Design and Implementation of New Communication and Lifelong Learning elements in a Master Engineering Course

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INTRODUCTION

In the last 20 years, engineering education has received calls from industry that graduates are not prepared for the labour market, because they do not have the transversal skills to be successful workers nor are they aware of their talents and weaknesses [1]. The gap between the competences of graduates and the competences required from the labour market has triggered researchers and educators to develop curriculum elements which focus on the acquisition of a particular set of transversal competences. The emphasis is on competences such as communication, problem solving, working in teams, and lifelong learning [2].

In this research, as part of the European PREFER project (Professional Roles and Employability of Future EngineeRs), importance is given to lifelong long learning and communication competences. Lifelong learning is the process of actively looking for continuous personal and professional development, thereby identifying own strengths and weaknesses [3]. Graduates who possess this continuous self-knowledge are most likely to be prepared to enter the labour market because they constantly look for improvement and adapt to different job requirements [4]. To stimulate this continuous

self-knowledge, we asked students to reflect on strengths and weaknesses, and on the contribution of the course to their student and professional careers.

Communication is often limited to oral and written exchange of information [5] and similarly university curricula restrict communication assessment to oral presentations and written reports. However, communication is more than that. It is an active process of listening, adapting conversation styles, and using feedback in terms of giving and receiving opinions and responses [6]. Therefore, in this paper, we discuss the development of a communication activity which takes account of a wide spectrum of ways to communicate, such as describing, listening, questioning, answering, and drawing.

To prepare students with the competences required from the labour market, we need to provide them with innovative methods to stimulate those competences. Herein, curriculum elements focusing on communication and lifelong learning competences are described and integrated in an existing Master course of the Aerospace Engineering (AE) faculty of Delft University of Technology. We report on the learning outcomes and the validation of the curriculum elements.

1. CURRICULUM ELEMENTS

1.1. Intended learning outcomes/objectives

At the end of this learning module, students will be able to:

- Experience different ways of communicating (e.g. describing images, effectively answering, asking questions, and drawing images)
- Understand the importance of communication for engineers
- Reflect on course contribution in view of their future student and professional career, on their strengths acquired and developed during the course, and on their concrete points for improvement.

1.2. Design and implementation

Two curriculum elements are integrated in an elective course of 7 weeks (84 hours study load) in the 1st year of the Master degree of the Aerospace Structures and Materials at the AE faculty of Delft University of Technology.

The first curriculum element focuses on communication and is based on the children's game, the Chinese whispers. This communication exercise lasts 40 minutes and allows students to practice their communication by describing, questioning, asking and drawing information. We expect that this activity prepares students for their final course examination where students have to communicate with witnesses and within the group in order to gather facts, to generate hypotheses and to draw conclusions about what may have happened in an accident scene. For more information about the Forensic Engineering course, previous publications can be consulted [7, 8].

The communication activity is conducted in the 5th lecture, in which students are divided in teams of 5. Each team is then divided into 3 roles as followed:

- Role A (2 students per group): students have access to an image (*Figure 1*) for 10 minutes, and after that have 2 minutes to describe it verbally to role B;

- Role B (2 students per group): students receive the verbal description of 2 minutes from role A (cannot ask questions to role A), and will only verbally reply to questions from role C for 10 minutes;
- Role C (1 student per group): students have to draw the initial image given to role A and to do that they have 10 minutes to ask questions to role B.

After a short explanation of the roles and tasks of the communication activity, role A stays in the room and roles B and C leave the room. Role B enters the room 10 minutes after the start of the activity and role C 2 minutes after that Role B enters.

At the end of the activity, a 10-15 minute brainstorm session is carried out where students are encouraged to reflect on the communication within the roles and between roles, and the whole team performance.

The second curriculum element centres on lifelong learning and the importance of self-knowledge for future development. This element is built around two moments of reflection, one at the beginning and another at the end of the course. The initial reflection focuses on expectations and possible learning contribution of the course to students' future career. The final reflection takes account of what students learn in the course and how they can apply that learning in the future, what strengths they acquired in the course, and what points need further improvement.

2. METHODS

To evaluate the curriculum elements, i.e. to understand whether the learning outcomes have been reached, the following methods were used:

- A self-assessment questionnaire delivered at the end of the communication activity to investigate how students perceive their communication competences. Students were asked about their communication performance during the activity, the points they can improve and the help of this activity to understand the importance of communication;
- A rubric (*Table 1*) based on [9] to assess the outcome drawings of the communication activity;
- A pre- and post-survey to find out whether students perceive the improvement of communication and lifelong learning over the period of the course. This survey was design based on the Siemens competence model ([3] Siemens proprietary information) and the data was anonymously analysed in SPSS. This survey is available upon request;
- A semi-structured interview simultaneously with the two lecturers of the course to explore students' performance and understanding of the importance of communication with the activity as well as to get feedback to improve the activity. This interview was recorded, transcribed, coded and analysed based on [10].

