NASA/DoD Aerospace Knowledge Diffusion Research Project

Paper Fifty

From Student to Entry-Level Professional:
Examining the Role of Language and Written Communications
in the Reacculturation of Aerospace Engineering Students

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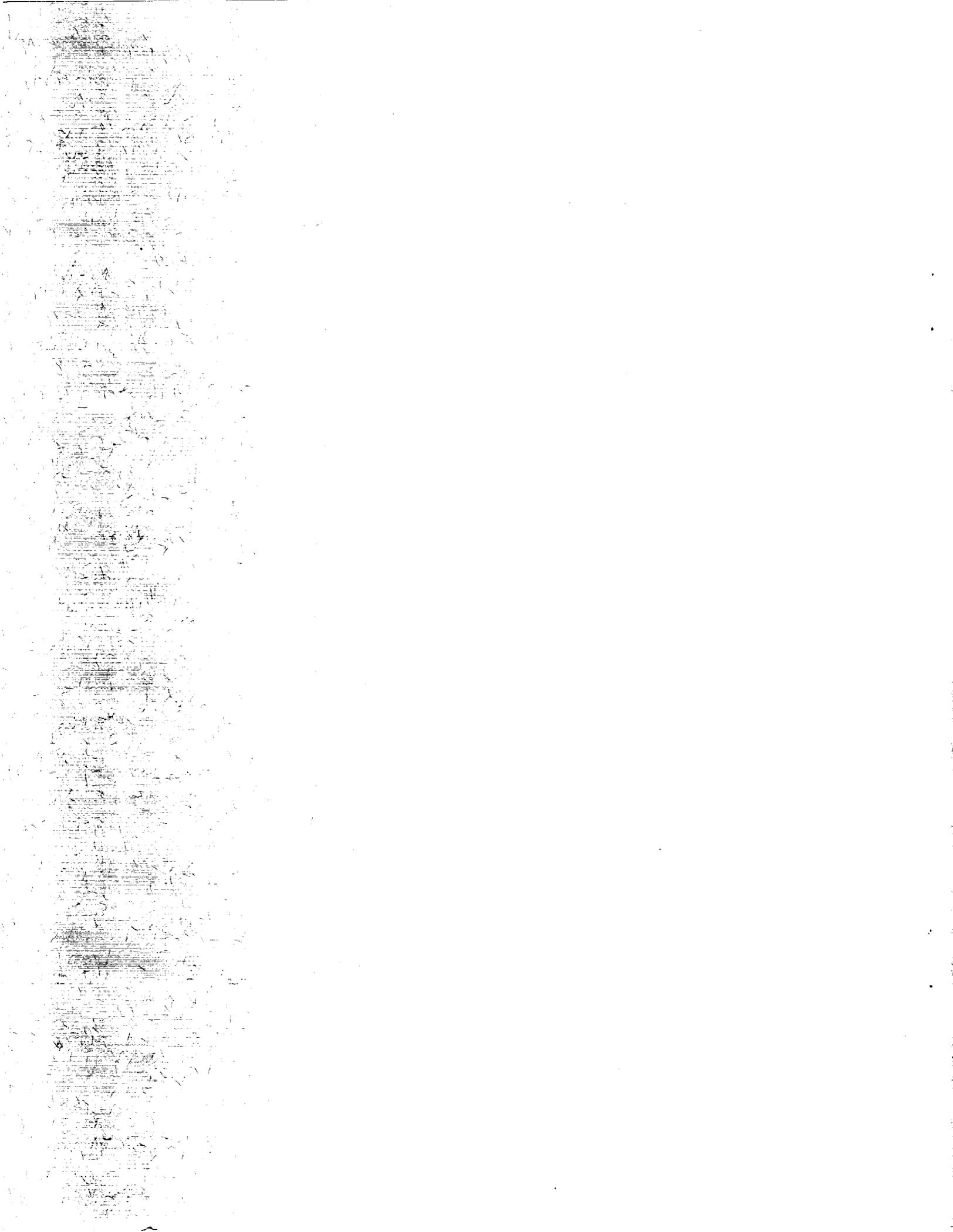National Aeronautics and Space Administration
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From Student to Entry-level Professional: Examining the Role of Language and Written Communications in the Reacculturation of Aerospace Engineering Students

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SUMMARY

When students graduate and enter the world of work, they must make the transition from an academic to a professional knowledge community. Kenneth Bruffee's model of the social construction of knowledge suggests that language and written communication play a critical role in the reacculturation process that enables successful movement from one knowledge community to another. We present the results of a national (mail) survey that examined the technical communications abilities, skills, and competencies of 1,673 aerospace engineering students, who represent an academic knowledge community. These results are examined within the context of the technical communications behaviors and practices reported by 2,355 aerospace engineers and scientists employed in government and industry, who represent a professional knowledge community that the students expect to join. Bruffee's claim of the importance of language and written communication in the successful transition from an academic to a professional knowledge community is supported by the responses from the two communities we surveyed. Implications are offered for facilitating the reacculturation process of students to entry-level engineering professionals.

