Presentation skills for engineers: Systematic interventions in a project-based learning course

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ABSTRACT

This article seeks to reflect on effective presentation skills for engineering students and the effect of specific interventions on the quality of presentation skills. Most authors, who discuss transferable competencies for engineers, refer to different types of communication skills in general to oral and written communication skills. Although there is a broad recognition on the necessity of developing transferable skills in engineering education, there is no general agreement on what these they should be. Therefore, presentation skills are studied in the context of a project-based learning experience at the Industrial Management and Engineering (IME) programme of the University of Minho. Six groups of seven first year students of the first semester of the IME integrated Master´s degree programme carried out a semester-long project from September 2010 till January 2011. Three project oral presentations were conducted, preceded by three interventions focused on specific aspects of oral presentations. The teachers and the educational researchers involved in the project coordination team commented on the presentations and a qualitative analysis of the comments was carried out. The organisation of the interventions revealed to be well adapted to the developments that student went through in the project.

Keywords

Engineering education, communication skills, project-based learning.

1. Introduction

Communicating effectively is an important skill for engineering graduates in many different contexts. Employers, engineering teachers and engineering students all recognise the necessity for engineers to communicate effectively in both written and oral formats. Communication skills are usually mentioned to be part of a larger set of skills that are not coupled to a specific technical area. Such set of skills is often known as transferable skills. Engineers can no longer assume that a sound technical foundation in their own area is sufficient for their professional practice, but need "skills and understandings that are developmental and are required by the student to be a competent practitioner and lifelong learner" [1]. Although there is a broad recognition on the necessity of developing transferable skills in engineering education [2, 3, 4], there is no general agreement on what these transferable skills should be. Most authors who discuss transferable skills for engineers refer to different types of communication skills, in general to oral and written communication skills. Written communication skills are widely discussed in literature, both in higher education curricula, and more specifically in engineering curricula. Guidelines, assessment rubrics, writing curricula and other initiatives are studied in many different contexts, including engineering education [5, 6, 7]. Presentation skills are also considered relevant for effective communication; however, scarce literature on the subject suggests that presentation skills, within the context of engineering curricula, have not yet been subject to broad concern nor in-depth study. This paper discusses the development of presentation skills in the context of project-based learning.

2. Presentation skills

Accreditation bodies like ABET [8] (Accreditation Board for Engineering and Technology) and EUR-ACE [9] (European Accredited Engineering programmes) emphasise the development of communication skills by engineering students. As part of transferable skills in general, communication skills were identified as essential skills for future engineers. The ABET criteria for accrediting undergraduate engineering programs, which include technical as well as transferable outcomes, are:

a) *an ability to apply knowledge of mathematics, science, and applied sciences;*

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an ability to formulate or design a system, process, or program to meet desired needs;

d) an ability to function on multidisciplinary teams;

e) an ability to identify and solve applied science problems;

f) an understanding of professional and ethical responsibility

g) an ability to communicate effectively;

h) the broad education necessary to understand the impact of solutions in a global and societal context;

i) a recognition of the need for and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

k) an ability to use the techniques, skills, and modern scientific and technical tools necessary for professional practice.

The EUR-ACE accreditation defines six categories, of which the last one refers to transferable skills. For First Cycle students, EUR-ACE identifies the following skills:

a) function effectively as an individual and as a member of a team;

b) use diverse methods to communicate effectively with the engineering community and with society at large;

c) demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice;

d) demonstrate an awareness of project management and business practices, such as risk and change management, and understand their limitations;

e) recognise the need for, and have the ability to engage in independent, life-long learning.

As presented above, ABET (item "g") and EUR-ACE (item "b") explicitly endorses the requirement for the development of effective communication skills for engineers. Additionally, EUR-ACE defined these transferable skills for second cycle students:

a) fulfil all the Transferable Skill requirements of a First Cycle graduate at the more demanding level of Second Cycle;

b) function effectively as leader of a team that may be composed of different disciplines and levels;

c) work and communicate effectively in national and international contexts.

