

How to stimulate SoSE engineers to develop soft skills?

How effective is a lecture in Non-Verbal Communication?

Lia Charité
HSN-NISE
Kongsberg, Norway
info@liacharite.nl

Gerrit Muller
HSN-NISE
Kongsberg, Norway
Gerrit.muller@hbv.no

Abstract—The human content of system of systems (SoS) is significant. The inclusion of humans and organizations as part of a SoS impacts the engineering process. The engineers need soft skills to operate effectively in the SoS arena. Most education focuses on the technical (hard) competences. We study the impact of a lecture in non-verbal communication as means to stimulate students to develop themselves in soft skills further. This lecture is part of a course in Reflective Practice, which is a core course in a master program in systems engineering in Kongsberg, Norway.

The study finds that students have a quite limited knowledge of expressions of non-verbal communication. The guest lecture has the desired effect that students perceive an increase in awareness of non-verbal communication. We advocate for a higher priority of soft skills in education of engineers

Keywords—education; systems engineering; soft skills; communication; non-verbal communication

I. INTRODUCTION

The increase in scope from system to System of Systems (SoS), brings an increase of the human factors too. This increase of human factors is both happening in the development as well as the deployment of the system or the SoSs. For many SoSs, humans and organizations are effectively part of the SoS. In development, we see an increase in organizations and stakeholders supplying the constituent systems that form the SoS.

When visiting companies to hear their needs for systems engineering education, we consistently hear a perception that good engineers, potential systems engineers, especially need more soft skills. Companies that run in-house programs educating potential systems engineers often have a significant soft skills component. The second author is participating or has participated in these programs in among others Nokia, Thales, and NXP, where soft skills were a significant part of the program.

Bredemeyer and Malan [1] emphasize the role of communication for systems architects. Muller [2] emphasizes the dominant role of communication is systems architecting.

Despite the need for soft skills, and the importance of communication for systems engineers and architects, the

master program in systems engineering at the University College of South East Norway (HSN) offers mostly hard skills. Several courses such as fundamental of systems engineering, project management of complex systems, and advanced architecting touch the topics of leadership, management, and cultural aspects. However, the program does not offer any specific soft skill training.

The HSN systems engineering program mandates that students work in engineering concurrently to their study. The idea behind this model is that engineers learn systems engineering by practicing, following Kolb's ideas on experiential learning [3]. A specific course "Reflective Practice" (RP) builds on this model by applying Schön's ideas [4]. We have reported on the RP course in [5].

Since soft skills play such essential role in practice, two of the nine workshops of RP address soft skills: workshop 6 on cultural differences and workshop 7 on communication. In 2011, the course owner asked first author to provide a guest lecture in non-verbal communication, as part of the workshop communication. The first author is social worker and as such better equipped to lecture on this topic, than the technical staff of the systems engineering institute. The workshop communication becomes in this way an effort by two different disciplines: technical-oriented systems engineering and social work.

In 2015, we have decided to measure and evaluate the effectiveness of the guest lecture in non-verbal communication. Underlying idea is that feedback on effectiveness may help to evolve the workshop and the guest lecture. In this paper, we discuss the measurement and evaluation of the guest lecture in the industry master in systems engineering at HSN-NISE in Kongsberg, Norway.

In section II, we discuss the relevance of soft skills for SoS engineering. Section III elaborates communication and the role of non-verbal communication. Section IV provides a model for competency development, that we will use to measure the effectiveness of the guest lecture. Section V describes the design of the measurement. In Section VI, we discuss the data collection and analysis. Section VII draws conclusions. Finally, we discuss further research in VIII.

II. THE RELEVANCE OF SOFT SKILLS FOR SOS ENGINEERING

The SEBoK [6] states “*Most systems of systems (SoS) are socio-technical systems that are composed of a number of interdependent resources, such as, people, processes, information, and technology that must interact with each other and their environment in support of a common mission...*”. The inclusion of people and organizations opens another dimension: the human sciences. Social, psychological, political aspects become part of problem and solution space. Humans are autonomous, emotional, and rational to some degree [7]. SoS engineers need to take all these aspects into account when designing systems. They need soft skills to interact with stakeholders associated with specific constituent systems and the stakeholders of the entire SoS.

