

Fostering communication and collaboration skills for computer science students by means of ICT tools

Nataliia V. Zaitseva¹, Svitlana V. Symonenko¹, Olena A. Titova²,
Viacheslav V. Osadchyi³ and Kateryna P. Osadcha⁴

¹*Dmytro Motorny Tavria State Agrotechnological University, 66 Zhukovsky Str., Zaporizhzhia, 69600, Ukraine*

²*Institute of Vocational Education of the National Academy of Educational Sciences of Ukraine, 98a Vito-Litovsky Lane, Kyiv, 03045, Ukraine*

³*Borys Grinchenko Kyiv University, 18/2 Bulvarno-Kudriavska St., Kyiv, 04053, Ukraine*

⁴*Bogdan Khmelnytsky Melitopol State Pedagogical University, 59 Naukovoho mistechka Str., Zaporizhzhia, 69000, Ukraine*

Abstract

The paper deals with the aspects of enhancing communication and collaboration skills for computer science students at higher educational institutions. The significance of communication and collaboration skills for successful careers of computer science professionals is discussed. Peculiarities of teaching communication and collaboration skills with the focus on pedagogical approaches, methods and strategies are given. Certain benefits of application of English interface online application in training collaboration and communication skills are highlighted. Authors' experience of implementing mock projects imitating professional assignments for training collaboration and English communication is presented. Assessment of the collaboration quality level while working on the projects is considered.

Keywords

communication, collaboration, computer science students, foreign language learning, project

1. Introduction

In the digital age, computer science has become an indispensable discipline, driving advancements across industries and shaping the way we interact, work, and live. As technology continues to transform every facet of society, computer science students are poised to play a pivotal role in driving innovation and addressing the challenges of the future. While technical

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✉ nataliia.zaitseva@tsatu.edu.ua (N. V. Zaitseva); svitlana.symonenko@tsatu.edu.ua (S. V. Symonenko); olena.titova@tsatu.edu.ua (O. A. Titova); v.osadchyi@kubg.edu.ua (V. V. Osadchyi); okp@mdpu.org.ua (K. P. Osadcha)

🌐 <http://tsatu.edu.ua/im/zaitseva-nataliia-volodymyrivna> (N. V. Zaitseva);
<http://tsatu.edu.ua/im/symonenko-svitlana-viktorivna> (S. V. Symonenko); http://ivetua-my.sharepoint.com/:w:/g/personal/info_ivet_edu_ua/EagxYolXINZEmyq_A9vd7AwB1UJshTC1UXddV2sRqeVtJg?e=SFpIHB
(O. A. Titova); <http://inf.mdpu.org.ua/2017/10/25/osadchij-vjacheslav-volodimirovich-2> (V. V. Osadchyi);
<http://inf.mdpu.org.ua/2017/10/25/osadcha-katerina-petrivna> (K. P. Osadcha)

🆔 0000-0002-8682-0434 (N. V. Zaitseva); 0000-0003-0599-3999 (S. V. Symonenko); 0000-0002-6081-1812 (O. A. Titova); 0000-0001-5659-4774 (V. V. Osadchyi); 0000-0003-0653-6423 (K. P. Osadcha)



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proficiency forms the foundation of their education, the acquisition and cultivation of effective communication and collaboration skills are increasingly recognized as crucial for their long-term success.

Historically, the perception of computer science as a solitary pursuit, marked by introverted individuals coding away in isolation, has prevailed. However, this stereotype no longer holds true in today's complex and interconnected world. Modern computer science encompasses multidisciplinary collaborations, diverse teams, and a strong emphasis on user-centered design. The ability to effectively communicate ideas, collaborate with colleagues, and understand the needs and perspectives of users has become paramount.

This article is aimed at considering the significance of communication and collaboration skills for computer science students, highlighting their relevance to their future careers. It examines how these skills not only enhance their professional growth but also empower them to become well-rounded, empathetic problem solvers capable of addressing real-world challenges.

