Improving Writing Skills Among Information Systems Students: Guidelines for Incorporating Communication Components in Higher Education

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***Abstract*—Students in Engineering, Computer science and Information systems often experience problems when writing the final examination theses. This paper reports on two cases, applying different strategies, with the ambitions to improve the students' possibilities to write, evaluate and verbally present scientific reports. The first strategy presented concerns using a specific course and the second strategy involves a revision of an entire programme. Using constructive alignment and curriculum theory the two strategies are compared with the purpose of extrapolating specific and general guidelines for how to incorporate scientific communication components in engineering programmes.**

Keywords—Communication, scientific writing, engineering programmes, constructive alignment, curriculum theory

I. Introduction

The communication skills of students enrolled in engineering programmes are often overlooked and the courses tend to focus on practical engineering skills rather than abilities to efficiently communicate results and findings [1, 2]. An external evaluation of a bachelor programme in Information Systems at the Örebro University School of Business came to the conclusion that the scientific papers produced in the programme were of poor quality. Likewise, course evaluations gave a clear indication that many students felt poorly prepared for the task of writing their bachelor thesis.

It is quite common that universities have courses and programmes to help engineering students to acquire communication skills necessary for a successful future career in industry and business. In this context, the ability to write and present engineering reports is essential. [3, 4]

However, many technically oriented programmes do not only produce professional engineers. It is also important to develop skills in academic writing and scientific proficiency such as theory use. This is particularly important in technically oriented programmes that do not necessarily belong in an engineering field, such as the field of Information systems which is a subfield of computing science. [5]

This paper reports on two different strategies to improve students' writing skills and scientific proficiency, to better prepare them for their theses, as well as their future professional careers. The first example is a course in engineering communication that is mandatory for first year computer science students at the Royal Institute of Technology. The course focuses on both written and verbal communication skills and results in a scientific report.

The second example used in this paper takes its outset in a collegial project at Örebro University School of Business where all course curricula were reviewed in order to include activities related to academic writing.

Theoretically, the research presented in this paper is positioned within curriculum theory and constructive alignment. Curriculum theory is a sub-theory of educational theory and is devoted to e.g., shaping educational curricula to improve learning or investigating which values govern curricula design [6]. Pinar [7] describes curriculum as a 'complicated conversation' between older and younger generations that should be based on research and educational experience. Within curriculum theory, constructive alignment is an approach, based on constructivist theories of learning, that proposes the alignment of intended learning outcomes, learning tasks and assessments [8]. Constructive alignment has had a major impact on the instructional design literature [9] and in curriculum design in higher education worldwide [10].

In this paper we will discuss and contrast the two concrete examples introduced above, in light of the proposed theories. The purpose is to report and compare the two different strategies used in the two example cases and to extrapolate a set of guidelines for how to introduce communication components in technically oriented higher education courses. These guidelines can be used to develop the practice of writing curricula for courses in Engineering, Computer science and Information systems.

II. Theoretical Framework

The theoretical frameworks we build on in this research are constructive alignment and curriculum theory. Constructive alignment is a theory, or an approach, that proposes that learning should be closely aligned between outcomes, activities and assessments. Constructive alignment is student□centred and activity-focused:

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"Learning takes place through the active behaviour of the student: it is what *he* does that he learns, not what the teacher does." [8, 11]

