



## **Descriptive Geometry in the Time of COVID-19: Preliminary Assessment of Distance Education During Pandemic Social Isolation**

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### **ABSTRACT**

The pandemic forced a change in the teaching of descriptive geometry, a basic subject of many engineering fields. To conduct classes during COVID-19, the following resources were used: the ELF platform, MS Teams, SketchUp, AutoCAD, email. It was decided to prepare the electronic textbook along with geometric problems to be solved, supplemented by on-line consultations with students. Despite difficulties (technological, psychological), the results obtained by students during the pandemic were very good. Although the average grade during distance learning was higher than in the case of traditional education, students reported a clear need for direct contact with the teacher.

**Key words:** Distance learning, Descriptive geometry, COVID-19

### **INTRODUCTION**

Descriptive geometry is the basic subject of many engineering fields, allowing for the development of spatial imagination (Suzuki 2002; 2014). The theoretical basics of this subject constitute an introduction to later design using CAD/CG/DG programs (Stachel 2007). Solving geometric problems directly on paper with the aid of drawing tools (pencil, compass, etc.) requires a different way of thinking and it's



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easier than in the case of computer drawing (Wojtowicz, Górska and Wojtowicz 2019). For this reason, this subject is taught at the Cracow University of Technology (Poland) through classic lectures with step-by-step presentation of a given construction and through practical classes during which students solve geometrical problems. However, we may observe the development of computer solutions that support teaching descriptive geometry, which can be used in distance learning, both based on CAD/CAM programs (Stachel 1992; Brakhage 2004; Bokan, Ljucović and Vukmirović 2009; Bokan, Sukilovic and Vukmirovic 2012; Di Paola, Pedone and Pizzurro 2013), as well as online textbooks and libraries of geometric problems (Vukmirović 1998; Santos and Rojas Sola 2000; Gorjanc and Jurkin 2019).

The described course lasts 2 semesters. In the second semester, after 2 weeks, the COVID-19 pandemic forced lessons to be conducted via distance learning due to social isolation introduced by the government.

The basic difficulties regarded the remote transfer of knowledge in such a way that students were able to understand the assumptions of a given construction as well as the correction and evaluation of drawings created by students in pencil technique without direct student-teacher contact. Students, in the case of lab-intensive courses, prefer the traditional form of direct contact with the lecturer than online consultation (Scherrer, Butler and Burns 2010). Other difficulties included:

- varied internet access and hardware capabilities of home computers used by students and teachers – some students and teachers had old types of computers; also, some students did not have access to a computer for several weeks (there was a almost complete lockdown in Poland, from 25 March to 19 April 2020), some participants lived in remote places without access to the broadband Internet, or the connection was overloaded;
- temporary lack of or limited contact with students – resulted from equipment or technical problems, but also from pandemic - related anxiety that thwarted students' normal functioning (diagnosis with COVID-19 among relatives, hospitalization, waiting for COVID-19 test results, undergoing quarantine, or media reports concerning the increase in morbidity and mortality, etc.);
- varied photo quality – students photographed their completed drawing tasks with cell phones that differed technologically;
- very short time to implement new solutions – announcement related to the closure of the university and the lockdown appeared overnight;
- the need to implement every topic outlined in the syllabus and to achieve all expected learning outcomes;
- uncertainty as to the duration of distance teaching, as government regulations changed approximately every 2 to 3 weeks, prolonging the existing restrictions.

The study aimed to check whether the methods of remote teaching introduced to descriptive geometry subject, despite emerging difficulties, resulted in students' mastery of the planned program,



and whether students' achievements and grades improved as compared to the fall semester. An important question was how the students evaluated remote classes of descriptive geometry.

## METHODS

To conduct classes, the ELF (E-learning Framework) platform, MS Teams, SketchUp and AutoCAD programs and email were used. Since no materials for remote learning were available at the university, it was decided to prepare a version of the electronic textbook along with geometric problems to be solved, supplemented by remote consultations with students.

