Learner-Centered Distance Education: Effects of Online Learning on the Self-Driven Learning Office Approach

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***Abstract*—This Research to Practice Full Paper investigates the impact of longer-term distance learning on the self-driven, student-centered learning office approach compared to traditional classrooms. The learning office is a school pilot project of a vocational secondary school (grades 9–13) introduced in 2016. Following the principles of learner-centered education, learning office students study in a self-driven way using flexible class schedules and self-explanatory course material. For the present study, we evaluated the average grade of all 548 students in both approaches upon the completion of the winter term 2020/21 and compared it to the data of the winter term 2019/20. Furthermore, we conducted an anonymous survey answered by 99 students allowing to gain insight into the students' perspective on online learning. The results revealed a significant shift in the location parameter of the average grade at the grades 9, 10, and 13 in the winter term 2020/21. The comparison of the grades of 2021 with the previous year showed that the average grade did not change significantly or has improved in the learning office. The average grading of the traditional approach has stayed at about the same level. These counter-intuitive findings, which may be a result of milder grading due to the challenging situation, are consistent with previous research found in the literature. The survey on emergency remote teaching revealed that the students did not report difficulties maintaining social contacts, were more satisfied with the used assessment methods in distance learning, had a quiet workspace, and felt that the teachers reacted appropriately to the switch to online learning. Learning office students reportedly saw the switch to online learning less difficult, felt more self-reliant, and perceived higher levels of support and appreciation by their teachers, but suffered from less cooperation compared to previous findings. We therefore conclude that while learning office students perform equally well in online learning, they are missing important advantages in distance learning otherwise granted by the self-directed learning office approach.**

***Index Terms*—emergency remote teaching, learning office, distance learning, 21^{st} century skills, computer science, student-centered learning, secondary education**

I. Introduction

The SARS-CoV-2 pandemic presented educational facilities with the challenge of transforming all classes to pure online learning within a few days. On March 16 2020, Austrian upper secondary schools were ordered to close their doors and teach their students in a distance education setting by government decree [1], which was issued four days before taking effect. Many institutions of education experienced such an abrupt and challenging switch to online learning, which is now known as "emergency remote teaching" in the literature (see, e.g., [2], [3]).

The aim of this paper is to provide insight into the effects of emergency remote teaching on an Austrian upper secondary vocational school covering K9–K13 with special emphasis on computing education. After a brief literature review on remote teaching and a summary of previous work [4]–[11], we present the results of a comprehensive evaluation of students' grades before and after emergency remote teaching came into effect, comprising the data of all 548 students of the grades 9–13. We also analyze the impact of longer-term distance learning on the two different branches at our department: traditional classrooms and the self-directed learning office approach. Furthermore, we introduce our findings gained from a survey conducted with 99 students of eight classes to explore students' view of the abrupt transformation from face-to-face teaching to online learning.

II. Background

A. Emergency Remote Teaching

To understand the context and challenges of emergency remote teaching, it has to be first distinguished from typical online education. While courses relying on online teaching and learning are usually carefully designed and well-prepared, emergency remote teaching describes a sudden and temporary switch to pure remote teaching for education that would have been provided face-to-face or in a blended-learning setting as a response to a crisis [2], [3], [12]–[14].

Bawa reviewed the literature on remote learning and conducted an experiment based on data collected from 397 undergraduate students of a college in the United States [14]. She compared the performance of students who experienced emergency remote teaching with learners who were taught in a face-to-face setting by evaluating students' grades in

courses on English, business, computer programming, and communication. Despite the general assumption of a negative influence on students' performance suggested in the literature, Bawa concluded that students experiencing emergency remote teaching performed equally or even significantly better: "There was no evidence to suggest that ERT environments led to lower performance grades" [14]. She also analyzed the students' perspective and found that while students experienced emergency remote teaching as highly difficult, they also perceived their increased self-responsibility as beneficial and positive, which could be a reason for the observed improvement in performance.

Iglesias-Pradas et al. analyzed students' academic records of 43 bachelor's level courses of a university in Spain affected by emergency remote teaching and compared them with the data of the year before [13]. They found an increase in students' academic performance and suggest that organizational factors may promote an effective realization of emergency remote teaching.

Gonzalez et al. evaluated the performance of 458 students of another university in Spain in three different subjects [15]. They compared the academic achievement of students who were affected by several confinements due to the pandemic with the data of the students of the two years before. The results once again revealed a significant positive effect of the confinements on student performance. Gonzalez et al. suggest that this improvement may be traced back to a change in students' learning strategies, following a more continuous pattern.

While there are numerous studies on the effects of emergency remote teaching on students' performance at university level, there is little literature on the effects on student's academic achievement at the secondary school level as well as in completely self-driven approaches allowing for individualized course progression.

