Fostering Graduate Students’ Interpersonal Communication Skills via Online Group Interactions

Shahaf Rocker Yoel¹ · Effrat Akiri² · Yehudit Judy Dori¹ ³

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Abstract
This paper presents a study that examines the effect of a graduate course titled “Selected topics in interpersonal communication skills” on the students’ interpersonal communication skills as part of their 21st century skills. Subject to the COVID-19 constraints, the course was taught online in the winter semester of 2021 to 46 students, who practiced in four groups. The students, who were studying at the Technion a science and technology research university for a research-oriented graduate degree in a science, technology, engineering, or mathematics (STEM) subject, attended synchronous bi-weekly 1-h lectures and 1-h practice sessions. The two research questions were as follows: (1) Did the interpersonal communication skills of the participants change following their participation in the course, and if so, how? (2) What was the effect of online learning on the students’ interpersonal communication skills of (a) written and oral communication, (b) peer evaluation and feedback, and (c) self-reflection? Research tools included students’ self-presentations, questionnaires, peer assessments, and reflections during the course. Analyzing the data quantitatively and qualitatively, we found that the graduate students improved their interpersonal communication skills and benefited from exposure to a variety of knowledge and research fields, contributing to a sense of pride in their university affiliation. The students suggested adding a practical component on providing constructive feedback and rendering the course mandatory to all the graduate students in the university. The contribution of this research is the creation and favorable assessment of an online course that develops interpersonal communication skills among graduate students from a variety of STEM faculties.

Keywords COVID-19 · Graduate students · Higher education · Interpersonal communication skills · 21st century skills · Online learning · STEM · STEM students

Introduction
This paper presents a study examining the effect of a specially designed graduate course on the students’ interpersonal communication skills as part of their 21st century skills. There is a need to adapt the skills that students develop during higher education studies beyond the core professional skills (Duderstadt, 2008). To qualify graduates as competent employees, 21st century skills must also be developed (Gover & Huray, 2007; Marbach-Ad et al., 2015). Indeed, developed countries emphasize adapting science and engineering education to the needs of the 21st century employment world, as employers claim that some of the graduates do not have the skills required by advanced industries. Yet, there are not enough courses in the curricula to encourage the development of communication and teamwork skills, as a result, students do not get enough experience in these skills prior to their graduation (Lavi et al., 2021; Oosthuizen et al., 2021; Wilson et al., 2018).

Interpersonal skills in general and interpersonal communication skills in particular have been defined as vital by leading organizations of engineers and scientists in the world, as well as by a variety of engineering education forums (ABET, 2019; Bentur et al., 2019; NGSS Lead States, 2013). Studies have found a link between teaching methods and the development
of different skills. Motivation and academic achievement have also been found to be related to teaching methods (Barak & Dori, 2009) or serve for developing 21st century skills (Lavi et al., 2021), as well as providing students’ psychological needs, efficacy, and communication (Talmi et al., 2018). Teaching and learning methods that include collaborations and interactions between students and lecturers in a constructive learning environment predicted the development of decision making, creativity, and problem solving (Mintz et al., 2018). A course for engineering students for skills development in academia, which combined professional content alongside emphasis on skills development, promoted the students’ confidence, communication, and self-exposure in front of people. A semester-long course proved to be better than participation in a few short workshops in terms of continuous development of the skills (Lopes et al., 2015).

The management of our institute, the Technion, Israel Institute of Technology, has recognized the need to adapt to the challenges in the changing world by developing students’ 21st century skills (Frenkel et al., 2009). Findings of a research on our institute graduates (Lavi et al., 2021) and ensuing management discussions raised the need to develop a course that encourages the development of interpersonal communication skills for research graduate students. In the winter 2021 semester, the experimental, elective course “Selected topics in interpersonal communication skills” was launched for the first time. Subject to the COVID-19 constraints, the course was taught synchronously online via the Zoom platform to 46 students, who practiced in four groups of about 12 each. Course assignments included preparing a short presentation titled “Who am I and what is my research?”. Each student presented their research in the small practice group and was provided with oral and written peer feedback. The students also practiced giving an “elevator pitch”—a brief, spontaneous, persuasive, self-presentation speech, aimed to spark interest in the research one is engaged in. Finally, each student wrote reflections during the course and at its end.

The aim of the study that accompanied the course was to examine the contribution of the course to the development of 21st century skills of the graduate students studying for a research postgraduate degree. The structure and content of the course were adapted to the findings of (Lavi et al., 2021), whose research included about 1500 graduates and final year graduate students. These findings showed that interpersonal skills were developed the least, while general thinking skills and thinking skills from science and engineering centers developed at a much higher level.

**Theoretical Background**

We start by presenting multidisciplinary courses in higher education, followed by discussing 21st century skills and how they are taught in higher education. Within the 21st century skills, we focus on interpersonal and communication skills. Given the nature of the course, we close this section with a discussion on online teaching and learning during COVID-19.

**Multidisciplinary Courses in Higher Education**

While STEM studies in general and engineering studies in particular emphasize teaching of field-specific technical abilities, engineers in industry need non-technical abilities along multidisciplinary engineering perspectives (Marbach-Ad et al., 2019). Larsen and colleagues (2017), who devised a multidisciplinary course to help engineering students improve their non-technical skills, showed that the non-technical abilities students had gained from this course were extremely useful for a large portion of their professional lives following graduation. In a study involving engineering students from five majors—biology, computer science, environmental, materials, and mechanical engineering—researchers investigated an interdisciplinary course (Qattawi et al., 2021). The multidisciplinary teams in this course scored higher mean values in terms of teamwork, contribution, and abilities than the single-disciplinary teams. As judged by industry experts, students who took the multidisciplinary course, regardless of their major, created engineering solutions that outperformed their monodisciplinary counterparts in terms of overall originality, utility, analysis, proof of concept, and communication abilities (Hotaling et al., 2012).