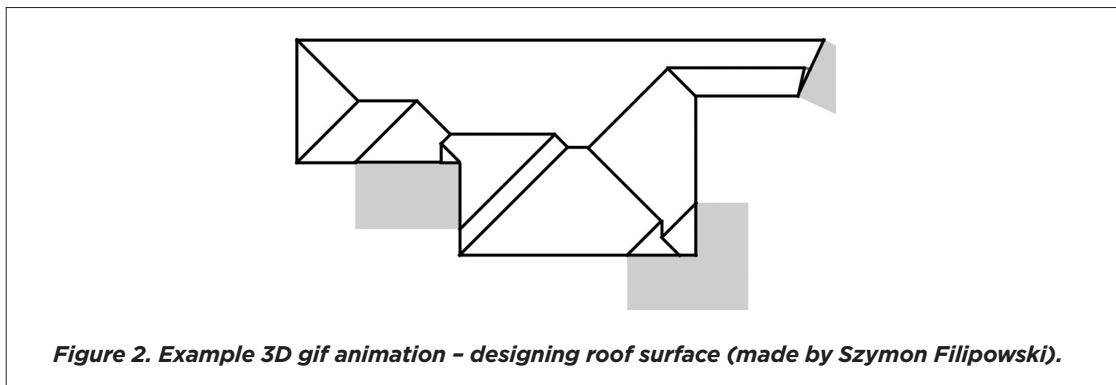
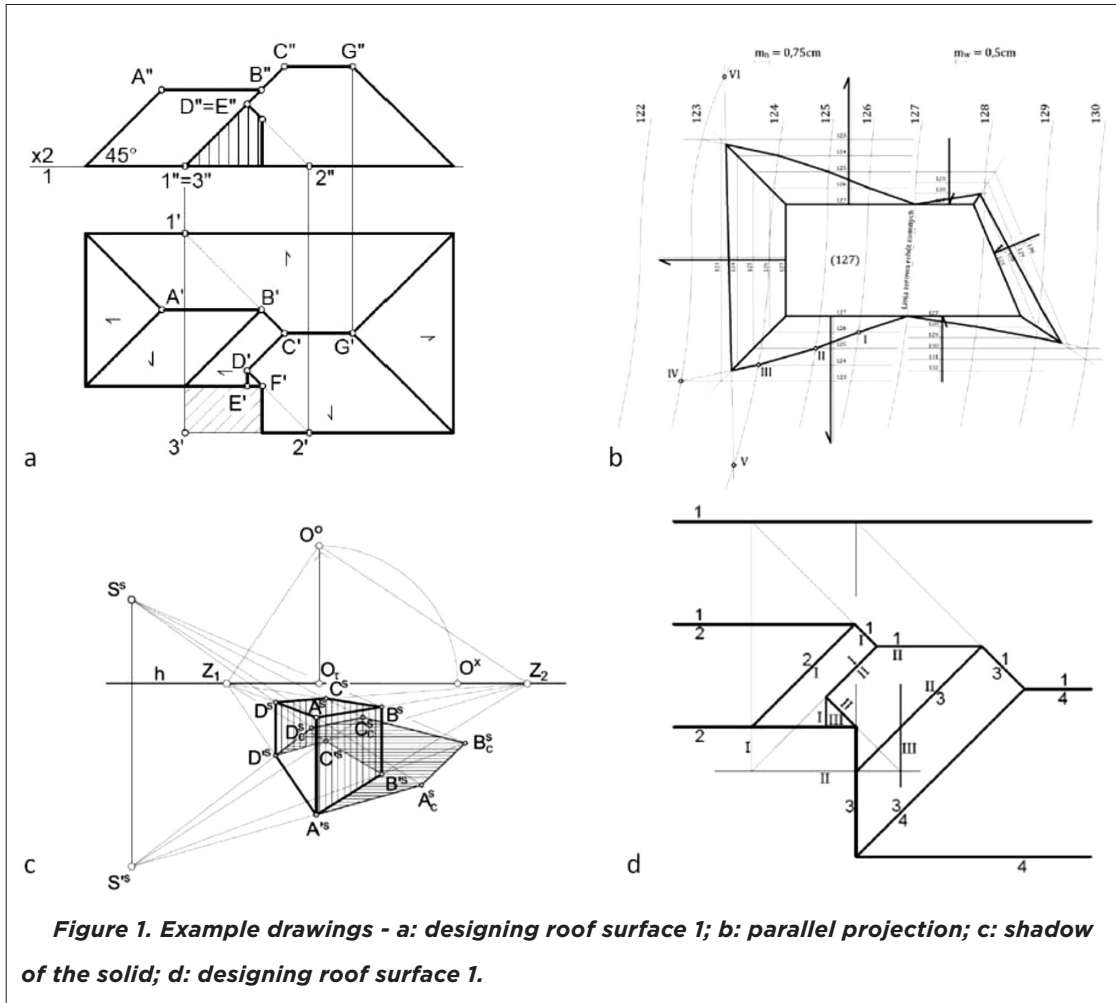
The learning curve was analyzed (6 consecutive tasks) and the average marks from the first and second semester were compared. In addition, 94 students (66% of all) participating in the course completed a short (~10 min), anonymous survey evaluating remote classes (see Appendix A), prepared in Google Forms, modeled on the survey by Martín-Gutiérrez et al. (2013), containing 14 closed questions (amount of work, comparison to the traditional lectures, preferred form of classes, quality of the on-line materials, etc.), 1 voluntary open-end question (ideas for improvement that could be implemented in the future). Calculations were done using the Statistica 13.3 program.