B. 21^{st} Century Skills

The global pandemic and the resulting transformation to online learning in numerous countries have distinctly demonstrated the importance of personal, social, and transversal skills in the modern world: Using digital media to acquire subject-specific competences, autonomously working on projects and solving problems, communicating, and collaborating in a self-directed manner belong to today's most essential skills. The work of Trilling and Fadel [16] addresses these exact sets of skills. They developed a framework for 21^{st} century learning and defined the following classes of 21^{st} century skills: "learning and innovation skills" [16, p. 49], "digital literacy skills" [16, p. 61], and "career and life skills" [16, p. 73]. The learning office is specifically designed to foster these skills [7]–[10].

Van Laar et al. conducted a comprehensive literature review and integrated the literature on digital skills with the theory of 21^{st} century learning to develop a "framework of 21^{st}-century digital skills" [17]. Based on this model, Van Laar et al. designed and validated a questionnaire designed to quantify these kinds of skills [18], which they used to conduct a large-scale study among a total of 1222 employed and self-employed workers [19]. The results of the survey revealed that educational attainment was linked to only one of the ten dimensions of 21^{st}-century digital skills in the group of self-employed persons. This finding is consistent with reports of an identified gap between the skills required in professional life and those acquired at institutions of education [20]–[22]. On the other hand, Van Laar et al. identified a connection between self-directed learning and five of the investigated skills in one or two of the surveyed groups of workers, including information management, communication expressiveness, collaboration, information evaluation, and problem solving [19].

C. Student-Centered Learning

Self-directed learning plays an important role in student-centered approaches, which are suggested methods to enhance 21^{st} century skills [23]. Carl Rogers, who is known for his research in person-centered therapy and learning [24], described numerous examples of successfully implemented learner-centered approaches employing self-directed learning in his book "Freedom to learn" [25], [26], including Shiel's 6^{th} grade class, Swenson's project approach at a high school, and Levitan's university course. All of the introduced examples required the students to work in a self-directed way and involved non-conventional elements, such as peer review, self-assessment, and a self-designed curriculum.

Freiberg extended the work of Rogers' and criticized the lacking possibilities for cooperation among students, while the business sector had long recognized the importance of interpersonal skills [27]. Rogers discussed the goal of modern education and suggested to focus on changingness and the learning process itself rather than on static knowledge due to its volatility [25]. The persisting relevance of this 50-year-old statement is illustrated by the fact that the ability to "adapt to change" is the most required skill found in European job advertisements [28]. Self-directed approaches, such as the learning office, address this issue by helping students become self-responsible learners and fostering their personal and social skills.

D. Learning Office Approach

The learning office[1] represents an alternative branch at the IT department of the TGM, an Austrian vocational upper secondary school [4], [6] and is based on Rasfeld's approach [29], [30]. As indicated in Table I, the class schedule of learning office cohorts allows learners to choose between several available subjects [6]–[9], [11]. During GE periods, students may choose between subjects of general education, while periods labeled as TS offer several technical subjects to choose from. Courses following a traditional approach may be held with the whole cohort during unlabeled periods.

This approach promotes differentiation and individualization [6]–[9], [11]: Struggling students may receive additional

[1]Translated from the German word "Lernbüro"

Table I
TYPICAL LEARNING OFFICE CLASS SCHEDULE [6], [8], [9], [11]

Period	Mon.	Tue.	Wed.	Thu.	Fri.
1	GE	GE		GE	GE
2	GE	GE		GE	GE
3					
4					
5					
6				TS	TS
7	TS	TS		TS	TS
8	TS	TS		TS	TS
9	TS	TS		TS	TS
10	TS	TS			

Note. GE: General education subjects
TS: Technical subjects

support by attending a specific subject more often, while advanced students can specialize in subjects of their choice by working on advanced exercises and projects. In a learning office, teachers do not hold lectures; they become coaches, while students take responsibility for their own learning. As the learners progress in a completely self-directed way, they acquire essential skills most relevant in the 21^{st} century.

Previous research showed no notable differences regarding student performance in traditional classrooms and the learning office after one year [6], [8], [9]. Furthermore, students of the new approach reported to collaborate more frequently [6], enjoy attending school more [6], feel better supported by teachers [8], and like their classrooms more [8]. Due to the global pandemic and resulting school lockdowns, many of these advantages ceased to exist: Minimized social contacts between peers, missing face-to-face time with teachers, no classrooms to study and work in, and fast-changing requirements hindering self-initiated planning are effects of pure online learning that especially affect the learning office in a negative way. This paper analyzes students' learning outcomes before and after the switch to a longer period of online learning.

In detail, we address the following research questions:

RQ1: How did emergency remote teaching affect student performance?

RQ2: Did emergency remote teaching affect learning office students differently than students of traditional classrooms?

RQ3: What is the perspective of students on the abrupt transformation to pure online learning?

III. METHODOLOGY

Since the main objective of this paper is to analyze the effects of the pandemic and resulting restrictions on students' learning, we coarsely outline the order of events in Vienna, Austria with respect to upper secondary schools in Table II.