Key questions in constructive alignment are: what should the student be able to understand/perform at the end of the learning experience? What activities would the student have to undertake in order to learn this? And how can the tutor find out if the student has learned successfully? [12] This is well in line with the initial questioning we had about how to better prepare our students for scientific writing and presentations. The answers to these questions are arranged according to three P's: the presage, the process and the product. The *presage* concerns factors including contextual constraints and opportunities, such as requirements for professional registration, funding, tutors' expertise, and participants' prior learning and beliefs. The *process* is about the activities undertaken to learn and the *product* is the desired outcomes of those activities. The underlying idea is that we should make sure that there is consistency and compatibility between these three components in the curriculum. The curriculum is therefore at the core of constructive alignment. Criticism, especially from engineering programmes, has been put forward to the idea of alignment with goals often based on the argument that there is no room for exploring and discovery when all activities are to be aligned with pre-defined outcomes [13]. Despite this critique, constructive alignment has had a major impact on how curricula are designed in higher education [7] and in the cases presented in this paper, constructive alignment has been seen as a prerequisite for achieving the outcome 'academic writing proficiency'. Constructive alignment has hence been implemented in our curricula in different ways. As such, our cases are also positioned within the field of Curriculum theory. Curriculum theory is concerned with how we shape educational curricula to improve learning or with investigating which values govern curricula design [6]. Of particular interest for this study is theories on curriculum development and change. A division is often made between curricula developed and/or changed by teachers or by national agencies (e.g., the Swedish National Agency for Education) where our cases concern curricula development and change by teachers only. Whether the curricula change is made by a single teacher, a team of teachers or a national agency will affect e.g., the level of sanction, assessment, evaluation and accountability [14]. A classical and simple model for curriculum planning is proposed by Tyler [11] who views curricula as consisting of the four elements: objectives, content and subject matter, methods or procedures and evaluation. For guiding purposes, and as used in this study, Tyler suggests four questions to guide curricula development:

1. What educational purpose is the school seeking to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be effectively organized?
4. How can we determine whether these purposes are being obtained?

III. Research approach

The overall aim of this paper is to extrapolate a set of guidelines for how to introduce communication components in technically oriented higher education courses. In order to do so, we will compare two different approaches. First, in relation to the three P's: the presage, the process and the product [8] and secondly to Tyler's [11] guiding questions in curricula development. Traditionally, this type of comparative analysis emphasizes the "explanation of differences, and the explanation of similarities" [15]

According to Tilly [16], comparative analysis can be divided into four types; *Individualizing comparison* – focusing on the peculiarities of each case by in-depth studies; *Universalizing comparison* – where we try to establish that every instance of a phenomenon follows essentially the same rule; *Variation-finding comparison* – seeking to examine systematic differences between instances in order to establish principles of variation in the character of a phenomenon; and finally, *Encompassing comparison* – where we place different instances at various locations within the same system, and explain their characteristics as a function of their varying relationships to the system as a whole.

We will apply Encompassing comparison in this paper as we compare the contents of each case with the systematic backdrop provided by our theoretical foundation in constructive alignment and curriculum theory.

As the final step, the findings from the two cases will be compared to each other and an analysis will be presented where the particulars of each strategy is compared to our theoretical background, and to each other, resulting in an extrapolation of both general and specific guidelines.

IV. Case 1 - A course in engineering communication

The first case that will be used in this paper is a course in communication developed at the Royal Institute of Technology in the mid 90's. The course is a mandatory 5 weeks (7.5 hp) course for 1st year computer science students and was developed in response to a need for training these students in how to communicate with different audiences both orally and in writing. The course will be described further below, after a short walkthrough of its major developments over the years.

A. Course development

The course has gone through several major changes since its first design, but the main deliverables have always stayed the same; one scientific report and one oral presentation of the report. The first version of the course included two main tracks – one theoretical and one practical. The theoretical part included lectures on, for example, media theory, metaphors and semiotics and was examined through active participation in seminars. The practical part included several smaller written assignments, the scientific report and oral group presentations as well as the concluding individual presentation. It also included some practical lectures and exercises. Feedback on the scientific report was given from the teacher, upon request, at one point during the course. Generally, the reports were of low quality.

The course was during this period not well received by students, mostly due to a lack of feedback on the scientific report and the wide range of small assignments causing a lack in focus. Prior to the 2007 course round, the course undertook a major change to address student concerns. The questions by Tyler [11] as well as constructive alignment theory guided the changes. The purpose of the course was reconsidered, and more emphasis was placed on the writing process through an additional practical learning goal, although understanding different audiences and acquiring writing skills was still of high importance. To align the process with this new direction all smaller writing tasks were removed and the scientific report became the backbone of the course – the lectures in the practical part of the course as well as practical writing exercises were focused on the report and planned so that they became aligned, in time, with the students' position in the writing process. To address students' concerns about lack of feedback a peer-review system was introduced. At four different occasions, during different stages of the writing process, the students read and commented on each other's drafts. The teachers also gave comments on the drafts. Once, again, the focus is placed on the process and incremental refinement. These changes strengthened the constructive alignment and addressed questions 2 and 3 by Tyler. The course was much better received by students at this point, but the theoretical track of the course was increasingly criticized.

