Assessment of Communication Competencies in Engineering Design Projects

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Reforms in engineering education have caused a shift from the traditional stand-alone course in technical communication for Engineering students towards communication training integrated in courses and design projects that allows students to develop four layers of competence. This shift creates opportunities for realistic and situated learning, but offers challenges for assessment of communication competence at student, course and program levels. On the basis of a detailed definition of communicative competence, three formats for integrated communication training are described: Linked to design projects, integrated in design projects and integrated at program level. Assessment of communication competence in these formats is constrained by their characteristics with regard to student motivation, individual and group work, and situated learning.

The Department of Communication Studies of the University of Twente (The Netherlands) provides service communication courses for the engineering and social sciences programs of the university. Over the past decade we have responded to the demand for communication training integrated into project-based engineering courses by developing three instructional formats, which are inspired by Writing-Across-the-Curriculum (WAC) and Writing-Intensive (WI) courses as approaches to teaching communication. The three formats each pose their own opportunities and challenges for assessment at student, course and program levels, as distinguished by Jo Allen in her 1993 article. For this study, we will first outline what we mean by Engineering students' communication competence, which directs what should be assessed at the student, course, and program levels. Then we will describe the three instructional formats we developed and their strengths and weaknesses when it comes to assessing students' communication competence. The final section identifies areas for concern when planning student, course, and program assessment in an integrated or WAC approach.

Context

Most universities in Europe do not offer or require the equivalent of the typical English 101 course of American universities. In Europe, general language education takes place at secondary school level. If any language or communication course is required in higher education, it focuses on communication in the profession or on academic writing. A decade ago, the Engineering students at our university took one or two stand-alone professional (technical) communication courses at some point in their curriculum. We assessed their achievements by means of exams on the content of the handbook used, or "fake" technical reports and business presentations, produced just for our course. We gave our students individual grades.

Reforms in Engineering education have changed the stand-alone course situation, for us and for many other departments offering service courses to Engineering programs all over the world. The Engineering programs are increasingly focusing on project-based learning, challenging their students to apply and integrate their newly acquired technical knowledge in realistic, situated design processes. To create time—that is, credits and hours—for the projects, the program directors tend to cut externally-supplied service courses. In addition to this worldwide educational reform, twenty-nine European countries have started a process of converging their widely varying higher education systems. The move towards a common framework and comparable degrees has created a need for international accreditation and clarity about assessment goals and practices ("Bologna Declaration"). The accreditation criteria of the USA-based Accreditation Board for Engineering and Technology (ABET) play an important role in this process, as a benchmark to define international standards for Engineering curricula and their graduates (for a detailed discussion, see Julia Williams, "Technical", "Transformations"). We will focus here on the ABET criteria about communication competencies and skills for engineers.

The general ABET criteria for programs at the advanced level state that any engineer should be able to communicate about and within his or her discipline in the realistic context of a design project. Engineering programs must include "... an engineering project or research activity resulting in a report that demonstrates both mastery of the subject matter and a high level of communication skills" (ABET, "2002-2003 Engineering," section II). ABET obviously favors assessment of communication skills in an integrated, project-based context.

When one compares the ABET criteria for the various subdisciplines within Engineering, diverging views of the required competence of graduates emerge. For example, architecture graduates should be able to communicate with the other design professionals involved in the building project, that is: just with peers within their field (ABET, "2002-2003 Engineering," section 1). In contrast, graduates of the Applied Science programs should be able to communicate their technical findings, general knowledge and analyses to non-technicians as well as to technicians (ABET, "2002-2003 Applied Science," section 1.C.4). In another place, the document states that "A good technical educator will insist that reports be neat, grammatically correct, and lucid." (ABET, "2002 -2003 Applied Science," section 1.C.4.a). Is this, then, what we need to focus on in assessment of communication competence—neat, correct and clear reports, to be produced within projects, either for fellow engineers or for a wider audience?

Communication Competence: Assessment at Student Level

We have found the ABET criteria for communication skills for engineering graduates lacking in useful content for assessment. As teachers of communication, we know that assessment of communication skills requires a much more fine-grained distinction of what constitutes good communication than is available from standard versions. For engineers communicating within the context of their work, as much as for professional communicators, literacy is layered (Cook). It encompasses much more than mechanical and grammatical correctness or clear text organization. We suggest, therefore, that good communication skills require competence in four literacy layers: text craftsmanship, genres, strategic communication and feedback.