Engineers in the world of work report that the communication of information takes up as much as 80% of their time, the communication of information is an essential element of successful engineering practice, and the ability to communicate information effectively is critical to professional success and advancement (Mailloux 1989). Feedback from professional engineers and from engineers' supervisors concerning engineering competencies

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This article has been peer reviewed.

shows that both groups rank communications skills—the ability to write effectively, make oral presentations, and search out and acquire information—high in terms of importance to engineering practice. This same feedback, however, shows that both groups rank the communications skills of entry-level engineers low (Bakos 1986; Chisman 1987; Katz 1993; Kimel and Monsees 1979). Although government and industry officials are generally satisfied with the technical knowledge preparation of new hires, they worry about the ability of entry-level engineers to communicate. Kandebo (1988) notes, "if there is a significant problem with entry-level hires, it lies in their lack of training and skill in communication ... a growing number of entry-level engineers cannot write technical reports, fail to make effective presentations of their ideas or concepts, and find it difficult to communicate with peers" (p. 47). Because effective communication is fundamental to engineering and to the professional (career) success of engineers, important questions arise about which communications skills should be taught to engineering students, when those skills should be taught, how much communications instruction is necessary, and how effective current instruction is.

Four elements are missing from current discussions of communications skills and competencies for engineering students:

1. A clear explanation from the professional engineering community about what constitutes "acceptable and desirable communications norms" within that community
2. Adequate and generalizable data from engineering students about the communications skills instruction they receive
3. Adequate and generalizable data from entry-level engineers about the adequacy and usefulness of the instruction they received as students
4. A higher-level theoretical framework, a comprehensive understanding of the nature of knowledge and learning, within which the interpretation of such data can take on consistent and fuller meaning

If these four elements were present, we could construct a mechanism that solicits feedback from the workplace and a system that uses that feedback to answer the questions of what and how much should be taught and when and to determine the effectiveness of instruction.

BACKGROUND

To contribute to the first element and to collect descriptive data concerning the use, frequency of use, and importance of technical communications to engineers in the workplace, as part of the National Aeronautics and Space Administration (NASA)/Department of Defense (DoD) Aerospace Knowledge Diffusion Research Project, we surveyed 2,355 aerospace engineers and scientists whose professional duties included research, design/development, manufacturing/production, service/maintenance, and marketing/sales. To supply the second element and to help provide a perspective on the communications skills of engineering students, we surveyed 1,673 student members of the American Institute of Aeronautics and Astronautics (AIAA) in the spring of 1993 (Pinelli et al. 1994c). The questions in the student mail (self-reported) survey were

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assembled around these topics: (1) the importance of selected communications skills to professional success, the instruction received in these skills, and the helpfulness (usefulness) of that instruction; (2) the use and importance of libraries and other information sources and productions; and (3) the use of computers, selected information technologies, and electronic networks.

To begin to supply the fourth missing element, a comprehensive theoretical framework, we adopted Bruffee's (1993) description of the socially constructed nature of human knowledge. Specific elements in Bruffee's model that are of particular interest to our work are his privileging of the role of language in the process of the creation of knowledge, the concept of "reacculturation" (Bruffee's word for the process through which we switch membership from one culture to another), and the important role of writing in the reacculturation process. As Bruffee defines it, "reacculturation involves giving up, modifying, or

renegotiating the language, values, knowledge, and mores that are constructed, established, and maintained by the community one is coming from, and becoming fluent instead in the language and so on of another community" (p. 225). For Bruffee, "Members of a knowledge community *construct knowledge* [emphasis added] in the language that constitutes that community by justifying beliefs that they mutually hold. But they do not justify those beliefs by testing them against a 'foundation'—either a presumed mental structure or a presumed reality. They justify them socially in conversation with one another" (pp. 221–222). Bruffee's model is particularly appropriate to our work both because the model privileges communication in much the same way that studies suggest engineers' careers do, and because Bruffee looks directly at the process by which people move from one knowledge community to another— the process which, applied to the transition from engineering student to engineering professional, is the focus of this article.