III. COMMUNICATION

A. Technical versus social communication

Schramm [8] and Clark [9] provide a theoretical foundation for communication. Core to their work is the need for achieving and maintaining a common ground. Continuous feedback cycles are required to maintain the common ground. Senders and receivers of information are continuously encoding and decoding the messages they exchange.

When searching for knowledge about communication in (systems) engineering literature, we dominantly get hits on system-to-system communication or human communication in technical ways. Much literature elaborates notations and formalism as means to facilitate communication. The social aspect of communication is barely touched. Nevertheless, the social content of the communication may modify the meaning of communication entirely. What does the phrase “yeah, sure” mean? Is it “yes, agreed” or “no, this is bullshit”? The systems engineering competencies framework [10] gives an acknowledgment of the relevance of social communication and non-verbal communication; it includes it in a list of basic skills and behaviors.

B. What is Non-verbal communication?

Navarro [11] states that alternate terms for non-verbal communication are non-verbal behavior or body language. He states that it is a way to convey information, where the communication takes place by “*facial expressions, gestures, touching (haptic communication), movements (kinesics), attitude, body decoration (clothing, jewelry, hairstyle, tattoos, etc.) and even the tone, timbre and volume of one's voice...*” [11]. Navarro also mentions physical symptoms such as blushing, sweating and trembling. He claims that most communication is non-verbal.

Non-verbal communication determines a significant part of the meaning and interpretation in social communication. When communicating with stakeholders, engineers are communicating in technical and social ways at the same time.

C. Content of the guest lecture in non-verbal communication

The guest lecture starts with a brief general introduction and mentioning the breadth of non-verbal communication. It explains the relevance of non-verbal communication in the

working situation. Next, the teacher provides about 10 specific gestures and movements with an explanation of their possible meaning, while relating it to practical situations. One of the messages is that participants need to be aware that signals of the speaker may apply to the listener or the transmitter. For instance, if there is a negative aura in the communication then the cause can be in the transmitter, listener, or both.

Some examples provided by the teacher are:

- A stakeholder is sitting with his arms crossed in front of him. This is typically a sign that the person is not open for the communication. There are many possible reasons for lack of openness; it may be the topic, however, stress from private circumstances is also possible.
- Your manager is holding the fingers entangled and palms together. The meaning of this can be that the manager is not telling the whole story; she may be withholding something.
- A colleague rubs her hand on her chin while listening to you. This may mean that she is considering a decision. When she stops rubbing the chin, then she has made the decision.
- The presenter is concluding his viewpoint while standing with his arms high and open. Arms high with an open attitude are a typical signal for an open and honest message.

The teacher warns that although non-verbal communication tends to be quite generic, people may show learned behavior. For example, managers that have followed a course on presentation skills may stand with their arms open and wide, because the course has taught them to do so. In that case, the manager suggests openness and honesty, while this may not be true.

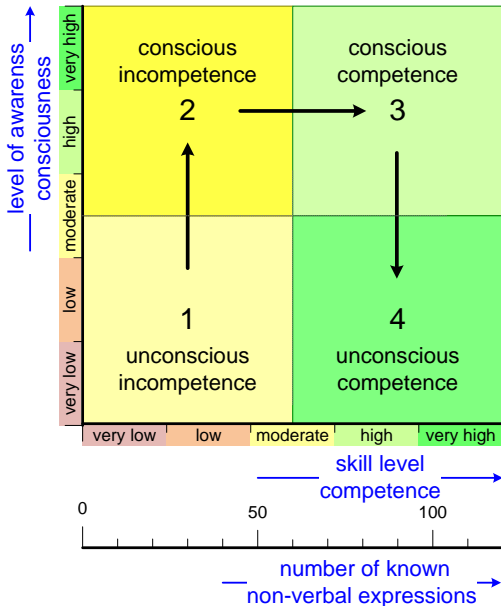
IV. A CONCEPTUAL MODEL FOR COMPETENCY DEVELOPMENT

The long-term goal of the guest lecture non-verbal communication is to stimulate students to develop themselves in the future further in non-verbal communication and other soft skills. Since we want to measure the effectiveness of the guest lecture, we need a measure for the competence in non-verbal communication. Fig 1 shows the conceptual model we use to define three parameters for measuring this competence.