As described in previous work, the study accompanying the learning office utilizes an observational study design with embedded case studies as well as quasi-experiments [6], [8], [9].

Table II
OVERVIEW OF COVID-19 RESTRICTIONS FOR UPPER SECONDARY SCHOOLS IN VIENNA, AUSTRIA

Timespan	Description
Mar. 16–Jun. 2 2020	First lockdown, switch to online education for all students, few exceptions (e.g. graduating classes)
Jun. 3–Jul. 3 2020	Face-to-face teaching with alternating halves of all cohorts under application of hygienic measures
Jul. 4–Sep. 6 2020	Summer break, relaxation of many restrictions in Austria
Sep. 7–Nov. 2 2020	Face-to-face teaching with full cohorts under application of hygienic measures
Nov. 3–Dec. 9 2020	Second lockdown, switch to online education for all students, few exceptions (e.g. exams)
Dec. 10–Dec. 25 2020	Face-to-face teaching (only) for graduating classes under application of hygienic measures
Dec. 26 2020–Feb. 8 2021	Third lockdown, switch to online education for all students, few exceptions (e.g. exams)
Feb. 9–May 16 2021	Face-to-face teaching with alternating halves of all cohorts under application of hygienic measures
Since May 17 2021	Face-to-face teaching with full cohorts under application of hygienic measures

The following research instruments were used to answer the research questions of this paper:

1. Analysis of final grades: We collected and evaluated students' final grades in both approaches, namely traditional teaching and the learning office, at the end of the winter term 2020/21 and compared them to the preceding year. The Austrian grading system comprises the five grades 1–5, where 1 is the best grading and 5 is the worst, which also amounts to failing a course. Therefore, a common measure for overall performance of students is the average grade calculated as the mean of all numerical grades in all subjects. The evaluation is based on 548 student records of the grades 9–13 after the introduction of emergency remote teaching and 442 records of grade 9–12 before the outbreak of the pandemic. To give a fair overview and since we wanted to focus on students experiencing both approaches to the full extent, we excluded students who repeated a school year at least once in their school career as well as newcomers from other schools and departments, unlike our previous evaluation in which we only considered the previous year [9]. The resulting final data set comprised 476 and 371 records respectively.

2. Emergency Remote Teaching Survey: To gain insight into students' perception of emergency remote teaching, we designed a questionnaire comprising 12 statements about the transformation to online learning using a 5-point Likert scale ranging from "completely agree"[2] to "completely disagree". Table III gives an overview of the presented statements and their short forms used in the results section. Participation in the anonymous survey was voluntary. The questionnaire was answered by 99 of the 125 students majoring in media technology at the grades 12 and 13.

[2]Rating scales were translated from German

Table III
SURVEY ON STUDENTS' PERCEPTION OF EMERGENCY REMOTE TEACHING

Short Form	Statement
Switch (F1)	The switch from face-to-face teaching to online teaching was difficult.
Workload (F2)	The workload has increased due to the switch to online teaching.
Learning Outcomes (F3)	Overall, I have learned more after the switch to online teaching than in face-to-face teaching.
Assessment Methods (F4)	I liked the used assessment methods in online teaching (homework, online quizzes, ...) more than those used in face-to-face teaching.
Self-Reliance (F5)	I felt self-reliant enough to independently solve the required exercises.
Social Contacts (F6)	I had troubles keeping in touch with my colleagues during online teaching.
Missing Contacts (F7)	The missing social contact in online teaching was burdening.
Teacher Handling (F8)	Overall, my teachers handled the switch to online teaching appropriately.
Cooperation (F9)	I study and work on exercises together with my schoolmates.
School (F10)	I like being a student of this school.
Teacher Support (F11)	The teachers support me if I don't understand something.
Teacher Appreciation (F12)	I am appreciated and perceived as a person by my teachers.
Workspace (F13)	I have a quiet workspace at home and can work without interruption.

Note. Statements were translated from German.

Table IV
SUMMARY OF STUDENTS' FINAL AVERAGE GRADE IN LEARNING OFFICE (LO) AND TRADITIONAL APPROACH (TR)

