AC 2007-2514: ASSESSING STUDENTS' ORAL COMMUNICATION SKILLS

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Introduction

Many reports have indicated that engineering graduates have poor communication skills.[1, 2, 3, 4, 5, 6] However, communication skills are often not the focus of those who teach engineering courses. Since the introduction of the new ABET criteria, many engineering programs have tried in various ways to incorporate communication skills in their curricula.[7, 8, 9, 10, 11, 12]

Engineering students at The Pennsylvania State University are required to take a Speech Communication course as part of their general education requirements. Co-op and internship evaluation and alumni survey data suggest that the current Speech Communication course does not adequately develop engineering students' communication skills for the workforce. Recently, the Engineering Cooperative Education and Professional Internship Program, the Department of Mechanical and Nuclear Engineering and the Department of Communication Arts and Sciences have teamed up to develop a section of this Speech Communication course geared specifically to engineering. To develop requirements for the content of such a course, we reviewed the literature and conducted a follow-up survey with our co-op and internship employers who indicated on the evaluation forms that communication skills needed improvement. We asked employers to rank oral communication competencies according to the extent that they need improvement. The four highest rated competencies were organizing the communication, displaying sufficient general knowledge about the topic, showing confidence, and adjusting to the audience. Many publications have described competencies that students should acquire to become good communicators [13, 14, 15]. Based on the employer input and communication skills literature, we believe that the following competencies are core to oral communications:
  (a) Content-development skills, i.e., competence in ideation generation, amplification, and organization;
  (b) Presentation skills, i.e., competence in generating interest, sustaining attention, using appropriate language, and being clear [14];
  (c) Receptive skills, i.e., listening and interpretive competence; and
  (d) Audience analysis skills.
The Speech Communication course for engineers will aim to improve these competencies.

Because we aim to make educational improvements, we will need to assess the effectiveness of those improvements. Therefore, the next step of the project was to find a valid and reliable instrument to assess these oral communication skill sets. A review of pertinent literature did not reveal an instrument that focused on these four skill sets. Therefore, we developed our own, building on existing work, and piloted it with engineering co-op and internship students and their employers.

Oral Communication Skills Assessment

To develop an instrument for assessing oral communication skills, we examined existing instruments in the fields of speech communication and engineering education. The College of Engineering at Iowa State University (ISU) has developed its own ABET-aligned workplace competencies instrument. [16] The method of development was constituents-based. Their main

premise was that abilities as defined by ABET are not directly measurable but instead need to be inferred from demonstrated skills and behaviors. Upper-class co-op and intern students, ISU faculty, partnering international faculty, employers, and alumni described critical incidents that demonstrated each of the ABET criteria 3a-3k. The results revealed that the following fourteen competencies underlie the ABET criteria: engineering knowledge, general knowledge, continuous learning, quality orientation, initiative, innovation, cultural adaptability, analysis and judgment, planning, communication, teamwork, integrity, professional impact, and customer focus. They mapped these fourteen competencies to each of the ABET abilities in a matrix.[13] Each ABET ability was mapped to more than one underlying competency. Approximately five items were developed to measure each competency. For our study, we were particularly interested in the communication competency items.

Around the same time, another group developed a framework to assess ABET criteria 3a-3k student outcome criteria based on Bloom's taxonomy.[17, 18] This project was supported in part by NSF funding,[19] and the team consisted of researchers from the Universities of Pittsburgh and Washington, Columbia University, Colorado School of Mines, and the Rose-Hulman Institute of Technology.

The items related to communication skills from both projects showed a striking overlap. Since the development of one of the sets was constituents-based, and the other was based on Bloom's taxonomy, we saw this overlap as demonstrating the construct validity of the items. However, a review of relevant literature did not reveal any psychometric properties of these instruments, for example the reliability consistency and validity. Therefore, we decided to base our items on both instruments and pilot them.

Research Questions
This paper aims to answer the following research questions.
  (1) Did our instrument measure students' oral communication skills reliably for both students and employers?
  (2) How many underlying factors did the items measure for students and employers?
  (3) To what extent did student and employer answers correspond (correlate)?
We expected acceptable internal consistency reliabilities (Cronbach's alphas), which means Cronbach's alpha values between .7 and .9 for the oral communication skills items. We conducted exploratory analyses to answer research question 2, because we did not have specific expectations for the numbers of factors. Furthermore, if the items indeed measured oral communication skills reliably, we expected student and employer responses to be correlated. If students or employers were less favorable in their evaluations, we expected them to be consistently so and, hence, the student and employer evaluations would still be correlated.

