

ENGINEERING AND COMMUNICATION INTEGRATED LEARNING - COLLABORATION STRATEGIES FOR SKILLS AND SUBJECT EXPERTS

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ABSTRACT

This paper focuses on the integrated learning of communication and communication skills within engineering education, and on the respective roles of the communication expert and the subject expert in courses and throughout the curriculum. Approaches to the *function* of communication in an overall engineering curriculum and to the learning activities are here referred to as *learning-to-communicate* and *communicating-to-learn*. These concepts are further merged into the term *communicating-to-engineer*. This means that all communication aspects are intrinsic components in engineering education and that factors such as learning activities, ambition, maturity, and resources together contribute to deciding how and to what extent communication can be effectively learnt and taught. This paper then suggests two distinct roles of the communication expert: the *direct* and the *indirect* where the direct approach implies an active classroom role, and the indirect approach being more focused on course and staff development. These roles are then placed on a continuum where the role may change over time, in accordance to the learning objectives and staff development ambition. By categorizing the role of the communication expert into these functionally and strategically different functions, the corresponding role of the subject expert is also changed.

KEYWORDS

communication, communicating-to-engineer, learning, teaching, integration, expert roles

1. INTRODUCTION

Engineering education institutions around the world acknowledge that our key stakeholders recognise both “knowing your subject matter” and “possessing engineering skills” as central aspects of engineering education. Society and employers share an interest in aligning program learning outcomes with the demands of professional engineering practice. Also our students

know that they will be better positioned for the increasingly competitive work life if they have both the disciplinary knowledge and the engineering skills necessary for the professional context.

In response to these stakeholder demands, many institutions have decided to embrace the CDIO model [1] for reforming the curriculum. The CDIO concept is based on a strategy of *integrated learning*, see CDIO Standard 3 (Integrated Curriculum), and CDIO Standard 7 (Integrated Learning Experiences) [2]. The idea is that engineering skills (like team work, entrepreneurship and communication) should be systematically integrated with technical subject knowledge throughout the curriculum. The rationale for the integrated approach is strong. On the one hand, training engineering skills during the education provides opportunities to express and apply technical knowledge, thereby transforming it and turning it into working knowledge [3]. On the other hand, skills development cannot take place separate from the technical context either. The communication competence required for engineering draws *simultaneously* on subject knowledge and communication skills. In fact, we cannot tell where one ends and the other begins; they should be truly integrated. Table 1 shows Barrie's [3] analysis of faculty perceptions of generic skills and attributes (such as communication).

Table 1
Faculty perception of generic graduate skills and attributes – the relation between skills and knowledge; the proper place of skills in the curriculum. [3]

Level	Place in curriculum	Perceived relation between skills and disciplinary knowledge
4	Integral	They are integral to disciplinary knowledge, infusing and ENABLING scholarly learning and knowledge.
3	Application	They let students make use of or apply disciplinary knowledge, thus potentially changing and TRANSFORMING disciplinary knowledge through its application. Skills are closely related to, and parallel, discipline learning outcomes.
2	Associated	They are useful additional skills that COMPLEMENT or round out discipline knowledge. They are part of the university syllabus but separate and secondary to discipline knowledge.
1	Not part of curriculum	They are necessary basic PRECURSOR skills and abilities. We may need remedial teaching of such skills at university.

The perceptions are not mutually exclusive, but classified in hierarchically nested categories, meaning that any category also includes the underlying aspects. Thus, faculty members who see skills as transforming disciplinary knowledge (level 3) will also acknowledge that remedial teaching may be necessary according to student needs (level 1). But faculty members who see skills as something belonging in the curriculum but best learned separately (level 2) would not see the point of integrating skills in their own subject courses. Those who do not see how skills training enriches student understanding of disciplinary content (level 3 view), might perceive it as something that just takes away time from teaching the subject. The idea of integrated learning is a fundamental part of the CDIO concept, and to achieve the intended synergy, we embrace and advocate the level 3 and 4 views.