In Fig 1, the two-dimensional space shows a model for competence development that [12] attributes to Noel Burch. This model describes the competence development in 4 steps:

1. Unconscious incompetence. Persons are not conscious that they lack competence.
2. Conscious incompetence. Persons are aware that they lack competence
3. Conscious competence. Persons have the competence, however, they have to pay conscious attention to apply it.
4. Unconscious competence. Persons have the competence, without being conscious of using it.

Fig. 1. Conceptual model of competence development



We combine the degree of consciousness and competence, with a measure of the number of non-verbal expressions that persons know. Navarro [11] describes over 100 expressions of non-verbal communication.

The terminology that this competence model uses matches partially with the terms from the European Quality Framework (EQF) [13]. EQF describes learning outcomes as knowledge, skills, and competence. Here competence is the ability to select proper knowledge and skills in given situations. We have added the knowledge dimension in the forms of the number of known non-verbal expressions. The horizontal axis then maps also on skills.

The course owner and the guest lecturer start from the assumption that the technical students that participate in the workshop are mostly unconscious incompetent (low, low), with few known forms of non-verbal expressions (below 8). The goal of the workshop is to wet their appetite, such that they will later be motivated to develop this competence further. That means that we hope for a small move in consciousness, in the expectation that being more conscious will motivate them later.

V. DESIGN OF THE MEASUREMENT

A. The context of the measurement

The RP course consists of 9 workshops over three years. Students make a pre- and a post-assignment for each course. The purpose of pre-assignment is to sensitize the students for the topic. The purpose of the post-assignment is to stimulate students to reflect afterwards on the topic. Students must submit pre-assignments one week before the workshop. For the post-assignment, they get 2 to 4 weeks, depending on the assignment.

B. Objectives of the measurement

The measurement needs to help find answers on the following questions:

1. What competence in non-verbal communications do the students have before the guest lecture?
2. What changes can we observe in the competence of the students after the guest lecture and post-assignment?
3. What is the effectiveness of the guest lecture non-verbal communication?

C. Procedure and respondents

We used pre- and post-assignment for questionnaires. Since submission of the assignments is mandatory, we achieved a 100% response rate.

The cohort following RP consisted of 17 students, 16 male, and 1 female. All 17 students participated in the workshop and submitted the assignments. The course owner anonymized the questionnaires before the guest lecturer analyzed the results.

D. Design of the questionnaires

To measure the effectiveness, which according to Hitchens [14] is “... the degree to which a system or process serves its purpose...”, we will perform a zero measurement before the guest lecture, and an post measurement after the guest lecture. These two measurements will then enable us to see any change of the three parameters of the conceptual model.

We chose for questionnaires with two types of questions:

- Questions with answers on a 5-point Likert scale
- Open questions

The Likert scale questions allow for further processing and analysis [15]. The open questions help to get input from the students. Some of the Likert scale questions and open questions overlap to check validity of the answers. We limited the size of the questionnaire to 2 pages, such that responders will pay attention during the answering.

We have several questions asking for the degree of recognition of non-verbal communication, which have the purpose to measure consciousness level. Later we cross check that by asking how aware they are of non-verbal communication. We determine their competence by asking them to their skill level.

The zero and post measurement use the same questions, except that in the post measurement we have asked the students to observe two meetings before answering the questionnaire. In that way, the students have listened to the guest lecture, and they have been able to use some of it in practice in the work environment.