Between 2009 and 2013 the last major changes were made. To put further focus on the writing process and the scientific report, the entire theoretical track was removed. This also allowed for several additional practical exercises to be added. Several of the old practical lectures were also transformed into exercises that directly addressed the different stages of the writing process. During these exercises the students worked with theoretical material which they should apply in practice. These changes were not only meant to further strengthen constructive alignment and get a more effective organization of practical educational experiences, but also to promote deep thinking [8].

B. Implemented course format

The last course round included 5 lectures and 15 practical exercises, organized in four modules. These modules – topic and focus, theoretical framework, methods and argumentation, and presentation – were aligned with the students' writing process. Each module began with a lecture, included several practical exercises and ended with peer-review as well as teacher comments on submitted drafts of a more and more complete scientific report. The topic and focus module included exercises that focused on choosing topics to write about and narrowing down on a specific research question and method. The theoretical framework module included exercises on literature searches, theoretical framing and source criticism. The methods and argumentation module included writing exercises on different means of scientific argumentation and how to direct messages to specific audiences (the scientific report was contrasted to several other types of texts), and oral exercises on debates and persuasion. The last module, presentation, included exercises on typography, language style and presentation techniques, as well as the final presentations of the reports.

There are three types of examinations used in the course. The largest part of the examination concerns the written report, which will result in a grade based on the quality of the content, language, style and writing process. The exercises are examined through active attendance and the quality of the debate and persuasion exercises and result in a pass or fail grade. The same goes for the oral presentation of one's own report and an oral opposition of another student's report.

V. CASE 2 - INTRODUCING WRITING ASSIGNMENTS IN EXISTING COURSES

The second case in the paper is a 3-year programme in Systems development at Örebro University School of Business in Sweden. The programme has systems development courses during 5 semesters complemented by one elective semester. The programme is quite practice oriented with several courses focusing on programming skills, and/or, systems development methods. The courses on the programme are between 4-6 weeks (6-9hp) with the exception of the basic course (a 20-week course divided into 4 course modules) and the bachelor level course (a 20-week course divided into 3 course modules, including the bachelor thesis course during the last 10 weeks of the semester).

A. Incentives for implementation

The subject of Informatics (teaching systems development), has for many years discussed the need to introduce scientific writing to the students earlier than at the graduation level. Before the changes to the programme discussed in this paper, the Informatics students only wrote a short report (1 week in time) at the basic level. This report was also more focused on formalities such as headings and reference management being correct, rather than developing their skills in scientific writing, including searching for and reading scientific literature. After this basic course, the students receive little support in their writing before they suddenly have to write a scientifically based thesis at the bachelor's level.

The students' bachelor's theses had also been criticized by the Swedish higher education authority (Universitets Kanslers Ämbetet) for the lack of scientific skills and use of scientific theories. In addition, as part of the business school's accreditation process (for AACSB accreditation), an internal mapping of the programme was conducted where generic knowledge and skills have been a key element. What the mapping showed was that the programme's teaching activities regarding scientific writing, theory application and critical review was lacking in terms of both scope and progression.

Against this background, the subject received internal funding from the university for 2019 to re-evaluate the programme and make changes so as to increase the scientific elements in the programme and to introduce both scientific writing and theory use earlier in our courses. More specifically, the steps followed were: 1) In collaboration with course coordinators, map content in all our courses to identify course elements (including examinations) where scientific writing and/or the use of theories can be implemented. 2) Work out a plan for how the above identified elements should follow a natural progression in terms of difficulty and maturity in scientific writing. 3) Write suggestions on how existing syllabuses can be reformulated to include more scientific elements in the courses. 4) Anchor the changes, discuss and decide on adjustments in proposed syllabuses with the subject group. 5) Each course coordinator completes the syllabuses that are submitted to the education administration during the fall semester 2019.

B. Curriculum analysis

The first step of the project included an analysis of all the curricula for the programme with the exception of the bachelor's thesis semester and the internship systems development project semester. Hence, 12 courses were analysed during this step. The analysis focused on three parts 1) What exist right now on the courses in relation to scientific writing? 2) What could be added to the course to increase the students' scientific skills? 3) What would constitute a progression from previous courses in the programme? Two faculty members did the analysis for all the courses by analysing the existing course curricula as well examining the student guides and examination instructions for each course. When needed, the course coordinators were also consulted. Table I shows an example of an analysis for a course in data modelling and data base systems.