Layer 1: Text Craftsmanship

In the following description of competence, we will use the word text both for oral and written forms of communication. The first layer of literacy is not unlike the neat, correct and lucid communications that ABET requested.

Standard grammar, usage and spelling, and clarity of organization are basic parts of the craftsmanship of a professional who writes or presents as part of the job; competence at this level should be demonstrated in every communication situation. Consequently, our students will always get feedback on their language use and text organization, and their achievements on this point will be part of every student assessment. Table 1, following, shows an overview of elements of competence for this basic layer of literacy.

Table 1

First Layer of Communication Competence: Text Craftsmanship

Elements of competence in language use and text organization
• The student produces texts with a clear organization and uses organizational cues to support the reader/listener navigating through the text, such as preview, forward and backward referencing, enumeration, and structure-signaling sentences or phrases.
• The student builds a logical argument and signals the argumentative structure to the reader/listener with verbal means.
• The student understands the function of titles and headings, introductions and conclusions, and demonstrates that s/he knows how and when to use them.
• The student knows the various types of summaries and demonstrates that s/he knows how and when to use them.
• The student recognizes various style registers and can write or speak in various styles that are appropriate for scientific and public discourse on engineering issues.
• The student recognizes style variations like level of difficulty and exactness, density of information, distance between author and reader, and liveliness. The student applies them in her/his own texts.
• The student understands basic principles of layout and typography and uses them to support readers of the text.
• The student produces standard language, both when writing and speaking.

Layer 2: Genre Competence

Specific types of texts, like technical reports, research articles, business presentations and meetings carry specific conventions, concerning for example acceptable rhetorical moves, order and format of text parts, layout, and quotations. For written texts, those conventions are often documented in style guides of professional organizations such as the IEEE. Good communicators know the conventions, are able to apply them and know when to apply them. This competence goes beyond just mimicking models: Conventions should be introduced and discussed in classes as part of the professionalism and institutionalization of the engineering discipline. In Table 2, below, the elements of genre competence are specified.

Layer 3: Strategic Communicative Competence

Language skills and understanding of genres alone do not make an engineer a competent communicator. Effective communication begins with rhetorical considerations, resulting in a trade-off of the interests of the target audience, the communicator's organizational and communicative goals (e.g., to inform, persuade, impress, keep face), and the context of the communication. We consider this to be the most important and pervasive layer of literacy, because strategic decisions give direction to layer 1 and 2 decisions. Engineering graduates must be able to make and explain layer 1 and layer 2 decisions from a strategic, rhetorical point of view. In Table 3, elements that constitute strategic communicative competence are specified.

Table 2

Second Layer of Communication Competence: Genre Competence

Elements of genre competence
• The student knows the conventional organization of the texts and genres that are most common in his/her discipline and the rationale behind it. • The student knows the verbal and graphical conventions for the elements of technical reports, such as cover, title page, foreword, abstract, summary, table of contents, lists, conclusions, recommendation, notes, bibliography, appendix, index. The student applies those conventions in his/her own reports, or can explain why non-compliance is appropriate for the rhetorical situation at hand. • The student knows the conventions for technical presentations and meetings, and applies them. If not applied, the student can explain why non-compliance is appropriate for the rhetorical situation at hand. • The student understands the function and use of sketches, drawings, figures, graphs, diagrams, tables and captions, and demonstrates mastery of the conventions of these elements, both in oral and written presentations. • The student demonstrates good use of sources to build up a scientific argument, and signals the use and evaluation of sources to the readers/listeners. • The student refers to sources in line with the style requirements of a particular publication, and can create quotations, title descriptions and lists of references that meet the prevalent style guides in his/her discipline.

Table 3

Third Layer of Communication Competence: Strategic Thinking

Elements of strategic communicative competence
• The student analyzes communicative situations in terms of organizational and communicator goals, primary and secondary audiences and their interests and needs, and requirements and conditions for producing the communication. • The student demonstrates that s/he can analyze the trade-off between (organizational) self-representation, the implied and actual reader/listener, the information to be conveyed, and the goals to be achieved. • The student demonstrates an understanding of the interaction between different communicative goals, such as information transfer, persuasion, instruction and emotional appeal, within the context of a particular text. • The student supports claims and points of view with arguments that are both logical and convincing for the audience, and demonstrates the use of verbal and visual means to present argumentation convincingly. The student can judge the validity and persuasiveness of arguments of others. • The student demonstrates awareness of the ethical aspects of public and scientific communication on engineering issues.