To meet the ethical board requirements of our university, permission of the board was sought and given, and students were asked to sign a consent to be part of this research. We informed students that their participation in the research would not influence their final grade and the lecturers would not have access to their individual results during the course. Of the 22 students, 21 students gave permission for us to use their anonymous data.

The study aimed at answering the following research questions:

Q1: How was the communication performance of the groups in the activity?

Q2: Did students understand the importance of communication with the activity?

Q3: Were students able to reflect on course contribution to future career, own strengths and weaknesses?

Q4: Did the self-perceived communication and lifelong learning competence level of students change over the running of the course?

3. RESULTS

3.1. Communication performance

To answer the first research question about the communication performance of the groups, both the self-assessment questionnaire, delivered to students at the end of the activity, and the final drawings of the four groups were analysed.

Of the 20 students who participated in the communication activity, 19 filled out and delivered the questionnaire after the activity. The findings showed that 17 students perceived that their communication skills were good (4 out of a 5-point Likert scale) during the communication activity. However, these students recognised that they should improve their communication skills mainly in terms of describing information (6 students), asking questions (6), paying attention to details (5), *Figure 2*.

The results of the comparison of the four drawings with the original image (*Figure 1*) using the criteria of the rubric (*Table 1*) showed that group 4 had the best communication performance (36 points out of 44), followed by group 1 (28 points). Group 2 and 3 had 24 and 25 points, respectively.

We can conclude that none of the groups could depict all objects with the right colour, position, shape and size, which means that their communication needs improvement. This corroborates the perception of student regarding their communication competences, which they thought were good but still need improvement.

From the observations during the activity and the final discussion with the students, we can point out some problems in the communication process which lead to miscommunication. For instance, the assumptions of the students in role C about the real world. In the words of two students: "Black was not in my mental view. It's difficult to not be biased about the concepts that we have in mind and change them." and "When I think about a cow, I imagined it to be white with black spots. The colours confused me. A black cow and black trees…"

Students also realised that the first step to take was to ask general questions to understand the image as a whole and then converge into more detailed questions. Some groups took their time to start with broad questions, and detailed questions were often missing. A comment of a student showed that: "I never thought about asking the sizes of the objects".

3.2. Importance of communication

Students were asked whether they felt this activity helped them to understand the importance of communication. 18 students out of 19 replied that they understood the

importance of communication with this activity (*Figure 3*). A lecturer on the other hand said that *parts of it* (the activity) *were useful in them* (students) *to thinking about what is important in communication, but I think the space meetings braked down, so students were diverging from the rules.*
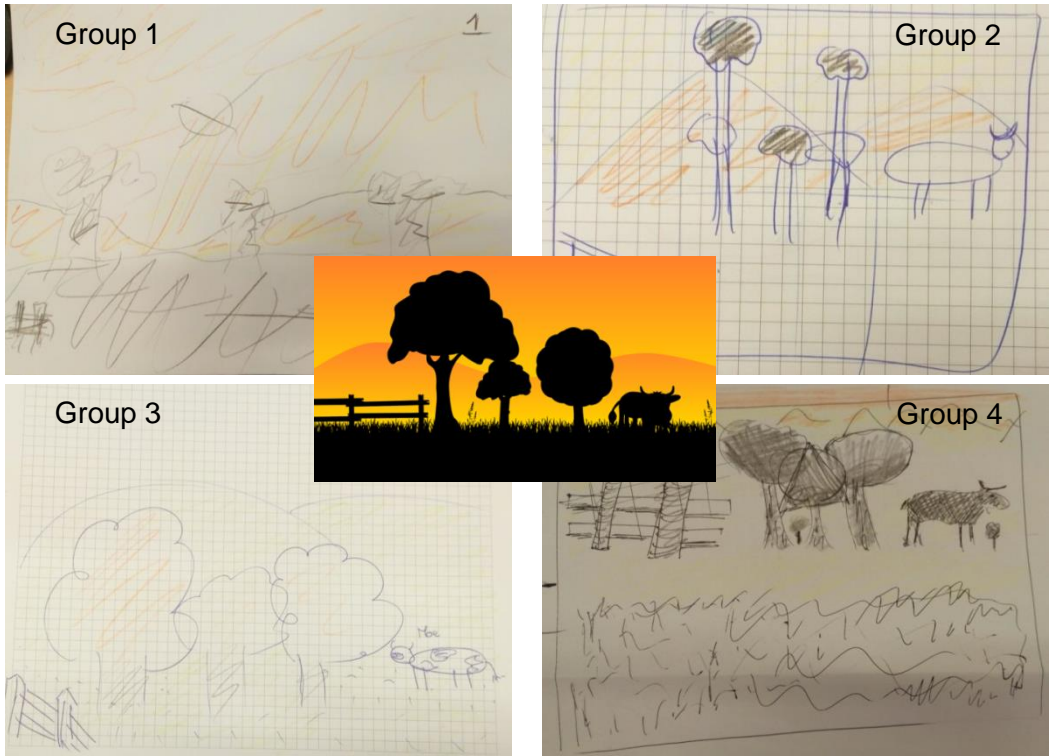