TABLE I: ANALYSIS OF A COURSE IN DATA MODELLING AND DATA BASE SYSTEMS

Existing course activities (in relation to scientific writing)	The course does not include any activities related to scientific skills.
Suggestion on what could be included.	A course activity where students have to search for scientific papers about data modelling. A course activity where students have to read and summarize the findings from the papers. An examination seminar where the papers are discussed and criticized by the students.
Goal and progression	The goal is to increase the students' skills in searching for and reading scientific papers, as well as critically evaluate them. By discussing the papers with other students, the students increase their skills in critically evaluating the papers.

C. *Incorporation of writing tasks in curricula*

Based on the curricula analysis discussed above, a suggestion for changes needed was developed by the two faculty members who did the analysis.

During a half-day workshop, the analysis was presented for all the faculty at the informatics department. After the presentation the faculty was divided into groups, and each group was "assigned" two courses and tasked with specifying which changes were needed. The changes included: a) changes to the course goals, b) changes to the course activities, and c) changes to the examination.

All the changes suggested were later looked at by the two faculty members to make sure that the changes resulted in a progression between the courses.

The curricula were then updated with the changes and presented at a faculty meeting for approval.

The changes to the courses could either be that the curricula were updated with e.g., new goals, activities or examinations, or it was determined that no changes to the curricula were needed and changes were instead done on the study- or exam guides (e.g., requiring students to reference scientific literature in home exams).

The changes made can be divided into three different types, with three different purposes:

1. Introducing new skills for the students. For example, in the introduction course to the programme, the examination was changed from a group PM, to a short literature review. The students learned the basics in searching, reading and synthesizing scientific literature, structure and format in writing a scientific paper (following the IMRAD structure) and how to reference papers correctly.
2. Enhancing the students' skills. For example, introducing discussion seminars on scientific papers. Students increased their skills in analysing and critically assessing the findings from papers, as well as discussing different perspectives with their peers.
3. Maintenance of skills. In all courses an added focus was done to also maintain the skills that students had already learned. This included searching for and reading scientific papers, as well as added emphasis on being critical of the sources used in e.g., reports and PMs.

VI. COMPARATIVE ANALYSIS

In this section, we will discuss the two different cases in relation to constructive alignment and curriculum theory as well as contrasting the two approaches.

A. *Discussion about Case 1*

The overall strategy followed in this case is to design a dedicated course, given at the start of the computer science programme, focusing entirely on engineering communication. This approach makes it possible for the students to acquire necessary communication skills early on, which can then be used and continuously refined during later courses. The dedicated course also makes it possible to let the students learn and follow an entire writing process from choosing a topic to writing a complete scientific report while being supported by peer-review, theory and exercises along the way. An overall goal with the course, which was also one of the reasons why the course was developed at first, is that the students should focus on the writing process and scientific writing as such early on so that they can acquire general skills and focus more on the topic at hand in later courses.

There are also some drawbacks of using this approach. Giving a course dedicated to engineering communication can give the students the impression that this subject is stand-alone and not really related to other courses in the educational programme, while the truth is that engineering communication has a strong relation to most of the courses that the students take. A related drawback with the course approach is also that the writing task is not related to the work that the students do in any other course.

a) Analysis based on constructive alignment: Relating back to constructive alignment theory, the presage has been continuously revisited over the years especially with regards to available competence within the faculty to make sure that especially the course responsible teacher had a background in both computer science and communication studies to increase the likelihood of the course being efficiently tailored to the target group of students. Teachers with this combination of competences were also sought for and care was taken to involve the university library, utilizing their competence in literature searches. Before each new update of the course plan, the students' current knowledge in engineering communication was also investigated by 1) checking the quality of theses on the bachelor and master levels as well as the reports from the last course round and 2) by discussing with and getting feedback from some teachers who use scientific reports as part of the assessment in their courses.

