DEVELOPMENT OF COMMUNICATION TRAINING PARADIGM FOR ENGINEERS

**Boris Aberšek,
Metka Kordigel Aberšek**

Abstract. *Engineers carry a stigma of being ineffective communicators, and various calls for teaching them communication skills have been performed. In the context of Bologna changes in European university space, such calls seem to be even more important, since the demand of employability and applicability of graduate engineers is one of the most important arguments for change. Many engineering educational institutions (mostly universities) have made efforts to improve the situation: they have included rhetoric or communication courses into the existing study programs. Rhetoric/ communication teachers, who used to undertake similar courses in the language and literature departments, have mainly taught these rhetoric courses. However no special rhetoric/communication courses have been developed for engineers. The fact is that research in the field of rhetoric for engineers has not got a lot of scientific research yet.*

This paper *will attempt to given answers to the following question: What kind of communication skills does an engineer require? A rhetoric course, designed for engineers and a didactic model for rhetoric education of engineers will be presented and evaluated.*

Key words: *education, rhetoric, communication, engineering education.*

Introduction

Engineers carry a stigma of being ineffective communicators, and various calls for teaching engineers communication skills have been performed (Ahearn, 2000). In the context of Bologna changes in European university space, such calls seem to be even more important, since the demand of employability of graduate engineers is one of the most important arguments for change (Aberšek, 2008b).

Searching for the answer to the question 'What kind of communication skills does an engineer require?' we should initially consider the following:

- what do engineers do and how do they think,
- who are the audience they address,
- which tools do they need for successful communication?

Engineers need to employ special kind of arguments compared to those of other (social and natural) scientists, because engineers do not only explore the world and solve problems. Another very important part of their work is to explain why a particular solution to a problem is the best one (Kordigel Aberšek, 2008). For this task they need not only to employ special logical arguments (which they learn in common study programs for engineers) but they also need to employ arguments from other angles of rhetorical triangle. In their future professional life engineers will need to be able to employ various arguments due to specific communication situations they might find themselves in, such as:

**Boris Aberšek,
Metka Kordigel Aberšek**
University of Maribor, Slovenia

- communication amongst peers,
- communication with peers with less specific knowledge, who are going to become colleagues with equal level of knowledge (education),
- communication with investors/buyers of their solutions,
- communication with the public.

Definition of the Problem: What Do Engineers Do and how Do Engineers Think?

Initially, one could conclude that engineers do similar things as scientists. But a closer look at science shows that engineering is the most reliable route of discovering how the universe works (the truth about the universe). In comparison to scientists, engineers do not only discover how machines work. Their research is motivated since they are solving problems to meet human needs. In fact, we could say engineers seek optimal solutions to problems. According to Robinson (Robinson, 1998) none of the general definitions according to the Oxford English Dictionary (1989) or Encyclopedia Britannica (1997) are successful in finding a suitable rhetoric and communication curriculum for engineers since none of them explain how engineers think (Aberšek, 2008b). What can be added to express the intellectual root of engineering? He suggests the following: Engineering is also explaining why a particular solution to a problem is the best, because engineers also make judgments and provide explanations to justify their choices (Robinson, 1998; Davidson, 2005, Aberšek, 2004).

A key question in this context is: does engineering also provide a different way of thinking to the one of science? Such characterization of engineering thinking would reveal *what kind of argument or rhetoric is appropriate for explaining engineers' decisions.* A preliminary exploration of engineers' thinking was carried out in the UK and it provides us with some results (Robinson, 1998). It identified the central role of analogy in finding and justifying engineering solutions.

This exploration pointed out a basic engineering need for at least *two modes* of argument, and *these depend on what the word "best"* means in relation to a particular problem:

- In the case of certain problems, which we will term as *"simple problems," the best* means the solution, which can be proved optimal through mathematical analysis or other deductive reasoning.
- In the case of so-called *"compound problems,"* it is not possible to find such an analytic optimum, and *the best* means the solution, which is judged as the most suitable tradeoff.

What Kind of Argument is Appropriate for Explaining Engineering Decisions?

In current university study programs, engineering students are taught both simple and compound problem solving, which serves them to explain a solution to a problem they had found. This problem solving is a valuable asset but the system fails on the account that engineers are not trained to employ arguments and to persuade others why their solution is the best one (Aberšek, 2003).