Once again communicating effectively is explicitly identified as an essential skill for engineers (item "c"), but one could argue that such requisite is, moreover, an implicit enabler for effective membership on teams and on effective leadership. Several authors also highlight such skills. They argue that communication skills are conditional to the implementation of technology, thus engineering students need to be able to communicate effectively [10, 11] According to some authors [12, 13] employers do not only look for engineers who master technical skills in a specific field of competence, but also insist on communication and presentation skills.

The foregoing as shown evidence that oral and written communication skills are emphasised by engineering accreditation boards as well as industry. However, *what effective communication means? What skills it includes? How to develop them?* These issues are neither well understood nor developed in the context of engineering education. While communication skills relevance has been demonstrated, it remains the case that accreditation guidelines do not provide a fully educational framework for engineering education practice on such a subject. This article seeks to reflect on effective presentation skills for engineering students and the effect of specific interventions on the quality of presentation skills.

3. Context of the study

The presentation skills are studied in the context of a project-based learning experience at the Industrial Management and Engineering (IME) programme of the University of Minho. During the first semester of the academic year 2010/2011, the students work on a project to develop technical competencies related to the following courses: *General Chemistry*, *Calculus C*, *Computers Programming* and *Introduction to Industrial Engineering*. The project was entitled *Air$_2$Water* and its final goal consisted on the specification of a portable device for the production of drinking water from air humidity and the specification of the respective production system.

Apart from technical competencies akin to each course, the students ought to acquire transversal competencies, such as: team work, oral and written communication, conflict management, time management and entrepreneurship. A document entitled Student Project Guide detailed all aspects of the project, including all the transferable competencies students should develop within the semester. These competencies characterise part of students' academic literacy [14, 15] that "are viewed as sets of practice, the focus shifts towards ways in which students learn to participate and make meaning within academic context" [16]. The study hereby documented seeks to characterise the influence of systematic intervention on the development of effective presentation skills.

4. Methods

Six groups of seven fresh students of the first year of the IME integrated Master´s degree programme carried out a semester-wide project from September 2010 till January 2011. During this project, students were assessed in various ways, varying from individual tests, team reports, construction of prototypes and presentations. The presentations were all analysed in detail and discussed with teachers and researchers. Based on the presentations, three interventions took place to enable improvement. Table 1 presents an overview of the initial training for the presentations, the presentation and the interventions that were organised to improve the presentations and the reports – that support the presentations - of the student groups.

The research question of the study was:

What is the influence of systematic intervention on the quality of group presentations?

The following instruments were used to analyse the performance of the students:

1) observation lists of videotapes of the three student group presentation moment;

2) assessment instruments of the presentations, developed by the project coordination team.

These observation lists and the respective assessment instruments include the following criteria:

i) ability to organise, structure and present concepts and argument;

ii) quality of the supporting materials, e.g. slides;

iii) ability to arouse interest of the public;

iv) posture during the presentation;

v) breathing and pausing;

vi) adequate use of time.

The interventions aimed at these criteria were reinforced by a mechanism that is called "talkback" [17]. Instead of feedback that is only related to the final result, students and teachers go into a dialogue aimed at the continuous improvement of the texts, in this case oral presentations. The focus of the three interventions were verbal (discursive, textual and linguistic) and non-verbal (posture, breathing and timing). Each presentation was considered complex as students had to "recontextualise" [18], meaning that they had to transform the group decisions and the written report, either preliminary or finished, into a systematic oral presentation, that showed the scientific and academic developments of the group. Each presentation is therefore characterised by a different social language [19, 20] that highlights the need to use dissemination strategies [18] in an academic context, able to convince an audience consisting of teachers and peers. The presentations were conducted in sessions of 2 to 4 hours in a classroom with a multimedia projector, a portable PC and Microsoft PowerPoint The target audience was the students (42) themselves, the group of teachers and tutors (12) and educational researchers (4) which make about 58 people audience. In this context, presentation skills are mainly practiced in a classroom setting, meaning that the students present intermediate and final results in front of their peers, their teachers and the researchers who are members of the project coordination team. Students are not being specifically prepared for this audience, but the first year project helps them to lose the initial inhibitions of speaking in public. Later on in the degree programme, the target groups become more diverse and employers also assist the final presentations as well as teachers and students of other degree programmes. All student team members have to participate actively in the respective presentation.

