

## Using Focus Groups to Identify Industrial Engineering Students' Perceptions of Selected ABET Outcomes

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### Abstract

As we began to review and revise the objectives for our Industrial Engineering program at the University of Washington, we decided to include students in the process. It is the students who are expected to meet program objectives before graduation, yet they may not understand the rationale behind the objectives or may not interpret them in the same way as faculty and others responsible for their implementation. In November 2000, we asked five students from the Department of Industrial Engineering for their interpretations of five performance-based outcomes for graduates of the program. We wanted to document in *their* own words—not ours—what the students thought the outcomes meant and how to assess them. Four of the outcomes were selected from a list of eleven outcomes developed by the Accreditation Board of Engineering and Technology (ABET) for all engineering disciplines. The fifth outcome was developed by the department and was specific to industrial engineering. Four students met together in a series of three focus group discussions. The fifth student was interviewed alone on three separate occasions because of scheduling conflicts. Students provided insightful perceptions, while also sharing their views of the industrial engineering discipline in general and of themselves as future industrial engineers. Some student perceptions were particularly revealing. For example, students focused on corporate and engineering issues when they were asked to describe a broad education. In general, students consider competence in the five outcomes as critical for practicing industrial engineers. They feel that they are developing such competence through the industrial engineering curriculum at the university, supplemented by technical electives and participation in voluntary activities outside of the classroom. In addition, they feel that graduates must possess the ability to describe to prospective employers the range of services that an industrial engineer can provide.

### Introduction

In November 2000, five students from the Department of Industrial Engineering at the University of Washington participated in a series of focus groups and interviews. Through this participation, the students gave their interpretations of five performance outcomes for students graduating from the department. This paper discusses the rationale, methods, and results of our study, with particular emphasis on how focus groups can be used to enhance an engineering program's efforts to meet the criteria established by the Accreditation Board of Engineering and Technology (ABET).

## Study rationale

Industrial engineers (IEs) recognize the need to include the voice of the customer in product design and manufacture. Listening to the voice of the customer is applicable not only to products—both tangible and intangible—but also to services. Universities are not exempt from the need to listen to the customer. Krueger says, “It is dangerous for a university, or for any public service agency, to take the customer for granted” (p. 10).<sup>2</sup> He cites an example of a Midwestern university that discovered only through a series of focus groups with potential students that its recruitment materials were discouraging rather than encouraging students to apply for admittance to its college of agriculture. Identifying customer requirements has also been applied in other academic areas, including the development of courses and curriculum.

IEs employ a variety of methods to tap into customer requirements. Methods such as Quality Function Deployment (QFD) can employ a combination of tools—surveys, contextual inquiry, interviews, and focus groups—that yield both qualitative and quantitative data.<sup>1</sup> Generally, surveys are used as a means to gather quantitative data to supplement and reinforce the qualitative data gathered initially through the other methods. There are a number of good reasons for starting the process with methods other than surveys. Surveys consist of topics predetermined by the research team. “This is a mistake, because the survey designers have no basis for determining the topics to be asked about” (p. 76).<sup>1</sup> The other more open-ended methods—contextual inquiry, interviews, and focus groups—provide the opportunity for the customer to identify the topics that are of concern. Moreover, the survey items may not be in the language of the customer and may therefore be open to a variety of unexpected interpretations. Once customer needs have been identified and subjected to preliminary analysis, however, surveys can be used to ask a larger sample of customers to rank the importance of the identified needs. Surveys usually are thought to be quicker and less expensive than the qualitative methods, especially if the surveys are developed by the researchers rather than by professional marketing associations. However, “most ‘home-grown’ surveys take much longer than planned, and thereby engender hidden costs” (p. 291).<sup>1</sup>

Contextual inquiry allows the researcher to interview and observe the customer in action. According to Terninko, “viewing the context that shapes customer requirements is an essential step for creating appropriate designs” (p. 7).<sup>3</sup> Both interviews and observations complement each other and provide greater insights than either used alone. Interviews help to focus the observations and gain information that may not be readily observable. Observations reveal needs and problems that customers may not have noticed and expressed or discrepancies between what customers say and what they do. But contextual inquiry can be time-consuming and expensive.

One-on-one interviews can yield a wealth of data on their own, especially if the interviewer probes beyond the surface responses of the customer. At the very least, the interviewer should capture customer attributes (CAs)—“phrases customers use to describe products and product characteristics” (p. 304)<sup>4</sup>—in the customers’ own words. The customers’ words may provide a closer correspondence to customer perceptions than the interviewer’s words. But the customer’s words are still open to interpretation. The customer may have a different meaning than the interviewer for words such as “good,” “bad,” and “easy.”<sup>1,4</sup> Skillful probing beyond the surface responses can give insight into these meanings. One of the benefits of interviews is the ability to

learn the “why” behind the “what” of any given answer. One of the disadvantages of interviews is the inability to document behavior.