While it is widely acknowledged within the CDIO Initiative that students need engineering skills and that such skills should not be seen as separate from technical knowledge, the questions and obstacles underlying the process of integrating skills still need to be addressed. The actual

process of integrating engineering skills with technical subject knowledge poses certain challenges to program directors, subject expert teachers and skills experts. For example, the question of who should do the actual teaching in the classroom is a longstanding discussion among CDIO collaborators. When it comes to communication skills, many institutions have independent departments, units or experts devoted to the teaching, but we often hear that their work is perceived as something separate from the 'real' or 'hard core' engineering curriculum. The starting point for this paper is that in order to take full advantage of the powerful idea of integrated learning, we should improve how it is implemented in the curriculum on a practical level.

This paper focuses on integrated learning of communication skills and technical knowledge, paying particular attention to the teaching situation. In section 2, we start out by providing a background and look at practices of integration in relation to what we call three "aims" of integrating communication skills: through the integration of communication skills and technical knowledge, students should be (i) learning-to-communicate, (ii) communicating-to-learn; and we therefore identify the overarching purpose of (iii) communicating-to-engineer. We then provide, in section 3, examples of courses with different level of integration and different purposes for communication as a skill and as subject knowledge. In section 4, we discuss integration and our examples relative to four contextual parameters governing the integration situation, namely (i) learning objectives, (ii) true integration vs. modular skills design, (iii) the role played by the subject expert and the communication expert, and (iv) curricular progression. In section 5, we discuss additional contributing factors such as activities, ambition, maturity and resources. We offer our conclusions in Section 6.

2. PRACTICES OF COMMUNICATION INTEGRATION AND PROCESSES FOR GOOD LEARNING

The integration of communication with technical knowledge can be manifested in any course design in multiple ways, and it is beyond the scope of this paper to provide a general review of practices of communication integration. However, in many cases the course design has been inspired by a rough "writing-to-learn" philosophy [4], and this is a concept we would like to use as our point of departure since it provides a solid and well researched foundation. In this first section, we suggest a collapse of writing-to-learn (often referred to as writing-across-the-curriculum) and so-called learning-to-write (often referred to as writing-in-the-discipline), where both processes should be held to contribute to learning in its widest sense, into a third, overarching, learning process.

Writing-To-Learn and Learning-To-Write

With their roots in the British education area (but subsequently exported worldwide), writing-to-learn and learning-to-write have long been considered successful processes for acquiring and working with new knowledge in (higher and lower) education. Ackerman [5], Klein [6], and Carter *et al.* [4], and additional sources therein, all offer informative accounts of the many tenets underlying forms of communication training and their relationship to learning processes, and we refer any reader interested in the background to this area to either of these sources.

The basic idea underlying writing-to-learn, or writing-across-the-curriculum, is that writing, in whatever form, promotes learning processes at a deep level, involving cognitive development on

many dimensions. Writing in writing-to-learn is characterized by expressive, free and often highly creative forms of writing, not necessarily tied to any particular types of discourse or text type.

Alongside writing-to-learn, learning-to-write/writing in the disciplines has developed as a parallel approach and philosophy of writing and learning. Learning-to-write is primarily concerned with writing for special purposes, and most often these special purposes are defined by a particular discipline and text types within that discipline. Learning-to-write could therefore be seen as involving a hands-on, concrete type of learning process, where students learn the “hows”, “dos” and “don’ts” of their disciplines and where the primary purpose of the writing is to inform (in its widest possible sense).

Writing-to-learn and learning-to-write could be seen as representing a “self-oriented” and an “other-oriented” form of writing and approach to learning respectively. Hoffmann *et al.* [7] frames this difference in terms of an important difference of understanding: self-oriented writing promotes “development of understanding” whereas other-oriented writing is used to demonstrate or communicate understanding.

The usefulness of writing-to-learn and learning-to-write has been claimed in numerous studies within a range of different university subjects over the past three decades (see for example, [8], [9], [10], [11]). Regardless in which discipline the study is based, what they all suggest is that writing assignments within content courses help internalize and consolidate subject knowledge in an effective way.

Some scholars have, however, questioned the usefulness of writing-to-learn schemes in content courses, not least on grounds of lacking scientific validity of the results reported. Ackerman challenges the wide acclaim of writing-to-learn in a review of 35 studies [5]. His conclusion is that strong quantitative evidence in favour of positive effects of writing-to-learn is often missing. Ackerman claims that “the inner speech acts and mental manoeuvres long associated with learning through writing have currency only in specific social activity” (1993:362); the possible consolidation of knowledge taking place in writing-to-learn schemes is dependent on subsequent social confirmation – otherwise, Ackerman argues, the learning is of limited use to the subject learners.

