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Comparing Students' Perceptions of Technical Drawing Teaching Before and After COVID-19 Emergency

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ABSTRACT

The advent of the COVID-19 emergency has affected all aspects of daily life, inevitably causing also significant changes at every education level. These changes have led to a sudden shift from face-to-face to online teaching, with a heavy impact on both interaction modes and methods and tools exploited meanwhile. The research described in this paper started by collecting data from university students about their perception of technical drawing teaching before and during/after COVID-19. The analysis of this students' point of view, along with considerations about their performance (exam passing rates and marks, etc.) highlighted some suggestions to improve university courses, making them more effective and attractive.

Keywords: Technical drawing teaching, Covid-19, Online teaching, Engineering education, Students' surveys

INTRODUCTION

As we are aware by now, the advent of the COVID-19 emergency (hereafter, COVID-19) has affected all aspects of daily life, inevitably causing also significant changes to every education level. These changes have led to a sudden shift from face-to-face to online teaching, with a heavy impact on both interaction modes and methods and tools exploited meanwhile. Around the world, and here in Italy as well, many institutions of all types and sizes decided or were forced to avoid face-to-face teaching, including lessons, labs and other modes, and move to online to prevent the COVID-19 spread. As suggested by Hodges et al. (2020), Gomez Recio and Colella (2020) and Govindarajan and Srivastava (2020), given the need to move to online, rather than talking about online teaching it seems more correct to refer to it as "emergency distance teaching," mainly to avoid the bad reputation that online teaching earned in recent years against face-to-face teaching. The University of Udine (Italy) made this choice to ensure the continuity of several educational offerings. At present time, close to the end of the COVID-19, there is a gradual return to face-to-face teaching; however, some teaching modes sprung up in the last three years have been maintained (Dagman and Wärmefjord, 2022; Bernardes and Oliveira, 2021; Paderno et al., 2022). Our university courses on technical drawing regard second-year management and mechanical engineering students. Before COVID-19, each course consisted of 48 hours of

theoretical lessons and classroom exercises. The first 40–42 hours focused on theory and hand drawing. The next six to eight hours were devoted to the use of 2D CAD tools. Two to four hours of optional classroom exercises were added, offering training about the exam preparation. The exercises, assigned weekly, were collected, corrected, and commented in subsequent lessons. Moving to online teaching due to the COVID-19, the 48-hour lessons, comprising both theoretical topics and exercises, were delivered through the Microsoft TEAMS platform. For the sake of custom and practicality of management, the exchange of materials (lessons slides, pictures of hand drawings, CAD files, etc.) happened using the Moodle system. In place of pre-exam training in the extra classroom hours, online exercises were offered in the form of guided exercises with the teacher present online and available to provide clarification or answer questions in real-time. As for what happened before COVID-19, the exercises collected were regularly corrected and commented during the online lessons. All online teaching (lessons, exercise corrections, etc.) were recorded and the recordings were immediately made available to the students in the Microsoft TEAMS repositories.

The work described in this paper, which is part of a broader research on technical drawing teaching carried out by the University of Udine (Italy) in collaboration with the University of Brescia (Italy) (Speranza et al., 2017), aims to investigate about possible correspondences, correlations, or variations in students' perceptions of technical drawing teaching and achievements before and during/after COVID-19. The research exploited Google Forms questionnaires, administered online since 2016-17. During/after COVID-19 additional questions related to specific teaching because of the COVID-19 appeared. The goal of this work is twofold. While we can quantitatively assess the impact of COVID-19 on technical drawing teaching by comparing exam passing rates and marks before, during, and after the COVID-19, the analysis of the data collected thanks to the questionnaires allows us reasoning about the effectiveness of the teaching from the students' point of view. Moreover, the research outcomes are helping us to keep tuning/optimizing our teaching. Starting from what we used to do before COVID-19, we are shifting toward a multimodal/multimedia approach, more flexible than before, scalable and able to adapt to different scenarios that could show up as time goes by but, at the same time, keeping teaching quality high.

In the following, the survey based on the Google Forms questionnaires will be presented; then, the collected data will be analyzed, and the results obtained will be discussed. Finally, the paper will offer some suggestions to make teaching even more effective and attractive. Conclusions and hints for future research developments will close the paper.

MATERIALS AND METHODS

The Questionnaire on Technical Drawing Teaching

A first version of the questionnaire, labelled as Q1, was proposed to students in the academic year 2016-17. It consisted of 26 questions. The first 14 questions referred to technical drawing topics and were based on the model proposed by Barr (2012) and Barr (2004). Other ten questions were related to

Industry 4.0 topics, to the use of educational support tools and to the involvement of specific CAD tools. There were also two open questions about technical drawing teaching and about the involvement in design competitions. The results have been already discussed by Motyl et al. (2021) and Motyl et al. (2022). Table 1 shows the section of this questionnaire of interest here.