The Students Advancing through Involvement in Research Program at Lamar University, USA, takes a multidisciplinary approach to recruiting, retaining, and transitioning students to careers in STEM. The students in the program, who work in teams, develop a sense of connection and solidarity, as well as friendships that often last long after the program has ended. Students in each area can advance further as a group than they might have advanced alone, and they gain significant experience in teamwork and leadership, which are both highly marketable abilities in the STEM workforce (Doerschuk et al., 2016).

**21st Century Skills in Higher Education**

Educators must acknowledge that the world outside the academia has changed. As graduated engineers need to master 21st century skills, it is essential that policymakers have a solid understanding of what these skills are, how these skills can be taught effectively, and what educational technologies are available to teach them effectively. Kivunja (2014) referred to the 4Cs skills: (1) critical thinking and problem solving, (2) communication, (3) collaboration, and (4) creativity and innovation. Institutions are beginning to require training and professional development to ensure that
educators they employ are familiar with the 4Cs and can effectively teach and assess these skills among their students. Moreover, there is a need to educate the general public about the importance of 21st-century skills (Kivunja, 2014).

In a study regarding critical 21st-century STEM competences at the workplace, five domains were identified as management skills: (1) problem-solving, (2) social communication, (3) technology and engineering, (4) system and time, and (5) resource and knowledge (Jang, 2016). The findings of the study suggest that current STEM education programs may provide insufficient preparation for students’ future employment needs and essential workplace skills. Engineering education should include a variety of learning experiences that help students build deep conceptual knowledge, apply professional skills, and participate in a variety of real-world engineering projects. However, engineering curricula and teaching techniques are frequently not aligned with these goals (Litzinger et al., 2011).

**Interpersonal Communication Skills**

Communication skills, which include listening, speaking, reading, and writing, are defined as the process by which people exchange ideas, emotions, and feelings in understandable ways (Hamilton, 2014). Khan and Colleagues (2017) described communication skills as the ability to convey messages clearly and concisely, transmit messages based on a common understanding between contexts and intended audiences. A successful communication process entails offering messages clearly and unambiguously. Dean and East (2019) noted that in the 21st-century general thinking capabilities and analytical-technical skills are no longer sufficient. Interpersonal skills are most important in today’s job market, where these skills are required to cope with challenges posed by growing system complexities. The students—the future employees—must think creatively so they can produce new ideas, solve problems and address challenges (Sahin et al., 2015).

Combining interpersonal skill and communication skill (Hargie, 2021), interpersonal communication is a complicated situated social process in which persons who have established a communicative relationship exchange messages to develop shared meanings and fulfill social goals (Burleson, 2010; Camilli & Hira, 2019). Interpersonal communication is the ability to communicate effectively at an interpersonal level. In this paper, we use the term interpersonal communication skill since it is an essential skill that contributes to success in personal and professional contexts (Hardjati & Febrianita, 2019; Hissey, 2000; Matteson et al., 2016; Zhao, 2019). Interpersonal communication processes cannot just happen; they are a process in which participants discuss their roles, apply verbal (oral) and non-verbal (body language) communication, and use text and visualization as means of written communication.

The Accreditation Board for Engineering and Technology (ABET), an organization that certifies college and university programs in STEM domains with focus on engineering, has defined a set of interpersonal skills that includes teamwork, communication, professionalism, lifelong learning, and time management (Shuman et al., 2005). Engineering students improved their interpersonal skills, which sustained over time after they were exposed to several skills that included giving and requesting feedback, coping with criticism, speaking in public, working in teams, solving problems, making decisions, and settling conflicts (Lopes et al., 2015).

Communication skills in all their forms, such as oral, written, listening, and interdisciplinary ones, are required for any engineer who wishes to practice their profession effectively (Riemer, 2007). Oral communication is the ability to express thoughts and ideas, and to demonstrate speaking skills in front of an audience. Writing complex memos, letters, and technical reports effectively and efficiently is known as written communication (Casner-Lotto & Barrington, 2006). It is critical for science students to study a communication curriculum that emphasizes written communication skills, such as spelling, grammar, audience analysis, clarity, concision, and correctness (Gray et al., 2005).

**Online Teaching and Learning During COVID-19**

The global COVID-19 epidemic has posed substantial challenges for higher education institutions around the world, driving an unexpected, urgent need to change university courses from face-to-face to online using digital technology. Teachers were encouraged to instantly try new teaching methods by creating effective learning settings and using online tools. Universities need to invest in their faculty’s professional development so that they are up-to-date on effective pedagogical methods that include the use of online technologies (Rapanta et al., 2020). Research at California State University, Long Beach, CA, USA, examined the challenges in an online course during the pandemic. The participants were faculty and students from six engineering departments. The findings revealed obstacles that have negative impact on online engineering education: logistical and technical constraints, privacy and security concerns, learning problems, and lack of training. Recommendations for educational stakeholders on how to close the gap in tools and technology and improve online engineering education were suggested (Asgari et al., 2021). Another study investigated the characteristics that are required for technology-mediated courses to meet their pedagogical goals. Differences between subjects
that build technical and interpersonal skills in a technology-mediated environment were also investigated. Findings suggest that a teacher’s digital competency is a critical factor in determining the effectiveness of meeting their course’s pedagogical objectives. Furthermore, when changing a course to being technology-mediated, the transaction of interpersonal skill subjects is better than the transaction of the technical skill subjects (Joia & Lorenzo, 2021).

**Method**

This section contains a description of the research setting, participants, tools, data collection, and analysis which uses a converged mixed methods approach that includes both qualitative and quantitative data collection (Creswell & Creswell, 2017).

**Research Goal and Research Questions**

The research goal was to examine the contribution of the course “Selected topics in interpersonal communication skills,” which was taught online during the COVID-19 lockdown, aiming to develop or improve postgraduate research students’ 21st century skills, focusing on their interpersonal communication skills. The course was held at the Technion, Israel Institute of Technology, an academic institution in the northern part of Israel. The two research questions were as follows:

1. Did the interpersonal communication skills of the participants change following their participation in the course, and if so, how?
2. What was the effect of online learning on the students’ interpersonal communication skills of the following:

(a) Written and oral communication
(b) Peer evaluation and feedback
(c) Self-reflection?