This thread is picked up by Carter *et al.* [4] in their very strong argument that learning-to-write is writing-to-learn; that no real learning can take place without a socialization into the discipline in question; that “learning is enculturation, the act of taking on the behaviours and worldview of a culture or knowledge domain that may be achieved through engaging in the authentic activities of the culture [learning-to-write]” (2007:283). The view offered by Carter *et al.* [4] and Ackerman [5] is in line with our own, and we return to this in the discussion below.

Abandoning “Writing” for “Communicating”; Communicating-To-Engineer

When we study the literature within the field of communication as linked to learning, it is noticeable that the emphasis on other forms of communication than writing and their potential impact on learning is quite limited. That is, the impact from speaking, listening and reading is often overlooked. However, many of the ideas underlying writing-to-learn lend themselves quite well to extensions into other aspects of communication.

Research reporting on qualitative findings from, for example, speaking-to-learn schemes, expresses that the benefits of speaking-to-learn parallel those of writing-to-learn (see e.g. [12] or

[13]). Needless to say, for engineering students, good oral presentation and dialogue skills are important. In an early study of the teaching of oral communication, Coté [14] says that engineers “must meet with users, ask questions, listen to answers, work in a team environment, sell their ideas, explain to the users how system works [and] respond to various questions” (1987:58); oral competency is thus crucial.

If we agree that engineering students need many different forms of communication as part of their engineering competency, this should be reflected in the extent to which different communication skills are integrated in the curriculum. We believe that one step towards a more comprehensive take on communication is the abandonment of the focus on writing as a primary skill and other forms of communication as secondary.

For this reason, we suggest that programs which aim to integrate aspects of communication (regardless of the form of communication) into engineering education, and where the aim is that students consolidate subject knowledge through communication and learn to communicate within their disciplines, should address this at the terminological level of communication only, not by reference to writing or speaking (or listening and reading). Anyone wishing to maintain a principled distinction between self-oriented and other-oriented communication could more appropriately refer to communicating-to-learn and learning-to-communicate respectively.

This is, however, not enough. It has been suggested that the differences between self-oriented and other-oriented communication should be deemphasized (but there are of course critics to this approach too, see for example [15]). The main reason for viewing learning-to-communicate and communicating-to-learn as complementary rather than distinct learning processes is that learning-to-communicate also very much contributes to learning, but learning within the disciplines; in other words, in addition to drawing learners’ attention to disciplinary conventions and norms, learning-to-communicate can be seen as an important socialization process which is crucial for learning in general [4].

Hoffmann *et al.* [7] focus on bridging the gap between self-oriented and other-oriented forms of communication and very much stresses the tandem role of (in their case writing-) communicating-to-learn and learning-to-communicate. Students benefit from both, but the order in which things are done is important: “writing is a process of first developing understanding, then communicating the results” (2006:119), but the same is true for all forms of communication (“think before you speak”). Thus, they claim that it would be counterintuitive to ask students to first produce disciplinary, other-oriented, communication before any real understanding has been established [7].

This final point is important in that it also highlights an aspect of the professional life of the practicing engineer; when engineers address a problem in real life, they are highly unlikely to go about it a strictly linear way. Instead, in producing a feasibility report (to take but one example), they are very likely to return to the drawing board, do some sketching, mind mapping or constructive brainstorming with a colleague, i.e. they will use communication effectively to understand and arrive at new perspectives which they can then incorporate into the report. Since practicing engineers appear to draw on skills being addressed by both communicating-to-learn and learning-to-communicate, both these kinds of processes should be reflected in engineering education.

Arguably, the tandem role of communicating-to-learn and learning-to-communicate in engineering education could be more emphasized in policy documents and course plans. One way of achieving this is to point more explicitly to the overarching idea, that communication skills

are necessary for practicing engineers. We therefore propose the term *communicate-to-engineer*, to show that the purpose of integrating communication training in engineering education is to support students' development into engineers in a better way. In fact, we feel that this view on communication skills has sometimes been lost in the discussion on curriculum development. The skills are often treated as something that is "good to have" to complement or polish the graduates (a level 2 view in Table 1), rather than as core *enabling* skills for engineering (level 3 and 4 in Table 1). How skills are viewed by faculty has implications for how learning experiences are placed in the curriculum, how they are designed and in particular how they are assessed.