In keeping with Bruffee's concept of reacculturation as a process that enables students to join communities in which understanding may differ from that of the community to which they presently belong, we reviewed literature that focused on understanding what constitutes the knowledge community of professional engineers. Our review of the literature centered on engineering as a profession, engineering knowledge and technical work, engineers and their use of information, and engineering communications and the composing and writing practices of workplace engineers. For the purposes of this article, we have limited our review to literature that focuses on engineering communications and the composing and writing practices of engineers. The composing and writing practices of individual engineers were studied by Selzer (1983) and Winsor (1990, 1992). Davis (1977) and Spretnak (1982) surveyed engineering professionals to determine the impact and importance of effective communications skills on career success and advancement and the value of technical communications training. Middendorf (1980) examined the academic subjects most needed for success in the workplace and proposed a competency inventory for engineering students that prioritized information retrieval and dissemination skills. David (1982) surveyed recent engineering and science graduates to determine the importance of writing proficiency to job performance. In an exploration of specific writing skills and applications, Goubil-Gambrell (1992) studied recent

electrical and computer engineering graduates to determine the types of communications they produce in entry-level positions; Strother (1992) surveyed electrical, mechanical, and civil engineering seniors to determine their expectations of the importance and types of writing they anticipate doing in the workplace.

Paradis, Dobrin, and Miller (1985) note that college training itself does not prepare engineering graduates to communicate successfully in the work environment because core engineering and science curricula seldom include writing and editing; when the core curricula do, instructors of engineering or science writing usually know little about the actual environments in which students will work. Paradis, Dobrin, and Miller suggest that the writing skills of engineering students be improved by modifying the curricula in schools of engineering on the basis of the results of studies of communication in the workplace. Tebeaux (1985) concluded from a review of the literature that many academic writing courses that purportedly focus on pragmatic writing (i.e., writing for business and industry) teach writing that bears little resemblance to on-the-job communications. Schreiber (1993) analyzed the differing discourse communities of academic writing and technical communication. The literature suggests, based on feedback from professional engineers about the communications abilities of new engineering graduates, that (1) a disconnect may exist between the academic preparation of engineers and the world of work that they enter on graduation, and (2) many academicians agree that college training may not prepare engineering graduates to communicate successfully in the workplace. They suggest that the curricula in schools of engineering could benefit from modifications based on studies of communication in the workplace.

METHODS AND SAMPLE DEMOGRAPHICS

Self-administered (self-reported) questionnaires were sent to a sample of 4,300 aerospace engineering students who were (student) members of the AIAA as a phase 1 activity of the NASA/DoD Aerospace Knowledge Diffusion Research Project (Pinelli, Kennedy, and Barclay 1991). The questionnaire and cover letter, on NASA stationery, were mailed from the NASA Langley Research Center in March 1993. Altogether, 1,673 AIAA student members returned the questionnaire by the completion date of 30

September 1993. Because of the summer break, only one mailing was possible. After reducing the sample size for incorrect addresses and other mailing problems, the response rate for the survey was 42%. This rate is very acceptable for a student survey with one mailing.

The AIAA has both undergraduate and graduate student members. Most respondents were undergraduates (948, or 55%), although 707 graduate students responded. (We received 70 additional questionnaires in which the respondents did not indicate a class status.) Males (84%) outnumbered females (16%) approximately five to one. The proportion of females is greater among undergraduates. The gender distribution is very similar (within two percentage points) to the distribution in our earlier survey of senior aerospace engineering students (Holland et al. 1991). Approximately 93% of the respondents were pursuing a degree in engineering. Approximately 83% of the respondents reported English as their native (first) language. There are substantial differences between the graduate and undergraduate samples in the percentages of students whose native language is not English and who are not native U.S. citizens. Each difference is approximately 10 percentage points. More than one-fourth of the graduate students are not native U.S. citizens, and almost one-fourth do not consider English to be their native language (Pinelli et al. 1994c).

Four separate surveys, conducted as a phase 1 activity of the NASA/DoD Aerospace Knowledge Diffusion Research Project, produced the responses of 2,355 aerospace engineers and scientists working in government and industry. The first survey, a pilot study, was sent to 2,000 randomly selected members of the AIAA; 606 usable questionnaires (a 30.3% response rate) were received after one mailing (Pinelli et al. 1989). The second survey included aerospace

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The student respondents clearly identify with engineering-oriented career goals.

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engineers and scientists employed at the NASA Ames and Langley Research Centers; 340 usable questionnaires (73% response rate) were received after the established cutoff date (Barclay, Pinelli, and Kennedy 1993). Participants of the third survey were U.S. aerospace engineers and scientists whose names were on the Society of Automotive Engineers (SAE)

mailing list (not necessarily members of the SAE). This survey produced 946 responses (a 67% response rate) after three mailings (Pinelli, Barclay, and Kennedy 1994a). Participants of the fourth survey were U.S. aerospace engineers and scientists whose names were on the Society of Manufacturing Engineers (SME) mailing list of subscribers to *Manufacturing Engineering* (not necessarily members of the SME). This survey produced 465 responses (a 41% response rate) after two mailings (Pinelli, Barclay, and Kennedy 1994b). The majority of the respondents work in government and industry, have an average of 23.5 years of work experience in aerospace, were educated as and work as engineers, and are male.