Rhetoric courses, which have been included in the EU engineering curricula lately, should solve this problem. The expectations are base upon the ancient rhetoric theories of Aristotle and Plato that promote the idea of the certainty of knowledge, in contrast to the Sophist idea that all is human and changeable (Ackrill, 2001, Frede, 1987). Rhetoric is about persuading others of your claims to knowledge or truth (Ahearn, 2000).

Aristotle teaches us that a speaker's ability to persuade is based on how well the speaker appeals to his or her audience in three different areas: ethos (ethical appeals), pathos (emotional appeals), and logos (logical appeals) (Lewis, 1991*)*. These areas are what later rhetoricians have called the *Rhetorical Triangle: ethos, pathos logos*. Within the rhetorical triangle EQUILATERALITY is essential because its equal sides and angles illustrate the concept that all three appeals are equally important. Additionally, common rhetoric courses for engineers mostly forget to teach about the BALANCE of the logos, ethos and pathos. The dominance of one of the aspects (for instance logos) is likely to produce an argument

that the readers will either find unconvincing or they will simply stop reading (Bizzell, 2000).

At this point, the clear structure of the rhetorical triangle and its usage in engineers' arguments about why their solution to a problem is the best one, gets rather confusing. Classical rhetoric provides engineers with the wisdom audiences need (wish for) and must be integrated in the speech planning process. Nevertheless, engineers are hardly told how this integration should occur. What engineers need at this point is a strategy of involving the listener/reader in his speech and knowledge or rather providing them with the knowledge of how he functions. The firs step in this strategy is without a doubt the answer to the following question:

Who are the Audience in Engineer's Communication Situations?

Most rhetoric courses divide engineers' future communication situations according to the criterion of channel and preparation of curricula for *engineers' writing and engineers' speaking* (mostly presentation). This is very good but certainly not good enough. A closer look at the process shows that the following have been overlooked:

- criterion of aim of the communication and
- criterion of addressee of communication.

Using the above criteria an engineering course should train engineers for at least four communication situations that they will encounter during their professional life:

- communication among peers (colleagues, scientific audience…, where merely logos is needed),
- communication with peers with less knowledge, who are going to become colleagues with equal levels of knowledge (education), where modified vocabulary is needed and beside arguments of logos also arguments of ethos and pathos must be used,
- communication with investors/buyers of their solutions, where equal part of logos, ethos and pathos are needed while ethos is the most important, and
- communication with public audience, where pathos is even more important than arguments from the field of logos.

The above communication situations differ according to audience (addressee) and according to aim of communication. And these communication situations can occur via oral (speaking - listening) channel and written (writing - reading) channel (Aberšek, 2003).

Example of Subject Specification for Subject Technology of Communication

In 2001 the Faculty of Mechanical Engineering offered a course of *Communication, Rhetoric and Public Appearance* as a part of a regular study program for our students (Aberšek, 2003, Aberšek, 2008a). The subject specification is shown in Figure 1. The most innovative theme of this course was writing and presenting a paper for the Student Conference. On the basis of this positive experience a similar course was also introduced at the Faculty of Natural Science and Mathematics with the Bologna renovation of study programs few years later.

SUBJECT SPECIFICATION

Subject Title: Technology of Communication

Study program	Study field	Year	Semester
Mechanical Engineering	All	3	Winter

Lectures	Seminar	Tutorial	Lab work	Field work	Individ. work	ECTS
30	15	45			90	6

Prerequisites:

No prerequisites

Content (Syllabus outline):

Lectures:
- Rhetoric
- History of rhetoric
- Argumentation
- Motivation/Manipulation
- Modern rhetorical samples
- Communication
- Participants and circumstances of communication
- Principles of successful communication
- Verbal and non-verbal communication
- Communication in engineer's life
- Speaking/listening communication
- How to explain?
- How to ask a question to initiate thinking and discussion?
- How to give homework and how to motivate?
- Communication in written channel
- How to form personal records?
- How to form internal reports?
- How to write instructions?
- How to write a presentation?
- How to use presentation tools and visual media?

Seminar work:
Seminar work is intended for practical student work (Student conference).

Tutorials:
In the frame of tutorials students strengthen adopted knowledge.

Objectives:

The aim of the course is to develop communication competence: to develop skills for successful communication with a group or a single person, via thinking-listening and reading channel.

