts or evidence. The second category was the same as the 4th stage of the Reflective Judgment model. In this stage, knowledge is uncertain because of limitations of the student. Evidence is used to support reasoning but is often heavily influenced by opinion. The third category directly corresponds with the 5th stage of the model. At this stage, understanding is based on interpretation so that no knowledge is certain. Evidence is evaluated within a perspective and beliefs are justified within a given context. The fourth category includes stages 6 and 7 of the model. Knowledge is uncertain and needs to be understood in relation to context and evidence. Evidence can be compared and evaluated as the basis for justification.

Table 1
Categories used to assess reflective judgment

Reflective Judgment Level	Pre-reflective Stages 1-3	Quasi-reflective Stage 4	Quasi-reflective Stage 5	Reflective Stages 6-7
Category	1	2	3	4

We addressed several questions. 1) What levels of reflective judgment thinking are evident in these groups? 2) Is maturity (as measured by age/ year in school) a factor in

reflective judgment thinking? 3) Does participation in a particular type of IPRO shape the level of reflective judgment demonstrated in the question responses? 4) How does the form of the question influence the level assigned?

Results

The questions we examined for reflective judgment yielded overall means ranging from 1.28 to 1.89 out of 4. The overall mean for all questions was 1.53. Breakdown by question can be found in table 2.

Our total sample contained 71 participants, with 50 of those participants reporting the year in school. For the first comparison of differences between year in school, a one-way Analysis of Variance (ANOVA) revealed significant differences for the mean scores $(F(3, 47) = 6.29, p < .01)$ of reflective judgment and differences on the reflective judgment scores for questions 5 $(F(3, 43) = 4.37, p < .01)$ and 6 $(F(3, 42) = 3.34, p < .05)$ on reflection 1, question 5 $(F(3, 41) = 3.13, p < .05)$ on reflection 2, and question 3 $(F(3, 31) = 3.20 p < .05)$ on reflection 3. Questions 2 and 8 on reflection 3 did not have significant differences. Post hoc tests (Tukey HSD) revealed significant differences between junior, sophomore, senior and fifth year levels of reflective thinking with juniors having the greatest mean reflective judgment score. Juniors also had higher reflective judgment scores than seniors on questions 5 and 6 on reflection 1, higher reflective judgment scores than 5th year students on question 5 on reflection 2, and higher reflective judgment scores than seniors on question 3 on reflection 3. All means are reported in the table 2.

Table 2
Reflective Judgment means by year in school

	Q5, R1	Q6, R1	Q5, R2	Q2, R3	Q3, R3	Q8, R3	Mean RJ level
Sophomore	1.75*	1.75	1.25	1.00	1.33	1.20	1.35*
Junior	2.21*	2.29*	1.67*	1.20	1.88*	1.40	1.87**
Senior	1.38*	1.60*	1.27	1.20	1.20*	1.40	1.32
Fifth Year	1.62	1.85	1.00*	1.50	1.33	1.50	1.51
Overall	1.72	1.89	1.33	1.28	1.40	1.40	1.53

* Significant difference between means

An independent samples t-test revealed no significant differences between the service-learning and non-service learning groups in terms of reflective judgment, $t(69) = -1.64, p = .106$, although the mean for the service-learning teams (1.59 out of 4) was slightly higher than the mean for the non service-learning teams (1.43 out of 4). No significant difference was found between service-learning teams and non service-learning teams for any of the individual reflection judgment questions.

Two reflective judgment questions were compared for differences between the spring 06 and fall 06 semesters. The spring 2006 questions resulted in significantly greater reflective judgment responses than the fall 2006 questions, although the mean scores were less than we had hoped overall. The first reflective judgment question we compared

had means of 1.53 for the spring 2006 question and 1.27 for the fall 2006 question, $t(106)$ = 2.17, $p < .05$. The second reflective judgment question we compared had means of 1.69 for the spring 2006 question and 1.37 for the fall 2006 question, $t(100) = 2.57$, $p < .05$. Since the samples for comparing the reflective judgment questions came from different semesters which contained different students, no control group was available. The questions that were compared also were given at different times during the semester. For the spring 2006 semester, the questions were included in the reflections given around week 11 of the semester while the fall 2006 questions were given at week 15 of the semester and were returned during the last week of the semester, finals week.