We do not assume that these numbers reflect the demographic composition of all aerospace engineering students and aerospace engineers in the U.S. because there probably are differences between students and professionals who join professional organizations and those who do not. In particular, non-U.S. native students are probably less likely to join a U.S. aerospace organization than are native U.S. citizens. There may be smaller or larger gender and family income differences among all aerospace students, but the degree of difference, if any, cannot be determined. In later analyses, we intend to examine the differences in the responses to questions by characteristics of the students, including gender and citizenship.

SHARED VISION OF PROFESSIONALISM

We attempted to determine whether engineering students and engineering professionals share a similar vision of aerospace engineering. In other words, do both groups share the same professional aspirations and career goals? Students and professionals were asked to rate the importance of 15 work opportunities to career success. These opportunities were categorized as engineering-, science-, or management-oriented goals (Table 1). We expected to find some differences among survey respondents, but, overall, there seem to be few differences except for two factors that reflect a research/academic career orientation more typical of graduate students—publishing articles and presenting papers; overall, the student respondents clearly identify with engineering-oriented career goals.

Those factors related to the engineering aspects of their careers (e.g., advanced technical applications) are most important to the students. Almost 85% rated

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Table 1. Career goals (aspirations) of U.S. aerospace engineering students

Goals	Per-centage[a]	Num-ber
Engineering Orientation		
Have the opportunity to explore new ideas about technology or systems	84.4	1458
Advance to high-level staff technical positions	49.9	851
Have the opportunity to work on complex technical problems	66.4	1151
Work on projects that utilize the latest theoretical results in your specialty	57.4	992
Work on projects that require learning new technical knowledge	69.8	1212
Science Orientation		
Establish a reputation outside your organization as an authority in your field	51.0	878
Receive patents for your ideas	25.1	425
Publish articles in technical journals	37.3	641
Communicate your ideas to others in your profession through papers delivered at professional society meetings	40.9	707
Be evaluated on the basis of your technical contributions	53.0	909
Management Orientation		
Become a manager or director in your line of work	41.0	699
Plan and coordinate the work of others	40.1	685
Advance to a policy-making position in management	35.0	595
Plan projects and make decisions affecting the organization	49.4	847
Be the technical leader of a group of less experienced professionals	47.0	805

[a] The students used a 7-point scale, in which 7 indicates the highest rating, to evaluate the importance of each factor. The percentages listed are the students who rated the factor as either a "6" or a "7."

the opportunity to explore new ideas about technology or systems very important for a successful career. Two other factors, working on complex technical problems (66%) and working on projects that require learning new technical knowledge (70%), were rated very important by the students. Over one-half of the students (57%) indicated that working on projects that use the latest theoretical results was very important. To have a successful career, the students think that developing a strong professional reputation is not as important a factor as the types of projects on which they work. It seems that enhancing a professional reputation is more important to graduate students than to undergraduates. Graduate students

(as expected) are much more interested in publishing papers and presenting at professional conferences. In addition, more graduate students than undergraduates think that it is important to develop a reputation for technical contributions, both inside and outside the organization. The AIAA students in the sample do not think that management achievements are as important to a successful career as are engineering achievements. For example, only approximately one-third of both graduate and undergraduate students believe that it is very important to advance to a policy-making position in management. The leadership positions valued most are technical leadership positions and project planning. Overall, these students are more oriented toward being engineers than toward managing engineers.

Engineering students and engineering professionals share similar career aspirations and goals. Those factors relating to the engineering aspects of their careers (e.g., advanced technical applications) are most important to the majority of the engineering professionals in our surveys. Having the opportunity to explore new ideas about technology or systems, having the opportunity to work on complex technical problems, working on projects that use the latest theoretical results, and working on projects that require learning new technical knowledge were deemed most important to career success by the practicing engineers we surveyed. Developing a strong professional reputation outside of their organizations, publishing articles, and presenting papers, although important to engineering professionals in academia and to those working in research, are not important career goals for the majority of engineering professionals who we surveyed. In comparing the data, we see that the two groups share similar goals and aspirations. Both groups view engineering as a career that provides many rewarding activities.

PRESENTATION OF THE DATA

In Bruffee's (1993) terms, the process by which engineering students become successful engineering professionals is one of reacculturation. Bruffee cites Thomas Kuhn (1970) in drawing educators' attention to "the special characteristics of the groups that create and use the knowledge in question" (here, that knowledge is the technical communications skills of aerospace engineering professionals):

How does one elect and how is one elected to membership in a particular community, scientific or not? What is the process and what are the stages of socialization to the group? What does the group collectively see as its goals; what deviations, individual or collective, will it tolerate; and how does it control the impermissible aberration? (Bruffee 1993, p. 74, citing Kuhn 1970, pp. 209–210).

