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Interdisciplinary and Global Studies Division

Date: **11/30/07**

To: Lance Schachterle, Associate Provost, ABET Accredited Departments

From: Kent Rissmiller, Associate Dean, IGSD

Re: Results from Summer IQP Review Relative to ABET Learning Outcomes

Introduction

The Interdisciplinary and Global Studies Division (IGSD) has supervised the summer assessment of Interdisciplinary Qualifying Projects (IQP) every few years for over two decades. Initially, the assessment focused only on the quality of completed projects as revealed by the reports. In the later 1990s, however, this assessment was expanded to gather information that might also serve as a measure of our progress in achieving ABET and WPI's learning outcomes. In this way, our assessment became important for providing data for accreditation purposes. In 2007, the Faculty also approved a set of IQP specific learning outcomes. We have designed the study, this year, therefore, to gather information on project quality and to measure our progress on this array of learning outcomes. This report provides information for use by engineering departments in their upcoming ABET accreditation reviews. Information on WPI's learning outcomes and our learning outcomes for the IQP will be contained in a separate report.

In prior years (2000 and earlier), an effort was made to read nearly every IQP completed during an academic year. In 2004, however, eleven faculty reviewed a sample of 88 projects drawn from the total of 261 reports written that year, whether the work was completed on campus or at an off-campus project center.[1] Following the same sampling procedure, this past summer, nine faculty reviewed 81of the 148 reports completed on-campus between E06 and D07.[2]

Methodology

When planning this study, the IGSD considered several assessment strategies in light of the limited budget available for this work. Ultimately, we decided to review only projects completed on campus during the '06-'07 academic year for the following reasons. First, every prior review showed that the quality of the on-campus projects, as a whole, was significantly lower than the quality of the projects completed at project centers (in the US and abroad), and the on-campus projects were weaker on

[1] David DiBiasio, *Results of Summer IQP Review, August 16, 2004.*

[2] Projects completed at the Worcester Community Project Center were excluded from this sample. WCPC projects were identified for their own assessment in 2001 and 2002 to determine whether our local project center achieved the same measure of academic success as our more distant project centers in the US and abroad. *See* David DiBiasio, *Summary of WCPC and On-campus IQP Review Activity,* July 17, 2003.

nearly every (if not every) measure (DiBiasio, 2001, 2004). We did not believe that we needed another study to demonstrate the differences in these programs. Secondly, we have taken some steps in the past years to enhance the on-campus projects. Among other activities, we have encouraged mentoring of faculty advisors, both by our assignments of faculty to project centers, and by mentoring and co-advising on-campus. We have used forums on-campus to train faculty in advising strategies and project expectations. We have formalized the project development and student recruitment process by offering the On-Campus IQP Opportunities Fair. A look at the on-campus projects would help us to determine whether our efforts to bolster these projects are producing positive results. Finally, with limited budget, we would obviously review a sample of recently completed projects. By constraining our population to IQPs completed during the academic year, we had the resources to sample a substantial portion of that population, and read nearly 55% of the 148 projects. A larger sample of a smaller population gives us greater confidence in the results. These 148 projects represent the work of the 358 students completing IQPs on-campus during the 2006-2007 academic year. Another 293 students (45%) completed their projects at off-campus project centers that year. In total 651 students completed their IQP during this term.

The sample size was determined on the basis of recommendations contained in a paper by Miller, Johnson and Petruccelli.[3] The authors determined that, given the nature of the instrument (5 point Likert style questions are common), a sample of 81 from a population of 150 would likely produce a 90% confidence level for resulting statistics. Using this 90% confidence level, all the means reported below fall in a confidence interval of +/- .2 to +/- .26.[4] The confidence intervals for the proportions (%) reported below were calculated at 95% confidence level for a sample of 81 from a population of 148. The margin of error for all reported percentages is less than +/- 7.5% (as the proportion approaches 50%). A proportion of .21 (21%) has a margin of error of +/- 6%.[5]

ABET Learning Outcomes

ABET Criteria for Accrediting Engineering Programs include the following learning outcomes:

"Engineering programs must demonstrate that their students attain:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component or process…
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively

[3] Judy Miller, Sharon Johnson, Joe Petruccelli, *Sample Size Recommendations for Project Reviews,* March 31, 2000.
[4] The confidence interval for the means was calculated using Dimensions Research, Incorporated's calculator for this statistic, http://www.dimensionresearch.com/resources/calculators/conf_means.html.
[5] Calculator provided by Australian National Statistic Service, http://www.nss.gov.au/nss/home.NSF/pages/Sample+size+calculator?OpenDocument

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills… for engineering practice"

Most, but not all of these learning outcomes are supported, in part, by WPI's Interactive Qualifying Project (IQP), normally completed by students in teams during their junior year.