2. Significance of communication and collaboration skills for successful careers of computer science professionals

The 4Cs (Critical Thinking, Creativity, Collaboration, and Communication) are highly important for computer science graduates in today's dynamic and evolving industry. These skills enable specialists to tackle complex challenges, adapt to changing technologies, innovate, and deliver high-quality solutions. By embracing the 4Cs, professionals can thrive in their careers, contribute to the growth of their organizations, and make a significant impact on the evolving IT landscape. Collaboration and communication skills are central to the 21st-century skills and are depicted in numerous curricula and assessment reports [1].

As the main focus of our paper is communication and collaboration skills, let us consider their importance for computer science graduates. Numerous studies emphasize the importance of communication and collaboration skills for computer science professionals.

According to Fullan and Scott [2], "communication entails mastery of three fluencies: digital, writing, and speaking tailored for a range of audiences". Communication skills are paramount for computer science graduates, enabling effective interaction with colleagues, clients, and stakeholders. Clear and concise communication ensures that project requirements, technical concepts, and ideas are effectively conveyed. Computer science graduates must be able to translate complex technical jargon into understandable language for non-technical audiences, ensuring that everyone is aligned and informed. Strong communication skills also facilitate active listening, understanding user needs, and gathering feedback to refine IT solutions. By communicating effectively, computer science graduates can build strong relationships, facilitate collaboration, and deliver successful projects.

Collaboration is also essential in the IT industry, where teamwork and interdisciplinary projects are common. Fullan and Scott [2] define collaboration as the ability to work independently and in teams, with the focus on the importance of possessing strong interpersonal and team-related abilities, such as effectively managing team dynamics, making collective decisions, and actively participating in the learning process of others.

Computer science professionals must work together effectively, leveraging each other's

strengths and expertise to achieve common goals. Collaboration skills involve active listening, respecting diverse perspectives, and effectively contributing to group dynamics. By collaborating with colleagues, computer science specialists can combine their technical knowledge and skills, share ideas, and collectively tackle complex challenges. Collaboration fosters an environment of shared learning, synergy, and improved decision-making, leading to more successful outcomes.

Strong communication and collaboration skills of specialists enhance their employability. Employers across industries increasingly value computer science graduates who possess strong communication and collaboration skills. In the era of rapid technological advancements, companies seek individuals who can effectively bridge the gap between technical expertise and organizational objectives. The ability to articulate complex concepts, work effectively in teams, and communicate with stakeholders from diverse backgrounds is highly sought after in the job market. Computer science students who can demonstrate these skills are more likely to secure desirable positions and excel in their careers.

Effective communication and collaboration play a vital role in fostering innovation and creativity within the computer science field. The exchange of ideas, perspectives, and insights between team members enhances problem-solving capabilities and facilitates the development of novel solutions. By engaging in open and inclusive discussions, computer science students can leverage the collective intelligence of their peers, generating groundbreaking ideas and pushing the boundaries of technological advancement.

As computer science continues to permeate every aspect of society, ethical considerations and societal implications cannot be overlooked. The ability to communicate and collaborate effectively equips computer science students with the tools to navigate these complex issues. They can critically analyze the potential impact of their work, engage in meaningful dialogue with stakeholders, and ensure that their technological solutions align with ethical guidelines and address societal needs. By integrating communication and collaboration skills into their practice, computer science students become responsible innovators, contributing positively to the world around them.

3. Teaching communication and collaboration skills to computer science students at universities

Recent researches highlight various teaching strategies and approaches that can enhance communication and collaboration skills in computer science students. Norris et al insist that collaboration skills can be fostered through school and extracurricular activities, such as the spontaneous challenge [3]. Sharov et al suggest using immersive technologies which can contribute to forming collaboration skills while working on a project [4].

Baird and Bell prove that project-based learning as a critical instructional strategy should be included in curriculum, since it provides students with opportunities to collaborate, communicate, and apply their technical knowledge to real-world problems [5], [6]. Group work, peer feedback, and teamwork activities have also been identified as effective pedagogical methods for fostering collaboration and communication skills [7], [8].