These research questions will be answered from both the perspective of students about their own perceptions and the perspective of their peers.

**Research Setting and Participants**

The study examined the graduate experimental course taught in winter 2021, which was titled “Selected topics in interpersonal communication skills.” Due to the COVID-19 epidemic constraints, the course was conducted synchronously during the 13 weeks of the semester, with bi-weekly 1-h lecture sessions and weekly 1-h synchronous practice. Online teaching utilized ZOOM\(^1\) and Moodle.\(^2\) Zoom is a software program developed by Zoom Video Communications for video meetings, which has become highly popular as an online meeting platform since the beginning of the pandemic. Moodle is a learning management platform, used as an online learning platform in schools, universities, and other sectors. The course timetable, content, and structure are presented in Table 1.

| Session # | Lecture subject for all the 46 students | Practice subject in four practice groups |
|-----------|----------------------------------------|------------------------------------------|
| 1         | Written and oral self-presentation     | Students’ self-presentation and peer feedback |
| 2         | -                                      | Students’ self-presentation and peer feedback |
| 3         | Lecture on the perceptions of alumni and students—developing 21st century skills | Students’ self-presentation and peer feedback |
| 4         | -                                      | Students’ self-presentation and peer feedback |
| 5         | Preparing an abstract, its components  | Students’ self-presentation and peer feedback |
| 6         | -                                      | Students’ self-presentation and peer feedback |
| 7         | Ethics                                 | Students’ abstract and peer feedback     |
| 8         | -                                      | Students’ abstract and peer feedback     |
| 9         | Peer feedback and self-reflection      | Students’ abstract and peer feedback     |
| 10        | -                                      | Students’ abstract and peer feedback     |
| 11        | Elevator pitch                         | Elevator pitch practice                  |
| 12        | -                                      | Students’ abstract and peer feedback     |
| 13        | Course summary—Six Thinking Hats by Edward de Bono (1985) | Students’ abstract and peer feedback     |

\(^1\) https://zoom.us/.
\(^2\) https://moodle.com/.
a teaching assistant. All four teaching assistants were experienced and well-prepared to guide their students in practicing the targeted 21st century skills.

Before the course started, the students had filled an expectation questionnaire. During the hands-on practice sessions, each student had three oral assignments to present: (1) a 3-min self-presentation research introduction, titled “Who am I and what is my research about?”; (2) an abstract of their research; and (3) a short, spontaneous “elevator pitch.” Following these sessions, a final product was submitted which included the student’s improved presentation and research abstract, along with a written reflection. Each week, two

Table 2: Distribution of students by faculty and field

| Field                              | Faculty                                      | Students per Faculty | Students per Field |
|------------------------------------|----------------------------------------------|----------------------|--------------------|
| Engineering faculties              | Civil and environmental                      | 2                    |                    |
|                                    | Electrical                                   | 4                    |                    |
|                                    | Mechanical                                   | 2                    |                    |
|                                    | Chemical                                     | 2                    | 15                 |
|                                    | Industrial and Management                     | 2                    |                    |
|                                    | Biomedical                                    | 2                    |                    |
|                                    | Science and engineering of materials          | 1                    |                    |
| Science faculties                  | Applied Mathematics                           | 1                    |                    |
|                                    | Physics                                      | 1                    | 3                  |
|                                    | Computer Science                              | 1                    |                    |
| Education                          | Science and technology education              | 12                   | 12                 |
| Interdisciplinary programs         | Nano Sciences                                 | 2                    |                    |
|                                    | Medical education                             | 2                    | 6                  |
|                                    | Energy                                        | 2                    |                    |
| Medicine                           | Medicine                                      | 5                    | 5                  |
| Architecture                       | Architecture                                  | 5                    | 5                  |

Fig. 1: The visual theme, its categories, and an example of a statement for each category

- “The animation was a good and original idea - it also caught the attention of the listeners and beautifully illustrated how the algorithm works” (Peer feedbacks - master student, code 9311 to master student, code 10321)
- “Using pictures / visual charts will help viewers understand and remember the things you talked about” (Peer feedback - doctoral student, code 9112 to doctoral student, code 1112)
- “A topic that stood out in the comments for improvement was that it seemed as if each paragraph was written on its own and lacked connection or flow between the paragraphs” (Self-reflections - doctoral student, code 11122)
- “The abstract is characterized with a large textual load and long and difficult sentences to follow” (Peer feedbacks - doctoral student, code 6312 to master student, code 2321)
- “Following the written feedback I received from the group members - I learned that I need to write down my details on the slide, write in larger fonts” (Self-reflection - doctoral student, code 1212)
- “Graph with different colors that was not understood what each color symbolizes” (Peer feedbacks - doctoral student, code 4122 to doctoral student, code 11122)
students gave their 3-min self-presentation or presented their abstract, and the group discussed the presented product. Each student then gave their written and oral feedback to their peers.

**Research Tools**

The research included four tools for collecting qualitative and quantitative data:

1. **Opening questionnaire**—All 46 students filled in a questionnaire regarding their expectations from the course. The questionnaire included demographic data, questions regarding their research topic, and the following open questions: (1) Why do you want to take this course? (2) What are your expectations from participating in this course? and (3) What is important for us to know in order to support you in the course?

2. **Peer feedback**—Students gave each other 912 feedback items during the course, half of which related to the presentations and the other half—to the abstracts. Submitted via Google forms, the feedback included the following open-ended questions: (1) Does the abstract include all the necessary parts? If not, what is missing? (2) Offer a point to preserve. (3) Suggest a possible improvement. (4) Was a visual representation used in the abstract? Did it contribute to understanding? There were also three closed questions on a 1–5 Likert scale relating to the students’ understanding, learning something new, and generating interest in the research.