## PRELIMINARY RESULTS

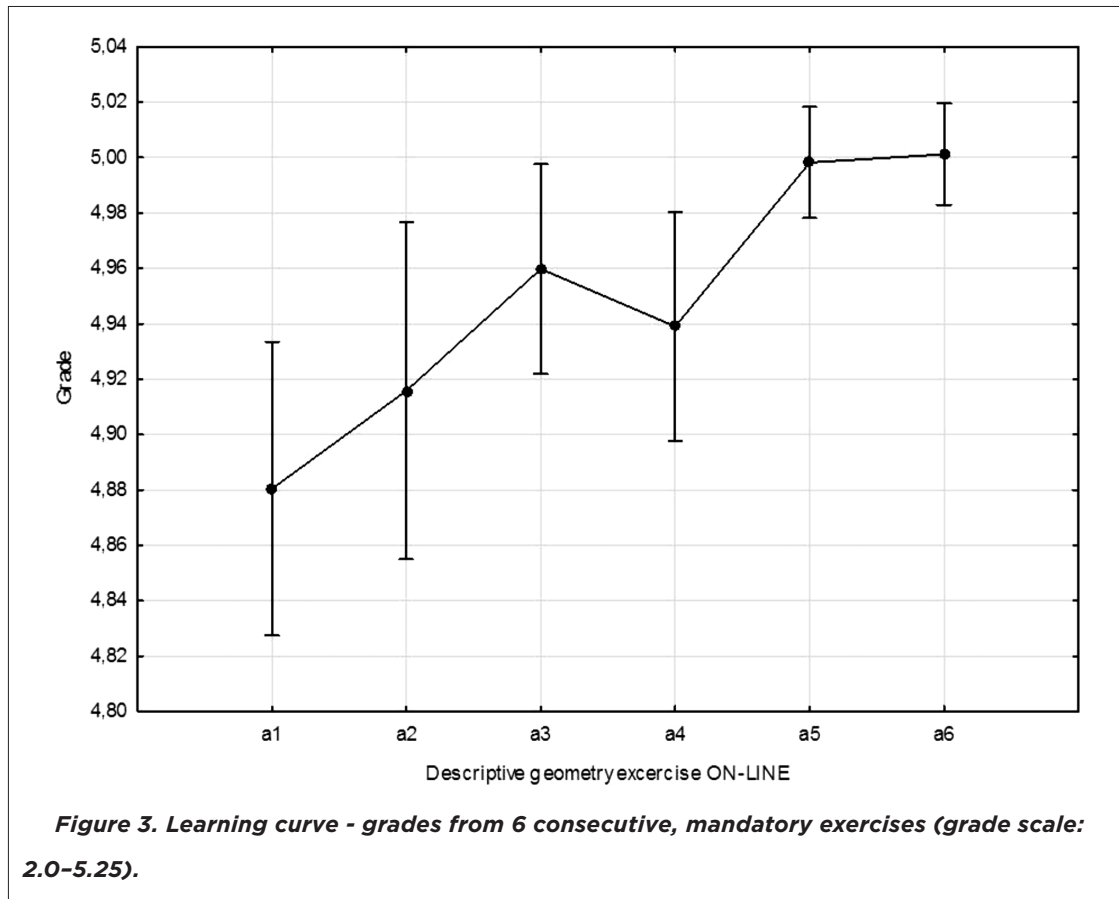
Every week, text materials (theoretical basics and detailed construction descriptions) and drawings (Figure 1) explaining individual geometric issues were published on the ELF, with intensive support in the form of electronic communication. Each student saved their private email address to ELF, which made it easier to contact them in the case of difficulties with the university server, which at times, couldn't cope with the huge transfer that resulted from the implementation of distance learning throughout the whole university.