Intended learning outcomes:

Knowledge and understanding:
Students will understand the meaning of communication competence in Slovene language for achieving aims in their professional and personal life.
- They will gain knowledge and skills needed for successful and quick use of professional literature and current informational sources and they will possess skills to transfer these knowledge.
- They will learn to use communication techniques in dialogue.
- They will develop skills needed for presenting their professional work via written and oral channel.

Transferable/Key skills and other attributes:
Communication skills, competence of using professional literature, competence of using ICT

Teaching and learning methods:

- frontal lectures,
- work in small groups;
- seminar work and presentation (Students conference),
- discussion in electronic forums,
- e-learning.

Figure 1.   Technology of communication – subject specification.

Methodology of Research

As we have shown, traditional rhetoric courses are not very appropriate for engineers. In our course we introduced and assessed a new method designed for rhetoric and communication training for engineers. We placed the rhetoric course students into a quasi-real communication situation: a student scientific conference. The aim was to check the suitability of a new rhetorical didactic method by means of a student conference for students of engineering.

For this purpose two questionnaires for the students have been prepared, see Figure 2. Questionnaires were almost identical, (we changed only the tense – from future to past in the second one). They were used at the beginning of the course, to find out the rhetorical pre-knowledge, and after the conference, for evaluation of students' new rhetorical knowledge and consequently their progress. Before the final presentation at the conference a brief self-evaluation by the students themselves had been performed. A self-evaluation checks list was prepared (Figure 3). This checklist was later used as a checklist for observation and evaluation of students' performances at the conference by a team of expert evaluators.

QUESTIONNAIRE FOR THE STUDENTS FOR PRESENTATION OF THE PAPER AT THE CONFERENCE

ETHOS
1. Which rhetorical methods could you use for increasing your personal image?
2. Which rhetorical methods could you use for presenting yourself as a rhetorical expert?
3. Which rhetorical methods could you use for convincing the audience that you are trustworthy?

PATHOS
1. Which rhetorical methods could you use when taking into consideration the emotion of the audience (anger, sadness, anxiety…?)
2. What should you say or show to the audience, to confirm the way your arguments are connected with their life?
3. In your presentation, would you chose to introduce a joke or an anecdote (Explain why!)
4. Could you use the argumentation and persuasion techniques from commercial propaganda? (If yes explain which one, if no – explain why not!)

LOGOS
1. In your presentation you will incorporate a lot of facts; it will support the "base idea". (If yes – which one, what kind? if no – why?)
2. Should you use the citations of authority on the subject, which will support your idea?
3. Will you take into account that audience has enough professional knowledge?
4. How will you analyse the audience?
5. Will you use scientific terminology? (If yes – explain where; if no – explain were!)
6. Will you use the professional visuals?
7. Will you use professional samples for scientific presentation? (If yes – where? if no – why not?)

Figure 2.   Questionnaire for the students.

REMINDER/CHECK LIST FOR STUDENTS FOR PRESENTATION AT THE CONFERENCE

What kind of argument or rhetoric was appropriate for explaining my (engineering) decisions, to explain why my solution is the best?

Before the process of preparing my presentation, I considered the newly acquired knowledge from the rhetoric course: »It is not enough to find the best solution and write it down, I must persuade others that my solution is the best!«	Yes ☐ No ☐ Partly ☐

- In preparing the text for my presentations I was considering the aim of my presentation and the needs of my audience. ☐
- I was aware of the necessity to consider the rhetorical triangle and the balance of ethos, pathos and logos arguments in my presentation ☐

Logos (use effective arguments)
- I included enough facts and other supporting details ☐
- I used testimonials from secondary sources, ☐
- I demonstrated caution in choosing and considering evidence. ☐

Ethos (refers to the writer's »ethical appeal,« that is, how well the writer presents himself)
- I used rhetorical strategies to make myself knowledgeable and reasonable. ☐
- I used rhetorical strategies to make me seem trustworthy. ☐

Pathos (refers to the argument's »emotional appeals«)
- I used rhetorical strategies to make my argument »matter« to readers. ☐
- I used knowledge of strategies I know from advertisements ☐
- I offered an anecdote ☐
- I used rhetorical strategies to appeal to readers' emotions—feelings of sadness, pride, fear, being young, anger, patriotism, love, justice ☐

Figure 3. Check list for students' self-evaluation and check list for the evaluation team ("I" has been replaced by "he/she").