Cohort	Year	N	Min	Q1	Med	Mean	Q3	Max	SD
LO 9	2020	59	1.07	2.08	2.84	2.90	3.68	4.80	0.96
LO 9	2021	66	1.00	2.19	3.11	2.98	3.73	4.58	0.97
LO 10	2020	38	1.15	2.07	2.55	2.39	2.76	3.61	0.62
LO 10	2021	47	1.38	2.10	2.50	2.58	2.88	4.07	0.67
LO 11	2020	37	1.15	2.16	2.50	2.48	2.83	4.15	0.69
LO 11	2021	31	1.00	1.96	2.30	2.30	2.48	5.00	0.81
LO 12	2020	35	1.33	2.33	2.58	2.60	2.83	3.81	0.49
LO 12	2021	34	1.00	1.90	2.17	2.15	2.44	4.10	0.61
LO 13	2021	34	1.00	1.68	2.05	2.06	2.33	3.88	0.64
TR 9	2020	63	1.33	1.91	2.38	2.42	2.79	4.08	0.67
TR 9	2021	67	1.16	1.79	2.33	2.36	2.75	4.54	0.81
TR 10	2020	54	1.15	1.83	2.31	2.29	2.68	3.50	0.58
TR 10	2021	62	1.00	1.64	2.30	2.30	2.82	4.46	0.80
TR 11	2020	55	1.15	2.00	2.50	2.42	2.88	3.30	0.57
TR 11	2021	53	1.15	1.69	2.15	2.22	2.66	4.00	0.64
TR 12	2020	30	1.00	1.51	2.08	2.15	2.61	4.00	0.73
TR 12	2021	53	1.00	1.63	1.90	1.93	2.33	3.27	0.57
TR 13	2021	29	1.00	1.11	1.44	1.60	1.88	5.00	0.78

IV. RESULTS AND INTERPRETATION

A. Average Grades

The analysis of average grades revealed a significant shift in the location parameter at the grades 9 ($p=1.1*10^{-4}$), 10 (p=0.0494), and 13 (p=0.0146) in favor of traditional teaching in the winter term 2020/21, revealed by a two-sided Welch two sample t-test. Fig. 1 and Fig. 2 show boxplots comparing students' distribution of average grades in both approaches in 2021 and 2020 respectively; a detailed summary of the distributions can be seen in Table IV.

Comparing the grades of 2021 against the previous year's grades revealed that the average grade of the learning office

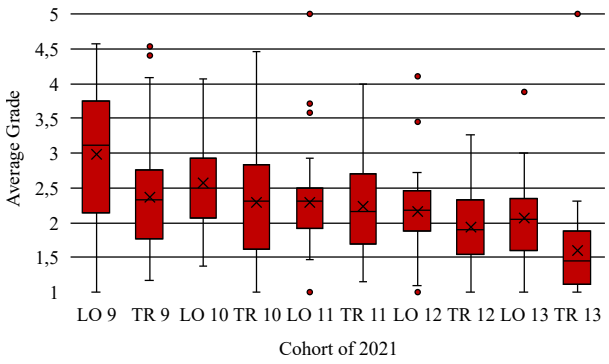


Figure 1. Average Grade Distribution in Learning Office (LO) and Traditional System (TR) in 2021

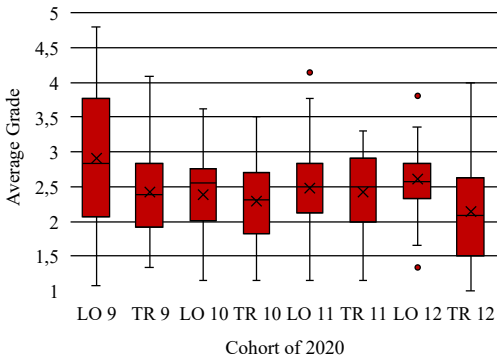


Figure 2. Average Grade Distribution in Learning Office (LO) and Traditional System (TR) in 2020

did not change significantly at the grades 9–11; At grade 12, the average grade has even improved significantly by an overall mean of 0.45, which corresponds to about half a grade, with p=0.0014 in the learning office. This indicates that learning office students achieved the same learning outcomes in online learning as before. In the traditional approach, no significant differences could be found at the grades 9–12 using a two-sided Welch test, suggesting that students of traditional classrooms achieved equal learning outcomes at all grades after COVID-19. This supports the counter-intuitive findings of an increase in student performance found in the literature [13]–[15]. Another possible interpretation for this effect is a milder grading by the teachers due to consideration of the difficult situation.

In order to further investigate the influence of COVID-19 on teaching and grading on the basis of each individual student, we compared the grades of each student of the winter term 2020 against the winter term 2021 in a paired setting if the student passed the year. This difference lies above 0 if the average grade of a student has become worse, whereas a number below 0 indicates that the student has improved. Fig. 3 shows the distribution of this difference in both approaches.

We observed that the first year learning office students had been struck most severely by emergency remote teaching, indicated by a significant shift of the mean value of 0.18

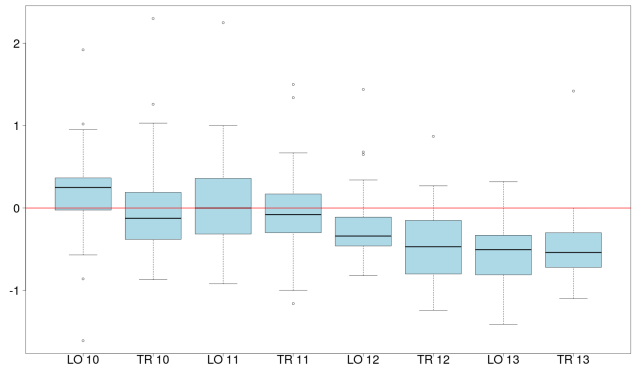


Figure 3. Average Grade Differences in Learning Office (LO) and Traditional System (TR) Between 2020 to 2021

with p=0.0235 revealed by a paired t-test. The underlying reason for this is that learning office students did not get a proper chance to settle in the new system, establish learning groups and networks with their peers. 75% of the learning office students had worse grades at grade 10 in the winter term 2021 than in the winter term 2020 before COVID-19. This is particularly striking, as we observe that the first year students of the learning office typically receive worse grades than other students, as they have to adjust to two new systems at once: from traditional teaching to the learning office approach and from lower secondary education to a higher vocational secondary school.