The integration of communication and collaboration into the computer science and IT curriculum has been explored by numerous researchers. For example, integrating communication-

focused assignments, such as technical writing, presentations, and documentation, into technical courses has been shown to improve students' communication skills [9], [10], [11]. Similarly, incorporating collaboration activities, such as group projects and discussions, into the curriculum facilitates the development of collaboration skills [12], [13], [14].

Moreover, studies suggest that the development of communication and collaboration skills positively impacts students' academic performance and career prospects [15]. Students who possess strong communication skills demonstrate higher levels of engagement, motivation, and critical thinking abilities [16], [17]. Similarly, communication and collaboration skills are linked to increased employability, job market competitiveness, and opportunities for professional growth [18], [19].

Recent researches also focus on various teaching strategies and approaches that facilitate the development of communication and collaboration skills for computer science and IT students studying the English language. Language immersion programs, which immerse students in English-speaking environments, have shown positive effects on language acquisition and the development of communication skills [20]. In-class activities, such as role-playing, simulations, and group discussions, provide opportunities for students to practice English language communication and collaboration within the context of proposed scenarios [21].

Integrating project-based learning into the curriculum has been found to be effective in fostering communication and collaboration skills while studying English. Project-based learning encourages students to work on real-world projects that require them to communicate, collaborate, and apply their technical knowledge in English [22], [23]. Peer feedback and self-assessment strategies can also be incorporated into the instructional process to enhance students' communication skills and provide opportunities for reflection and improvement [24].

The research consistently emphasizes the positive outcomes associated with teaching communication and collaboration skills to computer science and IT students studying English. Improved communication skills in English lead to enhanced interpersonal relationships, effective teamwork, and successful project outcomes [25].

The increasing significance of application of information and communication technologies for enhancing communication and collaboration skills has been proven by numerous articles. In our previous research we stated that cloud technologies could be of great importance for better communication within a group or a team [26], [27]. The impact of Web 2.0 tools on 21st century skills of EFL learners using Padlet in collaboration learning has been studied in [28], and it has been proven that it has a substantial and progressive effect on the collaboration skills of learners.

3.1. Advantages of using English interface online applications in training collaboration and communication skills

Since most aspects of study and work are nowadays digitized, the main transformation which is inevitable for the educational process in Ukraine is application of a great number and variety of digital resources in order to correspond the demands of efficiency and adequate time consumption while acquiring knowledge and mastering profession related skills. Moreover, the present computer literacy level of university undergraduates should be continually enhanced and new emerging skills should be developed in order to equip potential specialists with the ability to

Table 1

The students' experience in using technological tools for collaborative work.

Online application type	Video conferencing services	Online presentation editors	Online document editors	Typesetting systems	Messengers
Percentage of users	43%	40%	34%	2%	92%
Used tools	Zoom, Google Workspace, Adobe Connect	Canva, Google Slides, Powtoon, Haiku Deck, Prezi	Google Docs, Canva Docs, Adobe Acrobat	LateX, SILE Typesetter	Viber, Telegram, Facebook Messenger, WhatsApp, Messenger
Percentage of usage of English interface of the tools	2%	5%	1%	2%	1%

quickly become a fully functional team member within their professional environment. For computer science undergraduates it is crucial to learn how to use online services for partner and team work because current trends of cooperation in the IT-sphere assume a large amount of distant work and online communication. Choice of English interface is the most convenient way of enhancing communication within international teams and projects, and sometimes it is also the only option because the application may not provide interface in a specific language or may use English as the only interface language.

In order to equip undergraduates with skills in working online in pairs or teams and in communicating in English on academic and profession related topics, it is necessary to teach them how to use some online platforms crucial for their prospective professional environment of different kinds. For instance, dexterity in using one application for online document editing will be fundamental for fast acquisition of functioning principles of analogous tools.