The focus is squarely on the responsibilities of educators to know the conditions that comprise fluency in the language of the disciplinary knowledge community the students wish to join. Bruffee lists four questions educators must have answers for if they are to facilitate this reacculturation process in their students:

- What are those conditions and how can I best create them?
- How do the community languages my students already know reinforce or interfere with learning the language I am teaching?
- How can I help students renegotiate the terms of membership in the communities they already belong to?
- How can I make joining a new, unfamiliar community as unthreatening and fail-safe as possible? (Bruffee, 1993, p. 75)

To understand the reacculturation process that occurs as engineering students make the transition from the academic knowledge community to the professional engineering knowledge community and to learn more about the concomitant communications norms within each community, we compared the results of the engineering student study with those of our studies of practicing engineers. We compared the results to determine possible differences in communications norms between the knowledge community to which students belong and the one to which they aspire; in Bruffee's terms, it is the distance between these two sets of norms that students must transit to become successful engineering professionals.

Technical Communications in the Workplace

Engineering is essentially a social and collaborative process that takes observations of the physical world and changes them into products that can be used by others. To conduct these activities, engineers must communicate their ideas and interpretations of their data and findings to others. Therefore, the ability to produce, use, and acquire

technical information effectively becomes crucial to the professional success of engineers. This would help explain why employers of engineers and engineers themselves place a high value on technical communications skills. Overwhelmingly, the engineering professionals we surveyed indicated that the ability to communicate (e.g., produce written materials or oral discussions) was very important in their work and to their professional success.

These same individuals were asked to report the number of hours they spend per week communicating technical information (in writing and orally) to others and the number of hours they spend per week working with technical communications (in writing and orally) received from others. For the most part, the professional engineers we surveyed spent more hours producing technical communications than they did working with technical communications received from others. The hours spent per week varied slightly depending on the sector (e.g., design/development) in which they worked. The average number of hours spent per week producing technical communications (e.g., written materials or oral discussions) varied from a mean low of 19.6 to a mean high of 23.3. The average number of hours spent per week working with technical communications received from others (e.g., written technical information and technical information received orally) varied from a mean low of 14.9 to a mean high of 19.6. The engineering professionals we surveyed indicated that, during the past 5 years, the amount of time they spend communicating technical information to others has increased. These same individuals reported that, as they have advanced professionally, the amount of time they spend working with technical communications received from others has also increased.

Technical Communications Skills, Instruction, and Helpfulness

A recent article (Evans et al. 1993) presented the results of a survey of industry employers and engineering school alumni. Both the employers and the alumni respondents said that technical communications skills were the second most important skills (behind problem-recognition and -solving skills) for engineers to possess. Given a list of eight skills, both groups indicated, however, that engineers were least well-trained in technical communications skills. Among the alumni, technical

Table 2. Importance of communication and information use skills, skill instruction received, and helpfulness of instruction for U.S. aerospace engineering students

Skills	Importance		Received		Helpfulness	
	Percentage*	Number	Percentage	Number	Percentage*	Number
Technical writing/communication	83.8	1449	72.2	1250	53.7	670
Speech/oral communication	83.7	1446	62.2	1076	53.8	587
Using a library that contains engineering/science information resources and materials	63.9	1101	59.9	1037	39.4	411
Using engineering/science information resources and materials	80.3	1382	63.6	1100	44.7	494
Searching electronic (bibliographic) data bases	51.4	874	50.2	869	41.3	372
Using computer, communication, and information technology	90.9	1573	82.9	1433	68.4	968

* The students used a 7-point scale, in which 7 indicates the highest rating, to evaluate the importance of the skill and the helpfulness of the instruction. The percentages listed are the students who rate the importance of the skill or helpfulness of the instruction as either a "6" or "7."

communications skills were considered almost as important as engineering core courses. The authors summarize the alumni survey (in part) by stating "that insufficient development of communications skills remains a chronic problem that must be addressed" (p. 210).

In a NASA/DoD Aerospace Knowledge Diffusion Research Project survey that investigated computer-mediated communications in aerospace, more than 90% of the aerospace engineers surveyed rated skill (ability to) in oral communications very important, and approximately 80% rated skill in written communications very important (Murphy, 1994). Most of the engineering professionals we surveyed indicated that they had taken a course in technical communications (e.g., technical writing), the course had improved their ability to communicate technical information, and aerospace engineering students should take a course in technical communications as part of their undergraduate education.