A revised version of the questionnaire, labelled as Q2, was used to carry out the survey during/after COVID-19. This version, proposed first in 2020-21, consisted of 23 questions. Seventeen questions came from Q1 and concerned technical drawing topics. Six new questions aimed at collecting students' perceptions about changes such as online teaching, use of new technologies for remote meetings, etc. (Motyl et al. 2022). For example, the better focus on these specificities can be seen in question Q2-21, where the assessment of students' perceptions comes from considering their liking about 16 specific statements, developed also thanks to the answers to Q1-25. For this research, only some sentences (S5, S10, S11, S12, S13, S14, S15 and S16) are considered, as highlighted in Table 2, where the section of this second version of the questionnaire of interest here is shown.

The focus on the sections as in Tables 1 and 2 is because those questions cover topics comparable between the two versions of the questionnaire.

Table 1. Section of the questionnaire administered before COVID-19 of interest here.

#	Question
Q1-05	How important is to be able to generate drawings using 2D CAD tools?
Q1-06	How important is to be able to generate models using 3D CAD tools?
Q1-17	How important is to be able to interact with the teacher using digital devices (smartphone, tablet, PC, etc.)?
Q1-18	Which digital devices do you own (desktop PC, laptop PC, etc.)?
Q1-19	Have you ever used a LMS (Learning Management System)?
Q1-25	Have you any suggestion about teaching improvement?

Table 2. Section of the questionnaire administered during/after COVID-19 of interest here.

#	Question
Q2-05	How important is to be able to generate drawings using 2D CAD tools?
Q2-06	How important is to be able to generate models using 3D CAD tools?
Q2-17	Which digital devices do you own (desktop PC, laptop PC, etc.)?
Q2-18	Which kind of internet connection do you have at home?
Q2-19	Which device do you use most to take lessons?
Q2-20-S1	I own enough pieces of hardware and software to follow online lessons
Q2-20-S2	My skill and knowledge are enough to manage online teaching
Q2-21-S5	Communicating with the teacher during the online lessons was easy
Q2-21-S10	I am satisfied with the student-teacher interaction experienced during online teaching
Q2-21-S11	I would like to continue to attend online classes even after the COVID-19
Q2-21-S12	I am satisfied of the online lessons and of the materials available
Q2-21-S13	I had the opportunity to ask questions or clarify concerns during the online lessons
Q2-21-S14	Availability of the recordings of the lessons is useful
Q2-21-S15	Teacher's generalized comments of exercises are useful
Q2-21-S16	Online guided exercises in extra lesson hours are useful

RESEARCH ACTIVITIES

Once the questionnaires were ready to be administered, the second-year students of Management and Mechanical Engineering degrees at the University of Udine who attended technical drawing courses (face-to-face or online) in 2016-17, 2017-18, 2020–21 and 2022–23 have been asked for answer to them. Table 3 summarizes the characteristics of the student sample interviewed, classified by year. The lack of continuity in the administration of the questionnaires is due to the fact that surveys on different topics were carried out in the other academic years.

Table 4 and 5 summarize the answers to the questionnaires before the COVID-19 (2016-17 and 2017-18) and during/after it (2020-21 and 2022-23), respectively.

Table 3. Student sample involved in the research.

Academic year	Management Engineering		Mechanical Engineering		Totals
2016-17	46	65.7%	24	34.3%	70
2017–18	42	56.0%	33	44.0%	75
2020–21	62	55.9%	49	44.1%	111
2022–23	37	53.6%	32	46.4%	69
Totals	187	57.5%	138	42.5%	325

Table 4. Answers to the questionnaire before COVID-19.

#	Academic year 2016–17	Academic year 2017-18
Q1-05	Mean value (scale 1-5): 4.36	Mean value (scale 1-5): 4.18
Q1-06	Mean value (scale 1-5): 4.29	Mean value (scale 1-5): 4.25
Q1-17	Mean value (scale 1-5): 3.26	Mean value (scale 1-5): 3.86
Q1-18	Desktop/laptop computer: 100%	Desktop/laptop computer: 100%
	Smartphone: 100%	Smartphone: 100%
	Tablet: 41%	Tablet: 45%
	Other: 12%	Other: 15%
Q1-19	Moodle	Moodle
	Yes, often: 50.00%	Yes, often: 51.86%
	Yes, sometimes: 16.67%	Yes, sometimes: 16.56%
	Seldom: 5.55%	Seldom: 5.75%
	Never: 27,78%	Never: 25.83%
	Google classroom	Google classroom
	Yes, often: 0%	Yes, often: 0%
	Yes, sometimes: 2.78%	Yes, sometimes: 4.62%
	Seldom: 9.72%	Seldom: 10.71%
	Never: 87.50%	Never: 84.67%
Q1-25	More in-classroom exercises	Need of quick explanations during exercises
	Written correction of exercises	
	More practice on 2D CAD tools	Tutorials on 2D/3D CAD tools
	Use of 3D CAD tools	Exercises classified by topic

Table 5. Answers to the questionnaire during/after COVID-19.