Focus groups provide a compromise between surveys and one-on-one interviews. Focus groups offer the opportunity for in-depth interviewing on a specific topic (“focus”) with more than one person simultaneously, thereby increasing the sample size but not interviewer time. Thus, focus groups are usually considered to be more efficient and less costly than one-on-one interviews.<sup>2, 5, 6, 7, 8, 9</sup> As with interviews, focus groups generally are not an appropriate method for documenting behavior.<sup>6</sup> However, they can be used in some circumstances to document one particular type of behavior—the group processes that lead to shared assessments.<sup>6</sup> In any event, it is important to keep in mind that even though participants are interacting in a social setting and may be using their everyday language, focus groups are an artificial construct. They do not represent a “naturalistic” setting.<sup>10</sup>

The group dynamics in focus groups serve as both a blessing and a curse for gathering customer data. One assumption that researchers often make is that people have formed their own opinions on a topic of interest and that they have formed these opinions in isolation.<sup>2</sup> In fact, opinions are often formed in the company of others. People may need to hear other’s opinions before they can form their own. Focus groups provide the social setting for such opinion-forming to occur. The focus group moderator can take advantage of group dynamics by encouraging participants to defend opposing points of view.<sup>7</sup> The reasons that participants give for their points of view can add a rich source of detail to the data.

On the other hand, group dynamics may encourage conformity or polarization of opinions.<sup>5</sup> In addition, some participants in focus groups may dominate the discussion and restrict participation by others. Or people may feel reluctant to voice minority positions. One way to ensure that minority positions get voiced is to ask participants to complete a written questionnaire on which they commit to opinions before the focus group begins.<sup>9</sup> But results of these pre-group questionnaires may restrict the beneficial effects of group dynamics. Two other ways to walk the tightrope between the detrimental and beneficial effects of group dynamics are skillful moderation and holding a series of focus groups. Successive focus groups allow for adjustments in questions and procedures along the way. Further, successive groups that are held to discuss the same topic with different participants can compensate for any group that does not yield much data. And successive groups that are held to discuss different aspects of a topic with the same participants can enhance the comfort of participants and possibly promote more open discussion.

Although focus groups can serve as a single source of data, they usually are used in conjunction with other methods. Researchers stress that results of focus groups cannot be generalized to larger populations not only because the responses are not independent but also because the sample size is small and the sample bias may favor those who are willing to travel to a site and participate in such a group.<sup>8</sup> Surveys serve as an effective complement to focus groups. Depending on the purposes, focus groups can be held either before or after surveys are administered. As mentioned earlier, focus groups can identify both the range of customer requirements and the language necessary to help survey respondents interpret items as other

customers have done. Focus groups can also provide more in-depth understanding of survey responses or can test the effectiveness of the survey.

Engineering schools throughout the country are turning to surveys to help them gauge whether their graduating students are meeting (and their alumni have met) ABET performance outcomes. Interviews and focus groups can provide valuable insights that can be used in the construction of surveys or the deconstruction of survey results. ABET has provided us with a set of outcomes (*a* through *k*) that we must meet. They have given us the task of defining these outcomes for our own programs. Although it is difficult to interpret these outcomes as stated, formal surveys or course evaluations often use the exact wording of the ABET outcomes. Students and graduates may add their own set of interpretations to the outcomes while they complete the surveys. These interpretations and the perceptions that prompt the interpretations may have a great impact on survey results. Interviews or focus groups can help us to understand these perceptions and interpretations. This understanding, in turn, can help us to define the outcomes for our programs, construct survey questions that reflect the language of the respondents, or interpret survey results.

The purpose of our focus group study at the University of Washington was to help faculty and staff in the industrial engineering department (“the department”) to understand student perceptions and interpretations of four of the ABET outcomes that are particularly broad and abstract. We wanted to understand not only how students define these outcomes but also how well they think the department is helping them to gain proficiency in the skills and abilities specified in the outcomes. With these perceptions and interpretations in mind, we then could (1) pool them with our own perceptions and interpretations, (2) develop department-specific definitions for the outcomes, (3) use these definitions to gather and to analyze student perceptions of program performance through complementary methods such as student and alumnus surveys, course evaluations, and senior exit interviews, (4) compare and compile results from various methods, (5) prepare self-reports, and (6) meet with ABET evaluators.