Layer 4: Feedback Competence

Engineers seldom work alone. Their communicative competence also includes their ability to function well as a member of a team or an organization. The three layers of literacy cover much of what constitutes being a good communicator in groups. To perform well as member of a group, however, they need the additional competence of giving feedback. Engineers find themselves often placed in the role of reviewer of the texts of others. Therefore, they must be able to comment on texts written by others, in a stimulating, productive way. The feedback has to be relevant, starting from a strategic communicative point of view. It must not be limited to pointing out errors and flaws, but it should also contain diagnostic information and advice that can lead to improvement of the text or the content. On top of that, the feedback has to be formulated and delivered in a way that will stimulate the writer/presenter to benefit from the feedback. That in itself requires strategic competence. In Table 4, below, elements of feedback competence are specified.

In line with what Kelli Cargile Cook described for educating technical communication professionals, the engineering students should be offered "integrated, situated and multiple-literacy learning opportunities" (6). This does not necessarily mean that each course should pay attention to each of the elements mentioned. For student assessment, the listed elements help to formulate instructional objectives and to develop criteria for assessing student products. For program assessment, the lists of elements can be used to check whether the set of courses offers students enough opportunities to develop and demonstrate their multi-layered competence. In the next section, we will introduce three formats for communication training integrated in engineering projects, and evaluate these formats for their opportunities and constraints for assessment of these four layers of communicative competences at student and program level.

Table 4

Fourth Layer of Communication Competence: Feedback

Elements of feedback competence
• The student gives feedback on all levels of communicative competence: strategic, genres and text. • The student gives feedback that points out the problem, diagnoses the cause and suggests remedies. • The student formulates feedback in a positive way, focusing on the position and perspective of the writer, taking the rhetorical situation of writer and reviewer into account.

Integrating Communication Training in Projects: Three Formats

Over the past ten years we have developed three distinctive formats for our "Communication Across Projects" training. The various formats define both what we can teach and, hence, assess, and also how we can assess it.

Format 1: Communication Training Linked to Projects

The linked format is a combination of a traditional course and integrated communication training. Four or five "traditional" class meetings are offered, which have the character of writing or presentation workshops. The students work individually and in peer groups with the handbook. They develop their writing or presentation skills in relatively small and structured assignments, often derived from products of earlier generations of students. Besides this, students get lectures on topics such as collaborative writing, teamwork, and project deliverables. In the same term, the students have a chance to apply their developed knowledge and skills in a designated engineering project. The course is well linked to the communication products and skills that are essential for the engineering project, but the course assignments and products do not play an important part in the design project itself.

In the linked format, the students' grades for communication are based on two sources, each contributing 50 % to the final communication grade. At the one hand, students' individual achievements are assessed in a written exam, which contains both questions about the handbook and small assignments to demonstrate skills. Both the course and the exam focus on the two most basic levels of communication competence: text craftsmanship and genres and their conventions. At the other hand, the quality of the project deliverables is assessed, to see whether the students have applied the handbook content and the practiced skills strategically and effectively. For this part of the grade, the focus is on the levels of strategic competence and feedback competence (including collaborative writing). Assessment is based on the project reports, the written feedback the students provide to each other, and their presentations of the reports to clients or Engineering faculty.

Communication training is a relatively autonomous subject in the linked format. Communication appears as a separate grade on the students' school reports. The engineering faculty grades the project deliverables as do the communication instructors, but the two grades are treated separately and the two assessors have different objectives and criteria for the products. The linked form of integrated communication training offers the opportunity to assess students at all competence levels, but offers little possibility to develop and train those skills in a real-life, situated context because the communication instructor plays a very limited role in the engineering project.