All text and drawing materials were prepared according to the syllabus: roof design, parallel and central projection with vertical perspective. Based on the information from the lecture, students solved drawing tasks, then sent a photo of the solved task for teacher assessment. An individual explanation of errors and their correction was presented in the form of a text description. Since this didn't always allow achieving the assumed results, a correction was introduced by the teacher drawing and sending a photo of the appropriate solution. Animated gifs illustrating the correct solution in 3D version were also introduced (Figure 2).

The availability of materials was not time-limited, and consultations were also conducted from 6:00 p.m. to 12:00 a.m. because many students only then had access to a home computer, which was often used by the rest of the family for remote work or study during the pandemic.



*Figure 2. Example 3D gif animation - designing roof surface (made by Szymon Filipowski).*



The effectiveness of used strategies could be seen in the increasing course of the learning curve with grades improvement during semester of distance learning ( $F_{5,405}=6.55; p<0.001$ ; Figure 3). The difficulty of the topics varied over the semester - the initial four consecutive topics were increasingly difficult, and the last two were slightly easier.

The results obtained by students during the pandemic were very good. Comparison of two semesters showed that the average grade from 6 drawing tasks during distance learning was higher than in the case of traditional education (Table 1). A grade scale from 2.0 (letter grade: F) to 5.25 (letter grade: A+) was used.

**Table 1. Comparison of average grades during pandemic and traditional learning.**

|               | Mean sem1 | Mean sem2 | $t^*$ | $df$ | $p$    | N sem1 | N sem2 | Levene $F(1,240)$ | $p$ Levene |
|---------------|-----------|-----------|-------|------|--------|--------|--------|-------------------|------------|
| Average grade | 4.54±0.33 | 4.87±0.22 | -8.94 | 180  | <0.001 | 110    | 132    | 8.46              | 0.004      |

\* -  $t$ -test with separate estimation of variance



The group in the second semester was slightly larger due to the addition of 22 students who attended another lecturer's geometry classes in the first semester (there are two parallel lecture groups in both semesters). The grading rules were the same in both semesters - most grades were given by the same two persons, only about 20% of the grades in the first semester were given by an additional grader cooperating with the main lecturer for many years. The effect may have occurred due to more individualized feedback as compared to regular classes (Kulpa 2014) and increased time to complete the task. On-line classes also allowed for more detailed explanation regarding the theoretical basics of a given structure compared to time-restricted traditional classes.

The students mostly rated the quality of the materials as good, considering them comprehensible, clear and well-structured, while concluding that they required additional consultations to prepare for the exam. The need for consultations during geometric tasks was also noted, but was less pronounced. Sixty eight percent of students said that the prepared materials allowed them to acquire knowledge more easily than in the case of textbooks. At the same time, 85% stated that this was more difficult than during traditional classes, and as much as 91.5% would prefer descriptive geometry to be learned in the traditional way, which is not surprising, because 82% devoted more time to studying in the second semester during the COVID-19 pandemic. On-line classes were also associated with great effort and time-burden for the teacher.

The students appreciated the possibility of unrestricted access to materials (almost half of the respondents studied geometry between 6:00 p.m. and 12:00 a.m.), but would prefer to receive additional video materials containing a record of the individual steps to create a structure that would complement the textual description and final drawing. The analysis of the answers to the open-end question, which was made by three analysts, indicates that, for students, the greatest problem was to imagine the individual steps, so they would like to receive visual, "crib-sheet" templates to create the drawing (20 of 31 answers).

### **NEXT STEPS**

The pandemic and necessity of distance teaching showed that students need classes developing spatial imagination, and when necessary to conduct e-classes - the visualization of individual drawing steps for a given structure. Although the results indicate that all learning outcomes were met and the students earned better grades than in the fall semester with brick- and- mortar teaching, there was a clear need for direct contact with the teacher. While this is only a preliminary study, we intend to collect additional data to conduct more structured analysis of students' answers and comments.



In preparation for a possible second wave of the pandemic, we plan to:

1. Prepare analogous distance learning materials for the first part of the course, supplemented with video materials illustrating examples solutions for a given topic.
2. Improve e-contact with students and organize a forum with a specific time frame for consulting the teacher (before noon, in the afternoon and evening).
3. Maintain unlimited time access to materials.

Our expected result is that students should not feel overburdened by remote work and be able to see the beauty and sense of descriptive geometry, allowing the students to discover, despite the pandemic, that studying promotes their personal development.