Method

Oral communication skills assessment instrument
Based on the applicable items about communication skills from both projects described in the introduction, we created a list of eleven items that aimed to measure various aspects of oral communication. See Table 1 below for the individual items. The items were formulated similarly for students and employers, with one difference: items started with "I" for students and with "The

student" for employers, for example, "I adjust presentations to each audience and purpose" versus "The student adjusts […]". Students and employers were asked to rate the items on a six-point scale in the Likert format, with the following response options: Strongly Disagree (1), Disagree (2), Somewhat Disagree (3), Somewhat Agree (4), Agree (5), and Strongly Agree (6). "Not Applicable" responses were omitted from the analyses described below. Three items were phrased negatively to encourage respondents to read all items instead of relying on a consistent response pattern without paying attention to the item content.

Sample

We piloted the oral communication skills instrument during the summer of 2006 with 489 co-op and internship students and their supervisors at the employer sites. The items were part of the final evaluations that co-op and internship students and their employers are required to complete at the end of the work term. In total, 451 students completed the instrument, and 373 employers—response rates of 92% and 76% respectively. Note that sample numbers reported below may be lower given the students and employers who responded to particular items as "Not Applicable."

Results

Prior to conducting the statistical analyses reported below, we reverse coded the negatively phrased items so that higher scores reflected better communication skills for all items. These items are noted with ** in Table 1 and Table 2 below.

To answer Research Question 1, whether the instrument measured students' oral communication skills reliably for both students and employers, we conducted reliability analyses with student answers and with employer answers separately. The Cronbach's alphas for students and employers were .82 ($N = 380$) and .77 ($N = 207$), respectively, which shows a high degree of internal consistency for the item set. This means that respondents answered the items consistently. For students, item 1 ("listens carefully") did not correlate significantly with item 4 ("shows confidence"). All other items correlated significantly with each other, although the correlations between the negatively and positively phrased items tended to be lower than the correlations among the positive items and among the negative items. For employers, the correlations showed a similar pattern, except that the correlations between the negatively and positively formulated questions did not reach a level of statistical significance in ten out of twenty-four correlations.

To answer Research Question 2, we focused on whether multiple items measured the same underlying concept. To test this, we conducted factor analyses with the student answers and with the employer answers—this analysis looks into grouping items that measure a similar concept based on the answer patterns. For example, questions 5, 6, 7, and 11 (see Table 1) referred to the delivery of a speech. If these four items indeed measured just this aspect of oral communications, and the other items measured other aspects of oral communications, one would expect that these four items would correlate highly among themselves (i.e. load high on one factor), but they would show a weak correlation with the other items (i.e. load low on any other factors). In that

case, we would consider reducing the number of items, since all four items would measure the same aspect of oral communications.

The analysis of the student answers showed that our eleven items loaded on two separate factors with Eigenvalues > 1; the two factors accounted for 54% of the variance in the responses; factor 1 explained 40% of the variance, and factor 2 an additional 14%. To illuminate these factors further, we examined the Varimax rotated component matrix. This matrix showed for each item how strongly it was associated with each of the factors (factor loadings). Varimax is a rotation method that minimizes the number of items that have high loadings on each factor. This method simplifies the interpretation of factor structures. The matrix revealed that the nine items that were stated positively in the survey had high factor loadings on the first factor and the three items that were stated negatively loaded highly on the second factor. The correlations of each of the items with the factors appear in Table 1 in the "Student Responses" columns if they were .4 or higher. However, given the content of the items, there did not seem to be a common concept underlying each of the two factors. For example, both factors included items relating to the audience: items 8 and 9 in factor 1, and item 7 in factor 2. Whether an item was phrased positively or negatively seemed to be the common characteristic separating the items loading on first factor from those loading on the second factor. We will elaborate on possible meanings of this result in the discussion section.

Table 1: Factor Loadings Oral Communication Assessment Items *

	Factors				
	Student Responses		Employer Responses		
Items	1	2	1	2	3
1) listens carefully to communication from others	.7				.8
2) shows appreciation of importance of oral communication in ones professional career	.7				.7
3) understands questions from others well	.8				.7
4) appears to lack confidence when presenting orally **		.8		.8	
5) delivers a well-organized oral presentation	.7		.7		
6) uses appropriate presentation techniques (correct eye contact, use of voice, etc.)	.7		.8		
7) fails to keep audience engaged when presenting orally **		.8		.9	
8) is able to interpret results for various audiences	.7		.7		
9) adjusts presentation to each audience and purpose	.7		.8		
10) displays insufficient general knowledge about the topic **		.6		.8	
11) concludes oral presentations by paraphrasing or summarizing the information covered	.5		.8		

* Factor loadings < .4 are not displayed.
** These items were reverse coded so that a higher score meant better communication skills. For example, a higher score on item 4 means that the student showed *less lack of* confidence.