A survey has been conducted in order to estimate the students' experience in using online tools for working on educational tasks in collaboration with their advisors and groupmates (Table 1). 5 types of online applications which are typically used by undergraduates (at least for individual task accomplishing) have been chosen: video conferencing services, online presentation editors, online document editors, typesetting systems, messengers. The students had to answer if they had used the presented tool types for cooperative work, study or research and give the examples of the used applications.

The survey has stated that the respondents mostly use technological tools individually and discuss mutually important aspects of a project or an assignment live or in messengers instead of being collaborators within a service or a tool and editing their projects and products synchronically. Moreover, the undergraduates prefer applications with interfaces in their native language despite the benefits and sometimes even the superiority of alternative tools.

In order to develop students' collaboration skills with technological tools it is necessary to find weak points in their communication ability, to tailor their prospective improvement

means to their interest. Speaking of young adults, specifically of the undergraduates majoring in engineering and computer science, it is important to involve them into solving tasks of various range (a pair work assignment, team work, group project) which are academically apt, profession related and congruent with the syllabus. The assignments for developing and enhancing collaboration skills should be:

- authentic. The real world content as a research object, up-to-date information, a media event will motivate and engage the students more than a convenient course book task.
- sufficiently challenging. The complexity degree should be apt for the participants. It is preferable to design a more difficult assignment than a too easy and routine one.
- open-ended. The tasks of this kind let students work out the assignment thoroughly from planning and role allocating to conclusion and result presentation.
- suggesting extra benefits. Working in collaboration on their direct assignment students may be involved in some collateral activities, acquire new information not coherent with the assignment topic, and master new tools.

Using online applications with an English interface can both be challenging and suggesting extra benefits. Students train using an application of some kind (an editor or a messenger) and simultaneously learn how to communicate in English with their partners and supervisors within the specific online tool environment.

3.2. Mock projects imitating professional assignments for training collaboration and English communication

In order to motivate the undergraduates to widen their experience in using English interface software of any kind, several projects have been designed as mock projects imitating professional assignments like information search and processing, presentation designing and public speaking and included into the syllabus of the ESP course:

- a plenum discussion on a profession related theme,
- a report at a student scientific conference accompanied with an online presentation for a two person team,
- writing and submitting for publication a research work in a co-authorship.

Two aspects should be taken into account while planning training collaboration online with the use of technological tools with English interface. Not only usage know-how should be inculcated in students, but the specific vocabulary inherent in app description and interface should be introduced by teachers and learned by students. Knowledge of the lexical elements and tokens to use an app and to manage smooth online cooperation within a team and practical experience in the application usage ensure expertise necessary for prospective employees. Taking into account the importance of the language aspect, vocabulary training preceded every collaboration app introduction. First of all, the importance of using both English app interface and English as the only team communication means was highlighted. After that, the vocabulary inherent in the app interface was checked. The students were ensured that they know most technical terms as they are common for most computer software. The specific

aspects (prepositions, phrasal verbs) were trained in vocabulary exercises. After that, new vocabulary was introduced through definitions and synonyms. The examples from video tutorials were used in order to form the correct pronunciation and intonation in elliptical sentences. Finally, communication patterns and phrases for efficient dialogue within application usage with equals, supervisors and subordinates were trained (patterns for requests, orders, prohibition, suggestions, praise and criticism, as well as questions of different types were drilled).

The first project included into the ESP syllabus to train collaboration was a plenum discussion preceded by team work on assigned tasks within a video conferencing service. One of the most applicable apps to train collaboration online is Zoom. Nowadays, Zoom is more than a web conference service because it provides unified business communication and collaboration tools. In Zoom, virtual meetings, team chat, digital whiteboard, phone system, webinars, and rooms are habitual for education agents within 3 last years. Nevertheless, the Zoom platform evolves and extends with developer tools, integrations with external apps, and event solutions. One of the most prospective tools from Zoom is Zoom Events, the event management platform .