Table 3
Mean reflective judgment comparisons over 2 semesters

	Question 1	Question 2
Spring 2006	1.53	1.69
Fall 2006	1.27	1.37

Discussion

Overall, the reflective judgment means we found were lower than we had expected. Our hope was to find the levels of reflective judgment to be at lease quasi-reflective on average, which would have been a minimum of 2. We found that juniors had the highest level of reflective judgment in our sample, and there were no differences between service-learning and non service-learning teams. Initially it appears the changes we made to better evaluate reflective judgment in the students, however, the scores used to compare the groups were from different students over different semesters and given at different times.

We expected those further advanced in school would have responses indicating a higher degree of reflective judgment. However, we found that juniors produced answers with the highest degree of reflective judgment. While the sample size for sophomore participants was smaller than those of the other groups, juniors, seniors, and fifth year students were all represented with similar sample sizes (15, 18, and 13, respectively). The reasons for these results are not clear and even though juniors gave answers higher in reflective judgment, the answers were still below what we had hoped. The mean score of reflective over 6 questions we examined was 1.86, indicating the juniors were approaching levels of quasi-reflective thinking, but most were still in the pre-reflective stage. Seniors were closer to pre-reflective thinking than at a level of quasi-reflective thinking with a mean of 1.32. Fifth year student responses indicated they are somewhere in between pre-reflective and quasi-reflective thinking with a mean score of 1.51. The juniors in our sample may have greater degrees of reflective judgment than those in the other class years. Junior's also may have taken the reflections more seriously than senior and fifth year students. Since the reflections in the fall 2006 pilot were not counted in the grading process, seniors and fifth year students may have had less time to devote to reflections if they had a heavier work load from other classes and consequently may have given less effort.

Service-learning and non service-learning teams scored similarly on the reflective judgment questions. This could be the result of the questions asking students to focus both on the internal issues of the team itself and of those related to the project. Most teams had some issues that did not have a single clear solution and some of the non-service learning worked on projects involving ill-structured problems. Sample size was also an issue in this analysis, with only 4 teams from each group.

The decrease in reflective judgment responses from the changes made between semesters was a disappointment. We had included questions to ask students to explain their reasoning to help evaluate with the expectation that more information would reveal higher levels of reflective judgment. There are few possibilities of why we received lower scores with the new questions. The first possibilities is that with more information from the students we made better evaluations but revealed the reflective judgment of the students to be lower than originally thought. This is unlikely, however, since the reflective judgment scores were lower than that of the mean scores. The second possibility is that new questions simply did not work and did not allow for better evaluation. This scenario is also unlikely since the questions we used were adaptations from the King and Kitchener[7] questions used in the Reflective Judgment Interview. A third possibility involves the length of the questions and the timing the reflection was given. By adding extra questions and not including the reflections in the grade, it is possible the students did not put full effort into explaining their reasoning. Also, the timing of the reflection may have influenced the results. During the spring 2006 semester, the third reflection with the changed questions was given at week 11, during the second half of the semester. During the fall 2006 semester, the third reflection with the updated questions was given at week 15 of the semester, the week before finals. It is likely most students did not put full effort into the reflections as they were concentrating on their upcoming finals. The third reflection also had a drop off of completed responses. Twenty students that completed the first reflection did not complete the third reflection.

Finally, reflective judgment has been difficult to assess using written methods. Written instruments ask people to express complex ways of thinking through answering questions. Probing behind the answers is an important part of understanding reflective judgment and with written assessments only the initial written responses are available[9].

Although the reflective judgment data we obtained over this semester was not what we had expected, the reflections experience was positive. Over 38% of students reported the reflections helped them recognize their own contributions and help them understand the progress and the process of the IPRO team they were involved with. Faculty reported it helped to keep students on track and assess team members' contributions. Students also reported that the reflections helped them look back on the work they and realize the progress the team and themselves made individually.

The reflections pilot will continue with in the spring semester with some changes. We will continue to use 3 reflections, one at the beginning, middle, and end, but may change the timing of when those reflections are processed, particularly the third reflection. We

also will have reflections as part of the grade. The grade will be based on the effort put into the reflection rather than levels of reflective judgment.

Conclusions

The reflections pilot did not produce the results we had anticipated but overall we feel the reflections were an effective instrument that was beneficial to students in IPRO projects. We will continue to develop both reflections and continue our efforts to introduce and measure reflective judgment in the students in the IPRO program.

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