#### Description of our methods

Students were recruited for the study in three ways: an email message sent by the student advisor to all students in the department, flyers posted in the department, and announcements in classes. We asked students for five hours of their time in exchange for free pizza at each meeting and a \$50 stipend (\$15 after the first, \$15 after the second, and \$20 after the third focus group discussion). Five students out of the 61 juniors and seniors in the department responded. Four of the students met together in a series of three focus group discussions, preceded by one group orientation. The fifth student was interviewed alone because of scheduling conflicts with the other students. During the orientation, the students were asked to describe themselves and to prepare ground rules for the discussions. (The student who was interviewed accepted the ground rules prepared by the other students.)

The following performance outcomes were selected for discussion:

- c. An ability to design a system, component, or process to meet desired needs.
- f. An understanding of professional and ethical responsibility.

- h. The broad education necessary to understand the impact of engineering solutions in a global and societal context.
- g. An ability to communicate effectively.
- l. An understanding of the integrated, broad nature of the industrial engineering discipline.

The first four outcomes were selected from a list of eleven outcomes developed by ABET for all engineering disciplines. The fifth outcome was created by the department specifically for the industrial engineering discipline. The letters associated with the outcomes correspond to those assigned by ABET to its eleven outcomes (a through k). We continued with the lettering system when we added our own outcome (Outcome l).

The first focus group discussion and interview covered Outcomes c and f; the second covered Outcomes h and g; and the third covered Outcome l and any suggestions for methods for demonstrating that graduates are meeting the five outcomes. The discussion of each outcome was divided roughly into two parts. The first part focused on the importance and interpretation of the outcome. To help get students started and to get a general idea of the importance of an outcome, students were asked to rate the outcome's importance on a scale of one (not important) to five (very important). The second part focused on how students thought they were gaining or could possibly gain the abilities and understandings covered in the outcomes. In this part, students were asked to rate the department on a scale of one (poor) to five (very good) in terms of how well it was helping students to meet the outcomes. Figure 1 shows the question format for Outcome f.

This paper presents the results for outcomes f, h, and l. It does not cover outcomes c and g, nor does it cover the student suggestions for outcomes assessment. We limited the discussion to three outcomes because focus groups for these outcomes yielded the most insightful and sometimes surprising results and because we felt it was important to convey the results in enough detail to illustrate the depth information available from focus groups while keeping the paper to a manageable length. The complete discussion can be found in the technical report for the study.<sup>11</sup>

Each focus group discussion was videotaped and audiotaped. The one-on-one interviews were audiotaped. The tapes were transcribed for data analysis.

**Outcome f: An understanding of professional and ethical responsibility.**

1. In what ways do you think this outcome is essential or not essential for being a good industrial engineer?
  - Rate its importance (1 = not important; 5 = very important).
  - Give some examples of a professional responsibility in industrial engineering.
  - Give some examples of an ethical responsibility in industrial engineering.
  - Give some examples of how understanding of these responsibilities translates to action.
2. Which of your experiences in the industrial engineering department and in relevant jobs (such as co-ops and internships) have helped you the most to become more proficient in this ability? Which experiences have hindered you?
  - Rate the department in terms of how it has helped you gain proficiency in this ability (1 = poor; 5 = very good).
  - What would help you the most to become more proficient in this ability?

**Figure 1: Questions for Outcome f**

## Description of the participants

Three women and two men participated in the study. One of the students was in the last quarter of studies and is referred to in this report as the “graduating student.” This student has not participated in an internship or co-op but works as a checker at a Safeway grocery store. This student decided to become an industrial engineer (IE) after learning that Safeway employed IEs and thinking that it would make sense to try to be employed as an IE at Safeway in order to take advantage of five years of accrued seniority.

Three of the students, referred to as the “mid-program students,” started in the department earlier in the year. They are currently working on a senior project—the design of a car for an SAE competition—that involves working with mechanical engineering students. The student who was interviewed alone is one of these mid-program students. Because this student sometimes offered opinions that were different from those of the group, this student is referred to as the “interview student” when this distinction needs to be made. The interview student has not yet done an internship and may not do so if accepted for study abroad. This student has had experience working as a manager at a Starbucks coffee shop. The choice of an industrial engineering major came after reading a synopsis of what IEs do and realizing that this is “what I was doing all my life” (“trying to make things better or faster”).

One of the mid-program students in the group works as a wait person at a local restaurant and as an intern in a manufacturing firm. This student’s stepfather recommended industrial engineering as a major, but other relatives in engineering discouraged it or recommended getting a second degree. These responses did not discourage the choice but made the student realize that many professional engineers “don’t really see the value of industrial engineering yet...it’s such a new and emerging field.” The other mid-program student in the group will be starting an internship soon. This student decided on industrial engineering because of an interest in business and in processing and manufacturing that emerged after an initial interest in “building things” and in obtaining an architectural engineering degree.