Table 1. Presentations and interventions

Week	Activity
1	Training session: multimedia presentations
2	Presentation 1: the mini-project
5	Intervention 1: speaking in public
5	Presentation 2: project progress
7	Intervention 2: the written report
13	Intervention 3: the written report, individual sessions with each group
19	Presentation 3: result of the project

The duration and rules of presentations were set and student teams informed. For the first and second presentations a duration of 10 minutes was established. The third presentation had a duration of 15 minutes. A rule of minus 2 and plus 1 was applied to all three presentations, meaning that presentation durations would be considered time compliant if the presentation ended up no more than 2 minutes before the respective duration. By the opposite, presentation time could exceed no more than 1 minute the established duration. For the first and second presentations this meant that teams could conclude the respective presentation anytime between 8 minutes and 11 minutes. If exceeding 11 minutes the team presentation would have been abruptly terminated and the team faced a penalty (meaning that they had not planned and practice the presentation appropriately), while if using less than 8 minutes the team would face a penalty only (meaning that the presentation was poorly planned or project contents was poorly developed). On the third presentation, teams were allowed 13 to 16 minutes. During presentation, teams were visually informed of the 13th, 15th and 16th minute (presentation 3) and visually informed of the 8th, 10th and 11th minute (presentation 1 and 2). Following each team presentation a discussion phase took place. Discussion phase was short on the first two presentations (5-minute duration), and the final (third) presentation was a more comprehensive discussion (20-minute duration). Discussion phase included a short peer interaction (teams interaction) followed by team of teachers interaction. The discussion also serves as part of oral communication, as the responses of the students contribute to their final grades. All group members have to show that they understand all the details of the project.

Presentations were subject to qualitative and quantitative assessment by teachers, tutors and education investigators.

5. Results

The data collection resulted in a vast amount of qualitative data on the presentations of the students, the strengths and weaknesses of these presentations, the interventions that took place and the impacts of the interventions on the presentation skills of the students. Through a summary of the comments related to the criteria mentioned above, that were discussed with the student groups, an insight is provided in the strengths and weaknesses of the presentations. The comments are organised around assessment categories.

Table 2. Comments on the first presentation

i) ability to organise, structure and present concepts and argument The students do not reveal complete confidence with regard to the product they are developing. The images are not clarified with references of authors. Long hesitations, use of written documents showed insecurity; Long description of the HTML pages they had developed left little space for the discussion of decisions. Lack of scientific writing of the formulas used. Lack of focus on the goals of the project and too much attention for secondary aspects.
ii) quality of the supporting materials, e.g. slides Lack of references of authors, copying. Lack of diversity of diversity of references, many internet sites. Oral and written data on the HTML page are different. Spelling errors. Difficulty in managing the PowerPoint support while presenting. Lack of structure, no central ideas and secondary ideas. Good scientific consistence: use of adequate language and meta-language. Lack of construction of authentic texts for the presentation (plagiarism).
iii) ability to arouse interest of the public Three different evaluations were given to the groups: i) convincing and attractive content, presentation of ideas that go beyond the content of lectures; ii) partially convincing content with only a few new ideas; iii) hardly convincing content, too much common sense and known information: lack of interpretation of information in graphics, use of expressions like "As we all know" instead of referring to specific authors.
iv) posture during the presentation Appropriate gestures and movements. Repetition of unnecessary gestures like crossed arms, hands in pockets, hands in hair, backs to the audience. Good eye contact with the audience. Too much focus on the presentation screens. Talking too softly. Good problem solving in case of sudden technical problems.
v) breathing and pausing Talking too slowly, too many hesitations, indicating difficulties in the presentation. Non captivating rhythm. Sudden decease of voice volume when passing on to next presenter.
vi) adequate use of time Inadequate use of time as some groups used a lot of time for relatively unimportant information and details. These groups did not focus on more important parts of the presentation, e.g, solution purposes for the theme of the project.