In response to what was learned during the presage phase, the learning goals were re-evaluated and shifted from focusing a lot on smaller unrelated writing assignments to focusing on the writing process itself, the scientific report and review of other scientific material. The content of the course (process) was adjusted to reflect these changes in focus, as discussed above and the assessments have also been adjusted to focus more and more on the writing process and the scientific report. The activities performed within the course to meet the learning goals have been continuously re-evaluated accordingly. Most notably, the theoretical content has changed to focus entirely on the different steps of the writing process and the exercises have also been more tailored in this respect. Several peer-review exercises were also added during later years, which further strengthened the focus on the process and review of scientific material. Additionally, the desired outcomes – or the "product" – of the learning activities have also been re-evaluated in response to the above-mentioned changes. The desired outcomes of the course, at least during the later years, have been to acquire the skills necessary to being comfortable with the writing process and in following it when writing scientific reports in later courses. During the early years of the course, mentioned briefly above, the desired outcome was rather for the students to get familiar with many different types of writing tasks that are common at the university.

b) Analysis based on Tyler's guiding questions: Last, the four guiding questions related to curriculum theory, as proposed by Tyler [11], are answered according to the following for the current state of the course. *What educational purpose is the school seeking to attain?* The overall purpose with the course is twofold, and clearly related to the pros mentioned above. First, the students should get familiar with the writing process and the scientific report as a preparation for later writing assignments in the study programme. Second, the students should acquire general knowledge and skills in engineering communication. *What educational experiences can be provided that are likely to attain these purposes?* Participation in a series of lectures and exercises focusing on the different parts of the writing process. The main task – writing a scientific report and continuously peer-reviewing others' reports – is also an important component here. *How can these educational experiences be effectively organized?* The respective lectures and exercises are given when they are relevant in relation to the students' ongoing writing process. Hence, the entire course is planned according to the writing process to make sure all activities are aligned in a logical way in relation to that process. *How can we determine whether these purposes are being obtained?* Evaluate the students' writing processes as well as the quality of the scientific report and the presentation of it. It is also important to assess the quality of communication assignments given in later courses.

B. Discussion about Case 2

The primary strategy in Case 2 was to better prepare the students for writing their bachelors' theses by making writing scientific reports a natural and reoccurring task in the programme. The basic idea of students accumulating knowledge by revisiting tasks similar to what they have done before in order to enhance understanding is often referred to as the hermeneutic circle [17].

Every time a student is presented with a report task, they interpret the task in the light of previous experience. Thus, they build cumulative knowledge of how scientific reporting is done by progressively adding new aspects of the craft. For instance, the earliest report mainly focuses on finding and identifying scientific papers, using references correctly and complying with a specific format. In later courses, more advanced aspects are added.

The total overhaul of the bachelor programme made it possible to identify where and when new knowledge components could be added and how it would lead to a progression. One course could add the use of theories and another peer-reviews, thematic literature reviews, philosophy of science, or a specific research method. This gave us a chance to really see what we had and what we needed. An added bonus was that it also gave faculty the opportunity to re-evaluate the role each course had in relation to the others.

The chosen approach of revising the programme in a project, of course, had its challenges. One obvious issue that has to be solved for an endeavour such as this is to secure the necessary funding. We were fortunate enough to receive funding from the university to carry out the project but anyone who considers following us along this path must know that it requires resources in the form of available time. Furthermore, it is of vital importance that the project is an expression of the collective opinion and ambition. It requires that all involved faculty are comfortable with colleagues scrutinizing all courses and suggesting changes. Another challenge is of course to ascertain the proper order, timing and increase of the progression.

a) Analysis based on constructive alignment: In relation to constructive alignment the presage phase concerns contextual constraints and opportunities, such as requirements for professional registration, funding, tutors' expertise, and participants' prior learning and beliefs. Assessing the university and faculty perspective was quite unproblematic as we were in a process of conducting a self-evaluation report as part of our AACSB-accreditation. We basically had a current and detailed inventory of aspects such as skills, faculty qualification and supportive functions. Assessing the presage among the students is much more challenging. We like to think that we have good understanding of what they think and know but we can rarely assume we have the full picture. In order to get a more accurate understanding of this picture, we closely reviewed how students had expressed their opinions about their state of readiness for writing a bachelors' thesis. These statements could be found in submitted course evaluation reports. We also consulted the student union. However, the most valuable input came from our teachers' assistants. They are students working part time as supporting teachers and usually help students during lab sessions. Their opinions were closely considered and they were also involved in workshops and making suggestions for any changes.