The fifth student, referred to as the “early-program student,” just started taking courses in the department. This student does not have applicable work experience. This student had started undergraduate studies in business, switched to engineering, studied mechanical engineering and British politics in England for one year after being accepted into the industrial engineering department, and plans to get an MBA. The reason for switching to engineering is that an “arts” degree did not seem to be enough, that engineers are in demand, and that industrial engineering (based on the description of the discipline in the course catalog) seemed suited to this student’s interests (“didn’t want to do the specific technical aspects of things”).

## Results

For the most part, the students considered the five outcomes as either important or very important. The only two instances where an outcome was rated as being in between not important and very important were when students wanted to restrict the outcome to particular circumstances. In one instance, a student did not think that all engineering solutions have a global impact. In another instance, a student thought that having an understanding of the broad,

integrated nature of the industrial engineering discipline would apply only to those who are branching out from the standard IE route.

The ratings for how the industrial engineering department has helped students to gain proficiency in the outcomes often depended on student status—whether they were at the beginning, middle, or end of the program. For the broad education outcome (Outcome *h*), four students rated the department as very good. For the understanding of the broad, integrated nature of the industrial engineering discipline (Outcome *l*), three students rated the department as in the middle of the spectrum. Other students either refrained from rating or gave two ratings depending on whether they were rating for their ability at the beginning or the end of the program or whether they were rating mandatory or elective courses and activities. The professional and ethical responsibility outcome (Outcome *f*) received the lowest ratings: either poor or in the middle. (The graduating student would assign a good rating if an elective course on professional practice that he took is made part of the program.)

*Outcome f: An understanding of professional and ethical responsibility*

The student ratings indicated that having an understanding of professional and ethical responsibility is important or very important. Students assert that having this understanding is especially important for IEs because IEs change projects often and work with an array of people. Engineers, in general, are held to higher standards because they design processes for people. When something goes wrong, like a train or plane accident, for example, engineers are the first to be blamed for a poor design. One student says, “If you’re not responsible and you don’t have integrity with what the company’s standards are or what society’s standards are, it’s kind of negligible. It kind of doesn’t matter what you’ve done or what you do.”

The students struggle with defining this outcome. They say that the outcome is “kind of vague” and “fuzzy.” One student says that it is difficult to define because people have a lot of underlying, conflicting beliefs. Some students define *professional responsibility* by how well work is performed—having responsibility to the profession. They say that it is important to take the initiative to obtain whatever knowledge is needed to perform to the best of your ability. When working on teams, you must complete your portion—must “be true to what you say” by following through on what you have committed to do. This professionalism applies to university students as well. The classroom is a professional place, especially when working on projects with outside funding.

The interview student took a more people-oriented stance to professionalism. For this student, professionalism means being open-minded and collaborative. It means getting past stereotypes, embracing diversity, really listening to other’s opinions (including those who work on the manufacturing line), looking at many perspectives to get the best one, and creating an environment where people feel comfortable in sharing their opinions and perspectives. It also means acting in a respectful manner to everyone and working toward a common goal, rather than toward personal agendas. In terms of the work, it means taking pride in what you do and paying attention to details.

The definitions of *ethical responsibility* seem to reflect student status in the IE program. The early-program student says that people know that ethics are there, but they do not talk about

them. This student tries to, but cannot, define ethics, other than by saying that perhaps it involves situations in which a person thinks twice before acting. When a mid-term student in the group suggests that ethics is personal—a feeling of what is right and wrong—the early-program student agrees. The other mid-program student in the group expands on this thought by saying that a sense of what is right and wrong may depend on nations, cultures, and professions and that it might be best to define right and wrong with one's company, customers, and team members. This mid-program student and the interview student say that ethical responsibility means acting with mutual respect. The interview student also defines ethical responsibility as looking at the bigger picture and whom your decisions are going to affect to ensure that the decisions will not cause harm to others and the environment.

The graduating student feels that the one week of ethics that is currently taught in one required IE course is not enough for students to gain this understanding. This course and an elective course he took on professionalism provided case studies in which students applied a code of ethics for engineers. "So we could get real-world scenarios where we might see some of these experiences and kind of some gray area, and those code of ethics kind of nail it down for you." This student cannot remember any items from the code of ethics. "It's complicated. It's like really a long list of things." Other students in the group express a desire to see the code of ethics.