The following outcomes, from the list above, are not routinely supported by the IQP and our IQP review does not attempt to measure student progress on them:

(a): an ability to apply knowledge of mathematics, science, and engineering
(c): an ability to design a system, component or process…
(e): an ability to identify, formulate and solve engineering problems
(k): an ability to use the techniques, skills… for engineering practice

During the summer of 2007, the IGSD did gather information on the role of the IQP for assessing on the remainder of the ABET learning outcomes. Those data are summarized below. Additional information can be made available on request.

In general, the data indicate that there is much room for improvement if IQPs completed on campus are to play a major role in satisfying these learning outcomes. As a word of caution, however, the learning outcomes are addressed to WPI graduates, or students relatively close to graduation, not juniors. MQP assessment could demonstrate further achievement of these objectives for students in their senior year.

1. ABET (b): an ability to design and conduct experiments, as well as to analyze and interpret data

Experimental work is sometimes a part of an IQP, but this experimental work is normally of a social science nature and does not support engineering education, per se. Nevertheless, analyzing and interpreting data, and drawing conclusions from it, are normally a part of an IQP. Three questions address the reports' findings and analysis. They address the nature of the data collected and its analysis. The IQP tends to focus more frequently on qualitative data.

Findings/Data - Nature of the Information Gathered
Completely Qualitative (1) v. Completely Quantitative Data (5)

Absent	2.5%
Qualititive (1,2)	40.8%
Both (3)	18.5%
Quantitative (4,5)	28.3%
Mean	2.79%
S.D.	1.59%

Findings/Analysis- Conclusions Properly Derived from Analysis of Evidence

Questionable and Inadequate (1) v. Appropriate and Complete (5)

Absent (5%) or Questionable/Inadequate (1,2)	48.1%
Acceptable	14.8%
Appropriate/Complete (4,5)	37.0%
Mean	2.72
S.D.	1.4

Findings/Analysis- Conclusions Properly Derived from Analysis of Evidence
Inconclusive/Not Convincing (1) v. Well Grounded Conclusions (5)

Absent (5%) or Inconclusive/Not Convincing (1,2)	48.1%
Acceptable	17.3%
Well Grounded Conclusions (4,5)	34.5%
Mean	2.7
S.D.	1.4

Findings/Analysis- Overall Rating (Absent, 1-5)

Absent or Not Acceptable (1,2)	49.4%
Acceptable (3)	18.5%
Good or High (4,5)	32.1%
Mean (Calculated without missing data)	2.79
S.D.	1.3

These data suggest that students in about half of these project teams are able to adequately analyze their data. Some of the difficulty here may arise from the substantial use of qualitative data in these projects; however, further analysis would be required to make this determination. Students are less able to draw well grounded, well formulated and complete conclusions from their data, however. In substantially over half of the reports (58%), conclusions were missing or underdeveloped/not persuasive

Conclusions of Report

Missing	4.9%
Underdeveloped/Not Persuasive (1,2)	53.1%
Middle rating (3)	21.0%
Well Formulated/Complete/Persuasive (4,5)	21.0%
Mean	2.55
S.D.	1.19

2. ABET (d) an ability to function on multi-disciplinary teams

Students working alone on IQPs are obviously not functioning in teams, despite faculty involvement. Nearly 100% of projects completed off-campus are completed in teams and of those, it is reasonable to assume that essentially all are multi-disciplinary teams.[6] Of the entire population of projects completed on-campus during the period of the study, nearly 40% (39.8%) were performed by one student. Twenty-seven percent of teams had two students and 33% of teams had 3 members or were larger. Mean team size was 1.67.[7] One would expect it to be over 2.0.