In a case such as this, working with the process and the product must be conducted from two complimentary perspectives, each with its own level of granularity. We had to keep both the overall perspective and the individual course perspective in mind. And also, constantly switch between them.

Working with the process was done by applying a critical perspective on each identified course where improvement could be made. Depending on the course, suggestions were considered and related to the main objectives of the course, like the example in Table I. The course products, thus were adapted in accordance with the overall goal and suitable process activities had to be identified and the individual course curricula updated. In this work it was deemed vital that the new components were well aligned with the existing course objectives and learning activities, so as to maximize the relevance of, and providing a clear context for, these components. Working with the process components also raised discussions about and motivated an inventory of available pedagogical models. Working with the process and the product is, in our view, easiest to do concurrently.

Defining the overall product goal might be perceived as straightforward initially, but, what do we actually mean when we say that the students are "better prepared to write scientific reports". This is however not easily done and require a structured approach. We started by looking at a desired overall path of progression and distributed the responsibility of implementing a process suitable for the planned product outcomes. This work was done in collaboration with others to make sure we could get objective results that were fully aligned with the overall goals. Assessing the overall outcome will not be possible until enough students have gone through the revised programme but the next review by the Swedish higher education authority or AACSB will give us valuable input

b) Analysis based on Tyler's guiding questions: In accordance with curriculum theory, the four questions posed by Tyler [11] can also be answered and help highlight how the curricula actively were changed in order to implement a progressive and constructive alignment between the courses themselves and the students' abilities.

What educational purpose is the school seeking to attain? The answer to this question can be found in the ambition to help students to become academics and not only systems developers. Having a bachelors' degree awarded by a university must originate from the students' own abilities to conduct and report on a scientific study. The students should not only be prepared for a professional life in the tech industry, they should have progressively acquired new insight into what scientific knowledge is and how it is produced in the various courses.

What educational experiences can be provided that are likely to attain these purposes? In order to achieve the desired outcomes each curriculum was scrutinized, and new activities, goals and tasks were added in order to help students to progress and accumulate knowledge through the different courses in the programme, in the field of scientific writing.

A main obstacle was finding out *how the educational experiences could be effectively organized?* This required switching perspectives, back and forth, between considering the entire programme, and the individual courses. This was done in order to ascertain that the idea of the progressive, cumulative was able to transfer and implement in the courses. But also, that an implemented knowledge component would not stand out, or depart from the overall strategic plan.

How can we determine whether these purposes are being obtained? Answering this question obviously means that we constructed assignments and tasks suitable for assessing the intended progression. This involved revisiting scientific communication components the students already had experienced in earlier courses but at the same time using them increasingly more advanced and by raising the requirements.

TABLE II: COMPARATIVE SUMMARY BETWEEN CASES

	Case 1	**Case 2**
Presage	Focusing on that the assigned teacher has both computer science as well as communication studies competence. Assessing quality of students' earlier written reports in different courses.	Assessing overall faculty qualifications competences. Full inventory of goals and progression in programme and integrated courses. Assess quality of students' earlier written bachelors' theses. Involving both students and faculty in analysing progression and goals.
Process	All activities focus on the writing process and are aligned with this process.	Switching between programme and course focus to find suitable adjustments that aligns with the original individual course content. Deliver course content in accordance with identified goals.
Product	Acquiring general knowledge about the writing process and proficiency in evaluating, writing and verbally presenting scientific reports.	Two-fold fulfilment of programme goals and course objectives that creates better possibilities to evaluate, write and verbally present qualitative scientific reports.
Tyler Q1: *What educational purpose is the school seeking to attain?*	A student prepared to evaluate, write and verbally present a scientific report with high quality in following courses.	A student who progressively learn to write, evaluate and verbally present a scientific report with increasingly higher quality in following courses.
Tyler Q2: *What educational experiences can be provided that are likely to attain these purposes?*	A series of lectures and exercises focusing on the different parts of the writing process. Writing and verbally presenting a scientific report and peer-reviewing others' reports.	A series of progressive course activities that build cumulative knowledge in evaluating, writing and verbally presenting scientific reports.
Tyler Q3: *How can these educational experiences be effectively organized?*	The respective lectures and exercises are aligned with the students' ongoing writing process.	The new courses objectives must progressively align with the overall goal of the students being prepared to write, evaluate, and verbally present scientific reports.
Tyler Q4: *How can we determine whether these purposes are being obtained?*	Evaluating the students' writing processes as well as the quality of the scientific report and the presentation of it. Assessing the quality of later communication assignments in following courses.	Evaluating the students' ongoing writing processes in different courses as well as the quality of the scientific outputs. Assessing the quality of later communication assignments in following courses.