Student survey participants were given a list of six technical communications skills and asked to indicate the importance of each of these skills to their professional success (Table 2). The effective use of computer, communication, and information technology was considered to be very important by 91% of the students. The effective communication of technical information in writing or orally was rated important by approximately 84% of the students. Knowledge and understanding of engineering/science information resources and materials was considered important by approximately 80% of the students. Approximately 64% indicated that knowing how to use a library that contains engineering/science

information resources and materials was important to their professional success. Slightly more than half (51%) of the students indicated that the ability to search electronic (bibliographic) databases was important to their professional success as aerospace engineers.

Next, we asked the students to indicate if they had received instruction/training in the six communications and information use skills and to rate the perceived helpfulness (usefulness) of that instruction (Table 2). One-half or more of the students had received some form of instruction/training in the six skills. Approximately 83% and 72% of the students had received some form of instruction/training in using computer, communication, and information technology and technical writing/communication, respectively. Approximately 50% received some form of instruction/training in searching electronic (bibliographic) databases. However, even if engineering and technical communications educators provide access to the instruction/training and a substantial portion of the students avail themselves of the opportunity, the students still may not perceive the instruction/training to be helpful. In fact, the students' perceptions of the helpfulness (usefulness) of the instruction/training varied. Of those who had received instruction/training in using computer, communication, and information technology, approximately two-thirds found it helpful (useful). Approximately 54% of those student respondents who had received instruction/training in technical writing/communication and speech/oral communication perceived it to be helpful (useful).

The Nature of Engineering Work and Technical Communications

Engineering professionals were asked to categorize the most important job-related project, task, or problem that they had worked on in the past 6 months. They were asked whether they had worked alone or with others on this project, task, or problem. On average, approximately 70% of the respondents indicated that they worked with others (not alone). Furthermore, they reported working with three or more groups, with each group containing an average of 4.5 people. We also attempted to determine how much of the writing performed by aerospace engineering professionals is collaborative in nature. Survey respondents were asked to indicate the percentage of their written technical communications in the past 6 months that involved writing alone, with one other person, with a group of two to five people, and with a group of more than five people. The amount of writing performed alone or with others varied depending on the sector in which the engineer worked. (The percentages that follow total more than 100 because the respondents could work in more than one group.)

For example, approximately 41% of those engineering professionals working primarily in design/development indicated that almost all their written technical communications were prepared alone. Approximately 45% indicated that their written technical communications involved writing with one other person. Approximately 45% indicated that their written technical communications involved writing with a group of two to five people. Approximately 39% indicated that their written technical communications involved writing with a group of more than five people.

Approximately 40% of those engineering professionals working primarily in manufacturing/production indicated that almost all their written technical communications were prepared alone. Approximately 83% indicated that their written technical communications involved writing with one other person. Approximately 66% indicated that their written technical communications involved writing with a group of two to five people. Approximately 29% indicated that their written technical communications involved writing with a group of more than five people.

Those same engineering professionals were asked whether they find writing collaboratively, that is, as part of a group, more or less productive (i.e.,

producing more written products or producing better written products) than writing alone. Overall, slightly more of those engineering professionals working primarily in design/development and those working primarily in manufacturing/production indicated that writing with a group is more productive than writing alone.

Given the collaborative nature of engineering work and technical communications in the workplace, we asked students about the collaborative preparation of written technical communications. Specifically, they were asked to identify the percentage of their written technical communications that involves collaborative writing and the percentage of their written technical communications that is required to be collaborative. Approximately 28% indicated that none of their written technical communications involved collaborative writing; conversely, approximately 3% indicated that all their written technical communications involved collaborative writing. On average, approximately 34% indicated that their written technical communication involved collaborative writing. Approximately 38% of the students indicated that none of their written technical communication was required to be collaborative; conversely, approximately 8% indicated that all their written technical communication was required to be collaborative. On average, approximately 49% indicated that their written technical communication was required to be collaborative. Student respondents were also asked, in general, if they find writing as part of a group more or less productive than writing alone. Twenty-eight percent stated that they found writing as part of a group less productive than writing alone, and 28% indicated that writing as part of a group was about as productive as writing alone. Approximately 44% indicated that writing as a part of a group was more productive than writing alone.

Undergraduate Course Content for Technical Communications

In two of our surveys, we asked engineering professionals what principles should be included in an undergraduate technical communications course for aerospace engineering students. The top five topics identified for inclusion were: (1) organizing information; (2) defining the communication's purpose; (3) developing paragraphs (i.e., introductions, transitions, and conclusions); (4) assessing readers' needs; and (5) choosing words (i.e.,

avoiding wordiness, jargon, and slang). Students were asked to indicate the extent to which their lack of knowledge/skill about a specific communications principle impeded their ability to produce written technical communications. Approximately 25% indicated that their inability to (1) "define the purpose of the communication" and (2) "prepare/present information in an organized manner" was an impediment.