One mid-term student is gaining this understanding outside of classes by talking with professors and with others to help gauge what is appropriate behavior in interacting with professionals. For example, this student now knows that it is best to try to better define a problem by working through as much of the problem as possible before approaching a professor for help. This student would like courses that require IE students to express their views on professional and ethical responsibility to help "nail down" a definition, to gain a sense of standardized professionalism. But just taking a course on professional and ethical responsibility is not enough. On the first day of each course, professors should give ground rules for how to behave in the class and then should keep that awareness alive throughout the course. The early-program student says that perhaps passing an exam to become a member of a professional society would indicate that a person has this understanding of professional and ethical responsibility.

Participation on the SAE senior project has helped all three mid-program students to gain more proficiency in this understanding. Working with students from other departments gives a new perspective of professional and ethical responsibility and a better understanding of what it will be like in the workplace. These mid-program students were treated in a disrespectful way by one of the ME students on the project (negative references to their gender and major). This experience exposed them to examples of unprofessional behavior and helped them to identify the type of behavior they will not accept in the workplace. They learned about the importance of acting professionally even in the "face of unprofessionalism" and about the importance of establishing ground rules that include respect for all individuals. They also learned that unprofessional behavior decreases efficiency, because of the time spent having to work through problems generated by such behavior.

*Outcome h: The broad education necessary to understand the impact of engineering solutions in a global and societal context*



Four students rate outcome *h* as important or very important. The graduating student says that an IE serves as the link between the technical, business, and personal sides of industry. A broad education helps an IE to work with almost anyone. A mid-program student says that industrial engineering is a new and growing discipline. It is at the stage where IEs need to let other engineers know what IEs can do. A broad education will help in this regard.

Differences emerged between the content of the discussion in the group and in the interview. The interview student says that *broad education* means taking courses in other disciplines—political science, speech, economics, and philosophy—and reading the news. Getting more education can eliminate ignorance about what is going on in the world—why and how decisions are made and their possible impact. This student sees that there is a tradeoff between specializing and getting a broader education. Once in the department, a student is mostly learning IE principles. For the most part, the group defines *broad education* as taking the courses in other engineering disciplines that are required of IE students.

The interview student defines *the impact of engineering solutions in a global and societal context* by focusing on the decisions that IEs must make. Engineers often are either the decision-makers or the ones who provide evidence to support decisions. A broad education helps an IE to see the big picture and to take into account other factors besides numbers—factors that are difficult to measure, such as the effect on people and the environment. Socially responsible engineers will get information to support decisions from all sides. They will consider all possible solutions, rather than being one-sided and picking a solution that they may like but that may not be socially responsible.

This student has seen from their senior design project that even students in other engineering disciplines think differently than do IE students. The IE students on the project had to learn to ask the right questions:

I'm working with mechanical engineering students, so it's still in the discipline of engineering. But I can definitely see where they come from on things now. Like, Oh, wow, their perspective is totally different from mine, because I ask them, So is this component of the car hard?... That part isn't simple to me because it would be really hard to get that in and out of a factory, but to them, they're like, Oh, well, that math on that one's easy.

The interview student defines an understanding of the *global* context as being responsible environmentally; taking a broader look, learning about other cultures, considering other's ideas and solutions even if they are completely different culturally; and working together to succeed as a society or as a globe. A broad education is the key to tolerance. Ignorance keeps people apart. Further, a broad education allows engineers to work together better. When asked for an example of how an IE would put these principles into action, this student suggests that an IE might be asked to work on building a plant in Germany. If that IE had an understanding of the impact of engineering solutions in a global and societal context, he or she would take into account the work customs of the country, such as work hours and distribution of labor, rather than imposing his or her own customs.

On the other hand, this interview student acknowledges that not all solutions would have a global impact. The early-program student, who assigns a lower rating to the importance of the outcome than the other students, maintains that the impact depends on the company:

Having a broad education is good in some respects, but at the same time if you're doing something that's pretty isolated within the company, globally it doesn't matter what you're doing within that confined area.

One of the mid-program students in the group agrees that the impact could vary depending on the situation but says that it is important to look at the global perspective (big picture) first. For anything this student works on, the first question asked would be how the project will affect the company or the world. The early-program student counters that an IE could get "screwed" in society—in the world—by helping others. It may be impossible to look at the global aspect of not harming anyone, because your supervisor may fire you for not doing it the way the company wants the IE to do it.

When the group defines *understanding the impact of engineering solutions*, then the last part of the outcome—in a global and societal context—seems to grow dimmer or to take on a more restricted meaning. A mid-program student says that IEs need a broad education in order to see opportunities for IEs within companies that would call forth their IE skills and to explain what IEs can do for the companies. The graduating student says that with a broad education, an IE can voice an opinion on whether it was a good engineering design and why. "So a broad education in *other engineering disciplines* helps you to understand the whole spectrum, kind of in the whole global and society context." The other mid-term student in the group says that a broad engineering training has helped in recognizing that an engineer had something to do with a design, and how and why it got there and why the engineer designed it that way. The early-program student agrees. This student used to think that only architects designed bridges but now knows that civil engineers are involved.