Moreover, we have observed a tendency among students to perceive communication tasks solely as forms of assessment. To those students, the purpose of a report is mainly to record their efforts or display their knowledge to the teacher. But when students see how documentation and reporting serves a function in an engineering project, this creates a whole new logic which drives the communication task and makes it inherently meaningful. A report is then not something they produce just according to the teachers' specifications or preferences, but according to what is necessary for furthering the project task; the report actually serves a function in engineering work [16, 17].

For these reasons, we suggest that communicating-to-engineer is a better concept for what we are trying to achieve, since it highlights (i) the fact that the ultimate goal is to develop enabling skills for engineering (rather than communication skills *per se*), (ii) that engagement with aspects of communication (not only writing) enhances the acquisition of subject knowledge and facilitate the students' ability to apply it, and (iii) that learning the course contents and being socialized into the discipline are complementary learning processes for which communication is essential. This view can be described as in Figure 1.

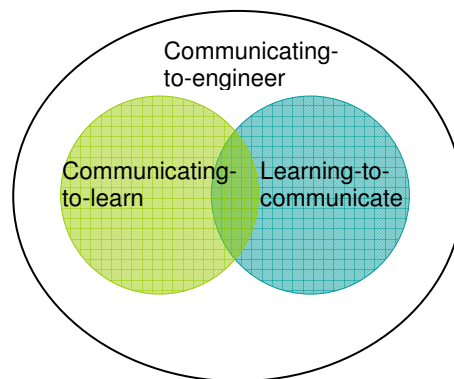


Figure 1 – Communicating-to-engineer viewed as the overarching goal, incorporating communicating-to-learn and learning-to-communicate.

3. LEVEL OF INTEGRATION AND PURPOSE OF COMMUNICATION – THREE CASES

In this section we provide three examples of communication intensive courses which differ in terms of their scope and learning outcomes, place in curriculum and teaching strategies. These examples are neither complete nor especially designed to accommodate all aspects we want to bring up in this paper, but they illustrate some of the issues that we will further touch upon in our discussion.

Example 1

During the first year of studies, the degree program in Microelectronics at the Royal Institute of Technology offers an elective course in “Spoken and Written Swedish” for all students (the vast majority of whom are native Swedish students). The course contains components involving writing in different genres, specialized and idiomatic lexis, grammatical correctness and a module on oral presentations (preparations, structure and performance). It is hoped that students taking the course will develop their awareness of textual patterns, be more comfortable expressing themselves using formal academic engineering vocabulary and improve their general oral proficiency. All the teaching in this course is done by a teacher from the Unit for Language and Communication, who is a specialist in Swedish and Rhetoric. No member of the teaching staff at the School of Information and Communication Technology is involved at any stage in the course.

Example 2

During their second year, the students at the *Design and Product Development* program at Chalmers university of Technology have a course called *Design and Communication* where communication is an integral part of the course setup and contents. This course builds on a previous course (in year 1) where communication was one of several components which were mainly taught separately. Both teachers (subject and communication) collaborate regarding classroom activities as well as course content, criteria and assessment.

In *Design and Communication*, however, the core content of the course is based around using communication as a tool for performing a ‘*conceive – design*’ project. This means that communication *per se* is used as a means for understanding, negotiating, performing, and displaying a design project [18]. The learning outcomes for the course also focuses on the intrinsic value and usage of communication at all stages of an engineering project; from the conception of an idea, to the design process and implementation, and finally, to communicating the final product in a written report in English and in a short presentation at a seminar.

Example 3

The third case we consider involves a three-step progression sequence where active learning of communication is an integrated part of several courses within a program. The first step at the Mechanical Engineering program at Chalmers University of Technology takes place during the first year’s *Introduction to Mechanical Engineering* which is a product design project. Here communication is mainly taught by communication teachers and part of the assessment procedure of the project reports is also carried out by the communication teachers together with the subject teachers.