These same engineering professionals were asked what mechanics should be included in an undergraduate technical communications course for aerospace engineering students. The top three mechanics identified for inclusion were: (1) references; (2) punctuation; and (3) spelling. We also asked them to identify those on-the-job communications that should be included in an undergraduate technical communications course for aerospace engineering students. The top four on-the-job communications identified for inclusion were: (1) oral presentations; (2) use of information resources; (3) writing letters and memos; and (4) writing technical reports. We attempted to validate these findings by comparing the recommended on-the-job communications with those actually prepared and used by these same engineering professionals. With one exception, the recommended on-the-job communications compared favorably with the types of communications produced and used on the job.

Use of Computer Technology

Students were asked about their use of computers (Table 3). Approximately two-thirds of the student respondents indicated ownership of a personal computer. Approximately 99% indicated they used a computer to prepare written technical communications. Of those using personal computers to prepare written technical communications, approximately 94% indicated that they used personal computers "always" (82.3%) or "frequently" (12.3%) to prepare written technical communications. Student respondents who indicated that they "never" used a computer to prepare written technical communications were asked to indicate their reasons for non-use. Approximately 39% gave "no/limited computer access" or "lack of knowledge/skill using a computer" as reasons for non-use. Approximately 17% gave "prefer not to use a computer" as their reason for not using a computer to prepare written technical communications.

Table 3. Computer use by U.S. aerospace engineering students

Factor	Percentage	Number
Do you own a personal computer?		
Yes	67.7	1172
No	32.3	560
Do you use a computer to prepare written technical communication?		
Never	1.4	24
Yes	98.6	1680
Sometimes	4.0	69
Frequently	12.3	209
Always	82.3	1402
Your reason(s) for not using a computer?		
No/limited computer access	37.5	9
Lack of knowledge/skill using a computer	37.5	9
Prefer not to use a computer	16.7	4
Other	20.8	5

Almost all the aerospace engineering professionals we surveyed used computer technology to prepare written technical communications. Furthermore, almost all indicated that computer technology had increased their ability to communicate technical information.

DISCUSSION

Bruffee's 1993 model of reacculturation enabling movement from the student knowledge community to the professional knowledge community provides a useful theoretical framework for this research. In this article, we considered the social construction of knowledge and the critical role played by language and written communications in the reacculturation of engineering students into the engineering profession. (For a discussion of the social construction of knowledge in aeronautics, see Vincenti, 1990.) The literature suggests that entry-level professionals must have appropriate language and communications skills to make the transition successfully from student to practitioner, and that proficiency in these skills smooths the process of transition and improves the chances for a successful transition. However, the same literature also suggests that these skills are usually underdeveloped in entry-level engineering professionals. We must urge caution, however, in generalizing from the data reported in this article. Our research focuses only on aerospace engineering students and professionals who belong to professional

societies (AIAA, SAE, and SME). The *Occupational Outlook Handbook* (U.S. Department of Labor, 1990) identifies 10 separate branches of engineering and 25 major specialties within those branches. To generalize to all branches of engineering and to engineering students in other disciplines from our research would be inappropriate and could be misleading.

Nonetheless, we have learned a number of things from this research. First, aerospace engineering students and professionals share a similar vision of their chosen profession. Both groups value opportunities to explore new ideas about technologies and systems, work on complex technical projects, and participate in projects that use the latest theoretical results and require learning new technical knowledge. Both groups want to be aerospace engineers (rather than scientists or managers) and anticipate that their chosen careers will offer many rewarding professional activities. Second, our research confirms the findings in the literature about the fundamental importance of effective communication for engineering practice and for the professional (career) success of engineers. Aerospace engineering students concur with what aerospace engineering professionals know: the ability to communicate effectively—orally and in writing—is crucial for career success. Third, although the students in our study recognize the importance of proficiency in communications and information use

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Both aerospace engineering professionals and students found collaborative writing to be more productive than writing alone.

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skills, there are marked differences between the percentage of students who recognize the importance of these skills and the percentage who have received instruction/training in these skills, and there are marked differences between the percentage of students who have received instruction/training in these skills and the percentage who find that instruction/training helpful. Fourth, aerospace engineering work is collaborative in nature, and much of the writing done in the aerospace workplace is also collaborative. Almost one-half of the aerospace engineering students in this study reported that their written technical communications were required to be collaborative. Both aerospace engineering professionals and students found collaborative writing to be more productive than writing alone.