Format 2: Communication Training Integrated into Projects

The integrated format goes beyond the linked format, because a large part of the communication training is taking place within the framework of the projects, rather than in separate class meetings. The number of class meetings is limited to one or two, in which a crash course on some aspects of the communication in the project is provided, for example on the meetings or the project documentation. For the rest of the duration of the design project, the communication instructors serve as communication coaches and troubleshooters for the design teams, reflecting on their collaboration (both in the writing process and in meetings) and providing feedback on their documentation, reports and presentations. Students are referred to the handbook (which they are supposed to use), but their individual knowledge or skills are not assessed in an exam. In this format, lecturing time and class meetings are traded for situated, face-to-face contact moments and just-in-time coaching. The communication instructors act as consultants, visiting the project groups in their project rooms, observing their activities and providing advice and feedback, adapted to the needs of the group and the state of their design project. They often take on the role of the "user advocate," reminding students over and over for whom they are writing for and to whom they are talking.

As a consequence, communication instructors have to work much closer with the engineering faculty members than in the linked format. The Engineering instructors and the communication instructors have to agree who the client is and what would make a convincing argument for the client. If there is no external client for the design project, they also have to agree on how to play the role of the client, both from the technical and the communicative point of view. Role-playing enables the communication instructors to address issues of strategic competence. Both the technical instructor and communication instructor monitor and review the same products and achievements, be it from a technical or a communicative perspective. Assessment of communicative competence is not singled out, but part of the final grade for the project. The grade is based on the project activities and deliverables of the group, not on individual achievements of the students.

On the one hand, this format for integration leaves room for addressing the group's skills and competence at all four of the levels mentioned above, in a communicative situation that is as realistic and situated as one can expect in an educational setting. On the other hand, this format offers less opportunity for developing and assessing the individual student's competence, particularly at the levels of text craftsmanship and genres. Individual assessment through an exam, as in the linked format, does not fit with the kind of coaching and monitoring that is offered to the project groups and the situated learning that is taking place. Judging each separate student's contribution to the project deliverables would violate the important notion that the resulting report is a product of collaboration, and not the sum of the individual contributions of the group members. The strength of this format is in situated learning, but its constraints are in ensuring learning gains for each individual student.

Format 3: Communication Integrated at Program Level

In the third format, the focus is on communication competencies at the program level rather than at the course or project level. Communication competence (and some other general skills and competences, such as management skills) are considered so basic and essential for graduates of Engineering programs, that they are to be acquired and demonstrated throughout the whole curriculum, rather than in isolated courses or projects. Taken to its fullest extent, this could imply that every assignment in the program should result in student presentations and texts that meet the standards of professional and academic communicative competence. For each successive communication product (text, presentation, etc.), the bar is raised and earlier achievements are taken into account, to make sure that by the end of the program the student has demonstrated competence in many different situations and genres. If the communication standards are not met, the assignment should result in a "fail," even when it meets the technical and engineering standards. We apply this model in two programs at our university. Both programs have introduced a form of portfolio assessment for the general and communicative competences.

In this model, the communication instructors should be involved in (re-)designing the Engineering curriculum. They create a "communication thread" throughout the program, designing backwards from competence to be demonstrated after graduation. They identify the courses and projects in the curriculum that offer good opportunities to develop and demonstrate one or more of the elements of competence. Such opportunities might be found in projects, but also in other courses. In our case, we participate in courses such as Interface design and Software Engineering, which have become communication-intensive courses. The identified courses and projects are mapped on the communication thread. To create credits for the general and communication skills, the Engineering curriculum should be "butter-knifed," for example for 10 % of its credits and hours. The technical instructors can "earn back" additional credits for a course by working with the communication instructors to formulate communication goals, develop instruction (to be delivered by the communication instructors or by trained engineering faculty) and set assessment criteria. The final grade for an assignment in the communication-intensive courses will not be determined without the consent of the communication trainer, who has a "right to veto." In this format, communication is addressed in a series of communication-intensive courses or projects over the years. The communication products of these courses become part of the student's portfolio. The students are coached and supervised for their portfolio work by an engineering or communication faculty member. The format and the portfolio allow assessment at student, course and program level.

Each of the three formats meets ABET's strong preference for situated learning for engineers, and gives students a good starting point for developing a high level of communicative skills. Each creates learning situations that evoke demonstration of competence, rather than just offer cycles of instruction and test. They offer good possibilities to teach professional and technical communication at a high level. But as we have hinted throughout our description of formats, quite a few of those new opportunities have drawbacks that make it difficult to realize our and our engineering partners' good intentions and to assess achievements at all levels. In the next three sections, areas of concern for assessment in integrated learning situations are discussed.