Figure 1 – Top: Image used in the communication activity and shown to role A. Bottom: Final drawings of the four groups in the communication activity.
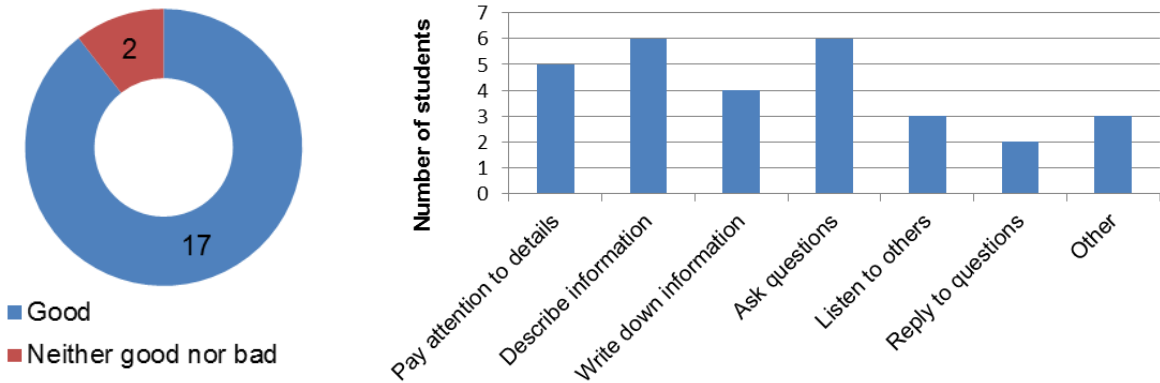

Figure 2 – Perception of students on their communication competences (on the left) in a 5-point Likert scale (very good, good, neither good nor bad, bad, and very bad), and on the competences they want to improve (on the right).
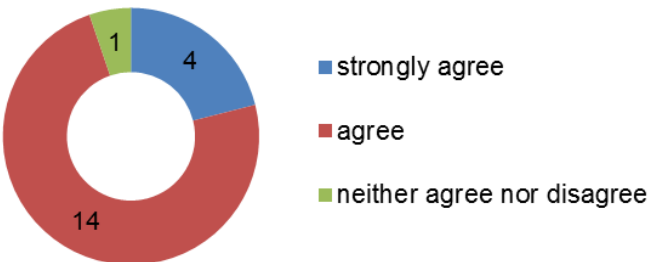
Figure 3 – Perception of students on whether this activity helped them to understand the importance of communication. A 5-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree) was used.

Table 1 – Rubric with detailed criteria used to compare the four drawings of the four groups to the original image.

Objects	Amount	Colour	Position	Details
□ Tree	□ 3	□ Black	□ Middle	□ The tree on the left is the biggest (at the front) □ The tree in the middle is the smallest (at the back) □ The tree on the right is medium size (compared to the other two) □ The tree on the left has triangular tree top □ The tree in the middle has triangular tree top □ The tree on the right is circular
□ Bull/cow	□ 1	□ Black	□ Bottom right	□ Tail □ Horns □ Hear □ Head to the right
□ Fence	□ 1	□ Black	□ Bottom left	□ Horizontal alignment □ 4 horizontal wooden sticks □ 2 vertical wooden sticks
□ Grass	-	□ Black	□ Bottom	□ ¼ of the image
□ Ears of wheat	□ 2 bunches	□ Black	□ 1 bunch between the 2 trees on the left □ 1 bunch on the right	□ Each bunch has 3 ears of wheat
□ Mountain	□ 2	□ Orange and yellow	□ Background	□ Rounded mountains □ Orange on the top and yellow on the bottom
□ Sky	-	□ Orange and yellow	-	□ Orange on the top and yellow on the bottom

3.3. Lecturers' feedback

Both the lecturers of the course liked the communication activity. They said *it was a really good activity* and that they think *it was for students a nice exercise.* Because students can *learn a lot about the communication aspects*, lecturers think that the activity would be very useful and could integrate it again in the course next year. However, they would try to deliver the activity before a specific exercise of the course so that students can apply the skills acquired during the activity to a concrete exercise of the course. Indeed, they intended to do it but, because of time issue, it was not possible.