Methodologies used for the examination of the results, i.e. students' communication progress, were a case study and triangulation methods (Abbas, 2003). We have chosen these methods, because they are in-depth approaches, useful to observe and evaluate a particular program or project or setting (Lichtman, 2009).

The effectiveness of the *student conference as a didactic approach for teaching rhetoric to future engineers* was assessed by triangulation, a combination of methodologies in the study of the same phenomenon (Denzin, 2006), where accuracy of judgments can be improved by collecting different kind of data bearing of the same phenomenon, in our case the student conference. The purpose of triangulation in qualitative research is to increase the credibility and validity of results:

1. The research designed for the case study explored *student performances* at the student conference. To do this, data was gathered through observation of students. And how was this carried out? A group of three evaluators (professor of rhetoric from the language department, professor of engineering and professor-course leader) observed students' presentations at the conference and evaluated them on the basis of the pre-prepared evaluation sheet, a checklist for the evaluation team. (Figure 3).

2. Material prepared by students for the conference (the written papers and power-point presentations) was analyzed and evaluated by the course leader from the point of view of proper usage of rhetorical triangle arguments and other rhetorical means that the students were introduced to during the rhetoric course.

3. Students' rhetorical progress and the effectiveness of student conference as a didactical method were also evaluated by means of comparison of results of students' rhetorical knowledge and rhetorical metacognition, shown in the pre and post-questionnaire answers (before educational intervention and after students conference - Figure 2)

Setting and Participants

This course took place at the University of Maribor - Faculty for Mechanical Engineering and involved 7th semester students of the university program *Mechanical Engineering and Mechatronic*. 35 students selected the course as a free selective subject, which means the participants had shown some previous interest in improving their rhetoric and communication skills.

The Role of the Researcher

The role of the researcher and assistant researcher was to design and perform a course the course and the evaluation of the course, to prepare a pre-test and post-test of rhetoric knowledge and tools for external evaluation and students self-evaluation, to organize the student conference, and to instruct external evaluators about the criteria of assessment and to evaluate the data.

Student's Conference

We placed the students of the rhetoric course into a quasi-real communication situation: we declared at the very beginning of the course that we are preparing for the student scientific conference. Now students were confronted with the problem: the majority of them dislike speaking publicly, the majority of them have a great fear of such situations, and their perception of themselves is "the image of a non-speaker". They don't believe something could really be done to improve it.

In the second instance we offered the solution**:** the curriculum of our rhetoric course. We announced, we would, step by step, gain the knowledge and skills, needed to successfully prepare a scientific paper and to successfully present a paper. At the end of the semester we performed a student conference and assessed the rhetoric skills of the participants. We also asked the students to make a self-evaluation of their performance at the conference - which was designed on the basis of the questionnaire about the rhetoric triangle and its use they filled in at the beginning of the course (Aberšek, 2010).

Results of Research

The assessment of the students' performance at the conference was carried out by a team consisting of three specialists, a professor of engineering, a professor who performed the rhetoric course for the students and a language and communication professor from the language department, and it showed good rhetorical results. The team observed and evaluated students' presentations on the basis of a checklist and evaluated the presence or the absence of usage of rhetorical triangle arguments. The results of this evaluation were very encouraging. The structure of students' performance was accurately balanced between logos, ethos and pathos. In their presentations students showed concerns about the addressee of the presentations, showed the right amount of visual support of their message and also showed a good level of using proper and convincing body language.

Also the analysis and evaluation of material prepared by the students for the conference (the written papers and power-point presentations) of the introduced science topics, performed by a course leader, showed good results. From the point of view of proper usage of rhetorical triangle arguments a good balance was observed. Papers showed a good relationship between logos, ethos and pathos. Logos arguments included enough facts and other supporting details; students used testimonials from secondary sources and demonstrated carefulness in choosing and considering evidence. Students' papers and power point presentations contained enough rhetorical strategies to make a speaker appear knowledgeable and well understood by the audience (ethos) and also

rhetorical strategies to make authors' arguments "matter" to readers (pathos). Throughout this process students used rhetorical means and samples they have been introduced to during the rhetoric course.

A comparison of the results of the pre-course questionnaire about the rhetorical triangle and its use, and post conference self-evaluation of the students, also shows a remarkable progress in students' rhetoric knowledge.