Of the 89 true project teams, only 16 teams were composed of students all enrolled in the same major. Therefore, of the 148 IQPs completed during the period, 73 (49.3%) were completed by multi-disciplinary teams. These 73 projects included 204 students. When we add these students to the 293 students completing IQPs off-campus during the period, it becomes apparent that 497 students, or 76.3% of all students completing IQPs in 2006-07, did so in multidisciplinary teams. The remainder of the students either worked alone or on teams composed of students from the same major.

Lack of team experience is now seen by this author as the major, correctable weakness in the on-campus IQP program. Appendix A details the relationship between team size and overall IQP performance. Further work evaluating the effect of team size on other learning outcomes may be performed in the future.

3. ABET (f): an understanding of professional and ethical responsibility

In our assessment instrument, we asked reviewers whether the report demonstrated an "awareness of social ethics." Specifically, reviewers were asked to rate the reports on "The extent to which discussion of the impact of technology on society reflected recognition of the social responsibilities of individuals, scientists and/or engineers" (Absent, 1 – 5). In 49.4% of the reports, this element was absent/missing. Another 17.3% of the reports were given low ratings (1, 2). Nearly on-third were rated as acceptable (3) or high (4, 5). As a result, roughly two-thirds of our on-campus projects show inadequate attention to the ethical issues commonly present in society/technology problems.

4. ABET (g): an ability to communicate effectively

To access communication skills, we examined IQP reports relative to the quality of writing, the document's design and visual communication, and an overall rating of "writing and presentation." All were assessed on a scale of 1 – 5 with 3 indicating "acceptable" work. The assessment result is nearly identical on all three measures and shows generally acceptable performance with regard to communication skills.

[6] It is our practice to assemble interdisciplinary teams of four students per project at project centers.
[7] These data are not estimates based on the sample, but are derived from the Regisrar's data on project registration.

Overall Rating of Writing

Not Acceptable (1,2)	23.5%
Acceptable or Better (3-5)	76.8%
Mean	3.19
S.D.	1.04

Rating of Document Design

Not Acceptable (1,2)	21.0%
Acceptable or Better (3-5)	79.0%
Mean	3.2
S.D.	1.05

Overall Rating of Writing and Presentation

Not Acceptable (1,2)	21.0%
Acceptable or Better (3-5)	79.0%
Mean	3.19
S.D.	0.96

5. ABET (h): the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Two questions on the review form enable us to assess the broad education necessary to understand the impact of engineering solutions in a social context. First we asked about the project balance in terms of technological and societal concerns. Reports were rated on a scale from "primarily social" (1) to "well balanced" (3), to "primarily technical" (5). Projects tended to lean slightly to the technical side with 33.3% rated 4 or 5, but over 43% were considered well balanced.

Balance in terms of technical and societal concerns

1. Primarily Social	8.6%
2.	14.8%
3. Well Balanced	43.2%
4.	25.9%
5. Primarily Technical	7.4%
Mean	3.09
S.D.	1.03

Secondly, we asked whether the report addressed the "evaluation of the impact of engineering or technological solutions on society." Here the results were more disappointing as in 26% of the reports this element was missing. Of the 60 reports where this concern was addressed, 29 (48.3%) of the reports were rated below "acceptable."

Evaluation of the impact of engineering or technological solutions on society

Absent	25.9%
Not Acceptable (1,2)	35.8%
Acceptable to Excellent (3 - 5)	38.2%
Mean	2.68
S.D.	1.25

6. ABET (i): a recognition of the need for, and an ability to engage in life-long learning

It is more difficult to determine whether students recognize the need for, or show an ability to engage in life-long learning from these reports. The ability to do so is measured, in part, by the students' ability to acquire and apply knowledge not (likely) obtained from prior coursework, and from their ability to complete a literature review and apply an appropriate methodology. Nearly two-thirds rated acceptable or above on the first measure:

The extent to which the students acquired and applied knowledge not obtained from prior course work

Not Acceptable (1,2)	33.3%
Acceptable to Excellent (3 - 5)	65.4%
Mean	3.05
S.D.	1.15

Several measures of the literature review are relevant.