Table 3. Comments on the second presentation

i) ability to organise, structure and present concepts and argument The information presented was not always sufficiently reflected upon, critical and justified. The groups presented different developments in the project work, but did not focus on what was new. Too much information on slides without explanation. Too many slides that are not discussed in detail and lots of attention of details; sometimes too little focus on discussion of the prototype.
ii) quality of the supporting materials, e.g. slides The groups use references to support their arguments and use a standard for the reference list.
iii) ability to arouse interest of the public Lack of justification of choices and decisions that were made.
iv) posture during the presentation Some talk very loud, others very soft. Lack of preparation leading to nervous students. Too much focus on screen of laptop. Lack of eye contact with the audience. Better explanation on images.
v) breathing and pausing One element of one specific group speaks far too fast.
vi) adequate use of time Adequate use of time.

Project Presentations deliverables (P1, P2 and P3) are subject to qualitative and quantitative assessment, and accounted for 20% of the overall team project grade. Since presentation 1 (P1) is conducted on early week 2 of first year fresh university students, it was considered that such presentation should be subject to qualitative assessment only. Quantitative assessment on the following presentations (i.e. P2 and P3) was weighted 37,5% (P2), and P3 weighted the remaining 62,5%.

After the second presentation, comments were given to the students, as summarised in Table 3.

The final presentation occurred at the end of semester (January 2011) and other comments were given to students after it.

Table 4. Comments on the third presentation

i) ability to organise, structure and present concepts and argument - Some groups made a significant leap in the project work and showed they were able to organise articulate and share concepts and arguments. Other groups did not show a quality leap or even decreased the quality of their work. For example: some showed enthusiasm at the beginning that had gone at the end or they did not carry out any revisions based on the feedback that was given during previous presentations. - Technical information, like the total volume of the device, was not mentioned by some groups. Other groups did well in terms of technical information. - Arguments on the advantages of the prototype were not presented. - Difficulties of team work could have been explained better. - Relative importance of main and secondary ideas needs to be explained better. - Differential equations were part of some presentations as a way to explain cooling of air. Climatic changes could also be explained. - Redundant information on the localisation of the company and the precise way of paying the workers was presented. - Lack of scientific precision in language (scientific meta-language), in graphics to present information and in explanations on the fundamental chemistry and the advantages of the product. - Lack of explanation on why the prototype did not work during the presentation. - Incoherence between marketing of the proposed company and the innovative character of the company.
ii) quality of the supporting materials, e.g. slides - Very attractive materials used (e.g. video to do publicity for the prototype/product). - Errors in the presentation on how the device works and in the presented formulas. - Unnumbered slides and spelling mistakes. - Lack of bibliographical references in text and at the end. - Very dark slides.
iii) ability to arouse interest of the public - Very convincing: prototype presented as a video. - Partly convincing: original ideas, but difficult to put into practice or a prototype that is too simple. - Not very convincing prototype: presentation similar to the previous one.
iv) posture during the presentation - Looking at the audience and adequate support materials. - Looking mostly at the computer screen or the slides. - Appropriate gestures and movements by most students. - Appropriate volume for the whole audience.
v) breathing and pausing - Very fast presentation, unable to balance primary and secondary ideas.
vi) adequate use of time - Groups who make adequate and inadequate use of time.