## REFERENCES

- Bokan, N., M. Ljucović, and S. Vukmirović. 2009. "Computer-aided teaching of descriptive geometry." *Journal for Geometry and Graphics* 13(2): 221-229.
- Bokan, N., T. Sukilovic, and S. Vukmirovic. 2012. "On modeling of competencies in a descriptive geometry course." *Pollack Periodica* 7 (Suppl.): 173-183. DOI: 10.1556/Pollack.7.2012.S.17.
- Brakhage, K.-H. 2004. "WinCAG - Education Software for Geometry." *The 11<sup>th</sup> International Conference on Geometry and Graphics*, 1-5 August, 2004, Guangzhou, China. [https://www.igpm.rwth-aachen.de/Download/reports/brakhage/china\\_icgg.pdf](https://www.igpm.rwth-aachen.de/Download/reports/brakhage/china_icgg.pdf).
- Di Paola, F., P. Pedone, and M.R. Pizzurro. 2013. "Digital and interactive Learning and Teaching methods in descriptive Geometry." *Procedia - Social and Behavioral Sciences* 106: 873-885. DOI: 10.1016/j.sbspro.2013.12.100.
- Gorjanc, S., and E. Jurkin. 2019. "Web textbook for descriptive geometry." *FME Transactions* 47(2): 263-266. DOI: 10.5937/fmet1902263G.
- Kulpa, T. 2014. "Experiences in classes conduction using Moodle platform." [in Polish]. *Zeszyty Naukowe Wydziału Elektrotechniki i Automatyki Politechniki Gdańskiej* 37: 33-36.
- Martín-Gutiérrez, J., F.A. Gil, M. Contero, and J.L. Saorín. 2013. "Dynamic three-dimensional illustrator for teaching descriptive geometry and training visualisation skills." *Computer Applications in Engineering Education* 21(1): 8-25. DOI: 10.1002/cae.20447.
- Santos, E.T., and J.I. Rojas Sola. 2000. "An On-Line Library of Descriptive Geometry Problems." In *Proceedings of the 9<sup>th</sup> International Conference on Geometry and Graphics*, Vol. 1, 295-299, Johannesburg, South Africa.
- Scherrer, Ch., R. Butler, and S. Burns. 2010. "Student Perceptions of On-Line Education." *Advances in Engineering Education*, Summer 2010, 2(2): 1-23. <https://advances.asee.org/wp-content/uploads/vol02/issue02/papers/aee-vol02-issue02-p07.pdf>.
- Stachel, H. 1992. "Educational Software for Descriptive Geometry." In *Proceedings of the 5<sup>th</sup> International Conference on Engineering Computer Graphics and Descriptive Geometry*, edited by V.O. Thomas, and W.P. Lewis, Vol. 1, 305-307, Melbourne, Australia.
- Stachel, H. 2007. "The status of today's Descriptive Geometry related education (CAD/CG/DG) in Europe." *Journal of Graphic Science of Japan* 41 (Supplement 1) 15-20.
- Suzuki, K. 2002. "Activities of the Japan Society for Graphic Science - Research and Education." *Journal for Geometry and Graphics* 6(2): 221-229.



Suzuki, K. 2014. "Traditional Descriptive Geometry Education in 3D-CAD/CG Era." *Journal for Geometry and Graphics* 18(2): 249–258.

Vukmirović, S. 1998. "Electronic Problem Book in Descriptive Geometry." Accessed May 21, 2020. <http://alas.matf.bg.ac.rs/~vsrdjan/files/zbirka/proba.htm>.

Wojtowitz, B., R. Górska, and A. Wojtowitz. 2019. *Visualization in architecture – theoretical backgrounds, research analysis and practical applications* [in Polish]. Kraków: Wydawnictwo Politechniki Krakowskiej.

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**APPENDIX A: RESULTS OF THE QUESTIONNAIRE**