The second step in the second year is part of another course, *Integrated Design and Manufacturing*, where the involvement of the communication teachers can be seen as having more of a focus on supporting the subject teachers by establishing writing guidelines, assessment criteria and assessment practices. The communication teachers are also engaged in scaffolding peer response regarding report writing as well as facilitating self-analysis of presentations (which have been filmed).

Worth noting in the two first steps is the fact that the teaching staff from year one is replaced by another teaching team for the second year's project, apart from the staff from the Centre for Language and Communication. By having the same communication teachers involved, the progression in communication themes can more easily be ensured.

The third step is the bachelor's theses. The Centre for Language and Communication is involved by offering a series of lectures on academic communication (focusing on the specific requirements of the bachelor's theses) and also by providing communication/writing tutorials to all students. However, all other aspects on communication in a bachelor's thesis are cared for by the subject supervisors. Instead the Centre for Language and Communication has been involved in developing guidelines and assessment criteria as well as giving seminars for subject supervisors.

4. KEY PARAMATERS FOR INTEGRATED LEARNING

As is evident in the examples in the previous section, integration of communication with subject knowledge is dependent on many different aspects of the context in which the integration is supposed to take place. In this section, we identify and illustrate four key parameters which we believe are important to consider, namely (i) how communication is reflected in the learning objectives of the course in question; thus essentially whether the course is designed according to a model which foregrounds communicating-to-learn or learning-to-communicate; (ii) the question of whether communication is taught as a separate course or as part of the subject course; (iii) the roles and functions of the communication expert and the subject expert. Finally we discuss the place of communication components in the curriculum and whether communication is integrated with curricular awareness or not.

Communication and learning objectives

Aspects of learning-to-communicate and communicating-to-learn should be made explicit in the intended learning outcomes as specified for a course or degree program. As suggested, it would often be sensible to frame this in terms of communicating-to-engineer rather than learning-to-communicate *or* communicating-to-learn.

However, the actual choice at the level of learning activities and assessment may often mean that educators let aspects of one learning process be more pronounced in certain courses, whereas the other learning process is more pronounced in other courses, and a communicating-to-engineer approach allows just that. It is important to stress that the choice that has to be made is not one of good vs. bad approaches to communication and learning – the context in which the choice is implemented is in all cases determinative.

We believe that this can be illustrated by drawing on the image of controls: depending on the context, whoever decides what aspect of communication and learning should be more emphasized, can set the control in the relevant position (figure 2).

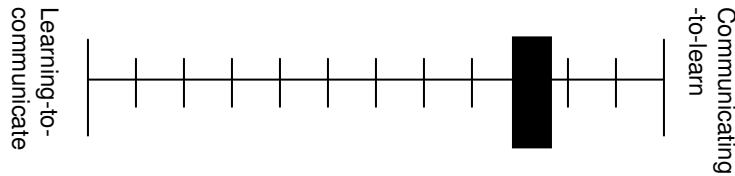


Figure 2. Communication and learning outcomes

Turning to the three examples introduced in section 3, we see that the control in Figure 2 would have to be set in different positions for all three courses. In example course 1, a learning-to-communicate perspective is clearly foregrounded; the students learn *how* to express themselves as academic and engineering communicators and *how* to write and speak in a way which corresponds to expectations based on genre. This is markedly different from the situation in example course 2 where the focus is much more on communicating-to-learn: students use communication to *do* something as part of their conceive-design project. Example 3 illustrates another interesting point: in a case where communication is integrated with progression in mind (see also below) for a program, the learning objectives will change over time and relative to the context. Using the image of the control again, we could say that for step one in part for step three, the control is set more towards the learning-to-communicate end of the cline; for step two and for parts of step three, we see a gradual move of the control towards communicating-to-learn.

Level of integration of subject and communication

The actual integration of skills into a disciplinary setting can look very different from case to case, and the degree of integration can be illustrated using the “slider control” seen in figure 3. One way of categorizing the level of integration is by looking at the learning activities in courses and their direct reciprocity – i.e. what relationship communication and subject have in a course. The matter at hand is how and to what extent content (subject) and skills (communication) share a common and mutual platform in order to promote learning. It is also a matter of what the perceived role of communication is; a separate but applicable skill, or an intrinsic part of the particular learning activity. The cline seen in figure 3 represents this scale of integration.