E. Reliability and validity considerations

This measurement set-up has several limitations. The measurement does not directly measures how much students are motivated to develop themselves later. We measure their perceived level of increase in awareness, skill, and knowledge of non-verbal expressions. Under the assumption that increased awareness will result in motivation for further development, we

have an indirect measurement for the effectiveness. A true measurement is only possible years later, when we can measure how much the ex-students actually invested in their soft skill development.

The use of questionnaires depends on the self-assessment of the students. With a few limited control questions, we try to increase the reliability. However, the use of self-assessment and questionnaires has limited reliability.

Finally, we articulated an expected outcome of the measurement, to be able to check the sanity of the answers. In the analysis, we will compare actual answers with initial expectation. A strong deviation makes the answers suspect; a strong correlation does not yet indicate validity.

VI. DATA COLLECTION AND ANALYSIS

For all questions, we determined the median of the Likert scale type questions. In the table the median is indicated by a black border around the percentage. If the median is in between two bins, then both bins have together a black border.

A. Discussion of the collected data

Table I shows the results for the question “How often do you recognize non-verbal communication in your daily work in the following situations?” The sub questions A to E provide a variety of situations. The expectation for question 1 was an answer of “now and then” or slightly higher. The responses are somewhat higher than the expectation, being closer to “regular” than “now and then”. In other words, the students perceive themselves more aware than our initial expectation.

TABLE I. RESULTS OF QUESTION 1 BEFORE AND AFTER GUEST LECTURE

| How often do you recognize non-verbal communication in your daily work in the following situations? | | never | now and then | regular | frequent | very frequent |
|---|---|-------|--------------|---------|----------|---------------|
| 1.A During meeting | B | 3% | 15% | 53% | 26% | 3% |
| 1.A During meeting | A | 0% | 0% | 35% | 41% | 24% |
| 1.B Bilateral with colleague | B | 0% | 32% | 38% | 24% | 6% |
| 1.B Bilateral with colleague | A | 0% | 12% | 38% | 44% | 6% |
| 1.C Bilateral with manager | B | 6% | 62% | 21% | 6% | 6% |
| 1.C Bilateral with manager | A | 0% | 12% | 44% | 44% | 0% |
| 1.D In the office | B | 0% | 29% | 59% | 12% | 0% |
| 1.D In the office | A | 0% | 24% | 24% | 47% | 6% |
| 1.E During events | B | 6% | 44% | 26% | 24% | 0% |
| 1.E During events | A | 0% | 29% | 15% | 38% | 18% |

After the guest lecture the responses shift in the direction of “frequent”. This question indicates an increase of awareness after the guest lecture and the observation of two meetings at work.

Table II shows the results for the question “How many different forms of non-verbal communication do you recognize?” The median, both before and after the guest lecture, is at 4 to 8 known expressions. Given the more than 100 expressions described in [11], we see that their knowledge

of non-verbal expressions is limited. The guest lecture did not increase the knowledge level.

TABLE II. RESULTS OF QUESTIONS 4 AND 5 BEFORE AND AFTER THE GUEST LECTURE

| | | 0..4 | 4..8 | 8..12 | 12..16 | more than 16 |
|---|---|------|------|-------|--------|--------------|
| 2. How many different forms of non-verbal communication do you recognize? | B | 24% | 59% | 6% | 0% | 12% |
| 2. How many different forms of non-verbal communication do you recognize? | A | 18% | 53% | 24% | 0% | 6% |

Table III shows the results for question 4, “How helpful is non-verbal communication, if you recognize it, for you personally?”, and question 5, “How much do you think that you transmit non-verbal communication yourself?” the initial expectation for question 4 was a score between “a little bit” and “moderate”. However, the appreciation by the students of the non-verbal communication was and is clearly higher, with a median at “much”.