In order to train a study group in using Zoom for cooperative work, a group project has been initiated. The undergraduates majoring in computer science were given a task to research application of artificial intelligence in different environments. After the theme introduction, the task instruction was provided. 5 teams were built. They worked in Zoom rooms in order to elaborate and present the group's common vision of the AI in a specific sphere. Students had to work together to present their reports not through just giving the examples, but through analyzing the adequacy and the efficiency of AI implementation. The teams researched:

- AI in education (communication training with chatbots / AR / VR usage),
- AI for industry 4.0 (providing prediction, detection, optimization, service provision, maintenance),
- AI in culture (as a tool for artists in their creative work, for individuals for music, speech and image idea transforming, Artificial Neural Networks),
- AI in science (identifying and solving problems, interpreting data, making predictions),
- AI in homes (monitoring, adjusting, controlling, connecting).

Each team had to find the up-to-date information on their specific theme, summarize and analyze and discuss it and, eventually, represent their common conclusion according to the following structure: advantages, drawbacks, challenges, and prospects. After all 5 group presentations were delivered, the plenum discussion was initiated in order to determine the most significant AI implementation spheres. In order to get 10 scores (the maximum amount) the group had to decide in the first place how the scores would be divided between the group members and explain the allocation principle. Some groups divided the scores equally, some groups allocated roles and tasks and allocated more scores for significant contribution, one group allocated 5 scores to the speaker who delivers the report and the short presentation and distributed the rest scores equally. After the plenum discussion about the role of AI in modern life, the collaboration specifics were analysed. The students had to give their feedback if it was difficult to distribute tasks, if they had arguments about the score allocation, if they were satisfied with their group project presentation, what was rewarding in their counterparts'

presentations. The discussion showed that the participants (no matter what their team strategy was) eventually chose the responsibility as the main factor in score allocation: the speakers should have got more scores because they had to represent the group, and give spontaneous answers to questions on the presentation content in plenum discussion. It was also stated that in 4 teams of 5 the speakers were also the leaders of the teams, so the command of English and public speaking skills were not the deciding factor in the decision for allocating more scores to the speakers.

For accomplishing a report at a student scientific conference accompanied with an online presentation for a two person team one of the most demanded online presentation editors Prezi was chosen. This presentation platform built on HTML5 technology is widely used for collaborating while working on presentations of any type. In spite of the fact that its demanded feature is adding the entire team as a collaborator, pair work is the most efficient way to train students to work synchronously on a common project. Another reason to choose Prezi for training collaboration as well as creating, editing and presenting online is that its interface only supports 9 languages, and there is no Ukrainian language which facilitates students' motivation to use English as a communication means.

The presentation accompanying the report in English for the student scientific conference was chosen as a prezi-project. Pairs of students worked on the same project and presented the report together, too. Since so-called prezis are presentations of a specific type (interactive infographics, dashboards, animated visualizations and videos can be embedded), creating a prezi should be carefully preplanned. The stages of creating a pair speaker prezi are the following:

- report writing,
- prezi concept discussing,
- dashboard and background choosing,
- visuals designing,
- animation adding,
- 2 speakers training and practicing delivering the prezi.

First of all, the students should be aware that prezi is a very impressive and attractive format which distracts the audience's attention from the text content. The report should be well-thought and verbally absorbing in order to maintain balance between the content and the form. It should also contain the explanatory phrases for linking all the visuals logically, that is why the report cannot be considered ready until the prezi is accomplished and delivering the report is rehearsed and practiced.

Prezi is also one of the most demanded cloud-based graphic design tools because of its ready-made dashboards, designs, story blocks and frames. The speakers-to-be had to decide if they wanted to use the ready-made elements or to create their own product. Prezi dashboards provide a plenty of options like infographic style, a world map or a route to the destination point, linear structure, abstract design and thematic dashboards. It is important to choose the appropriate dashboard in order to make the audience keep in mind both the theme (and, consequently, the goal) and the structure of the report.

Prezi suggests unlimited creativity for its users that is why the speakers can choose any means to make their report more comprehensible and rewarding.