#	Academic year 2020–21	Academic year 2022-23
Q2-05	Mean value (scale 1-5): 4.43	Mean value (scale 1-5): 4.42
Q2-06	Mean value (scale 1-5): 4.40	Mean value (scale 1-5): 4.53
Q2-17	Desktop/laptop computer: 100% Smartphone: 95.5% Tablet: 47.7% Other: 3.6%	Desktop/laptop computer: 100% Smartphone: 92.9% Tablet: 46.7% Other: 3.6%
Q2-18	Fiber: 36.9% ADSL: 44.1% Hot spot with smartphone: 24.3% Other: 11.7%	Fiber: 53.6% ADSL: 35.7% Hot spot with smartphone: 21.4% Other: 14.3%
Q2-19	Desktop/laptop computer: 96.4% Tablet: 2.7% Smartphone: 0.9% Other: 0%	Desktop/laptop computer: 92.9% Tablet: 7.1% Smartphone: 0% Other: 0%
Q2-20-S1	Mean value (scale 1-5): 4.71	Mean value (scale 1-5): 4.42
Q2-20-S2	Mean value (scale 1-5): 4.52	Mean value (scale 1-5): 4.14
Q2-21-S5	Mean value (scale 1-5): 3.65	Mean value (scale 1-5): 3.35
Q2-21-S10	Mean value (scale 1-5): 3.49	Mean value (scale 1-5): 3.36
Q2-21-S11	Mean value (scale 1-5): 3.32	Mean value (scale 1-5): 3.21
Q2-21-S12	Mean value (scale 1-5): 4.29	Mean value (scale 1-5): 4.03
Q2-21-S13	Mean value (scale 1-5): 3.95	Mean value (scale 1-5): 3.50
Q2-21-S14	Mean value (scale 1-5): 4.84	Mean value (scale 1-5): 4.46
Q2-21-S15	Mean value (scale 1-5): 4.79	Mean value (scale 1-5): 4.35
Q2-21-S16	Mean value (scale 1-5): 4.34	Mean value (scale 1-5): 3.53

Table 6. Exam passing rates and average marks.

	Management Engineering				Mechanical Engineering			
	Enrolled	Passed	Rate %	Marks [18-30]	Enrolled	Passed	Rate %	Marks [18-30]
2016-17	203	111	54.67	23.60	121	79	65.29	23.88
2017-18	196	125	63.78	23.74	126	85	67.46	23.84
2020-21	109	94	86.24	24.09	118	109	92.37	24.91
2022-23	31	20	64.52	24.35	14	11	78.57	26.85
Totals	539	350	64.94	23.82	379	284	74.93	24.66

Finally, Table 6 reports the passing rates and the average marks of the exams for the academic years considered. For each academic year, students have six exam sessions available, distributed over three periods: winter, summer, and autumn. Please note that in 2022–23 only one session took place up to now.

RESULTS AND DISCUSSION

The analysis of the answers reported in Tables 4 and 5, as well as the consideration of the exam passing rates and average marks as in Table 6, allow evaluating the performance of the technical drawing teaching before and

during/after COVID-19 from the students' point of view as well as suggesting some correcting/improving actions. The refinement of the questionnaire from before to during/after COVID-19 consisting in the introduction of new or more specific questions/sentences, made possible to classify teaching aspects as general rather than specific to technical drawing. Thus, the analysis is structured according to two points of interest referring to general teaching (General Points of Interest - GPI): GPI1 - level of interaction expected or perceived by students during lessons (face-to-face and online) and GPI2 - possible methods and tools to promote interaction and quick communication both during and after lessons, and four points of interest related to specific technical drawing teaching (Specific Points of Interest - SPI): SPI1 - availability of supplementary materials such as recordings, video explanations, collection of structured exercises, etc., SPI2 - availability of teachers' explanations during the lessons and comments/guided corrections of exercises, SPI3 - attention to the use of 2D and 3D CAD tools, SPI4 - willingness to follow extra hours exercises.