|  |          |          |
|--|----------|----------|
| 1. How would you evaluate the time needed to comprehend the material and to do the tasks sent electronically compared to standard lectures and practical classes held earlier? |          |          |
| <b>Answers</b>   | <b>#</b> | <b>%</b> |
| a. I spend less time on learning geometry on-line during the 2 <sup>nd</sup> semester  | 0        | 0.00     |
| b. Comparable  | 77       | 81.91    |
| c. I spend more time on learning geometry on-line during the 2 <sup>nd</sup> semester  | 17       | 18.09    |
| 2. Was it easier to comprehend the discussed topics during traditional lectures and practical classes or during on-line learning?  |          |          |
| <b>Answers</b>   | <b>#</b> | <b>%</b> |
| a. Much easier through traditional lectures and practical classes  | 58       | 61.70    |
| b. A bit easier through traditional lectures and practical classes   | 22       | 23.40    |
| c. Comparable  | 4        | 4.26     |
| d. A bit easier through on-line learning   | 10       | 10.64    |
| e. Much easier through on-line learning  | 0        | 0.00     |
| 3. How would you evaluate the easiness of acquiring and comprehending the topic presented in our materials compared to books, e.g. by Z. Palasinski?                           |          |          |
| <b>Answers</b>   | <b>#</b> | <b>%</b> |
| a. Much easier via on-line materials   | 33       | 35.11    |
| b. A bit easier via on-line materials  | 31       | 32.98    |
| c. Comparable  | 25       | 26.60    |
| d. A bit easier based on books   | 5        | 5.32     |
| e. Much easier based on books  | 0        | 0.00     |
| 4. If you could take part in our classes once more, which form of classes would you choose?  |          |          |
| <b>Answers</b>   | <b>#</b> | <b>%</b> |
| a. Traditionally held classes  | 86       | 91.49    |
| b. On-line classes in the form of those held in the 2 <sup>nd</sup> semester   | 8        | 8.51     |
| 5. What form of on-line descriptive geometry classes do you believe to be the most effective?  |          |          |
| <b>Answers</b>   | <b>#</b> | <b>%</b> |
| a. Sharing text and graphic materials (without access time limitation)   | 9        | 9.57     |
| b. Video tutorials with lecturer voiceover and video/animation demonstrating the discussed topic (without access time limitation)  | 78       | 82.98    |
| c. Live, on-line classes, in which participation is only possible on given days and at particular times, e.g. via the ZOOM platform  | 7        | 7.45     |
| 6. Of what significance for you is the possibility to have constant access to materials and, at the same time, freedom to choose work-time?                                    |          |          |
| <b>Answers</b>   | <b>#</b> | <b>%</b> |
| a. This is very important because I can study on days and at times selected by me and I can work at my own pace  | 88       | 93.62    |
| b. I would prefer strictly selected times for participation in classes   | 6        | 6.38     |
| 7. At what time (when) did you study geometry most often?  |          |          |
| <b>Answers</b>   | <b>#</b> | <b>%</b> |
| a. in the morning (6:00 a.m.–12:00 p.m.)   | 4        | 4.26     |
| b. in the afternoon (12:00 p.m.–6:00 p.m.)   | 43       | 45.74    |
| c. in the evening (6:00 p.m.–12:00 a.m.)   | 41       | 43.62    |
| d. at night (12:00 a.m.–6:00 a.m.)   | 6        | 6.38     |
| 8. If you believe that the classes held on-line could be improved, please describe in what way this could be done (optional open-end question)?                                |          |          |



**Evaluate distance learning of the subject “Descriptive geometry” during the 2<sup>nd</sup> semester. Please, provide an honest reference to the statements, using the 1 to 5 scale given below**

|     | 1   | 2          | 3                           | 4         | 5               |           |
|-----|---|------------|-----------------------------|-----------|-----------------|-----------|
|     | I totally disagree  | I disagree | I slight agree/<br>disagree | I agree   | I totally agree | Mean      |
| 9.  | The on-line materials were well- and carefully presented  |            |                             | 1 2 3 4 5 |                 | 4.10±0.69 |
| 10. | The on-line materials regarding theoretical content (lecture) were clear and well-constructed                                       |            |                             | 1 2 3 4 5 |                 | 3.85±0.70 |
| 11. | In my opinion, the form of presenting the theoretical part (lecture) was appropriate (type of description, explanatory drawings)    |            |                             | 1 2 3 4 5 |                 | 3.64±0.81 |
| 12. | After becoming acquainted with the materials, I felt I could solve the exercise (do the task)                                       |            |                             | 1 2 3 4 5 |                 | 3.02±0.87 |
| 13. | I needed an on-line consultation (e.g. e-mail, forum, ZOOM) with the lecturer to solve the exercises (do the task)                  |            |                             | 1 2 3 4 5 |                 | 3.43±1.10 |
| 14. | I needed an on-line consultation (e.g. e-mail, forum, ZOOM) with the lecturer to prepare for the exam                               |            |                             | 1 2 3 4 5 |                 | 4.10±0.98 |
| 15. | The form of conducting classes (type of on-line materials, number of consultations) allowed me to sufficiently prepare for the exam |            |                             | 1 2 3 4 5 |                 | 3.24±0.91 |