As indicated in Fig. 3, students of grade 11 showed no significant differences in a paired test compared to their grades at the 10^{th} grade.

Quite the opposite effect was observable for 4^{th} and 5^{th} year students of both approaches, out of whom more than 75% improved their average grade from the winter term 2020 to the winter term 2021. A paired t-test showed that students of both approaches could significantly improve their average grades by an overall mean of 0.20 and p=0.0126 (LO at grade 12), 0.47 and p=4.3*10^{-10} (TR at grade 12), 0.54 and p=4.9*10^{-9} (LO at grade 13), as well as 0.48 and p=1.0*10^{-5} (TR at grade 13). These results are once again consistent with other counter-intuitive findings of the literature [13]–[15].

We observed clear differences between the different years and the learning office and traditional approach. In order to model those, we fitted an ANOVA model to simultaneously control for the type of class and the year of study, as shown in Table V. We used the second-to-third year students of the learning office as reference class as their median improvement is exactly 0 and their distribution of grades was found to be quite symmetric. Here, traditional students received a slightly better improvement in grading, while 4^{th} and 5^{th} year students of both class types were significantly better in their relative performance measured by grades.

From the ANOVA model for grade differences we can discern that the 12^{th} and 13^{th} year students perform highly significantly better than younger students with only a weakly

Table V
ANOVA MODEL OF THE DIFFERENCES IN AVERAGE GRADES BETWEEN THE WINTER TERM 2021 AND 2020 AND THE EFFECT OF COVID-19 GRADING

	Estimate	**Pr(>|t|)**
(Intercept)	0.10	0.12
typeTR	-0.15	0.01
class2	0.05	0.52
class4	-0.37	0.00
class5	-0.54	0.00

Note. We chose the 2^{nd} year Learning office as a reference group, as their median is exactly 0 and their distribution is symmetric.

Table VI
MODELS OF AVERAGE GRADES OF STUDENTS

	Estimate	**Pr(>|t|)**	**Estimate**	**Pr(>|t|)**
(Intercept)	2.54	0.00	2.54	0.00
termWT2021	-0.12	0.02	-0.08	0.12
TypLO 11	0.03	0.78	-0.11	0.37
TypLO 12	-0.06	0.57	-0.12	0.31
TypLO 13	-0.44	0.00	-0.40	0.01
TypLO 9	0.37	0.00	0.44	0.00
TypTR 10	-0.20	0.05	-0.20	0.05
TypTR 11	-0.15	0.15	-0.17	0.10
TypTR 12	-0.40	0.00	-0.48	0.00
TypTR 13	-0.82	0.00	-0.85	0.00
TypTR 9	-0.09	0.37	-0.11	0.29
Repeating	0.76	0.00	-	-

Note. We chose the 2^{nd} year Learning office as a reference group, as their median is exactly 0 and their distribution is symmetric. The first two rows include models with student who failed a year and had to repeat it, where the third and fourth row model only students who passed regularly to the next year.

significant difference between learning office. This indicates that graduating students had a higher motivation for showing an improved performance, measured by grades, while younger ones had no such motivation for improvement.

We also created a model which models the average grades directly instead of an ANOVA model for the differences between the years, as indicated in Table VI. Here, we compared two types of modeling approaches, once we include students repeating a year, because they failed too many courses in the previous year, and once focusing only on the once who passed before. Again, year 10 learning office students were chosen to be the reference category for all comparisons. Within the learning office, students of the first year of vocational school and the learning office (year 9) performed significantly worse than those of higher years and students of the graduation class performed significantly better. In the traditional system, students of the first year performed comparably to second year learning office students, while the graduation class and the year before performed significantly better regarding their grades.