3. **Self-reflections**—each student completed two reflections, one following the self-presentation and another following the discussion of the abstract. In total, 92 reflections were collected.

4. **Teaching survey**—24 responses were received to the standard institutional survey questionnaire, which students are requested to fill in at the end of the semester for each course. The survey included closed statements on a scale of 1–5 and open-ended questions.

We analyzed the qualitative data from the open-ended questions, feedback items, and reflections in three stages. In the first stage, we collected all the data from the open-ended questions and reflections in the questionnaires, as well as the feedbacks submitted via the Moodle platform. In the second stage, we divided the data into 2622 statements, each containing data from one subject. Finally, in the third stage, we identified the relevant theme and category for

![Fig. 2 The content theme, its categories, and an example of a statement for each category](image-url)
each statement. Within each main theme, we identified several categories that were mentioned by the students in their statements. Based on the literature, we divided the statements into four main themes: visual, content, emotional, and diversity (Akiri et al., 2020; Dangur et al., 2014; Dori & Sasson, 2008). In each theme, we searched for a category that was discussed in the literature. In the process of categorization, three science and engineering educators (the authors), who are highly experienced in conducting thematic analysis, took part in analyzing jointly in-depth 270 statements (about 10%) of the statements. This process was carried out to ensure the study’s validity and reliability, until 90% of consensus was reached.

Figures 1, 2, 3, and 4 present the four main themes, their categories, and an example of a statement for each category. Figure 1 presents the visual theme, which relates to statements on visual aspects of the presentations and abstracts. The categories in the visual theme are pictures and charts, fonts and title, colors, overload, paragraphs, and animation.

Figure 2 presents the content theme. This theme describes statements related to the content of the presentation or abstract, and its categories are self-presentation, clarity and understandability, interest, space and time limit, and sequence of the topics.

Figure 3 shows the emotional theme, which relates to emotions that students raised. The categories identified in this theme are stress, excitement, humor, attracting peers, storytelling, and feedback.

Figure 4 describes the audience diversity theme, which relates to the fact that the students in the course were from various faculties and had different background knowledge. The categories in this theme are professional concepts, simplification, and meeting the challenge.

Results

The results of the study are presented with respect to the two research questions.

Change in Interpersonal Communication Skills Following Participation in the Course—Self- and Peer-reflection

We examined the effect of the course on the participants’ interpersonal communication skills through their self-report, starting with their expectation before the beginning of the
course, followed by peer reflections after each presentation, and ending with self-reflections during the course.

**Opening Questionnaire**

The findings that emerged from the opening questionnaire regarding the expectations before the beginning of the course are presented in Table 3.

**Peer Feedback**

We present a quantitative analysis of the feedback peers provided on the abstracts, students had presented. Figure 5 shows data of the Likert scale items on the 486 feedback items that were provided along the six-week timeline during which the abstracts were presented.

A total of a repeated measures was performed to compare the effect of the course during these 6 weeks on the following three parameters: (a) understanding the abstract, (b) learning something new from the abstract, and (c) the interest the abstract creates. There was a statistically significant difference between the six weeks only in understanding the abstract ($F(1) = 16.889, p < 0.00$). The gradual increase of understanding the abstract over the weeks indicates that the students learned from their peers’ performances and improved throughout the semester so that each week the abstracts were better.

**Self-Reflections After the Presentation**

In the next stage, we examined the close- and open-ended questions of the self-reflections that the students wrote after discussing their presentations and abstracts. We analyzed the open-ended questions by dividing the answers into statements and classifying the statements into the themes and categories that were identified previously. Figure 6 lists the four themes, each accompanied by two examples: one related to the self-reflection on the presentation and the other—to the abstract (Table 6). Table 7 in Appendix 2 presents all the categories in each theme with a statement example of a self-reflection on the presentation and another example of a self-reflection on the abstract.

**Development and Changes in Themes Throughout the Course**

Table 4 presents the theme and category probed by each research tool along the course timeline, showing the development process from the opening questionnaire toward the end of the course.
There are five tools, which were used as the course progressed: the opening questionnaire, the peer feedback—presentation and abstract, and the self-reflection—presentation and abstract. A V symbol in a table cell indicates that a category was found to be expressed in the corresponding tool.

**Table 3** Opening questionnaire expectations—theme, categories, and statement example

| Theme             | Category                      | Statement example                                                                                                                                 |
|-------------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Content           | Self-presentation             | [Why do you want to take this course?] The way I present myself, my abilities, and what I do, is very important in a world where there is sometimes short time to listen to every candidate and every important detail (a master’s student, code 10321) |
|                   | Clarity and understandability | I look forward to learning tools that will help me communicate my research effectively, both orally and in sharp and clear writing (a master’s student, code 11311) |
|                   | Interest                      | [My expectations from attending this course] Learn techniques to convey the message in an interesting way (a doctoral student, code 6312) |
| Emotional Stress  |                               | I still find myself apprehensive of any scenario of a performance in front of a class (a doctoral student, code 6312) |
|                   |                               | I do not know how to participate in mingling with other researchers, I don't find myself at scientific conferences, I have difficulty giving presentations and generally speaking in front of an audience (a master’s student, code 6121) |
|                   |                               | I want to develop skills for interpersonal interaction, learn how to communicate my research, overcome insecurity in social situations with other researchers, which can contribute to my development as a researcher (a master’s student, code 6121) |
|                   |                               | I feel that I'm not good at interpersonal communication orally, as if I have a “short-circuit” in my mind when I have to talk about my research or about things I have read or learned (a doctoral student, code 2222) |
| Diversity         | Professional concepts         | My expectations from the course: refining ideas and formulating them so that I can show the relevance of my findings to stakeholders in practice and to audiences with a different set of terms (a master’s student, code 11311) |
|                   | Simplification                | I would love to learn how to present my research topic to an audience that is not from the field of research and in general to get tools for good presentation to an audience (a master’s student, code 6221) |
|                   | Meeting the challenge         | It's hard for me to present in front of people. It's also hard for me to answer questions orally (feels more comfortable to answer in writing) and also sometimes it's hard for me to criticize others and I'm really interested in improving that (a doctoral student, code 4122) |

**Fig. 5** Mean change in abstract feedback throughout the semester

- How well did you understand the abstract?
- Did you learned something new from the abstract?
- Did the abstract generate interest in the research?
Figure 7 presents for each of the four themes the number of categories (number of Vs in Table 4) that students mentioned in each of the five tools, showing an overall increase in each category as the course progressed.