At the beginning of the course students hardly had an idea that **ethos** refers to the writer's "ethical appeal," that is, how well the speaker presents himself. After attending the course and after the conference, their answers to this question were much more relevant. Students underlined the importance of eye contact with their listeners, they mentioned, they spoke fluently, without "looking" at the power point presentation on the screen of their computer or on the wall, they would use proper body language (and underlined the importance of hands in that context). Students knew, it would be very useful to mention, they have had experience in solving particular problems, they were talking about, and that it would be also useful to show, how they possess general knowledge about the world we live in, such as world economic crisis, high fuel prices, etc...

At the beginning of the course students hardly had an idea that **pathos** arguments refer to the "emotional appeals". They answered with great suspicion and distrust: "Using anecdotes is not professional!" and "I would never use tricks form advertising because my listeners would immediately know that I am being dishonest!" or "No, I am not selling washing powder. I am selling my project!"

After participating on the course and after the conference, their answers to this question were also improved: "I showed some pictures, which could be from every day life of my audience!", "I used a case from a film that a lot of them have seen", "I showed a possible future of my audience!", "I used phrases such as "we all know..." or "our way of life" or "we will all have to adapt!". After the conference the knowledge collected from product managers and product promoters also seemed more useful: „If I would want to sell my project, I would use strategies from advertising companies. In that case, I would try to convince the audience to invest in my project." "I told the audience about the advantages of my solution!", "I would use that strategy, if the aim of my presentation would be the promotion of my product."

In the case of **logos,** the statements of the students before the beginning of the course and after participation in the course and conference did not change as much as in the case of ethos end pathos. The reason being that their ideas of arguments needed for good presentations were adequate before starting the course. Their study programs equipped them with the logos argumentation already.

They knew they have to include scientific facts and other supporting details to back up their claims before the course and they included them into their presentation, they used testimonials from secondary sources, they demonstrated caution in choosing and considering evidence, they used the relevant (terminological) vocabulary, and they used the professional visual code. The only significant difference was knowledge about rhetorical samples (scientific article, project proposal, assessment report...). Before the course hardy anybody knew these samples but after the conference in self-evaluation the students pointed out that they used those communication samples and relayed on the fact that their audience would be familiar with them.

Conclusion

There is no doubt: engineers need communication skills and they must be trained for them. They need special kind of logical argumentation, because engineers do not only explore the world and solve problems - the important part of their work is to explain, why a particular solution to a problem is the best one. For this task they need not only special logical arguments (which they

learn in common curriculum for engineers) but they also need arguments from other angles of rhetorical triangle.

Engineering program students (and consequently also engineers) traditionally do not display great interest for "language" and "language use". And they usually do not respond very well to traditional language teaching techniques that include learning of grammar and writing of compositions. For that reason we developed a special course and tested a student conference, as a didactic method for rhetorical education of engineers. The results of our research showed that the students made a remarkable progress in their knowledge about the rhetorical triangle. But this is not all. The assessment of students' performances at the conference, carried out by a professor of engineering, a professor who performed the rhetoric course for students and by a language and communication professor from the language department showed that the structure of students' performances was accurately balanced between logos, ethos and pathos. It also showed the students' concerns for the addressee of the presentations and they included the right amount of visual support for their message and also showed a good level of using the body language. Also the analysis and evaluation of material prepared by students for the conference (the written papers and power-point presentations) of the introduced science topics, performed by a course leader, showed good results. Consequently, the comparison of the results of the pre-course questionnaire about the rhetorical triangle and its use, and post conference self-evaluation of the students, also shows a remarkable progress in students' rhetoric knowledge. In short, our research confirmed the following:

- engineering students need specially developed courses and
- a student's conference is as a proper didactic tool for developing rhetoric and communication skills for the future engineers.

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Boris Aberšek	Professor, Dr., University of Maribor, Faculty of Natural Sciences and Mathematics, Koro ka 160, 2000 Maribor, Slovenia. Phone: + 386 2 2293 752. E-mail: boris.abersek@uni-mb.si Website: http://tehnika.fnm.uni-mb.si; http://ucitelj.fnm.uni-mb.si/
Metka Kordigel Aberšek	Professor, Dr., University of Maribor, Faculty of Education, Koro ka 160, 2000 Maribor, Slovenia. Phone: + 386 2 2293 677. E-mail: metka.kordigel@uni-mb.si Website: http://www.pfmb.uni-mb.si/