The interview student has gained enough broad education but would like to have even more. This student says that some of their IE classes have "intertwined and kept a good job of associating engineering with other disciplines...maybe not directly...but definitely references to how important things are...how industrial engineering relates to other issues, like socially responsible issues and political issues." This linking to other disciplines has occurred mostly through the suggested readings. Some of these readings are required and linked to assignments; others are optional. One of the interview student's most valuable classes in other disciplines was philosophy (logic) because it helped to solidify thoughts and beliefs and to communicate logically (concise and clear arguments). Also, traveling and working with IE students from other countries has broadened this student's education.

The graduating student and the mid-program students in the group feel that they also have the necessary broad education and that they have gained it almost exclusively from their school experience. One of the mid-program students says that talking with people, primarily with family members who are engineers, has helped in understanding how engineering affects the world. Talking with others has "kind of been the driving force to pay more attention in school and really absorb what I can." The graduating student says that "a few other university credits" such as

writing and communication courses “hit the spectrum well enough to cover” the non-technical areas.

The early program student says that without the curriculum [possibly meaning IE courses] and the access to speakers that come to campus, IE students would not be getting a broad education. As with the rest of the group, this student seems to be defining a broad education in terms of exposure to other engineering disciplines, and much of this assessment of the IE department comes from dissatisfaction with some of the core classes taught in other engineering disciplines. The two mid-program students say that condensing or combining core classes would leave more room to take upper level IE courses. “There’s a lot of IE classes that are optional that I would like to take, but I don’t have the time to take them if I want to get out of here and graduate on time.” One of these students says that the core courses that include real-life applications, either through discussion or hands-on experience, are the most valuable and that the IE department should perhaps look carefully at what courses are most relevant.

*Outcome 1: An understanding of the integrated, broad nature of the industrial engineering discipline*

All students say that it is good to have a broad sense of what IEs can do and how they relate to other engineering fields. Being prepared when they graduate to do a variety of jobs will diversify their opportunities. One student says that they may be cheating themselves of opportunities if they do not have this understanding. Another student says knowing all the options available for IEs could provide the flexibility to adapt to changing situations:

The future is unpredictable.... Our position as we know it today may not be around 20 years from now, so that’s why I think it’s [understanding of broad nature of IE] pretty important.... And we could be asked to declare or define what it is we’re going to do for a company. And they might not have a clear understanding of what industrial engineering can do in a non-engineering arena.

The students in the group discussion are torn between the idea that it is important to have the ability to recognize and seize opportunities in the workplace and the idea that this ability may not be as important for those who choose to follow the standard industrial engineering route (manufacturing, time studies, process flow).

When asked for interpretations of the word *integrated* as it appears in the outcome, a mid-program student in the group defines it as knowing how industrial engineering fits in among the other engineering disciplines and how IEs bring all these disciplines together. But the graduating student offers another definition that this mid-program student and the other students in the group accept. The graduating student says that *integrated* refers to how all the different aspects of industrial engineering are linked.

Generally, students say that this understanding of the integrated, broad nature of the IE discipline is gained primarily outside of the classroom or in technical electives. The interview student expresses concern at least three times for students who do not participate in activities outside of the classroom. “I’m starting to define that, I guess [which electives to take]. The more exposure I have to all those things. But I don’t know how a student that isn’t going to the things that I’m doing, how they would know.”

The graduating student expresses satisfaction with the understanding he has gained in technical elective courses, such as the elective professional practice course offered last spring. One of the mid-program students looks forward to taking that class if it is offered again and would probably rate the department higher after doing so. The interview student says that because so much of this understanding is gained outside of the required courses, getting more guidance from the department in selecting technical electives would help.

In addition to taking technical electives, students say that they are gaining this understanding through participating in extracurricular activities and taking advantage of opportunities the department provides outside of classes, including IIE, student advisory boards, exposure to undergraduate research, career fairs, informal talks with other students, research into how companies define IEs, talks with recruiters, speakers who come to classes, observations of senior projects, emails that describe jobs, postings outside of the IE office. The graduating student mentions that some outside speakers are invited to classes, such as in the professional practice and the user interface design courses, and that this is a good way to gain an understanding of the broad nature of the discipline.