Since this is a pilot study, we were interested to know what improvements could be done. Lecturers suggest that:

- The instructions of the activity could be more clear to students. To solve this issue, simple handouts containing the explicit times per roles, the precise rules of what students can and cannot do, and the available materials can be distributed at the beginning of the activity.
- Lager or different rooms are needed to avoid contact between groups.
- There should be an observer per group, who could be for example a student of another group, to make sure that the rules of the activity are kept.

There should be more oral feedback at the end of the activity where students can reflect on individual and group communication performance. In this way, it is possible to quantify what happened to the communication in between steps and to understand where communication does not properly work. The use of the observer can also be useful to find this out.

3.4. Reflections on strengths and weaknesses

The aim of the reflection exercise at the beginning and at the end of the course was to make students think about the influence of their present choices on their future life. For this reason, some questions to reflect on were given to students. The response rates of the initial and final reflections were 8 and 17 students, respectively. The low response rate of the initial reflection was because students were asked to do it at home in a voluntary basis. To encourage students' participation, the final reflection was done in class. In *Table 2* the students' strengths gained in the course and points that need improvement are illustrated.

Table 2 – Students' reflections on strengths and points to improve.

A strength that students discovered or developed over the course	Reporting information and communication (4 students) Taking time to evaluate the given data before taking hasty conclusions (2) Thinking outside the box (2) Problem solving (1) Critical thinking (1) Structuring/organizing groups/tasks (1) Look for additional information when needed (1) Listen to others (1) Understanding and valuing group capacity (1) Stay calm (1) Rely on team members (1)
A concrete point which students would like to improve	Management of team members (3 students) Patience (2) Technical knowledge (2) Leadership skills (2) Quick problem solving and decision making (2) Listen to others (1) Get rid of bias information (1) Assume that others have the same information (1) Adaptation to new situations (1) Personal contact (1) Personal feedback (1)

3.5. Communication and lifelong learning competence levels

To investigate whether students self-perceive improvement of communication and lifelong learning competences over the course, a pre- and post-survey was applied at the beginning and at the end of the course. We asked students to grade themselves on a 4-point scale (0: absent, 1: basic, 2: advanced and 3: expert with detailed level description) per competence. A Wilcoxon signed-rank test was carried out to evaluate whether there was significant difference in students' competence level before and after the course. Students' communication competence level were not significantly higher after the course ($\text{Mdn} = 18$) than before the course ($\text{Mdn} = 19$), $z = -1.446$, $p = 0.148$, $r = 0.36$ (medium effect size [11]). A reason for this result may be that the Bachelor degree of AE faculty already focuses on the development of communication skills and students perceived a high level when they enter the Master degree. On the other hand, students' lifelong learning competence level were

significantly higher after the course ($\text{Mdn} = 11.5$) than before the course ($\text{Mdn} = 13$), $z = -2.191, \ p = 0.028, \ r = 0.55$ (large effect size [11]).

CONCLUSIONS AND REFLECTION

Curriculum elements focusing on communication and lifelong learning were designed and implemented in the Aerospace Engineering Master of TU Delft. The pilot study results showed that students perceived an increase in their lifelong learning competences over the course. At the same time, reflections helped students to identify their own strengths and weaknesses.

Moreover, the communication activity helped students to understand the importance of communication, and made them realise that their communication skills still need improvement. Students, however, did not perceive an increase in communication shown by the pre and post-surveys. According to the lecturers this activity has a lot of potential and with small adjustments can be reintegrated in the course of next year.

From the results of the methodology triangulation used to assess student communication (with rubric, pre and post-surveys and lecturers' feedback) and lifelong learning (with reflections and a pre and post-surveys), we are confident that these new elements help students' competency development. Since these curriculum elements are engineering independent, easy to plug and play in existing courses and a step forward in very traditional engineering learning environments, they will be implemented in the universities of the other two partners of the project and comparisons will be made.

ACKNOWLEDGEMENTS

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