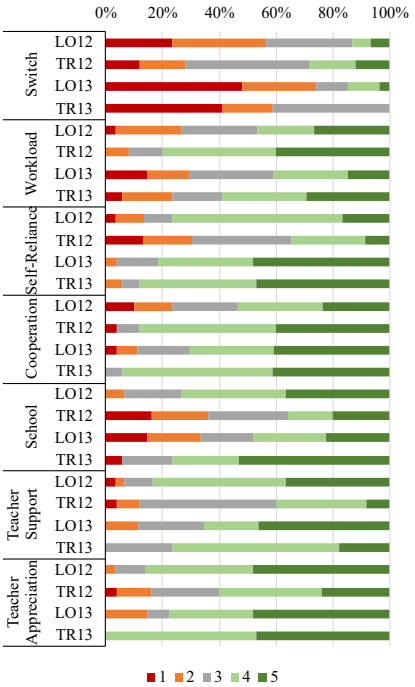
B. Emergency Remote Teaching Survey

The emergency remote teaching survey has been distributed to all students majoring in media technology at the grades 12 as well as 13 and was answered by 99 of the 125 students. Table VII shows the detailed ratings of the students as well

Table VII
STUDENTS' ANSWERS TO EMERGENCY REMOTE TEACHING SURVEY ON A SCALE FROM 1 (COMPLETELY DISAGREE) TO 5 (COMPLETELY AGREE)

Factor	Approach	Rating					Mean
		1	2	3	4	5	
Switch (F1)	**LO12***	7	10	9	2	2	2.40
	TR12*	3	4	11	4	3	3.00
	LO13	13	7	3	3	1	1.96
	TR13	7	3	7	0	0	2.00
Workload (F2)	**LO12***	1	7	8	6	8	3.43
	TR12*	0	2	3	10	10	4.12
	LO13	4	4	8	7	4	3.11
	TR13	1	3	3	5	5	3.59
Learning Outcomes (F3)	LO12	6	7	6	4	7	2.97
	TR12	6	7	5	4	2	2.54
	LO13	4	6	9	4	4	2.93
	TR13	1	1	10	2	3	3.29
Assessment Methods (F4)	LO12	1	3	6	13	7	3.73
	TR12	2	1	7	10	5	3.60
	LO13	2	2	5	4	14	3.96
	TR13	0	2	1	7	7	4.12
Self-Reliance (F5)	**LO12****	1	3	3	18	5	3.77
	TR12**	3	4	8	6	2	3.00
	LO13	0	1	4	9	13	4.26
	TR13	0	1	1	7	8	4.29
Social Contacts (F6)	LO12	7	3	4	9	7	3.20
	TR12	9	7	2	4	3	2.40
	LO13	11	5	4	4	3	2.37
	TR13	5	6	2	3	1	2.35
Missing Contacts (F7)	LO12	3	6	8	3	10	3.37
	TR12	4	4	4	6	6	3.25
	LO13	7	7	5	5	3	2.63
	TR13	0	5	6	5	1	3.12
Teacher Handling (F8)	LO12	0	4	12	8	6	3.53
	TR12	1	3	15	3	3	3.16
	LO13	0	2	6	8	11	4.04
	TR13	0	1	5	8	3	3.76
Cooperation (F9)	**LO12***	3	4	7	9	7	3.43
	TR12*	1	0	2	12	10	4.20
	LO13	1	2	5	8	11	3.96
	TR13	0	0	1	9	7	4.35
School (F10)	**LO12****	0	2	6	11	11	4.03
	TR12**	4	5	7	4	5	3.04
	LO13*	4	5	5	7	6	3.22
	TR13*	1	0	3	4	9	4.18
Teacher Support (F11)	**LO12****	1	1	3	14	11	4.10
	TR12**	1	2	12	8	2	3.32
	LO13	0	3	6	5	12	4.00
	TR13	0	0	4	10	3	3.94
Teacher Appreciation (F12)	**LO12***	0	1	3	11	14	4.31
	TR12*	1	3	6	9	6	3.64
	LO13	0	4	2	8	13	4.11
	TR13	0	0	0	9	8	4.47
Workspace (F13)	LO12	4	1	3	5	17	4.00
	TR12	2	1	2	8	12	4.08
	LO13	2	2	1	2	20	4.33
	TR13	0	1	3	7	6	4.06

Note. The original ratings scales and statements were formulated in German. *p<0.05, **p<0.01.



Note. The original ratings scales and statements were formulated in German.

Figure 4. Students' Answers to Seven Questions of the Emergency Remote Teaching Survey on a Scale From 1 (Completely Disagree) to 5 (Completely Agree)

as the mean ratings, while Fig. 4 displays all the factors with significant differences between the two approaches. The first significant difference could be found in students' responses to their experience of the switch to online learning: Students of traditional classrooms reported to have experienced the transformation to digital education more troublesome than learning office students at grade 12. A Kruskal-Wallis test returned a significant result of p=0.0436.

Another significant difference could be found in students' answers to the perceived workload: Learning office students once again tended to disagree more with the statement that the workload has increased due to the switch to online learning, which was found significant with p=0.0353.

Students of both approaches showed no notable tendency regarding a change in the learning outcomes, suggesting that the achieved learning outcomes did not change as perceived by the students.

At our school, many teachers changed their assessment methods to involve more homework, exercises, projects, and online quizzes rather than large exams, since face-to-face meetings were prohibited during longer periods of time. Students seemed to appreciate this: Both approaches showed a tendency to rather appreciate the new assessment methods.