We added the perspectives of the lecturer and teaching assistants to the results from the research tools reported by the student reflections and peer feedbacks. From the lecturer and teaching assistants’ point of view, the course has contributed to the students by improving their interpersonal communication skills. Students’ critical thinking, self-reflection, and peer feedback improved every week. In addition, we noted that the submissions improved from one week to the next, as students learned from comments their peers in the practice group had provided. The improvement along the semester is evident in both peer feedback self-report (Fig. 5). The fact that over time the participants’ statements included new categories, demonstrated that the students had developed their analysis, feedback, and reflection skills during the course.

The Effect of the Online Learning During COVID-19 on Students’ Interpersonal Communication Skills

We examined the effect of the online learning during the COVID-19 lockdown on the participants’ interpersonal communication skills through their self-report. We analyzed the data from the standard institutional teaching survey that the students filled in at the end of the course, as well as the statements in the opening questionnaire, peer reflection after each presentation, and self-reflection during the course. We looked for statements regarding the fact that the course was online using Zoom and statements that related to the COVID-19 lockdown and its effects.

Teaching Survey

At the end of the course, students were requested to respond to the standard institutional teaching survey, in which the student ranked each question in a scale of 1 (to a very small extent) to 5 (to a great extent). The survey average results for each question are shown in Fig. 8. We received 24 responses. The responses demonstrate the respondents’ opinions regarding the course lecturer’s preparedness, organization, clarity, and interest. The respondents (97%) answered that the lecturer arrived ready (average 4.9 of 5.0), organized (average 4.7), and the explanations were clear (average 4.7). The level of interest in the lectures was high or very high in the opinion of 71% of the respondents (average 3.9). The respondents’ opinions regarding atmosphere, student involvement, and relevance of the material studied, with over 80% of the students responding very positively (atmosphere average 4.75, active learning average 4.75). On the relevance of the material studied, over 80% responded “agree” or “strongly agree” (average 4.33).
Contributions to parts of the course, coordination between lectures and exercises, contribution of homework and course site are also shown in Fig. 8. Over 60% of the students strongly agreed that there was coordination between lectures and exercises (average 4.33). Over 85% strongly agreed that the homework contributed to the course (average 4.75), and they agreed that the exercises and digital resources contributed to the course (average 3.96).

Although the course was given online during the challenging COVID-19 lockdown, the feedback from the...
students in the teaching survey was highly positive in all the parameters. The students though that the teaching team came well-prepared, the course was understandable and interesting, and the practice was effective. According to this feedback, it seems that the fact that the course was given remotely online rather than face-to-face did not have a significantly adverse effect on the students’ learning experience.

From the lecturer and teaching assistants’ perspectives on the effect of the online learning, at the beginning of the course, we were concerned that the challenge of developing interpersonal communication skills through online teaching is too difficult to overcome. This concern gradually faded as the course progressed, as despite the physical distance, professional and personal friendships were formed among the students in the group, as well as between students and the teaching team. These friendly relations continued even after the course ended, when it was already possible to meet face-to-face. The online sessions allowed students to experience online communication, which is a necessary 21st century skill whose centrality increased during the COVID-19 pandemic.

**Statements Regarding Educational Technology**

As the course was delivered remotely during the lockdown following the COVID-19, the challenge was to develop students’ interpersonal communication skills, giving and receiving feedback, and developing presentation abilities and personal reflections, all through distance learning using Zoom. Table 5 presents for each research tool the number of statements that is related to educational technology. Of the 4403 statements, only 45 (1%) mentioned distance learning, Zoom, or COVID-19. Hence, the fact that the course was given entirely online was not a limitation for students; they succeeded in the learning task even though it was online. The students were able to develop interpersonal communication skills despite the lack of physical closeness, testifying to the success of the process they went through in the course despite the digital media through which it was conveyed.

![Fig. 8 Respondents’ opinions regarding the course in the teaching survey](image-url)
The course success can be partly attributed to the students’ involvement, which was achieved as they gave each other written and oral feedback. This requirement for a bimodal feedback provision required the students to think over what they said and wrote. The course team gave clear instructions and questions that guided the feedback provider what to focus on, e.g., starting with positive feedback and then providing feedback for improving. There was a culture of respect while listening to the feedback. The students noted that it was important for them to experience learning via an online course, as this would train them to master this mode of learning, which is expected to intensify following the COVID-19. They experienced presentations in Zoom, participation in conferences, and respectful interpersonal communication despite the physical distance.

Of the 45 statements related to distance learning, Zoom, or COVID-19 that the students came up with, 17 statements were in the contexts of advantages, 17 in the contexts of disadvantages, and 11 were neutral statements. There were more (29) statements that related to educational technologies at the presentation stage, where Zoom was used, than at the abstract stage (13 statements), submitted through Moodle.

An example for advantage in a statement in the self-reflection on the presentation is as follows: “In the presentation I realized that I could overcome my fear and speak with confidence. In this respect, I think it was easier for me to perform via Zoom than directly in front of an audience” (code 4222). An example for a disadvantage statement in the peer feedback to the presentation is: “Unfortunately, I could not be in your presentation and could not see the recording due to technical issues” (code 3422 to code 11,421). Finally, a neutral statement example in the peer feedback to the abstract is: “The abstract is well edited, easy to understand, and its subject is contemporary, very neatly arranged, and the beginning of the subject (on the COVID-19) was very appealing, the key words were very helpful in understanding” (code 9222 to code 7211).