Animation is one of Prezi characteristic features, it is famous for rotating and zooming prezi blocks and elements focusing attention on the content.

After all the previous items had been prepared, the speakers' training in public speaking with prezi began. It is only possible to demonstrate the same presentation for one speaker, but multiple presenters can open the same project in the Prezi Video app, and navigate their prezi to the part where each would start presenting. The speakers used the content toggle to hide the content before presenting. It was important not just to divide the report text between the speakers, but to train smooth slide change over the dashboard, to click the next arrow in time, to allocate enough time for the audience to perceive the visuals and to prepare for the next block.

Since a prezi dashboard is one big background or a canvas and not a set of slides (like a Microsoft PowerPoint presentation) while progressing with the blocks it is important to return to the high-level slide in every content block in order to let the audience follow the prezi structure. Consequently, prezi is an impressive means to attract attention but the structure should be clear and time allocation well elaborated which needs careful preparation and practice from both speakers.

As a collaboration tool Prezi is very efficient. It is easy to add a collaborator, to give rights to edit, to comment or to present. The collaborators pop-up window with the list of current collaborators is at the top right corner of the interface, their contribution is shown over the block which is being changed, a yellow dot demonstrates that a collaborator has commented on the block. Moreover, up to 10 people can be added as a collaborator as a Prezi team. Prezis can be accessed and edited any time, they can be shared, downloaded or saved as a PDF file.

The third collaboration project was writing and submitting for publication a research work in a co-authorship. This project suggests collaboration of the authors with their scientific advisor on every stage of research work and paper submission in Overleaf, an online LaTeX editor. In Ukraine, LaTeX is a typesetting system frequently designated by publishers as obligatory for submitting technical research papers as LaTeX includes features designed for the production of technical and scientific documentation. LaTeX enables users to implement complex typesetting elements such as mathematical expressions, tables, references, and bibliographies very quickly due to consistent document markup across all sections. The system separates the content of a document from its style, and the editors of scientific journals create templates for submissions. These templates have predefined markup so only the content should be added. In LaTeX, there are hundreds of ready templates ranging from various submission markup forms to slide presentations.

For collaborative work in Overleaf, the option for multiple authors to edit the same file simultaneously is a benefit as well as advanced history and version labelling. Moreover, a link between Overleaf and Git (the Overleaf-Git bridge) provides a way of keeping projects offline and being able to work from the command line. Both link sharing and inviting named collaborators give access to projects to users with an Overleaf account.

The undergraduate authors of the mock project and their scientific advisor researched the virtual tools for education. Professional training and foreign language learning were the aspects highlighted in the study. Within the research, the team should have determined the roles and allocated the tasks. When the conference for the study results presentation was chosen, the submission demands included a LaTeX version of the submission file. The advisor,

experienced in using online LaTeX editors, referred the young scientists to Overleaf, where they created accounts and turned to the tutorial section. For successful and efficient project result representation, the co-authors used diagrams and graphs, and tables. So, the Overleaf functions which the co-authors had to master included:

- adding collaborators,
- using the Overleaf file-tree,
- adding and formatting a preamble,
- adding and formatting text,
- preparing, inserting and positioning images,
- adding and formatting a table,
- drawing diagrams,
- compiling,
- labelling and comparing versions and history using,
- simultaneous editing a project,
- adding comments,
- bibliography management,
- downloading a project (at different versions).

The co-authors studied the tutorials and allocated the tasks in the following way: one of the co-authors preliminarily worked on the text (a preamble, text adding, bibliography draft designing), the second co-author preliminarily designed and inserted diagrams, images and tables. Further on, the co-authors studied the result as a common project in Overleaf and started online collaboration. As one of the most apt Overleaf functions the collaborators and the scientific advisor noted the comments function which lets both give the suggestion and mark and explain the made improvements in the project. Referring to project versions is also helpful as it allows editing the project more efficiently.