After this third session, the teachers and the educational researchers involved in the project coordination team, discussed the presentations of the students and found that the students showed a positive development in their oral presentation skills. Teachers used the following criteria for grading the presentations:

Table 5. Criteria for grading presentations

Team presentation	Weight
1. Structure and graphics aspect	20%
2. Communication	25%
3. Creativity	25%
4. Content	30%

As depicted in Table 5, there were 4 criteria to grade presentations, each of which had a number of sub-criteria, e.g. the first one: *Structure and graphics aspects*, weighted 20% (and incorporated 7 sub-criteria. The second one, *Communication*, had another 7 sub-criteria (weighted 25%). *Creativity* had 3 sub-criteria (weighted 25%) and the forth, *Contents,* had 5 sub-criteria (weighted 30%). The sub-criteria are not presented in detail here.

In addition, during this discussion, the teachers made the following general comments on the quality of the presentations of the students:

Table 6. Final comments

"Their effort increased during the semester and their commitment to the project as well. They tried to surprise us."
"The originality was an explicit criterion of one of the teachers related to her area (Calculus) and this made the students come up with more original solutions."
"The management of feedback remains difficult. Some of the students did not get back to their teachers after they had received feedback."
"There are some failures in the projects, especially in the scientific approach used by the students, especially with regard to their ability to be critical on their own work."
"Some calculations that validate certain decisions are missing."
"Students need to be more precise in their use of language and in using the correct formulas."

Quantitative results to the second and the third presentations were tabulated (table 7) and graphically depicted in figure 1.

Table 7. Assessment of Presentations

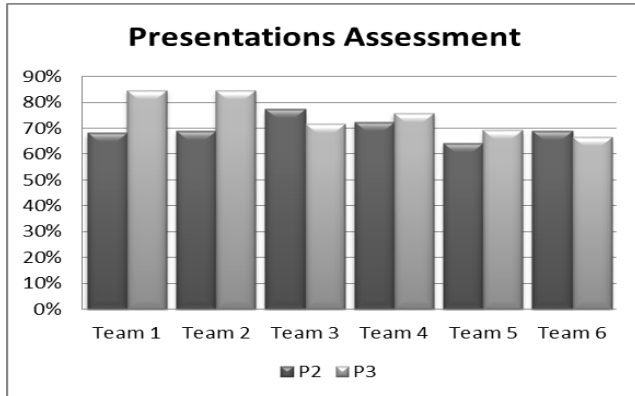| Assessment of presentations	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
Presentation P2	68,3%	68,9%	77,4%	72,5%	64,4%	69,1%
Presentation P3	84,7%	84,7%	71,8%	75,9%	69,2%	66,6%
Final result*	**78,5%**	**78,8%**	**73,9%**	**74,6%**	**67,4%**	**67,5%**

*P2=37,5%; P3=62,5%

Figure 1. Assessment of presentations 2 (P2) and 3 (P3)

A final remark on the nature of final presentation: P3 is the last presentation where projects are ultimately presented, teachers expectations are high, main lines of reasoning are discussed and prototypes showcased. Some teams exhibited a coherent and convincing message, others produced a professional presentation, yet others surprised the teachers with highly innovative features, both with technical solutions and out-of-the-box strategies to illustrate details of the production system or promote the *Air₂Water* device. When looking back and reflecting on such presentations one almost forget that these are still first year students that just got into the University and started their higher education degree.

6. Discussion

An analysis of the comments as given by the teachers clearly shows a development of the students from the first to the last presentation. With regard to the first criterion - the ability to organise, structure and present concepts and arguments - the comments started with sincere shortcoming in the presentations like lack of focus and lack of referencing in the first presentation and changed into comments on missing details and redundant information in the last one. The comments on support materials, the second criterion, reveal large differences between the student teams, but also indicate an improvement of the quality of the presentations, being characterised by attractive publicity materials for the products that were developed and weaknesses that are of minor importance. The third criterion, the ability to arouse the interest of the public, did not show a clear development for all student teams. Some of the teams showed original ways to capture the attention of the audience whereas others did not change much in between the different presentations. The posture during the presentations showed, in general, a positive development. As a very first presentation in the first year of a degree programme is a nerve-wrecking experience for many students, some difficulties were to be expected. The second presentation still demonstrates some problems, but the last one is carried out rather confidently by most of the students. The comments on effective use of time do not show a positive development for all student teams, although some of the teams have improved significantly and became aware that they had to practice their presentation in order to guarantee compliance with the given time.