### Discussion

Based on several studies, interpersonal communication skills are a dominant part of 21st century skills (Hargie, 2021; Sahin, 2009), and are essential and valued for competing in today’s increasingly complex workplace (Zhao, 2019). In agreement with our findings, the contribution of a similar course, which was provided to improve students’ interpersonal skills in parallel to content field has also been found to be effective in a study of Lopes and colleagues (2015). Dmoshinkaia and colleagues (2022) reported that students were interested in a course content although most of it was presented by the students themselves. They felt it was effective, emphasizing the importance of their active participation and feedback providing. Interpersonal skills development value is rising (Camilli & Hira, 2019) as well as working in groups and collaboration (Marbach-Ad et al., 2019). Our course “Selected topics in interpersonal communication skills” was found to be effective and beneficial to the STEM graduate students, even though they came from various faculties, degrees, and stages in their research career. Exposure to a variety of research faculties and variety ways of thinking encourages not only the way self-reflection is presented, but also the thinking about different students’ developmental possibilities. In the course, the interpersonal communication skills were developed during class discussions in the exercises, which also facilitates the development of thinking. The facilitation of the practice groups enables the development of interpersonal communication skills, providing and receiving feedback in a respectful and constructive manner and enabling teamwork, where the entire group mobilizes to contribute to the presenter constructive comments to improve their work, thereby contributing to the skills of our institute graduates in the world of employment (Marbach-Ad et al., 2015). As described earlier, engineers who wish to do well in their jobs should clearly communicate their ideas and possess good oral, written, listening,
and multidisciplinary communication skills (Riemer, 2007). The participants of our study, practiced oral communication by expressing thoughts and ideas, present their research in front of an audience and gave oral feedback to their peers during the meetings. They also gained experience in written communication by writing their abstract, as well as peer feedback and self-reflection, as suggested by others (Casner-Lotto & Barrington, 2006). All those experiences are critical communication skills for science and engineering students (Gray et al., 2005; Lavi et al., 2021).

Exposure to the variety of studies conducted at our institute contributes to the expansion of the participants’ knowledge as well as to their sense of pride, as they are part of the institute. Students could also feel how their research is perceived as unique and innovative and had the opportunity to learn how to tailor the presentation of their research to the general public.

The reported research findings on the alumni at our institute (Lavi et al., 2021) showed that interpersonal skills developed at the lowest level compared with scientific-engineering and general thinking skills. We followed the data throughout the course from its beginning, through feedbacks and reflections students provided during the course, all the way to the teaching survey at the end of the course. We found that interpersonal skills and communication skills can be improved as an integral part of graduate studies. The results of the study have demonstrated that interpersonal skills can develop or progress even during a one semester course. It would be worthwhile and interesting to follow the students during several semesters to examine the long-lasting effect of this course. The fact that the course was online due to the COVID-19 lockdown required the course team to adapt in order to ensure that the interpersonal communication skills were developed despite the physical distance. According to recommendations of other researchers (Rapanta et al., 2020), the teaching staff in universities have to continue their professional development in order to be able to apply the most up-to-date pedagogical techniques, including the use of online technology. We followed this recommendation and incorporated online technology in the course, not only due to the pandemic, but also to prepare the future engineers and scientists to communicate well with their superiors and peers via similar platforms.

Analyzing the students’ reflections, we see the effect of the course in four themes: visual, content, emotional, and audience diversity. Within each theme, we identified different categories that were developed during the course. Additionally, the lecturer and teaching assistants witnessed the contribution of the course to the students, and specifically to improvement of their interpersonal communication skills, which was evident by the weekly presentations, the peer feedbacks, and their self-reflection.

The limitation of this study is the fact that the results are based on the first semester of teaching the course. Since then, we taught the course in the following semester in a hybrid format. After the third time we will teach the course, we plan to analyze and re-examine the findings, this time from all the three course cohorts. Another limitation is the participants’ background: all are from STEM domains. A future study should examine the effect of this course on students from another university with non-STEM domains, and/or with undergraduate students, in addition to graduate and postgraduate students who participated in our study. It is also recommended to check the effect of this course on interpersonal communication skills when taught face-to-face or hybrid rather than online only.

**Conclusion**

The current study presented the development and improvement of STEM graduate students’ interpersonal communication skills during a dedicated one-semester online course and their positive feedback on the course.

The contribution of this research is the design, implementation, and favorable assessment of this course that aims to develop interpersonal communication skills among graduate students from a variety of STEM domains. This study highlights the importance of explicitly teaching interpersonal communication skills to a heterogeneous population of STEM graduate students.

Based on the favorable results reported here, we recommend that managements of higher education institutions incorporate teaching of interpersonal communication skills into STEM graduate courses and dedicate a course in the spirit of “Selected topics in interpersonal communication skills” to the curriculum, which follows the design principles presented here. The course can be taught online, as described in this study, or face-to-face. Our recommendation is, to the extent possible, to combine online and face-to-face lessons so students get to practice both skills.
### Appendix 1