The employers' responses showed a similar pattern as the students' responses; however, three factors had an Eigenvalue greater than one. Compared to the student responses, the positively stated items seemed to embody two different factors instead of one. The three factors explained 66% of the variance in the responses; the first factor explained 38% of the variance, the second

factor an additional 19%, and the third factor 9% more. Similar to the student responses, it seems that the way the items were framed determined on which factor they loaded. The location of the positively formulated items seemed to be an additional determining factor for employers. The positive items preceding the first negative item clustered into one factor; the positive items following the first negative item comprised the third factor. We will elaborate on possible meanings of this result in the discussion section.

To answer Research Question 3, whether student evaluations of their own oral communication skills differed from the employer evaluations, we examined whether the average scores overall (for all eleven items combined) and each of the individual items were statistically significantly different in paired t-tests. We also examined how strongly the overall average and the individual items correlated.

First, we conducted paired t-tests of student and employer answers for the average score that combined all eleven items and for each of the items individually. We applied a Bonferroni correction to adjust for the increased probability of Type I errors resulting from multiple independent tests. We set the probability level to 5% ($p = .05$) for a single analysis; therefore, we tested at significance level of $p = .0045$ (.05 / 11) for the multiple analyses with the individual items. The paired t-tests showed that students rated their oral communication skills as significantly less effective than did their employers. Analyses of the individual items showed this to be the case for five of the eleven items. See Table 2 for the averages.

Note that the standard deviations for the negatively phrased items were consistently higher than the standard deviations for the positively phrased ones. Consequently, we inspected the distributions for all individual items. Interestingly, only 1 to 6 students (0.5% - 1.5%) and 0 to 7 employers (0% - 2.4%) used the lowest two categories ("strongly disagree" and "disagree") for each of the positively stated items, whereas 24 to 50 students (5.9% - 12.2%) and 27 to 33 employers (9% - 9.9%) used the lowest two ("agree" and "strongly agree") for the three negatively stated items.

We additionally examined the correlations between student and employer responses. The correlations were significant for seven of the eleven items. However, they were unexpectedly weak; they ranged from .1 to .2. This indicates that even though we found that students tended to be less favorable in evaluating their oral communication skills, they did not evaluate themselves *consistently* less favorably than their employers did.

To gain a better understanding of this result, we examined how strongly the oral communication scores (the average of all eleven items) correlated with another item from the final co-op and internship evaluation survey. Students and supervisors were asked how well the student demonstrated the ability to communicate effectively through interpersonal skills, formal presentations, and technical writing (ABET criterion 3g). The answer options ranged from "very poorly" to "very well" on a 5-point scale in the Likert format. We compared the oral communication scores of both the students and employers with their answers to this ABET criterion 3g question. The correlations between these two measures were statistically significant for both students and employers, with $r = .35$ ($N = 380$, 28% of the variance explained) and $r = .53$ ($N = 207$, 12% of the variance explained), respectively, and $p < .01$.

We also examined to what extent the students' and employers' evaluations of criterion 3g were correlated; we found a minimal correlation of $r = .18$ ($N = 358$, 3% of the variance explained). This indicates that employers and students did not seem to agree on the level of the students' communication abilities measured by the ABET criterion 3g question, similar to what we found with our eleven items that measured oral communications skills.

Table 2: Paired *t*-tests of Student and Employer Evaluations of Students' Oral Communication Skills

Oral Communication Items Answer categories ranged from 1 (strongly disagree) to 6 (strongly agree)	Student Mean (St. Dev)	Employer Mean (St. Dev)	N	T	p
All oral communication items combined (sum of all eleven answers divided by 11)	4.80 (0.54)	5.00 (0.54)	182	-3.96	.01
1) listens carefully to communication from others	5.17 (0.67)	5.41 (0.64)	346	-4.75	.00
2) shows appreciation of importance of oral communication in ones professional career	5.31 (0.67)	5.37 (0.65)	342	-1.43	N.S.
3) understands questions from others well	4.89 (0.73)	5.33 (0.67)	344	-9.00	.00
4) appears to lack confidence when presenting orally **	4.31 (1.27)	4.55 (1.27)	311	-2.60	N.S.
5) delivers a well-organized oral presentation	4.80 (0.83)	5.14 (0.74)	280	-5.64	.00
6) uses appropriate presentation techniques (correct eye contact, use of voice, etc.)	4.77 (0.82)	4.98 (0.74)	296	-3.53	.00
7) fails to keep audience engaged when presenting orally **	4.53 (1.06)	4.65 (1.22)	280	-1.33	N.S.
8) is able to interpret results for various audiences	4.63 (0.86)	4.95 (0.70)	254	-4.82	.00
9) adjusts presentation to each audience and purpose	4.80 (0.82)	4.96 (0.82)	226	-2.31	N.S.
10) displays insufficient general knowledge about the topic **	4.87 (1.20)	4.85 (1.33)	304	0.16	N.S.
11) concludes oral presentations by paraphrasing or summarizing the information covered	4.60 (0.92)	4.8 (0.90)	266	-2.8	N.S.