Regarding GPI1 - level of interaction expected or perceived by students during lessons (face-to-face and online), the following questions were considered: Q1-17, Q1-18, Q2-19, Q2-20-S1, Q2-21-S5, and Q2-21-S10. Students' interest in being able to interact with the teacher before COVID-19 was very high, with mean values well above 3 (Q1-17). This is further reinforced considering Q1-18, which attest to the students' good technological equipment. Most of them declared that they had multiple devices (tablets in particular). These conditions were also maintained for the years during/after COVID-19 (Q2-17), where we see that tablet ownership reaches almost 50% of students. In addition, during/after COVID-19 students stated that they had excellent internet connection methods (Q2-18). Considering the level of perceived interaction during the lessons, Q2-21-S5 and Q2-21-S10 have mean values above 3. These very positive data are also confirmed by Q2-19 and Q2-20-S1, which further state very good conditions that enabled students to follow online lessons in a very effective and better performing way.

As regards GPI2 - possible methods and tools to promote interaction and quick communication both during and after lessons, Q1-19 and Q2-20-S2 were considered. In addition, a premise needs to be made. In 2016–17 and 2017-18, only the Moodle system was available at our university, and, as it can be seen from Q1-19, only about 50% of the students reported the regular use of it. In those years, the Moodle system was mainly used by teachers to distribute materials in the form of slides or notes/handouts and to collect material submitted by students (e.g., images,.doc or.pdf documents, etc.). At that time, not all teachers of engineering courses used it, while the Moodle system was regularly used for teaching technical drawing. This situation improved considerably over the years during/after COVID-19. The increased use of the Moodle system and the use of platforms such as Microsoft TEAMS made students become familiar with these kinds of tools (values above 4 for Q2-20-S2 and above 3 for Q2-21-S5), to the extent that they are now a common practice, for example, to carry out student reception or to get quick answers from teachers. All this denotes an excellent ability to

adapt and to learn and acquire new skills in a short time, which must be maintained considering the regular use of these tools.

Regarding SPI1 - availability of supplementary materials such as recordings, video explanations, collection of structured exercises, etc., Q1-25, Q2-21-S11, Q2-21-S12, and Q2-21-S14 were considered. Students' responses attested to high satisfaction (mean values above 4 in Q2-21-S12) for the quality of the materials and explanations provided, all of this against the suggestions coming from Q1-25. Although in 2022–23 there was the return to the traditional teaching mode (face-to-face lessons), recordings of lessons continued to be provided for technical drawing courses. This opportunity was appreciated by a good number of students (mean value above 4 for Q2-21-S14). Students, on the other hand, did not seem particularly interested in continuing to take online-only lessons, given the mean value around 3 for Q2-21-S11.

As regards SPI2 - availability of teachers' explanations during the lessons and comments/guided corrections of exercises, Q1-25, Q2-21-S13 and Q2-21-S15 were considered. It is worth to say that teaching changes were already introduced to the lessons due to the answers to Q1-25; therefore, there is inevitably some bias in the collected data because actions occurred meanwhile had been driven by the outcome of Q1 rather than having been performed independently. For example, after 2018, some additional exercises were introduced regularly during classroom lessons, based on the specific topics covered in class. Returning to the responses received to the questions considered above for SPI2, these two practices were highly valued by students in 2020–21 during COVID-19 and continued to be highly valued in 2022-23, as evidenced by the mean values around 4 for Q2-21-S15 and well above 3.5 for Q2-21-S13.

Regarding SPI3 - attention to the use of 2D and 3D CAD tools, Q1-05, Q2-05, Q1-06 and Q2-06 were considered. Both before and during/after COVID-19, students show considerable interest in the use of 2D and 3D CAD tools since the answers provide mean values well above 4 for all questions. It should be noted that in the years before COVID-19 such tools were used in equipped computer classrooms, while during and after COVID-19, students were given the opportunity to install the software packages on their PCs by taking advantage of academic licenses.

Finally, regarding SPI4 - willingness to follow extra hours exercises, Q1-25 and Q2-21-S16 were considered. Again, some teaching changes were introduced over the years due to the answers to Q1-25. The responses received revealed two different perceptions. While in 2020–21 students showed a high appreciation for the possibility of attending exercises led by teachers during extra hours outside the lessons (mean value above 4 for Q2-21-S16), in 2022-23, this possibility is less appreciated (mean values around 3). A possible reason is that during COVID-19 exercises management was offered in online mode, while now they occur face-to-face again, adding up to other initiatives offered by different courses/teachers and forcing students to make choices about how to spend their time.