C. Comparative summary

In this section, the two cases are compared, as seen in Table II above. The comparison is based on a theoretical framework including the three p's (presage, process and product) from constructive alignment as well as the four questions proposed by Tyler, as a way to strengthen the connection between the strategies used and the theories that gave them a foundation.

VII. GUIDELINES

Based on the knowledge acquired while working with the two cases, in line with theories of constructive alignment and curriculum theory, we propose the following guidelines for teachers who want to incorporate content related to engineering communication in their programmes and/or courses. There are two types of guidelines in Table III: those specific for the respective cases and those that are general. The guidelines are based on the comparative summary in Table II and structured in a framework based on the theory used when developing curricula in the respective cases. The presage and process parts are directly related to constructive alignment and the evaluation part is related to the fourth question by Tyler. The other questions by Tyler are closely connected to the presage and process. The overall aim with these guidelines is to show, by concrete examples, how you can work towards the product – students that are continuously improving their ability to assess, write and present scientific material. During the work that led to the research presented here, care was taken to align presage, process and outcomes and this has of course affected the way in which the guidelines are presented. Hence, the product is omitted in Table III.

A. Presage guidelines

These guidelines relate to activities that should be performed in relation to presage, including investigation of current prerequisites, general requirements on student readiness in communication and views among faculty and students. Even though some guidelines are general in nature, the case specific guidelines differ as a consequence of the initial inventory being a lot more complex when several courses and teachers have to be involved.

B. Process guidelines

These guidelines are also directly related to constructive alignment and focus on the activities performed (e.g. teaching and assessment methods as well as use of pedagogical theory). The main difference between the case specific guidelines in relation to the process is of course that we have one course to consider in case 1 and an entire programme of courses, where progression should be seen between them, in case 2. Examples of teaching activities that have been used in the specific cases are writing reports, conduct short literature surveys and verbally presenting scientific material.

C. Evaluation guidelines

These guidelines do not relate to any of the p's used in constructive alignment theory, but rather question 4 by Tyler about how we can "determine whether these purposes are being obtained". In this instance the case specific guidelines differ in the respect that the writing process should be considered extra important to assess in a dedicated communication course while to continuously progress from one course to another in case 2.

VIII. GENERAL DISCUSSION

Table III below presents the guidelines for using either of the two case strategies presented in our paper. The third column contains general guidelines that are applicable regardless of chosen strategy. For both strategies the intended outcome is essentially the same, i.e. that students should be better prepared in writing, evaluating and verbally presenting scientific reports. That is also, as stated above, the reason why the product according to constructive alignment is omitted in the table. The two cases discussed in this paper represent two strategies for achieving the same goals. Case 1 is a strategy where extra effort is put in early in the students' education to prepare them for the tasks coming in the future, whereas Case 2 represents a cumulative addition of knowledge which intends to make sure the students are prepared when it is time to write the final examination thesis. An analogy could be made with, to either get the entire toolbox with instructions in the beginning of the education or getting one communication component tool at a time to get acquainted with, learn and