TABLE III RESULTS OF QUESTIONS 4 AND 5 BEFORE AND AFTER THE GUEST LECTURE

| | | not at all | a little bit | moderate | much | quite a lot |
|--|---|------------|--------------|----------|------|-------------|
| 4. How helpful is non-verbal communication, if you recognize it, for you personally? | B | 0% | 6% | 32% | 59% | 3% |
| 4. How helpful is non-verbal communication, if you recognize it, for you personally? | A | 0% | 6% | 41% | 29% | 24% |
| 5. How much do you think that you transmit non-verbal communication yourself? | B | 0% | 6% | 32% | 59% | 3% |
| 5. How much do you think that you transmit non-verbal communication yourself? | A | 0% | 0% | 24% | 65% | 12% |

Similarly, we expected “moderate” as answer for question 5. The median is here “much” as well. This indicates that students think that they send significant amount of non-verbal communication. Looking at the numbers themselves, we see a minor shift to right (transmitting more non-verbal signals).

TABLE IV RESULTS OF QUESTIONS 6, 7, 8, AND 9, BEFORE AND AFTER THE GUEST LECTURE

| | | very low | low | moderate | high | very high |
|--|---|----------|-----|----------|------|-----------|
| 6. How do you rate your own awareness of non-verbal communication? | B | 0% | 12% | 56% | 29% | 3% |
| 6. How do you rate your own awareness of non-verbal communication? | A | 0% | 0% | 35% | 47% | 18% |
| 7. How do you rate the awareness of non-verbal communication of your colleagues? | B | 0% | 6% | 85% | 9% | 0% |
| 7. How do you rate the awareness of non-verbal communication of your colleagues? | A | 0% | 6% | 59% | 35% | 0% |
| 8. How do you rate your own skill level in non-verbal communication? | B | 6% | 35% | 47% | 12% | 0% |
| 8. How do you rate your own skill level in non-verbal communication? | A | 0% | 29% | 47% | 24% | 0% |
| 9. How do you rate the skill level in non-verbal communication of your colleagues? | B | 0% | 18% | 82% | 0% | 0% |
| 9. How do you rate the skill level in non-verbal communication of your colleagues? | A | 0% | 29% | 53% | 18% | 0% |

Table IV shows the results for questions 6 to 9, which ask directly for the students' assessment of their awareness and skill level. The initial expectation was "low" for all questions. However, we see that all questions result in a median at "moderate" before the guest lecture. The students assess themselves and their colleagues higher than expected.

The main change before the guest lecture and after the guest lecture and observing two meetings is the increase in awareness for the students themselves. This increase matches the increase that we measured in question 1.

TABLE V. RESULTS OF QUESTION 10 AND 11 AFTER THE GUEST LECTURE

| | | not at all | a little bit | moderate | much | quite a lot |
|--|--|------------|--------------|----------|------|-------------|
| 10. Did communication with your colleagues improve after observing two meetings? | | 18% | 53% | 29% | 0% | 0% |
| 11. Did communication with your manager improve after observing two meetings? | | 18% | 71% | 12% | 0% | 0% |

Table V shows the answers of the questions that we only posed after the guest lecture and the observation of two meetings. We did not expect a significant change in their communication with colleagues or their manager. The answers, with a median at "a little bit" match with this expectation.

B. Discussion of the outcome

The objectives of the measurement were to answer three questions, which we will discuss one by one based on the collected data.

1. What competence in non-verbal communications do the students have before the guest lecture?

The students score themselves as "moderate" aware, and "moderate" in skill level, knowing 4 to 8 expressions of non-verbal communication. The questions on recognition show a slightly lower awareness

2. What changes can we observe in the competence of the students after the guest lecture and post-assignment?

The students perceive that their awareness level increases from "moderate" to "high". The questions about recognition show a similar increase from close to "regular" to close to "frequent". The skill level and the number of known expressions do not show any significant change.

3. What is the effectiveness of the guest lecture non-verbal communication?

The goal of the guest lecture is to increase the awareness level of the students, with the expectation that this will motivate them later to develop their soft skills more. The obtained results indicate that the guest lecture is effective, since it meets its objective.

C. Considerations of reliability and validity

We looked at the distributions of the answers, which for nearly all questions show an even distribution with few outliers. The typical variation is two or three bins. The distribution of the responses supports the reliability.

We discussed several limitation of the measurement set-up. Having only 17 responders is a clear limitation of the validity. However, the results of the measurement provide sufficient confidence to continue the guest lecture and this research.