A highly significant difference could be found in students' perceived self-reliance at the 12^{th} grade: Learning office students reported to be more self-reliant than students of the traditional system with p=0.0086.

Students' answers to the questions about having troubles keeping in touch with classmates and missing social contacts did not reveal clear or notable tendencies to agree, suggesting that, in general, students used virtual communication channels to keep in touch with each other.

A very positive finding is that students overall rather agreed with the statement that the teachers at the investigated school acted appropriately to the switch to distance learning.

An interesting and meaningful finding is that learning office students reported to cooperate with each other significantly less frequently than their traditional peers with p=0.0172 at grade 12. This finding contradicts previous research, in

Table VIII
FACTORS AND THEIR LOADINGS IN CORRESPONDENCE WITH THE QUESTIONS LISTED ABOVE AT GRADE 13

	"Respect"	**"Social contacts"**	**"Workload"**
F1	0.09	-0.49	0.25
F2	0.25	-0.08	0.96
F3	-0.07	0.36	-0.15
F4	-0.29	0.58	0.05
F5	-0.40	0.39	0.02
F6	0.05	0.29	0.04
F7	-0.01	0.45	-0.19
F8	0.26	-0.09	0.15
F9	0.34	-0.68	-0.18
F10	0.53	-0.07	0.09
F11	0.73	-0.14	-0.03
F12	0.98	0.18	0.11
F13	0.47	-0.17	0.11

Table IX
FACTORS AND THEIR LOADINGS IN CORRESPONDENCE WITH THE QUESTIONS LISTED ABOVE AT GRADE 12

	"Teacher"	**"Social contacts"**	**"Covid"**	**"Collaboration"**	**"Support"**
F1	-0.18	0.37	-0.51	0.07	-0.21
F2	-0.43	0.28	-0.25	0.34	-0.06
F3	0.08	-0.02	0.58	0.04	-0.06
F4	0.14	-0.06	0.53	0.33	0.09
F5	0.47	-0.25	0.32	0.21	0.01
F6	0.14	0.72	0.08	-0.30	-0.12
F7	-0.17	0.49	-0.24	0.07	-0.01
F8	0.49	-0.22	0.15	-0.18	0.18
F9	0.01	-0.16	0.17	0.67	0.01
F10	0.66	-0.01	0.17	0.01	-0.01
F11	0.65	-0.13	0.05	0.07	0.73
F12	0.78	0.05	0.01	0.01	0.23
F13	0.34	-0.37	0.10	0.13	-0.06

which we found that learning office students reportedly work together more than students of traditional classrooms [6]. This is a strong indication for the hypothesis that learning office students were affected more severely due to the switch to online education and missing social constructs.

Regarding students' answers to the statement "I like being a student of this school", we observed two completely different patterns at grade 12 and 13. While learning office students agreed with this statement highly significantly more at grade 12 with p=0.0057, the opposite effect could be observed at the 13^{th} grade with p=0.0205. A reason for this could be that the very first learning office cohort may be an outlier, biasing the results at grade 13.

Learning office students' appreciation of their teachers can be seen in their answers to the questions to the support and appreciation provided by their teachers. Learning office students were highly significantly more satisfied with the received support by their teachers at grade 12 with p=0.0010 and felt more appreciated with p=0.0184

Students of both approaches reported to have a quiet workspace.

To further analyze the evaluated factors, we performed an exploratory factor analysis to combine the answers of correlated questions and the content of our student survey, as shown in Table VIII. We identified three main factors which drove the responses at grade 13:

- "Respect and support": This includes feeling respected and supported by the teachers, having a workplace at home during distance learning and liking to be student at this school, but also not feeling self-reliant enough.
- "Social contacts and flexibility": This includes missing social contacts and coincides with working less with others on the one hand, and more easily switching to distance learning, having learned more and liking the assessment as well as being more self reliant in solving exercises.
- "Workload": The last factor is focused on the increase of workload during distance learning.

Interestingly, we found that the main driving factor is that students who feel less self-reliant show an even higher appreciation for their teachers' support and respect, which is particularly relevant for students in their 9^{th} and 10^{th} year in the learning office and students of traditional classroom forms.

The second relevant factor was connected to students' collaboration and contacts with their peers, which have been reduced drastically during the pandemic. Students acknowledging to miss these social contacts and reduced collaborating with their peers tended to feel having become more self-reliant, learned more, adapted more quickly to distance learning, and preferred new forms of examination. This points towards students in their 12^{th} or 13^{th} year who adapted to the changes more self-reliantly than the younger ones.

The last aspect which is shared among students of all groups and stands on its own independent of social contacts, respect, or support is that the perceived workload has increased from the students' perspective. Relevantly, this factor is independent of the class system or teacher, of support or social contacts.

We also compared a factor analysis with 5 factors indicated as the second-best option in the scree plot which yielded the same factors as described before and in addition points out two additional aspects: "keeping contact with peers" was a single relevant dimension as well as "appreciation for teachers handling distance learning well".