The extent to which the project demonstrates the students' ability to locate relevant literature

Missing	4.9%
Not Acceptable (1,2)	34.6%
Acceptable to Excellent (3 - 5)	60.5%
Mean	3.05
S.D.	1.22

The extent to which the project shows evidence of critical evaluation of the quality of information resources

Missing	7.4%
Not Acceptable (1,2)	40.8%
Acceptable to Excellent (3 - 5)	51.8%
Mean	2.8
S.D.	1.2

The extent to which the project contains research that integrates multiple sources that reflect different and contradictory perspectives

Missing	12.3%
Not Acceptable (1,2)	37.0%
Acceptable to Excellent (3 - 5)	50.6%
Mean	2.7
S.D.	1.22

The last of these three measures attempt to gauge more complex cognitive tasks and demonstrates less success on these measures of critical thinking with about 50% of our students achieving these goals.

Lastly, we believe use of appropriate methods demonstrates some ability to engage in life-long learning.

Overall rating of methodology

Missing	3.7%
Not Acceptable (1,2)	37.0%
Acceptable to Excellent (3 - 5)	59.2%
Mean	2.88
S.D.	1.23

Here our project reports demonstrate that our students are performing somewhat better, with nearly 60% properly applying appropriate research methods to the work.

7. ABET (j): a knowledge of contemporary issues

Finally, our reviewers were asked to rate "the extent to which the project indicated an understanding or appreciation of contemporary issues" (Absent, 1-5). In nearly 10% of projects, contemporary issues were not addressed. Of the remaining projects, 25% were rated unacceptable (1, 2), while over 65% were rated as acceptable or higher (3-5). (40.8% were rated 4 or 5.) The mean for those rated was 3.19. As some IQPs appropriately address historical topic, we do not expect that all projects will reflect a knowledge of contemporary issues. Those that do, appear on the whole to adequately attend to these issues.

A knowledge of contemporary issues

Missing	9.9%
Not Acceptable (1,2)	25.0%
Acceptable to Excellent (3 - 5)	65.5%
Mean	3.19
S.D.	1.25

Appendix

While the correlations are not high,[8] it is apparent that one-person "teams" do not perform as well as multi-person teams. The following table compares team size with overall project rating, where a rating of 3 is "acceptable" for college credit.

Overall Report Evaluation (9a) * Team Size Crosstabulation

			Team Size					Total
			1	2	3	4	5	
Overall Report Evaluation (9a)	1	Count	10	2	2	1	0	15
		% within Team Size	38.5%	8.0%	8.7%	16.7%	.0%	18.5%
	2	Count	3	8	6	0	0	17
		% within Team Size	11.5%	32.0%	26.1%	.0%	.0%	21.0%
	3	Count	10	6	4	3	1	24
		% within Team Size	38.5%	24.0%	17.4%	50.0%	100.0%	29.6%
	4	Count	2	6	8	1	0	17
		% within Team Size	7.7%	24.0%	34.8%	16.7%	.0%	21.0%
	5	Count	1	3	3	1	0	8
		% within Team Size	3.8%	12.0%	13.0%	16.7%	.0%	9.9%
Total		Count	26	25	23	6	1	81
		% within Team Size	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

It is clearly apparent that a student working alone can complete a project worthy of college credit, but fully 50% of one-person "teams" fail to do that. In comparison, 40% of 2-person teams fail this test and 34.8% of three person teams. It is equally true, however, that larger teams are capable of doing poor work, which explains the weak correlation here. Many elements, besides team size, are associated with high quality projects.

Team size is not equally important to every aspect of an IQP. While team size is less closely related to reviewers' ratings of methodology or topic choice (balance between social and technical issues), it is more strongly related to the students' ability to adequately analyze findings and develop well-grounded, persuasive conclusions. One might reasonably assume that the advisor has more influence on the choice and use of research topics and methods, but that groups working together are more likely to analyze data and develop conclusions more completely.

[8] Pearson's R is .272 and significant at the .05 level.

Team Size	1	2	3
Findings - Rated Poorly (1,2)	60.8%	45.9%	36.4%
Conclusions - Rated Poorly (1,2)	70.9%	54.1%	40.9%

Therefore, there is some evidence that engaging students in teams can promote these critical thinking skills, but it also appears that the IQP alone is insufficient for this purpose. See data on findings and conclusions under point 1, above.

It should also be noted that reviewers' expectations are for team work and are, therefore, more likely to rate team projects more highly than single-person projects. The assessment results may reflect our bias that team projects are superior, but the IQP is *designed* to be a team experience, nevertheless.