**Table 6** Thematic analysis of peer feedback with examples from presentations and abstracts

| Theme                  | Category                     | Example from a presentation                                                                 | Example from an abstract                                                                 |
|------------------------|------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Visual                 | Pictures and charts          | Try to reduce text and add more images, schemas, and graphs (code 4122 to 1112).             | The image was very suitable for the text, it displayed all the stages of the research, constantly pointing to the pictures, so the process became clearer (code 11221 to 5211). |
|                        | Fonts and titles             | The first slide is very busy with small font, there are no titles at all, and it is not clear what is being talked about (code 1112 to 2111). | Slightly increase the font. For me, the font size should be at least the same as the font size in the body of the text (code 1421 to 7412). |
|                        | Colors                       | I like turquoise shades, so I connected to the colors. However, a darker background (dark gray, for example) would have emphasized the turquoise even more (code 3121 to 8121). | Colors in parts of the illustration and the size make it a little difficult to read. I would suggest slightly enlarging the font, switching to darker colors (because the font is white), and enlarging the entire illustration (code 11421 to 4421). |
| Overload               |                               | Your presentation is the kind I prefer – with no visual overload. What appears in it is intentional and for a good reason (code 2422 to 12421). | The abstract is characterized by a large textual load with long sentences that are difficult to follow (code 6312 to 2321). |
| Paragraphs             |                               | I think it would have been worthwhile to arrange the paragraphs in the first slide in a more chronological order and in groups, because it is a bit confusing to jump between different stations in your life without some organization (code 7211 to 8211). | I was missing a division into paragraphs, each dealing with one topic: what they are and how professional learning communities are conducted/ the theoretical framework of the research / goals / research methods / findings (code 7312 to code 2321). |
| Animation              |                               | The animation in the second slide is excellent. Despite this, I would consider shortening the amount of time you devoted to this animation, as it seems to me that it slipped a little beyond the optimal time (code 1312 to code 8321). | - |
| Content                | Self-presentation            | Your self-presentation was excellent. You presented relevant details about the research, and you were able to present yourself in a warm and engaging way (code 7112 to 11122). | - |
|                        | Clarity and understandability| You presented in a very clear way, and it was very interesting. You managed to present everything at a good pace and in a simple and structured way (code 12421 to 3422). | The abstract is structured and focuses on the study itself. It describes the problem clearly, concisely and focused on the study itself (code 2321 to 9311). |
|                        | Interesting                  | The order was very clear, the purpose of the study was clear to me, and the combination of topics is interesting (code 5111 to 2111). | The research is interesting and now more than ever, it is relevant to the learning and teaching we are facing nowadays (code 11421 to code 1421). |
| Space and time limit    |                               | You have exceeded the time limit. Think about where you can cut it short; it seems to me that you can decrease self-presentation and the part of the COVID-19, even though it was very interesting (code 12421 to code 8422). | The explanation you wrote for the method of the study is excellent, very clear and accurate in length (code 3211 to code 5211). |
| Sequence of the topics |                               | I recommend explaining first the motivation for the research and then the purpose of the research in order to create a logical sequence of what is being said (code 8422 to code 1421). | Your abstract is very nicely edited and readable. There is a clear order and separation between the paragraphs so that it is pleasant to receive the page and read. In terms of contents, the sequence and transition of topics between paragraphs is very structured and well edited (code 4222 to code 5211). |
| Theme      | Category       | Example from a presentation | Example from an abstract |
|------------|----------------|------------------------------|--------------------------|
| Emotional  | Stress         | During the presentation you conveyed confidence, I couldn't notice that you are stressed at all (code 7412 to code 4421). | -                        |
|            | Excitement     | First, a very beautiful presentation! The excitement is completely understandable. You did very well despite the excitement (code 3121 to code 11122). | The abstract is fascinating, I read it with excitement, and in every line I felt that it gives more depth and an additional layer to the understanding of the processes (code 321 to code 7312). |
| Humor      |                | You started with humor; I really like the initial bonding creation and a little laughing at yourself, it always adds to the feeling of relaxation (code 8121 to code 10111). | -                        |
| Attracting peers |             | You started by telling a story—the personal connection of the background to the motivation in the research. It was excellent and attractive to listen to (code 7211 to code 4222). | The abstract is appealing, making one want to keep reading. This, in my opinion, is perhaps the most important thing (code 3211 to code 8211). |
| Story telling |               | You should leave the personal story you told at the end and even move it to the middle of the presentation; such an example would greatly clarify why your research is important (code 4311 to code 6312). | The abstract was written in a good and understandable way. I liked the fact that it was told in the form of a story (code 4122 to code 1112). |
| Diversity  | Professional concepts | There were some professional concepts that you did not explain clearly, or you did explain but I did not understand (code 12421 to code 6411). | It is better to introduce fewer professional concepts that are not understood by those who are not in the field. Also, the key concepts attached included a lot of concepts that made it difficult to understand (code 1212 to code 8211). |
| Simplification |             | You managed to simplify a topic that I do not understand at all and make it accessible even to people who do not come from the field at all (code 9421 to code 5421). | You managed, in most of the abstract, to keep writing in a relatively simple language, without compromising on the quality and level of writing (code 1312 to code 9311). |
| Meeting the challenge |        | The subject of the study is not simple to explain to an audience that comes from diverse backgrounds. It is a big challenge, and you have succeeded well (code 3121 to code 9112). | An abstract on a scientific/engineering subject is a challenge to write to a diverse audience, and it seems to me that you did it well (code 9112 to code 4122). |
## Appendix 2