From the questionnaire among 12^{th} year students, we received similar, yet slightly different responses, which led to fitting 5 factors and their respective interpretations, as indicated in Table IX. We fit a factor analysis with 5 factors that indicated the best option in the scree plot for this student population, which yielded the similar factors as described for the other group and in addition points out two additional aspects: "collaboration with peers" was a single relevant dimension, as well as "teachers' active support".

- "Teachers' respect and support": This includes feeling respected and supported by teachers, having a work place at home during distance learning and liking to be student at this school and coincides with feeling less workload, which was a separate factor with graduating students.
- "Social contacts and flexibility": This includes missing social contacts and coincides with working less with others on the one hand, and more easily switching to distance learning, having learned more and liking the

assessment as well as being more self reliant in solving exercises.
- "Online": Switching to online-teaching easily and liking the different way of assessment due to Covid.
- "Collaboration": A single effect that represents the importance of collaboration with peers.
- "Teachers' Support": The last single factor is the teacher supporting students independent of feeling respected.

V. Discussion

A. Findings

The findings showed that while the average grades underwent an overall improvement in the online learning setting except for the 9^{th} grade, the students reported to have experienced difficulties in relation to the sudden switch to distance education. This especially applied to the learning office, which heavily relies on social constructs, student-student interaction, and teacher-student interaction. In this analysis, we found significant differences in the average grade at the grades 9, 10, and 13 in favor of traditional teaching in the distance learning setting, which contradicts previous findings in the face-to-face setting in which learning office students achieved the same learning outcomes after their first year [6], [8], [9].

The emergency remote teaching survey provided additional insights into students' perception of the transformation to online learning. The students reported to achieve about the same learning outcomes, but tended to be more satisfied with the used assessment methods in distance learning. Contrary to intuition, the students did not report difficulties maintaining social contacts. Overall, the teachers reacted appropriately to the sudden switch to online learning according to students' answers and the students seemed to have a quiet workspace. Learning office students reported to see the switch to online learning less difficult, felt more self-reliant, and perceived higher levels of support and appreciation by their teachers, but had lower cooperation compared to previous findings [6].

Comparing the students of year 12 against year 13 (graduation students), we observed many similarities, but also some dissimilarities regarding some factors. For the younger students who had been confronted with remote teaching at a younger age, the role and active influence and support of their teachers is much more relevant. Their older peers evaluated their teachers' handling of remote teaching more critically and relevantly, showing a greater deal of self-reliance. Along this line is their statement of staying in contact with their peers, rather than putting relevance on active collaboration, which is of much greater relevance for their younger counterparts.

Our model pointed towards the observation that graduating students also have a higher motivation for obtaining better grades and additionally working on improving their performance in the COVID-19 winter term 2021, while younger ones had no such motivation for improvement. Comparing the learning office against the traditional system, we observed that students required the first year to accommodate to the different type of class organization and work attitude. While 10^{th} and 11^{th} year students showed no difference regarding their performance, this accommodation year is also observable when students near graduation. Again, year 12 is required as an accommodation year in which traditional students show slightly better performance regarding their grades, while learning office students again adapt in their graduation year and catch up with their peers again. This shows the higher self-reliance and flexibility, which is observable for learning office students.

B. Ethical Aspects and Limitations

The results of this paper are based on real data. Therefore, it was essential to take any possible precaution to protect our students, as described in previous work [6], [8], [9]. First and foremost, the performance data were anonymized before any evaluation was done to prevent any inference that could be drawn. Furthermore, the analyses were carried out only by teachers of the students' department. Last but not least, the Austrian Federal Ministry of Education authorized the learning office project and its accompanying study.

Although we strongly believe in the clear findings of this paper, several limitations should be considered. First, since the learning office is an observational study, it is subject to selection bias. We believe that anything else than providing students and their parents the possibility to choose between both approaches would be highly unethical. Second, there are a possibly infinite number of other variables the results may stem from. As this study was carried out in the educational field, it is not possible to filter out undesired variables. Third, since random assignment could not be used, the findings do not assess causalities and describe only statistical associations.

VI. Conclusion

We conclude that emergency remote teaching had an overall positive effect on students' grades, except for students in their first year at the school. Learning office students at grade 9 faced the challenge to adapt to three major changes of system at once: adapting to a new school, getting used to a new approach to learning, and studying in distance education.

As for the grades 10–13, students of the traditional system and learning office students seemed to achieve the same learning outcomes in the online learning setting. However, learning office students are missing important advantages granted by the self-directed approach, such as an increased cooperation. Nevertheless, learning office students of grade 12 saw the switch to online education less critical, were more confident in their self-reliance, liked being a student of the school more, and felt better supported and appreciated by their teachers. We are therefore looking forward to switching back to face-to-face teaching to provide our students the essential and necessary social constructs and interactions to make their learning experience whole again.

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