3.3. Assessment of the collaboration quality level

The participants of the mock projects imitating professional assignments for enhancing collaboration and English communication have been assessed according to their collaboration quality level in the course of work on their mock projects and after the projects were successfully accomplished and their results were presented properly. The following levels have been defined – emerging, developing and proficient ones (Table 2).

The undergraduates who demonstrated the first (emerging) level tend to be passive project participants. They are reluctant to speak out, often agree with the opinion of the majority but at the same time provide support to the group and are ready to obey the instructions in order not to damage the process. The developing level participants show more interest in role and task allocation and more engagement into the project management. They are aimed at efficient work and tend to offer their ideas to enhance the progress. The undergraduates who are proficient in collaboration are fully involved in every project stage from planning to feedback reviewing. They are not necessarily a leader or a speaker (presenter) but the leaders often turn to them for support or a piece of advice.

Table 2

Student performance in collaboration as a process.

Dimension	Quality of collaboration		
	Emerging	Developing	Proficient
Contributing	Considers suggested ideas, means and ways of action, accepts suggested roles and tasks	Adds ideas, is open to discussion, suggests roles and tasks and accepts them	Suggests ideas, means and ways, is aware of alternatives, takes responsibility for decision-making
Monitoring and giving feedback	Assumes the allocated role, works on their own task, follows the process, restrains from offering feedback	Considers own input, takes into account the other participants' and the group's progress, speaks out about the project development	Analyzes the group's progress, adjusts participants' contributing and communicating to benefit the project, provides and receives constructive feedback
Communicating	Is reserved, restates other participants' ideas, is flexible to avoid conflicts	Participates in discussions, is willing to speak out, is flexible to move the group forward	Enhances discussion and input from other participants, prevents and resolves conflicts, draws common conclusions

The assessment of the mock project participants' collaboration skills has been openly discussed with the participants themselves. Firstly, it has been stated that every participant regardless of their collaboration quality level is a significant asset to benefit the project. Secondly, the level characteristics have been presented to the participants in order to highlight the preconditions for the transition from the emerging to the developing level and, correspondingly, from the developing to the proficient level. Thirdly, the expanded characteristics of the proficient collaboration quality level have been explained to the participants in order to form the correct set of qualities (for example, different from leadership, grit and ambition) for successful communication in study or work pairs, groups or teams.

4. Conclusions

Skills in collaboration and in communication (especially, foreign language communication) are equally important for prospective professionals who are determined to be competitive in the labour market. Since collaboration and communication are coherent in most professional environments, it is important to develop undergraduates' ability to interact with prospective equals, superiors and clients and engage them in continuous and efficient collaboration. Command of English enhances common understanding and is an efficient means of communication for international teams. Consequently, developing collaboration and communication skills is one of the most significant goals in ESP courses, since university students as young adults are motivated and professionally trained enough to mock accomplishing a project demanding

well-regulated collaborative work. The academic and profession related projects for various spheres, of different complexity level, with a different participant status and number included logically in the ESP syllabus are the efficient means to train pair, team, and group work. Current working environments are inconceivable without online work therefore online applications are an integral part of collaboration. The survey results have stated that most undergraduates use ICT tools individually and prefer the ones with an interface in their native language. Nevertheless, an appropriate explanation and promotion of specific applications for accomplishing profession related tasks is an efficient way to enhance usage of collaboration options and English interface of the ICT tools such as Google Workspace, Google Slides, Google Docs, Canva Docs, Adobe Acrobat, Microsoft Visual Studio Code, and Adobe Connect. Training undergraduates in using a technological tool for online communication and collaboration creates scaffolding for quick mastering alternative online tools. Assessment and self-assessment experience in profession related mock projects demonstrates undergraduates the most valuable skills demanded in collaborative work and encourages enhancing their collaboration quality level to proficiency in being a reliable and supportive team member or a responsible project leader. Within projects like preparing a presentation, plenum discussion and submission for a conference with online applications like Zoom, Prezi or Overflow, undergraduates learn how to effectively apply technology to benefit the outcome.

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