In order to get a picture even more complete, the analysis of these points of interest was coupled with the consideration of the students' performance achieved in these years. Both exam passing rates and the average marks

were examined. The most significant finding concerns the exam passing rate which has increased significantly over the COVID-19 years (we exclude current year because data are partial) from above 60% to 90%. Less significant is the comparison with the average marks achieved, which remains almost unchanged, with a very slight increase (from 24 to almost 25 points out of 30). We can hypothesize that the increase in the pass rate was influenced by several factors such as the changes made to the lessons over the years or the move to the online mode. Whether there are correlations between these aspects could be analyzed in future research.

All this said, actions occurred during the last seven years, aimed at improving quality and effectiveness of our technical drawing teaching, could be coupled to fresh interventions related to both the general and specific points of interest.

From GPI1, it would be optimal to maintain a high level of teacher-student interaction both inside and outside the classroom (e.g., by ensuring wide opportunities for students to receive clarifications and to get reception).

This could be coupled with suggestions from GPI2, as one may consider making a more efficient use of different digital devices, such as PCs, smartphones or tablets, during face-to-face lessons. In addition, the use of Interactive Response Systems (IRS) such as Kahoot (https://kahoot.com/) or Poll Everywhere (https://www.polleverywhere.com/) could also be of great help. In fact, the introduction of small quizzes or simple questions on key lesson topics could help maintain student participation high. In general, we will keep encouraging the rapid exchange of information between students and teachers through LMS or Microsoft TEAMS features.

Regarding the specific aspects, focused on technical drawing teaching, the following observations can be made.

From SPI1 and since the distribution of recordings has become a well-established practice and is highly appreciated by students, we might consider making the most of this possibility by combining it with the providing of additional recorded or written content, such as collection of exercises structured by level of difficulty based on errors commonly made by student.

As far as SPI2 is concerned, it could be considered the adoption, alongside the more traditional teaching methods, of methods based on flipped classroom teaching (Akçayır and Akçayır, 2018) to devote more time to guided classroom exercises to be carried out during regular class hours. In fact, the basic idea of the flipped classroom is that the lesson becomes homework while classroom time is used for collaborative teaching, experiences, discussions, and workshops. In this context, the teacher does not take the lead role, but becomes a kind of facilitator, the director of the teaching action. Furthermore, another possibility could be the introduction of regular question and answer (Q&A) sessions at the end of each lesson or topic.

Considering SPI3, to address the need of students to use more 2D and 3D CAD tools, we could consider to introduce software packages with cloud and collaborative functions (e.g., Autodesk Fusion 360, https://www.autodesk.it/products/fusion-360/overview), exploiting the possibility of further interaction between teachers and students.

Finally, considering SPI4, also on the basis of the observations made during the analysis of the answers relating to this point, the timing of the extra hour

Table 7. Suggestions for possible improvements of technical drawing teaching.

General suggestions
Maintain a high level of teacher-student interaction (GPI1)
Use several digital devices also during face-to-face lessons (GPI2)
Introduce the use of Interactive Response Systems (Kahoot, Poll everywhere, etc.) (GPI2);
Encourage information exchange via LMS or Microsoft TEAMS functionalities (GPI2).
Specific suggestions focus on technical drawing teaching
Provide supplementary materials, for example recording of guided exercises focused on specific topics (SPI1).
Create collections of exercises structured by level of difficulty based on the errors commonly made by students. (SPI1)
Dedicate more time to practical exercises in class by applying flipped classroom methods (SPI2).
Introduce regular Q&A sessions at the end of each lesson/topic (SPI2).
Exploit the use of CAD tools considering their cloud and collaborative functionalities (SPI3).
Reposition extra hours exercises or record these contents (SPI4).

exercises could be repositioned, or it could be thought of proposing them again in online mode and/or recording them to give students the possibility to follow them offline, at the most favorable moment.

Table 7 collects all suggestions sprung up from the analysis of the answers to the questionnaires and of the students' performances; in other words, Table 7 summarizes the outcome of this research.

CONCLUSION

The research described in this paper aimed at highlighting suggestions to improve technical drawing teaching at university courses due to the advent of COVID-19. This happened considering the students' point of view, by comparing their opinions and performances (exam marks) before and during/after COVID-19. These data were collected through the administration of questionnaires and thanks to queries to the university databases. Some suggestions on possible improvements in both general and specific teaching practices for technical drawing teaching have emerged. It should be noted that the research was conducted within a single university, so it is necessarily limited. It would be interesting and useful to consider other Italian and foreign universities, as well as involve colleagues teaching different topics to highlight again both general aspects and topic-related specificities.

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