Assessment Addressing Student Motivation

Over the past decades, we found ourselves lucky in experiencing very few problems with motivating the engineering students for our courses. Even in the traditional, non-situated learning courses, they perceived that they acquired knowledge that they could use well in their future professional work life. The move to communication integrated in courses and projects, has at the same time increased and decreased student motivation. Even more than before, the students see that they are learning things they can apply, both in their schoolwork and in their future work practice. So, as communication teachers, we benefit from the shift towards project-based curricula in the engineering programs. At the same time, however, the scope of the projects defines (and delimits) the scope of the students' communicative interests. If they have to write a project proposal and know they will be assessed on the basis of that document, they want us to teach the tricks of the proposal trade, rather than a broader type of rhetorical reflection. Project-based curricula put even more time pressure on the students than other forms of instruction. From an engineering point of view, there is always much more to do, much more to find out, many additional problems that need to be solved, but only little student time (credits) available. Time spent on achieving or demonstrating a high level of communication skills, reduces the time available for what the students and their technical instructors often perceive as "the real work." Therefore, the opportunities created by project-based instruction are threatened by a too narrow focus on the texts and genres produced in the particular project.

Students are only human, and their grades are a prime motivator for working hard. When we give grades in stand-alone communication courses, like in our traditional courses or in the linked format of integrated communication training, there is a direct relationship between their work and the grade students get for it. In the projects, the final project grades are often the outcome of a juggling act with engineering grades and communication grades. The extra work that students have to do to produce a good report or presentation remains hidden in a grade that is compiled on the basis of assessing many different learning outcomes. Hence students choose to spend their time on meeting the engineering goals rather than the communication goals, even if they are aware that good communication might contribute to meeting the engineering goals. Having communication achievements hidden in compiled project grades threatens to reduce the motivation of students. Even when communication training is integrated in Engineering projects or courses, assessment of communication competence should have a clearly recognizable place.

Assessment of Individual Student Work in Group Projects

Students work in teams during project work, as they will in their future workplaces. They produce documents and presentations together and are reviewed as a group, rather than as individuals. If a project presentation is planned, one of them will present on behalf of the group. This work practice offers us a wealth of opportunities to talk and teach about collaborative writing, group dynamics, work ethics, individual responsibilities, and communication activities and skills needed for successfully working in a group.

However, the situation of group work also threatens the students' opportunity to meet the ABET criteria. As in real-life work, the student team members are inclined to assign the communication task to the team member who is the most experienced and prolific writer, or the most persuasive or entertaining presenter. This practice, which most of us would find completely acceptable in a professional situation, can easily lead to an educational situation in which those who need the training least, practice their skills most. At the same time, it is relatively easy for those with insufficient skills to hide behind the back of the more skilled. This conflicts with the ABET requirement that each student should graduate in the engineering program with a demonstrated high level of competence. Questions remain about how to assess individual achievements in curricula and learning situations that promote group work. The group work also conflicts with our intention to guarantee each student sufficient opportunities to develop competence and to practice in situations where communication really matters.

We have tried to address this constraint for assessment at the student level by singling out each student's contribution to the project deliverables, and to relate individual student's drafts to the complete report. We required the groups to compose a detailed report outline and define style issues early in the design process, before the individual students write their draft chapters. And we taught them to give draft review meetings an important role in the design process. Although this way of working has a value in itself, it did not solve our assessment problem. More often than not, we saw the student teams becoming more and more focused on the technical design issues. Reviewing and revising drafts was postponed until the end of the project, when the deadline approached. Under the time pressure that seems inevitable in student design projects, the strongest writer (or even worse: the least assertive team member) got assigned the task to pull it all together. We have not found the solution for the problem of how to assess the individual student's competence in group work situations, but it is clear that this is one of the most urgent matters to be addressed when student assessment in project-based curricula is planned.

Assessment and Situated Learning

To a certain extent, one can teach and assess text craftsmanship and genre competence in a shallow way, as a bag of tricks that students need to master. However, one of the things that distinguishes good communicators from mediocre ones is that they understand when to apply a particular trick, and when not. This requires strategic competence: the ability to do a careful analysis of goals, audiences and contexts, and to put the results to good use, that is, choose the appropriate and effective options from the wealth of word, style, and text type alternatives that the communicator has available.