At this point, the interview student does not know much about the options available to IEs. This student says that because IEs do not learn to design but rather they learn the tools they can use to design, keeping track of the cutting edge of technology can help students gain an understanding of available options. Other suggestions for ways that IE students can gain this understanding are to find out what companies need and then take the appropriate technical electives to meet these needs and to learn from professional groups and from jobs. Two mid-program students would like the department to offer tracks, minors, or specialties, such as computer science or manufacturing. Knowing about these tracks would help perspective students and others to see how diverse IE is and might attract more students. Even though IE is so small, it could work in coordination with other departments (pooling resources) so that it would not have to teach all the courses in a particular track.

## Discussion of results

Student responses seemed to be influenced by their position along the program trajectory; by experiences in required courses, technical electives, and non-course activities; and perhaps by whether they participated in the one-on-one interview or the focus groups.

One of the students remarked, "I've noticed here that we've all been answering differently depending on how much classes we've taken and where we're at in the department." Some of the early-program student's responses were expressed in an "it depends" context or were related to everyday situations outside of the engineering context. For example, this student said that students must behave in an ethical way but did not know where to start to define ethics. According to this student, ethics may be relative and may depend on culture, company, and team definitions. The idea that right and wrong may depend on group definitions was also voiced by the mid-program students. The interview student expressed a desire for a standardized definition and for more opportunities in courses to discuss and write about ethics, which might enable such a definition to emerge. The graduating student did not look at ethics in such shades of gray. This

position may be the result of exposure to the engineering code of ethics that the other students had not yet had.

Although the graduating student has had the benefit of courses that have covered ethics, this student did not mention experiences that have grounded the material learned. In contrast, even though the mid-program students had not been exposed to the code of ethics, their experience on the senior project—the SAE car design project—had given them a sense of professional and ethical responsibility, mainly through examples of unprofessional behavior. In the context of this experience, these students seemed to be able to more clearly articulate their interpretations of this rather abstract outcome. All three of these mid-program students felt that the SAE project had given them a better sense of what they might encounter in “real” work experiences. Much of this insight came from working with students in another engineering discipline who have different backgrounds and perspectives. The interview student suggested that senior projects would be even more valuable and could provide more of a broad education for IE students if students from many disciplines, not just students from other engineering disciplines, could participate.

Differences in the definition of a broad education occurred between the interview student and the students in the group, rather than between students at different stages in the program. One explanation may be that an interpretation offered early in the discussion may have been adopted without question by others in the group. Two other possible reasons for the group’s more limited interpretation may apply. One reason could be the broad nature of the industrial engineering discipline itself. Perhaps students in other disciplines, such as mechanical or electrical engineering, who are not required to take such a broad sampling of courses from other engineering departments would interpret this outcome differently. Another reason could be the words *impacts of engineering solutions*, which may have limited the interpretation to engineering-related education. The students in the group interpreted an understanding of the impact of engineering solutions as allowing an IE to be more aware of what engineers do, to judge whether engineering solutions are good, to see opportunities for IEs, and to inform others of what IEs can do. The interview student focused on the decisions that engineers must make: what factors should be taken into consideration in making these decisions and how these decisions may affect others.

It would seem that the words *global and societal context* would require students to move beyond the scope of engineering, but students in the group at times seemed to think of global and societal more in terms of the “big picture” within a company that would employ them or the range of companies that would employ them, rather than in terms of the world at large. The world was brought up in the discussion, but nothing specific was said about possible impacts on the world. The discussion mostly concerned whether there would or would not be an impact. Further, “impact” seemed to carry a neutral interpretation by students in the group. The early-program student did talk in terms of the world, but stressed that not all industrial engineering solutions would have an impact on the world. The solutions may have only a local impact. This student added that a supervisor might not allow an IE to make decisions based on whether they will harm others. (This statement may indicate that the early-program student’s interpretation of this outcome was closer to the interview student’s interpretation than were the interpretations of the other students in the group.)

The interview student's interpretation of *global and societal context* seemed to be more aligned with expert interpretations than were the interpretations of the focus group students. The interview student defined these contexts in terms of being responsible environmentally, learning about other cultures, considering other's ideas and solutions even if they are completely different culturally; and working together to succeed as a society or as a globe. A group composed of engineering educators throughout the country felt that societal context included "concepts such as culture and aesthetics" and "issues associated with...groups of people and their beliefs, practices, and needs."<sup>12</sup> The same group defined global as referring to "issues that cross national boundaries, cultures, and/or societies," with key issues being "the interrelationships among systems and societies and the specific reasoning that must be included in order to make informed engineering decisions."<sup>12</sup> According to these experts, both *societal* and *global* encompass areas such as politics, economics, and the environment.

The satisfaction with the department's efforts in helping students to meet the broad education outcome seems to contradict some of the dissatisfaction with the core courses that they must take in other engineering disciplines. The students in the group considered the courses taken in other engineering disciplines as the cornerstone for their broad *engineering* education. Perhaps the students agreed in principle with the exposure to other engineering disciplines, or they felt they were getting more than enough exposure, or that despite problems in the program, it is working overall.