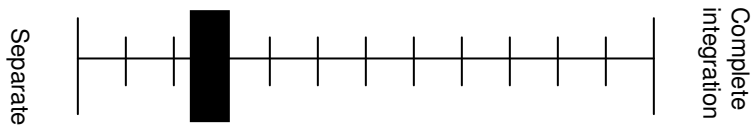


Figure 3. Level of integration

In our examples from the previous section, it is obvious that example 1 can be seen as separate, while examples 2 and 3 move the slider more towards complete integration. However, it is

important to stress the fact that the contents and activities of a separate course may be fully contextualized and adjusted to the larger engineering curriculum and surrounding courses without being directly integrated with any particular course or activity. Complete integration, on the other hand, requires both context and setting to be immediately shared between the communication activities and the content activities, in essence making them one and the same.

The role and function of subject expert and communication expert

A very important and overarching question when it comes to skills related activities in engineering education is of course *who* should be teaching it. In this paper we define two possible roles for the communication expert: the direct and the indirect roles (see figure 4). Even though these roles can be seen as opposite poles, it is, again, more often a case of a gliding scale in one or the other direction.

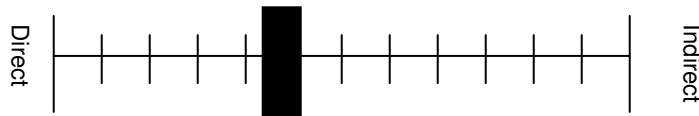


Figure 4. The role of the skills expert

For our three examples, it is possible to see a gradual shift from an absolutely direct approach in 1 with a little more indirect stance in 2, where, although being active in the classroom, the communication expert also supports and takes part in subject course development. In example 3, we can also see that the “slide control” moves towards a more indirect approach over the three-year cycle.

Below we explain what we mean by direct and indirect involvement.

The *direct involvement* of a skills expert is perhaps the most obvious and most widely used approach in teaching communication or generic skills in engineering education. The direct approach includes situations where the communication expert is engaged in actual classroom teaching and is responsible for the teaching and learning of communication. This can either be carried out in individual and separate courses (as in case 1), or in integration with subject courses or projects (as in cases 2 and 3).

As the direct approach is traditionally regarded as the norm, there are many preconceived ideas on what it means and how it should be carried out. The communication expert is then most often seen as a teacher who should teach the subject or skill *communication*. However, it is important to realize that this commonly strict division of labor between the subject expert teacher and the communication expert teacher is not necessarily always the case. In many integrated courses, the distinction between *communication* and *disciplinary content* is less important as the roles of the teachers merge to a certain extent.

So, even if the traditional view of the direct mode may have been that of separating skills and subject knowledge, we acknowledge that this is not intrinsic to the role of the teacher, but instead we see many examples of truly integrated courses and assignments, made possible just through the direct involvement of the communication expert.

The *indirect* approach is a new kind of role where the skills expert *supports the subject experts* in developing and assessing student communication skills rather than doing any actual teaching in the classroom. Many subject experts initially express concerns about engaging in students' development of communication skills, because they perceive they lack the necessary competence for this task. Specifically, we often hear faculty express worry that it would take too much time to assess communication skills. Therefore, we believe that skills experts can help faculty implement, for instance, effective ways to give feedback or how to design communication intensive activities to enhance learning.

Working in an indirect approach may involve supporting the subject expert in developing the course in which the students practice communication. The role here is that of a consultant helping subject experts formulate appropriate learning objectives, design teaching and learning activities as well as assessment including feedback and grading. The skills expert will be able to draw on a large repertoire of learning and assessment formats, and can help creating interesting and effective activities, avoiding over-use of routine-like formats.

A skills expert may also be involved in a “backseat role” when the course is carried out, helping the subject expert behind the scene, for instance by scaffolding various peer learning activities, providing extra supervision or supporting the students when necessary. This can be done in many different ways, and one of them might be through writing center activities, with either trained peer tutors or professional staff.