** These items were reverse coded so that a higher score meant better communication skills. For example, a higher score on item 4 means that the student showed *less lack of* confidence.

Discussion

The research reported herein served to bring greater clarity to the psychometric properties of a set of eleven items involving various aspects of engineering students' oral communication skills.

Our items were derived from two different sources: Bloom's taxonomy [17, 18] and critical incidents described by a wide range of constituents relating to ABET criteria 3a-3k abilities.[13, 16] Since the items from both sources showed considerable overlap, we expected them to provide a valid means for assessing communication skills.

Overall, students were tougher in the judgment of their oral communication abilities than employers. However, this was not a consistent difference. The weak correlations between student and employer responses indicated minimal correspondence between student and employer

evaluations. If a student thought he or she were adept in a particular respect, an employer might think the opposite, and vice versa.

Our factor analysis offers more insight into the convergent validity of the items. We tested whether multiple items measured a similar underlying concept. If two or more items strongly correlated, we would consider removing one or more of them from our instrument. Even though our instrument consisted of only eleven items, it was part of a longer co-op and internship evaluation survey, and the fewer items measuring oral communication skills effectively, the better. Interestingly, the items that loaded on the factors that emerged from the analysis seemed to be correlated on the basis of whether the item was positively or negatively phrased instead of its focus. The responses to the negative items were more variable than those to the positive items because the more extreme negative answer categories were selected more often, meaning that employers and students selected "Strongly Agree" more often for negatively framed than "Strongly Disagree" for the positively framed answers. This could mean that our participants were more critical in responding to negatively framed items. It may also be an indication that not all participants paid attention to the negatively formulated items, but instead relied on a general pattern on the agree-side of the response continuum. To determine the cause of this difference, we could frame all items negatively or positively. If the latter explanation is accurate, the distributions would narrow. If the alternative explanation that negatively formulated items would encourage people to think more about the content, the distributions of all items currently formulated positively would widen if we would frame all items negatively. The question is whether it would be desirable to construct an instrument having only negatively formulated items.

In view of a Cronbach's alpha of .82 and the statistically significant correlations among the items for the students, the instrument seems to allow for the reliable assessment of oral communication skills. The employer data showed a similar pattern. However, because the respondent cohorts did not agree concerning the students' ability level, the question of whether students or their employers are better able to assess their communication skills was a matter to be resolved. Therefore, we examined the correlations of the communication items with the answer to ABET criterion 3g, the ability to communicate effectively. Both students' and employers' answers to ABET criterion 3g correlated significantly with the combined oral communication score (the average for eleven items), although both correlations were relatively weak. The employer correlation was higher than the student correlation; $r = .53$ and $r = .35$, respectively, explaining 28% and 12% of the variance, respectively. These data suggest that the employers were more consistent in their evaluation of communication skills than the students were. However, even the employer correlations were relatively low. This may have been due to the fact that ABET criterion 3g also includes writing skills. The relatively low correlation might also indicate that employers did not have a clear understanding of how to evaluate the items. In the latter case it might be most effective to involve a trained speech communication expert who will be better equipped to evaluate the specific oral communication skill sets to enhance engineering students' oral communication skills.

Our instrument can also be used to evaluate communication skills of different groups of students. For example, once we have developed a version of the Speech Communications course for our

engineering students, we plan to compare the skills assessments of students who take part in it with those for students who have completed a traditional, not specifically adapted one. Finally, individual items comprising the instrument can also be used to identify areas that need improvement. One way to interpret the data is to examine the distribution for each item to determine which ones elicit relatively more negative assessments. Another way might be to examine the average score for each item. Our data showed that both students and employers rated students' confidence relatively lowest. This could lead to the development of programs or activities aimed to improve confidence levels.

In summary, the instrument we developed to measure students' oral communication skills proved to result in a high degree of internal consistency but a low degree of inter-rater reliability. Because students and employers showed little correspondence in their evaluation of students' oral communication skills, we will need to determine how well students are able to assess their own oral communication abilities, and how to enhance these skills. A comparison of student responses with responses from a Speech Communication instructor in the Speech Communication course could be a first step into gaining a better understanding if students' self-assessment abilities related to oral communication skills.

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