From presentation 2 to presentation 3, four teams, out of 6, have observed an improvement in their respective grade (teams 1, 2, 4 and 5) while 2 others have received lower grades (teams 3 and 6). Team 1 and 2 registered the strongest growth with gains of 16,4% and 15,8%, respectively. Final presentation (P3) scores were considered good scores overall.

Although there are very positive points in oral presentations, teachers recognise that the students were strongly influenced by the guidelines. Many students do not develop their own arguments yet. The students limit themselves to the topics as given by the teachers. In discussions after the presentations, a small selection of students is very involved, where others remain rather passive. It was also discussed that students need more guidelines on how to cite sources of tables and figures, how to write captions and how to make references in reference list. The teachers decided that students are to receive the written feedback of the teachers, as many of them do not take notes while receiving feedback in the presentation sessions.

With regard to the content of the presentations and the reports, the students were given the following comments to consider for the next report and presentation. Firstly they were asked to reflect more critically on what they write, keeping the reader in mind all the time and asking whether or not the reader will understand, how to be more convincing and how to explain what is special about the work that is being carried out. Secondly, the coordination team recommended the students to give more emphasis to the structure of the report and have a connecting thread that is clearly present and make connections that are more obvious between parts of the text.

7. Conclusions

The systematic improvement of presentation skills in project-based learning is not an isolated activity, as the results show. It is embedded completely in the context of the project and strongly related to the improvement of the intermediate and final report, as the presentations are largely based on these reports. Comments that are made with regard to the quality of the presentation are often based on the report, especially with regard to the first three criteria used in this study (ability to organise, structure and present concepts and argument; quality of the supporting materials, like slides; ability to arouse interest of the public). A presentation with an adequate structure is usually based on a report that has corresponding structure and the development of a line of argumentation cannot be started in the final presentation only. Capturing the attention of the audience is also based on the report and the degree of novelty that the students are able to bring. The remaining criteria on posture, breathing and pausing and time management are not so much context specific in a sense that they need this very specific project theme. Nevertheless, these criteria become more meaningful to students when they are embedded in a context that is highly relevant to them. The students are determined to make the presentations a success as they have been working on the project for a full semester and a successful presentation does not only mean to them that they can talk fluently and have adequate audiovisual support, but also means that the presentation as such is able to convince the audience of the quality of work that has been carried out during the whole semester in the project.

The authors found that systematic intervention aimed at student presentations in a project context, has, in general, a positive impact on the quality of the presentations. The interventions were well received by the students as they were closely linked to the concerns of the students at the different stages of the project. At the first moment, the anxiety of speaking in public is the most relevant preoccupation for many of the students. At the second moment, the structure of the presentation and its organisation, supported by e.g. PowerPoint, become more relevant while by the end of the project students really want to communicate effectively on the content of the project. Organising interventions that follow the developments of the student in this way proved to be a valid way of supporting students to enhance their oral communication skills.

For future presentations, the authors recommend that feedback is given and processed in such a way that students take more advantage of it. At the moment, there is no explicit attention for how students respond to feedback between the intermediate and final presentations. Furthermore, the criteria for the assessment of presentations need to internalised better by the students. Encouraging them to practice and evaluate the presentations more frequently within their groups is expected to contribute to higher scores on each one of the criteria.

More research on a number of issues is also recommended. The first one is the presentation contexts of future graduates. In what situation they have to do presentations or otherwise speak in public at the beginning of their careers? For what types of oral communication do we need to prepare them more specifically, without losing a focus on oral communication in general?

The second issue for further study refers to the difficulties as experienced by both the students in the first year of their degree programme as well as by the recent graduates in the first years of their professional activities. What problems, difficulties and anxieties do students and recent graduates face most, how do they currently respond to these difficulties and can oral communication experiences in the projects support the development of their competencies?

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