TABLE III: DERIVED GUIDELINES

	Case specific guidelines		**General guidelines**
	Case type 1	***Case type 2***	
Presage	Make sure that the responsible teacher has a background in both computer science and communication studies.	Make an inventory of the collective competence in relation to the respective course goals. Make an inventory of the objectives covered in the programme's courses. Secure resources to enable participation by both faculty and students.	Assess the historical quality of scientific output in relevant courses, like thesis level courses, and continuously evaluate output in earlier course rounds. Use the potential of external audits or invite external assessors. Ensure that the faculty involved in the course(s) share a common view about the overall objectives and means of fulfilling them. This means agreeing upon being open for constructive critique, an open and allowing communication climate, and a joint sense of collaboration. It also entails giving all involved faculty members equal opportunities to participate in course development.
Process	Plan all activities around the writing process, to make sure that all course content will have relevance for the current stage of the student's course work.	Align the new course goals with current content and objectives. Ensure that the new learning goals add to the intended progression of knowledge within the programme.	Deliver course content that is relevant for the new goals and aligns well with the other course activities. Focus on creating a sense of progression and cumulative knowledge enhancement within and between courses.
Evaluation	Evaluate not only the quality of the scientific output, but also the process as such.	Evaluate the scientific output, not only in relation to individual course goals but also in relation to the expected, accumulated level of skill.	Assess the quality of future scientific output in especially thesis level courses.

place in the student's own toolbox. Both strategies can rely on the students interpreting new phenomena (Case 1) or tools and phenomena (Case 2) in relation to previous experiences and understanding [14].

The pros and cons with both strategies are discussed in section VI, but we have, so far, not discussed the possibilities to combine the two strategies. Starting with a dedicated course and adding more sophisticated use of the tool-box content along the line of the programme is of course fully aligned with, not only, a hermeneutical ideal but also with theories concerning constructive alignment. On the other hand, one can elaborate upon the obvious benefits of exploring one tool after another through a series of courses and then revisiting them in a course that would sum up all that the students have learned and organize the content in their respective tool-box's in a synthesis before the final examination thesis. This latter variant would also be aligned with hermeneutics and constructive alignment. Deciding which combination strategy is best is difficult to say but it is likely much more difficult to ensure that the knowledge progression truly is cumulative if one chooses to put the dedicated course in the beginning of the programme. Revisiting a communication component in the toolbox could easily become just repetition and not an increase in sophisticated use.

IX. CONCLUSIONS AND FUTURE WORK

The purpose of this paper was to compare the strategies from two cases where the overall goal was to improve the possibilities for students in the field of Engineering, Computer science and Information systems to evaluate, write, and verbally present scientific reports. The cases used different strategies in fulfilling their goals but they both were founded in theories on constructive alignment where the planned activities are considered in coherence with overall goals. This also affected the design of the curricula involved, in case 2, most courses within the programme were updated according to the strategy.

Comparing the two cases and the strategies chosen, enabled us to extrapolate three sets of guidelines to incorporate scientific communication components in order to improve the students' abilities to evaluate, write and verbally present scientific reports. These are presented in section VII, Table III.

Firstly, if the strategy of a specialized course is chosen, it is of vital importance that the competence and experience of the teacher is adequate in relation to the course content. Preferably, this course should be given by someone who has a completed doctorate and some years of practical research under the belt. This person must also have competence in engineering communication. In order to succeed with the strategy, delivering the course with quality is highly important. This gives a hermeneutical foundation which can be revisited later on in the education.

Secondly, if the strategy of cumulative knowledge enhancement through a series of courses is chosen, it is very important that the collective majority of the faculty, as well as students, are present when the redesign of the programme is conducted. There has to be a common understanding about the goals (course specific and overall), but more importantly, that the order and content of each course is adding to the progression of accumulated and enhanced understanding of what it means to evaluate, write and present scientific output. Timing and order have to be addressed in a conscious manner. This strategy also requires more resources.

Thirdly, as far as general guidelines go, it is important that the issue of this being a problem at all must be thoroughly understood. Any basis for making this type of alteration should stem from a proper analysis of the students' earlier thesis work, preferably by an external reviewer, such as a national office of higher education or an accreditation board.

Combination between the two strategies is possible but a decision has to be made regarding whether to place the specialized course in the beginning of, or late in, the programme.

The discussed approaches in this paper could be applied for other purposes than just enhancing students' communication skills. One could easily imagine a similar approach for topics such as ethics or sustainability.

In future studies we intend to follow up and review the results of our two cases. For both cases, interviews will be conducted with students and teachers and compared in order to study differences and possible knowledge transfer. Quite possibly, a combination of the two strategies will be implemented at one or both universities.

In order to measure longitudinal effects in case 2, a suitable number of students would have had the possibility to experience the intended progression and write a final examination thesis. It also means that an external reviewer, such as mentioned above, would have had the possibility to ascertain the level of quality in the theses produced and compare them with earlier ones.

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