The analytical part of strategic competence can be taught. In the handbook we developed at the University of Twente (Steehouder et al.), which is the most widely used handbook in Dutch higher education, students are instructed and prompted to make a "communication task analysis" before they start producing texts. The task analysis explains the strategic choices of the communicator. But the best opportunity for assessing whether the results of such an analysis indeed have been put to good use is in realistic situations with well-defined goals and audiences. Only then it can be demonstrated that the chosen content and form of the text indeed meets the goals and needs of both the communicator and the audiences of the communication. Acquiring and demonstrating strategic competence is greatly enhanced by real-life learning experiences.

Together with the engineering faculty we have created many of these situated contexts. For undergraduate students we often work with semi-external clients, such as university and student organizations, or non-profit organizations and charities that are represented by faculty and staff members who volunteer for these organizations. For the more advanced students, we work with real clients or cases derived from real client contacts. In these realistic contexts, students see that what they do and say as engineers really makes a difference. Teaching communication in the context of realistic design projects with realistic clients offers many invaluable and motivating teaching and learning opportunities. We would not want to go back to "traditional" courses. But we also see constraints for assessing the students' competence.

Even in the realistic educational setting of a design project, there is often a tension between the realistic but simulated professional context and the actual educational context. For example, in the Engineering design projects, the project documentation and presentations are produced for the client, but at the same time must serve as assessment tools for the Engineering professors. The students are smart enough to notice and will often come up with written work that in the first place will please their Engineering professors. They produce impressive calculations or detailed chronological accounts of their efforts even when their clients do not need those, just to show their acquired technical skills or to make the right impression (hardworking) on their professors. Such reports indeed help the engineering faculty to assess the Engineering learning outcomes, but are not suitable for assessing students' strategic communicative competence.

A second constraint is in the situation that is created. It defines to a large extent what teachers can focus on. When an instructor designs instruction, s/he will start with defining goals and learning objectives, and make sure that the instruction and practice help students to achieve these goals. For example, a course on skills in chairing a meeting will contain instructional materials and situations that cover the whole range of skills and give every student a chance to practice. However, when students are working in design projects, one group might run into situations where training for chairing skills makes sense, whereas others might not. It is not the set of goals and objectives of the teacher or the program, but the requirements and conditions of the situation that define what realistically can be addressed in training and feedback. The result is that by the end of the design project, some students are exposed to instruction and feedback on specific areas of competence, and others are not. As a consequence of the choice for situated learning, communication instructors might have a hard time proving that each individual student had a fair chance to learn. At the course and program level, it will be hard to assess what training and instruction actually took place.

A third constraint of realistic, situated learning contexts is that there is barely an occasion for practice, for the development, rather than demonstration, of competence. In projects, the students immediately start to work on their project deliverables, be it for internal use or for presentation to a client. There is very little room for learning how to do it; there is mostly room for performance and feedback on performance. For some students the leap to a professional level of competence simply is too big; they need room to fail and time to practice and learn. The consequence is that communication training integrated in projects can be disadvantageous specifically for students with lower skills levels, if we cannot provide additional instruction and practice for them.

A fourth constraint for assessment in situated learning situations can be in the quality of the client. The client is supposed to impersonate real-world, high standards for professional performance and to demand those of the students too. Most clients do play that role very well, but we have also met situations where a lack of professionalism at the side of the client caused problems. We have seen clients that treat the design projects as "just" student projects. They see their efforts as a service to the students or the university and do not think carefully enough about the problem they want to be addressed in the project. This results in continuously shifting project goals, or an ill-defined design problem. Others do not make a real commitment to the project, so they "forget" to make people and information available to the project teams. Some show that they are not really committed to the project outcome, which reduces student motivation. And we had some clients who lauded a project report that we thought was beneath professional standards. Of course, all this can happen in non-educational settings too, and as such it can be a good learning experience for students to cope with the situation and solve the problems. However, meeting communication objectives is often impossible in these situations, and the same goes for the Engineering objectives.

Every department that offers Writing-Across-the-Curriculum or Writing-Intensive Courses must address the constraints connected to situated, integrated learning in projects, when planning assessment at the student, course, and program levels. Understanding the layers of communicative competence can help us to identify gaps in what is being offered or the skills acquired by individual students and can help us to design curricula that address the contextual constraints of contemporary engineering education.

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