Also, in contrast to contributing to a single course, the skills expert may be assigned to support a strand of courses – developing a sequence of communication training within several courses, taking on a program perspective (as in example 3). Creating progression through the coordination between courses is a central idea of CDIO, expressed in Standard 3 [2]. Here, the skills expert can take on a more strategic role in the curriculum design. One potential benefit is to develop course materials that are used in more than one course – for instance rubrics, templates, instructions etc.

The indirect approach may also include supporting the competence development of subject teachers in their work to teach and assess the skill. This can be organized through workshops and included in staff development programs, but it is important to note that informal and incidental competence development is often also a by-product of collaboration in course development and/or during the course activities. This may even be a way to reach those subject experts to whom it seems more attractive to get ‘support and assistance’ rather than ‘training’.

Communication and curricular progression

Regardless of the positions of the previous “controls” described in this section, the curricular alignment of activities in separate or integrated courses is necessary if we truly want to achieve sustained learning. It is possible to design an activity with different level of curricular coherence, on a range from *unrelated satellite modules* to *progression with purpose*.

This means that, if communication is regarded as an important skill that engineers should possess, it is also important to maintain this throughout the education through progression. If, on the other hand, communication is treated as a “one off” (no matter how “big” or important), then we might end up with a course that does not ensure the continuous learning which can be made possible in a progressive sequence.

So, here it is not necessarily whether or not we are looking at the direct level of integration (see figure 3), but rather whether the activities themselves have a sequential position in the curriculum and aim at building knowledge on knowledge.

5. ADDITIONAL FACTORS AFFECTING INTEGRATED LEARNING

As the courses in our examples are different in many respects, it is important to realize that that is true also for the learning objectives in each of the cases. So, there is nothing intrinsically *good* or *bad* in having more or less integrated courses, or having more or less of the communication teaching done by a communication expert. The fact is instead that this should be decided by what role communication has in the particular course and what learning outcomes are desired from the activities.

The different positions of the controls in figure 3 and 4 must be seen in relation to the context in terms of place and time in the curriculum, as well as in relation to other overarching factors such as learning outcomes, sequence, ambition, and resources. The three courses that we use as examples illustrate this relationship and the corresponding positions of the controls. Of course, it is important to realize that the examples are neither perfect nor especially designed with the different controls in mind, but they are useful as real examples that can be analyzed from these three points of view.

There are many contributing factors that we see as consequential for deciding the positioning of the controls seen in the figures. It is clear that the actual assignments, classroom activities and artifacts the students should produce are dependent on the level of ambition, the maturity, and the available resources. We will therefore try to briefly explain and develop these factors below.

Activities

By activities we mean the assignments and tasks the students work with and which should promote learning. Therefore, an activity involves not only the artifact (e.g. a report) but also the actual process of creating the artifact. So, with the term *activity* we want to move beyond a rather superficial view on artifacts and assignments in terms of products, and instead discuss what students *do* and *why* they do it. That is, taking a more holistic approach to learning by including the processes and the teaching elements necessary to reach a certain learning outcome [19].

Ambition

Of course, ambition in terms of *wanting* to facilitate different kinds of learning outcomes and activities is of utmost importance for any attempt at making communication learning outcomes truly manifested and put into practice. Another aspect on ambition would be the level of overall integration and alignment, both in the isolated course setup as well as at the larger curricular level. That is, “how much” that can be fitted into modules and courses. This is not only depending on the actual ambition of the teacher or the program director, but it also on the perceived role and use of communication within the courses. Teachers who see skills development as taking time from teaching the subject (consistent with level 1 and 2 in Table 1) may resist integrating it into their courses, and thus lose the potential benefit for student learning of the subject (according to level 3 in Table 1).

Maturity

Another important factor is the maturity of the course and the assignment setup. At the initial stage of forming a new activity or course, the need for a more direct approach (figure 4) may be more obvious than when the course has run for some time and the direct role of the communication expert can be phased out as the competence has been built up within the group of subject experts. Maturity can also be used to describe the students' level of proficiency and knowledge regarding the roles and functions of communication. So, the term can refer to either the maturity process of a single assignment or course, or it can refer to the students' acquired knowledge made possible through a progressive sequence of learning activities.