### Table 7  Thematic analysis of self-reflections with examples from presentations and abstracts

| Theme                | Category                     | Example from a presentation                                                                                           | Example from an abstract                                                                 |
|----------------------|------------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Visual               | Pictures and charts          | Combining the short video with the photos and diagram helped explain the research plan (code 12311).                     | The illustration has a major contribution to the understanding of the research and to the visualization of a process (code 08422). |
|                      | Fonts and titles             | Following the written feedback I received from the group members, I learned that I need to write down my details on the slide using larger fonts (code 1212). | From the feedback I realized there was inconsistency in font sizes and paragraph alignment. I do not know if I will be able to improve my ability [to improve] the subject (code 2111). |
|                      | Colors                       | Another habit of mine is to produce attention by grabbing colorful presentations, some of which may need to be reduced (code 11421). | The issue of representation has arisen in the context of the need to pay attention to the colors in the figure, although it is coincidental and shows the different complexes (code 9222). |
|                      | Overload                     | Following the written feedback I received from the group members, I learned that it is worthwhile to reduce the visual load of the presentation so it will be more pleasant for viewers (code 7312). | What have I learned about the way research should be presented is that the illustration is important and significant! I first planned to use a table, and after consulting with the practitioner the transition to a different type of representation contributed greatly to reducing the cognitive load (code 11421). |
|                      | Paragraphs                   | This form of presentation made me realize that even in writing a thesis it is worthwhile to incorporate short and focused sentences to keep the reader well-informed (code 12311). | A topic that stood out in the comments for improvement was that it seemed as if each paragraph was written on its own and connection or flow between the paragraphs was lacking (code 11122). |
|                      | Animation                    | Combining the short video along with the photos and diagram helped to understand the method of the research (code 12311). | -                                                                                           |
| Content              | Self-presentation            | I learned that creating an emotional connection is critical to capture the audience’s initial perception, and this attention accompanies you throughout the presentation if you succeed (code 10111). | Following the opportunity to answer at the end of the feedback, I learned that I need to think in advance what questions or concerns can arise from the audience and be prepared with an answer (code 6121). |
|                      | Clarity and understandability | It was difficult to narrow down and provide points that I relate to. I learned how to present the research in a clear and refined way (code 08121). | At the time of writing, I felt there was a lot of material I needed to include in the abstract so others would be able to understand what it is about and I would be able to present all the components of the research, because my research is complex. While writing, I started to delete text that was not essential. I learned that I could explain the subject in simpler terms (code 09222). |
|                      | Interesting                  | I learned that my research is interesting and that people got connected to it and wanted to read more and know more about it (code 4122). | The abstract caused the students to search the literature regarding medical leadership in the world compared to what is happening in Israel. For me, this is a success, because the abstract stimulated interest and caused readers to probe deeper (code 8121). |
|                      | Space and time limit          | Limiting to three slides requires us to pay close attention to every word and illustration (code 10212).                  | I learned to try to reduce words in the body of the text itself in order to focus on existing ideas and not to repeat things that have been written (code 8422). |
|                      | Sequence of the topics        | I learned how to break the study into stages and how to arrange them in an appealing way that raises interest and curiosity (code 5421). | A logical order is important, so that a thing leads to a thing. In my opinion, otherwise, the subject is lost, and people will not be able to follow what I say (code 11421). |
| Theme    | Category          | Example from a presentation                                                                                                                                                                                                                                                                                                                                 | Example from an abstract                                                                                                                                                                                                                     |
|----------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Emotional Stress | I learned that sometimes I am too stressed out when I received positive feedbacks after the presentation, which made me feel better. I was really stressed and wasn’t sure if I could present successfully, but after hearing the feedbacks, I realized it went well. I was able to attract the attention and curiosity of the people (code 04122). | I learned that accepting criticism isn’t easy; You must listen even if you do not agree with the content. However, it is an important process that improves the presentation skills. I received feedback about issues that I did not think about while writing. (code 05211). |
| Excitement | Following the presentation in front of an audience, I learned that I could convey material clearly, and when I get excited, it is expressed in enthusiasm and an increase in the pace of speech (code 9222). | I learned that my research excites a lot of people, and people find it very attractive to explore what I research. This conclusion came at the right time for me, because the COVID-19 and other budgetary issues made me a little discouraged from setting up the research set-up as I wanted. The enthusiasm of the team greatly motivates me to continue (code 3121). |
| Humor    | I learned that it is important to share and use humor while creating closeness and empathy among the listeners, and that this attitude should also be expressed in body language and mimicry (code 10111). | -                                                                                                                                                                                                                                                                                                                                                             |
| Attracting peers | I learned that my research concerns all the people, and that it can be presented in an interesting way that can attract any audience, even people who are not from the field, because the research touches on their daily lives (code 4122). | I learned that I know how to write concisely and accessibly. Sometimes I have to expand more and “sell” the topic I am working on more in order to attract the reader. A slight expansion in the abstract I wrote would have been able to improve it (code 5211). |
| Story telling | I learned that I know how to build a story and manage to simplify it (code 5421). | I learned about how I tell the story of my research and applied it in writing the presentation for the seminar I am giving as part of the degree (code 10111).                                                                                                                                                                                                 |
| Feedback  | The feedback was good, indicating that people were able to understand my presentation in a comprehensive manner rather than just point-by-point. My feeling at the end of the presentation was good. Presenting the research to new people is an opportunity for to rehearse towards my faculty seminar (code 02321). | First, I read the feedback anonymously, then I could not hold back anymore. I was happy to read that some members of the group said I had managed to convey myself and my enthusiasm through this text… I know I might overdo it and was afraid it will sound unprofessional… (code 09112). |
| Diversity Professional concepts | I realized that there is no need to use very specific and professional concepts if the goal is for people to understand (code 12421). | Following the preparation of the materials, I learned how to write scientific explanations without the use of professional terminology. This skill is important when presenting to a diverse audience but also when presenting to researchers from the same field, as research often deals with specific niches that even researchers from the same field are not always acquainted with. (code 09311). |
| Simplification | I have learned that the subject I am dealing with can be simplified, like any subject, and nothing is too complicated when one knows how to make it accessible (code 09421). | I have learned that being clear and understandable is of utmost value, so all my efforts have been focused on achieving this goal, on how to simplify the issue as much as possible so that it is clear and understandable, even if it feels like I am lowering the bar (code 5421). |
| Meeting the challenge | Following the presentation, I learned about myself that I really enjoyed delivering the presentation and enjoyed meeting the challenge of presenting the research in a comprehensive yet concise and clear manner to a diverse audience (code 6221). | Following the preparation of the abstract for a diverse audience, I learned about myself from the writing process that simplifying professional concepts in technologically complex research is challenging, especially in such a short summary (code 8121). |
Data Availability  The dataset generated and analyzed for the current study is not publicly available due to privacy reasons but is available from the author on reasonable request.

Declarations

Ethics Approval  The research was approved by the research university Technion Ethics Committee, approval number 2021–001.

Informed Consent  Informed consent was obtained from all individual participants included in the study.

Conflict of Interest  The authors declare no competing interests.

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