For all the students except the graduating student, participation in extracurricular activities have played a major role in moving them closer toward meeting the outcomes discussed. The interview student expressed a concern that the students who do only what is mandatory may not be able to meet the outcomes. This student mentioned the suggested course readings as an example of a non-mandatory activity that greatly added to a broad education. Students questioned whether extracurricular activities are much different from technical electives. Both depend on student choices and both may not be a consistent indicator of how the department is measuring up to the outcomes. For example, the graduating student had gained confidence in the outcomes mostly through courses taken. However, this student said that the courses that have provided the most confidence in meeting the outcomes were technical electives and that the one technical elective that had helped the most—the course on professional practice—may not be offered again.

Further, the focus groups and interviews revealed how students are beginning to think of the industrial engineering discipline and of themselves as emerging industrial engineers. Through their experiences so far, students are seeing that others do not understand the discipline very well. Students felt that a large part of being an industrial engineer is to explain what they do or can do. In their minds, students saw the main role of industrial engineers as identifying what is missing and finding simple solutions to make things more efficient. The interview student saw it as involving more than just efficiency. This student used the word *improvement* instead to indicate that efficiency may be only one component in the decision-making process. The students said that developing the awareness of what needs to be changed is a key component in their education. Technology is also a key component in their education because they felt that efficiency is closely linked with the use of technology. And students see industrial engineers as the link between other engineers and other people in the workplace.

Although students were generally satisfied with their program, they suggested areas for improvement. They expressed a desire for more explicit guidance in choosing technical electives, for greater and more consistent integration of the ABET outcomes into IE courses, for more technology in the IE courses or for more access to technology courses, for more design courses earlier in the program, for more project-oriented courses that apply principles learned, for more exposure to ethics, and for the option to take minors or “tracks.”

## Conclusions

The focus groups produced a wealth of information on the use of focus groups as a methodology, and on how students interpret the outcomes and how we are doing as a department to help them gain proficiency in the outcomes. Some of this information, such as how students view the outcome on broad education, would have been difficult to identify through survey research alone. We also learned more about the students that we are teaching—that they value courses, technology, and tools that will help them perform in the workplace and that they bring many outside experiences to their education. Further, they revealed their perceptions of the industrial engineering discipline in general and how it relates to other engineering disciplines.

In terms of focus groups as a methodology, the group dynamics seemed to expand the range of opinions available to each student. Interaction in the group appeared to help students think in ways that they may not have considered. One example of the influence of another’s interpretation is when a student gave an interpretation of the integrated nature of industrial engineering and then later adopted another student’s interpretation. The group interaction also helped students to learn more about electives that are available, such as the course on professional practice, about what the department is doing (the exit interview), and about what IEs can do in the workplace (one student’s friend at Intel).

On the other hand, the group dynamics may have had a restrictive effect, which is more difficult to discern because there is no way of knowing what students may have said if interviewed alone. Clearly, the interview student had a different interpretation of a broad education than did students in the group. This student’s interpretation centered on courses in non-engineering disciplines and on perspectives gained from working with people who have other perspectives. Had the group discussion not begun with an interpretation that centered more on courses in other engineering disciplines and courses in communication, students might have been more likely to consider a broader interpretation. Moreover, some students may not have felt comfortable inserting either their supporting or opposing views into a discussion.

In addition to the interactions, the structure of the focus groups may have expanded students’ repertory of tools. One student mentioned that focus groups could be used as a means to interview students about whether they are gaining the outcomes. Another student alluded to setting ground rules such as those used in the focus groups as a means to ensure professional and ethical behavior on a project.

In terms of the information gained from the focus groups, the student evaluations of the IE program confirm information gathered from other methods to assess student perceptions,

including student and alumnus surveys, senior exit interviews, and course evaluations. We have made changes in our program to address many of the issues identified by students. For example, we have incorporated a module on ethics into the senior design project class and added more courses on technology and professional practice. In addition, the department is currently conducting an analysis on the topics that we teach across the curriculum. We have identified key topics that we are integrating throughout the curriculum in order to progressively build on knowledge with each successive course.

The definitions of the outcomes that emerged from the focus groups have helped us to interpret the information gathered from other methods and to identify additional areas that need attention in our curriculum. For example, as a result of the focus groups, we recognize that we may need to help students expand their concept of “the broad education necessary to understand the impact of engineering solutions in a global and societal context” beyond engineering and corporate aspects. And, finally, the process of reconciling student definitions of concepts with our definitions has illuminated our own difficulties with these concepts and the interpretive work that must continue to resolve these difficulties.

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