Resources

Needless to say, resources are deciding factors in many ways and this is true also in this case. Sometimes the roles of subject experts and skills experts are defined and governed by funding and staffing issues rather than on educational considerations or ambition. It is not just the level of funding which is an issue, but also the allocation model. In some cases, the only activity that a communication expert can be funded for is the direct classroom teaching, and working in the indirect approach would require a completely different "business model". This makes strategic and informed choices even more important and it also puts focus on the need for a clear and well defined alignment of the level of integration, coherence, and the roles of the skills and subject experts.

When taking all these factors mentioned above into consideration, it is quite clear that the levels of the different controls in our figures (2, 3, and 4) are, and should be, on a gliding scale. The role of the communication expert and the level of integration can vary, and so can the role of communication vary. What is important in any of these cases is the level of curricular coherence to ensure systematic progression in the learning sequence. Here, the overall purpose of communication (or other skills) must be taken into consideration to ensure progression and sustainable learning.

In the final section of this paper we would like to conclude our views on the various potential roles of the communication expert within an engineering education setting and that these roles should be governed by good learning activities and a well designed engineering education.

6. CONCLUSION

Various communication activities such as, for instance, report writing or oral presentations are not uncommon in many course setups, not only in CDIO programs. However, we sadly note that this is far too often done in unreflected, routine-like ways. Often it is just a matter of including a *report* as one of the deliverables (products) in a course, without any particular attention to how and why this should be taught, learnt and used as an activity.

So, there is a risk that the learning outcome is stated very generally, such as "*to write a (good) report*". This, in turn, may lead to a focus only on the actual product rather than on *learning* and *understanding*, without any real tools for either teaching or facilitating the process and meta-structures needed in order to make informed choices in communication situations. False assumptions on what is being learnt may of course include any superficially designed task or assignment, no matter whether constructed by a subject expert or a communication expert. Therefore, it is vital that all activities are connected to a learning outcome and that this is properly facilitated and actively dealt with in the course [19], as the *purpose* of the task or assignment is crucial when designing learning activities. It is also due to this that the different

roles of subject expert and communication expert must be negotiated in order to assure a good learning environment for the students.

When deciding on the potential roles of the communication expert, we can see that the indirect approach is quite different from being the direct teacher, and it is potentially much more strategic. The competences necessary for making valuable contributions in the indirect approach is more like that of an educational developer and it is clear that for a communication expert with, perhaps, a traditional language teacher background, additional skills are necessary in order to become a good designer of integrated learning experiences, as well as being able to support competence development for teachers.

We certainly acknowledge the complexity of the relationship between subject experts and skills experts, whether they have clearly defined realms of expertise or whether they jointly work cross disciplinarily. The conditions for collaboration are influenced not only by pedagogical ambitions and student expectations, but by issues concerning power, control and authority, organizational boundaries, funding mechanisms, tradition, theory, status, motivation and self image.

We would therefore want to stress the necessity for strategic choices as to when to take a direct approach and when to have a more indirect role in courses or programmes. Perhaps it is strategically important to be more directly involved as a communication expert when setting up a new course or project and then allowing for a gradual takeover by the subject expert as the course has matured. Other factors such as sustainability in course delivery and management, or shear economy and staffing obviously have an impact on strategies as well.

It is also important to acknowledge the fact that the students themselves can be active agents in holding and maintaining progression from one course to another, *if* this is encouraged and facilitated by their teachers. So, by creating a foundation and then allowing progression from that foundation in consecutive courses and assignments, it may be possible to vary the degree of direct and indirect involvement in a sequence of aligned courses.

This could mean that, for instance, the communication expert has a direct role in the first of a series of courses or activities in order to create a foundation and prepare for the coming steps in the progressive sequence. Then in the next steps, the communication expert takes on an indirect role by supporting and developing staff to build on that foundation in their courses. Most likely, this setup would repeat itself in the next level, where a new foundation is needed for further progression.

So, to conclude, we see that the roles of the communication expert, and thereby that of the subject expert, are changing depending on the educational context, the objectives, the level of integration, and whether there is coherence in curriculum and communication alignment. It is therefore important to adjust to the specific situations, institutionally and over time, in order to facilitate a good and well tuned collaboration between subject experts and communication experts when dealing with the implementation and active learning of the many and varying aspects of communication in engineering education.

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