VII. CONCLUSIONS

The literature describes a rich collection of non-verbal expressions, more than 100 [11], where participants know only a small amount of them. There is clearly room for further development of the non-verbal communication competence.

The guest lecture achieves its objective of increasing the awareness of the students of non-verbal communication. We assume that this increased awareness will stimulate them later to develop themselves further in soft skills. However, we did not perform any measurements to validate this assumption.

VIII. SOME REFLECTIONS AND FUTURE RESEARCH

The research affirms that the guest lecture fulfills its original purpose by increasing the awareness of the students. However, in the discussions about this paper, we started to challenge the ambition level of the workshop communication. Given the relevance of soft skills for SoS engineering, we assert that soft skills deserve a higher priority in education of systems engineers.

As small step in such increased priority, we plan to extend the guest lecture with an active exercise during the workshop to amplify the effect of the guest lecture.

In the same discussions, we discovered that we assume that employers offer education opportunities in soft skills to their employees. This assumption deserves further study. What is the soft skill level of beginning employees, what are the needs

for soft skills? Our effort in stimulating the students to develop themselves later should fit the opportunities they may get when employed. Consequently, we should also research what opportunities for soft skill development employers offer.

Finally, we measured the effectiveness for a single cohort of 17 students. We need to continue measuring and analyzing for several years to increase reliability and validity of the results.

ACKNOWLEDGMENT

The students of HSN following the course RP enabled this paper by answering the questionnaires and participating in the lecture.

REFERENCES

- [1] D. Bredemeyer and R. Malan The role of the architect. (2006) Retrieved October 2015 via http://www.bredemeyer.com/pdf_files/role.pdf
- [2] G. Muller, "Systems Architecting: A Business Perspective" CRC Press, Boca Raton, 2011
- [3] D.A. Kolb, Experiential learning: Experience as the Source of Learning and Development, Englewood Cliffs, NJ: Prentice-Hall, 1984.
- [4] D.A. Schön, The Reflective Practitioner: How Professionals Think in Action, Ashgate Publishing Limited, 1984
- [5] G. Muller, "Reflective Practice to Connect Theory and Practice; Working and Studying Concurrently", proceedings of CSER 2015 in Hoboken, NJ
- [6] BKCASE Editorial Board. 2015. The Guide to the Systems Engineering Body of Knowledge (SEBoK), v. 1.5. R.D. Adcock (EIC). Hoboken, NJ: The Trustees of the Stevens Institute of Technology. Accessed 30 January 2016. www.sebokwiki.org.
- [7] D. Kahneman, "Thinking, Fast and Slow", Macmillan, 2011
- [8] W. Schramm, The Process and Effects of Mass Communication. Urbana, IL, USA, University of Illinois Press, 1954.
- [9] H. H. Clark. Using Language. New York, NY, USA, Cambridge University Press, 1996.
- [10] INCOSE UK. INCOSE UK Systems Engineering Competencies Framework. Retrieved February 9, 2016 from <http://www.incose.org/members/index.aspx>
- [11] J. Navarro and M. Karlins, "What Every Body is Saying, An Ex-FBI Agent's Guide to Speed-Reading People", William Morrow Paperbacks, 2008.
- [12] Examined Existence (2013). The Four States of Competence Explained. Retrieved October 2015 via <http://examinedexistence.com/the-four-states-of-competence-explained/>
- [13] European Commission, Education and Culture, Explaining the European Qualifications Framework for Lifelong Learning, Luxembourg: Office for Official Publications of the European Communities, https://ec.europa.eu/ploteus/sites/eac-eqf/files/brochexp_en.pdf, 2008
- [14] D. Hitchens, Putting Systems to Work, New York: John Wiley & Sons, 1992
- [15] S. Jamieson, Likert scales: how to (ab)use them. Medical Education. 2004, retrieved on 29 January 2016 from <http://xa.yimg.com/kq/groups/18751725/128169439/name/1LikertScales.pdf>