Fifth, almost all the aerospace engineering professionals and students we surveyed use computers to prepare written technical communications. Sixth, three principles that aerospace engineering professionals recommend be taught as part of an undergraduate technical communication course—assessing readers' needs, organizing information, and defining the communication's purpose—are the very principles that aerospace engineering students report great weakness in when they prepare their written technical communications.

IMPLICATIONS FOR IMPROVING THE REACCULTURATION PROCESS

The literature we reviewed suggests that, in general, entry-level engineers lack the communications and information use skills to write effectively, make oral presentations, and search out and acquire information—the very skills that the literature indicates are needed for a successful engineering career. In the absence of an explanation from the professional engineering community about what constitutes acceptable and desirable communications norms, and given the lack of adequate and generalizable data that would demonstrate the communications and information use skills of entry-level engineers, we will assume that entry-level engineers may not be skilled communicators. Three possible explanations may account for their lack of skill: (1) they do not receive communications and information use skill instruction/training as part of their academic preparation; (2) the communications and information use skill instruction/training they receive as part of their academic preparation is not helpful; and (3) the communications and information use skill instruction/training they receive as part of their academic preparation is inappropriate for the workplace—that is, there is a "disconnect" between academic perceptions of workplace communications and the realities of workplace communications.

The data produced by our research is consistent with Bruffee's model of socially constructed knowledge. If we follow Bruffee's account of the vital role of language and written communications in the reacculturation process that enables movement from one knowledge community to another, any discussion of a potential "disconnect" between two communities must look for the source of that "disconnect" in the communities' languages and methods of communication. Specifically, we would seek to

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identify more precisely the differences that exist between workplace communications and academically oriented communications (both as taught in technical communication classes and as experienced by students in other academic settings). How much should and do engineering and technical communications academicians know about workplace communications, and how much of that knowledge should and do they incorporate into their communications and information use skill instruction/training? It is likely that, whereas workplace communications emphasize conformity to organizational culture, standards, and norms, engineering and technical communications academicians instruct students in the processes of creating written and oral communications based more on prevailing rhetorical and communication theory and less on firsthand knowledge of workplace communications.

Although the findings of our study have provided some insights about the communication and information use skills instruction of aerospace engineering students, we have raised more questions than we have answered. We suggest the following. Conduct a series of coordinated studies designed to obtain adequate and generalizable data about the communications skills instruction that students in various engineering disciplines receive as part of their academic preparation. Undertake a study of entry-level engineers across engineering disciplines to determine what kinds of communications they produce and what skills they use to produce them. Collect adequate and generalizable data from entry-level engineers across engineering disciplines about the adequacy and usefulness of the communications skills instruction they received as students. Finally, determine from members of the professional engineering community what constitutes acceptable and desirable communications norms in light of the persistent complaint that entry-level engineers lack the communications skills needed for professional success. Increased knowledge of the communications environment and workplace culture could help academic technical communicators improve instruction.

What responsibility should employers of entry-level engineers assume in developing the communications and information use skills of new hires? Specifically, can the information professionals (technical writers, editors, and information specialists) who work for the companies doing the hiring play a role in the reacculturation process of entry-level aerospace engineers? As part of the reacculturation of entry-level professionals into the workplace, could technical communicators in the workplace provide instruction about the impact of organizational culture and norms on workplace communications products? Rather than making either the academic community or the professional community solely responsible for preparing entry-level engineers for the workplace, we would also encourage the academic and workplace communities to work together to reacculturate students successfully for the world of work. If entry-level engineers are not skilled communicators, members of the academic and workplace communities could explore collaborative opportunities for improving and enhancing the communications skills of entry-level engineers. Technical communicators from the workplace might serve as consultants in academic settings to help academic technical communicators prepare students for reacculturation. In Bruffee's reacculturation process, the role of transition communities is a powerful one: these groups provide a setting in which individuals facing the reacculturation process are enabled to relinquish their dependence on fluency in their former language and pursue the linguistic improvisation that can enable them to join their new community (Bruffee, 1993, p. 75). Do such communities exist in some academic and professional settings but not in others? Could such communities profitably be made up of both technical communications teachers and technical communications professionals, functioning here as collaborative readers for soon-to-be and newly graduated engineers? Finally, what role should professional societies play in providing forums for discussion of these issues at the national and regional levels?

Although the questions we raise here outnumber the answers, we have been able to provide both a quantity of reasonably reliable data on student writing in aerospace engineering and a corresponding account of writing in the professional knowledge community. Especially when seen in light of the larger, social construction model of knowledge (which itself remains hotly debated in some circles), this data suggests fairly clear explanations for the current perceptions of professionals in aerospace engineering that new graduates lack requisite technical communications abilities, skills, and competencies that would help them succeed as they move from one knowledge community to another. The data also suggests clear directions for future research that may point the way to changing those negative perceptions. We believe that the opportunities look promising. Ω

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