8th International Conference on Higher Education Advances (HEAd'22)
Universitat Politècnica de València, València, 2022
DOI: http://dx.doi.org/10.4995/HEAd22.2022.14568

Improving Learning Quality in CS Education during the COVID-19 Pandemic

Antje Gieraths, Dieter Pawelczak
Department of Electrical and Computer Technology and Communication Technology, University of the Bundeswehr Munich, Germany.

Abstract

Teaching introductory computer science (CS101) to first year engineering students during a pandemic provides a challenge that can be met with different measures. In this paper we give an analysis of how the course setup evolved during the pandemic, which changes we decided to make in terms of group size and offering additional learning opportunities. It is detailed and compared how an oral summative assessment and a newly introduced written midterm exam influence the final grades of the course and students' contentment. We conclude by discussing the exam results and comparing them over several years and describing what we see as a future proof setup for online and face-to-face teaching.

Keywords: *COVID19; computer science education; midterm; summative assessment; hybrid teaching.*

1. Introduction

Students who began their university studies during the worldwide COVID-19 pandemic were facing severe challenges due to the restrictions. Partly, the restrictions were in place before they even started their studies at the university during their graduation period at school or while working in regular jobs. Since March 2020 and still in the following year professional and educational settings were characterized by strict social distancing and remote learning situations world wide, see Crick et al. (2021).

First year students begin a new chapter of life when entering the university campus – often life long friendships start during the first weeks, study groups form and the new social activities are formative for this period of life. In autumn 2020 it was clear that larger groups of students weren't allowed in the classroom due to the risk of infection at our university. The continued social distancing prevented a normal start for the first year students. Furthermore, a sense of belonging, i.e. feeling as an accepted member of an academic community (see Hehir et al., 2021), is supportive for the learning outcome as well as important for creating equitable and inclusive learning environments.

Riese and Kann (2021) conclude in their study about computer science major students during the pandemic that students needed more help with structure due to the social restrictions and preferred traditional lecture to online formats. First year students often need to establish structure in their study organization. Flynn-Wilson and Reynolds (2021) confirm this observation by a study among students over four semesters comparing virtual, hybrid and face-to-face teaching: students develop their online learning capabilities over time. A similar effect described by Lorås, Haugset and Trætteberg (2021) shows large differences between students managing their online learning, and outlines a greater ability gap among the student group. Finally, according to a study by Gherhes et al. (2021) more than 40 % of the students prefer a return to face-to-face learning after the end of the pandemic.

On the other hand, Katalnikova et al. (2021) describe in detail that students generally prefer online classes to face-to-face teaching while lecturers favour the traditional lecture in the classroom to online teaching. One should not deny the benefit of technological advance with online teaching methods available offering also more flexibility for both students and teachers. However, especially for first years students the authors consider the interaction in the classroom as well as the social structure that regular lessons offer as important. Learning is a social-emotional activity and the higher intensity of university studies also can be fostered by the direct face-to-face contact between professors and students. The first semester course *Introduction to Computer Science* (CS101) was therefore planned with the highest possible percentage of face-to-face lectures.

2. Teaching Setup during the Pandemic Years

The CS101 course at our engineering faculty with typically about 70 students, taught in one large group before the pandemic years, was divided in two groups in October 2020. However, the number of students was still too large to be taught face-to-face in lecture halls. As there are three time slots for the lecture per week, the groups were further subdivided into three small groups. A weekly plan is shown in Table 1. While one group was present in the lecture hall, the two other groups joined the lecture via a videoconferencing system online. This guaranteed the required distance between the students in the lecture hall and allowed every student to participate face-to-face once a week. A similar teaching setup is described by Hunter, Haynes and Kim (2021) and is further referred to as hybrid teaching (HT).

Table 1. Dividing the student group 2020 into small subgroups for face-to-face lectures.

Total Number of Students	Lecturer Group	Students in classroom	Teaching Days Face-to-Face	Teaching Days remote
75	A	A1: 14	Monday	Thursday, Friday
	37 Students	A2: 9	Thursday	Monday, Friday
		A3 14	Friday	Monday, Thursday
	B	B1: 9	Monday	Thursday, Friday
	38 Students	B2: 17	Thursday	Monday, Friday
		B3: 12	Friday	Monday, Thursday

In the autumn of 2021 the group of CS101 was again divided into two groups, one for each lecturer, but further subdivision wasn't necessary as students and lecturers were required to wear masks, and the majority of the students and lecturers were vaccinated. Similar to the previous year students could take part via video conferencing system and additionally recordings of each lecture were made available to the students.

Table 2 shows the different course setups from before the pandemic and during 2020 and 2021. The general layout of the course remained similar to the previous years: five exercises that were to be prepared by the students before discussing them in class, a test exam was conducted at the end of the course and alongside a Q&A session was offered.

In 2020, students in the lecture hall had the opportunity to collect points: Points were given for correct answers to revision questions at the beginning of each lecture and for active participation in problem solving during the exercise discussion in class. The points were added to the points in the final exam at the end of the semester as a "safety cushion" for the students. This summative oral assessment allowed a maximum improvement of one grade

and the students could not worsen their grade by not participating. Exercises respectively the test exam were arranged in a way that each face-to-face group could attend two sessions. Due to the small group size the lecturers could ensure that students are called in equal measure and there was an upper limit to the number of points that could be collected per lecture.

Due to the larger groups in 2021 we decided to use the revision questions for activation of the students at the beginning of each lecture but switched from giving points for answers to an actual written midterm (MT) exam, see Table 2. It consisted of three problems similar to the ones in the final exam, mainly calculations. To motivate students to prepare for the written midterm exam they had to reach at least 25 % of the total number of points to count for the final grade. Students received the graded midterm exam to enable them to revise their mistakes and use the midterm to study. This way they also had knowledge about the size of their "safety cushion" for the final exam. Both, the midterm exam as well as the oral assessment in the year before, were voluntary but strongly encouraged by the lecturers.

Table 2. Course setups before and during pandemic years 2020 and 2021.

Year	Before Pandemic	2020	2021
Number of students in classroom per lecture	75	max. 17	max. 36
List of questions	Done informally by students for exam prep	Oral answers used for summative assessment	Used for revision in classroom only
Written midterm exam	None	None	After six weeks: 30 min.
5 Excercises	Yes	Yes	Yes
Test exam + Q & A	Yes	Yes	Yes
Possibilty to follow via video conference	No	Yes	Yes
Lectures recorded	No	No	Yes

3. Methodology and Analysis

3.1 Course Evaluation Methodology

A variety of measures were used to evaluate the different course setups. In the following, we will refer to the oral summative assessment and the written midterm both as MT results or MT exams. We analyzed points reached per student for both – the MT results and the final exam. For better comparison of the points reached we used a relative scale from zero to 100

percent. The percentage of the points of the final exam are calculated without adding the MT points. The goal was to draw conclusions about a correlation between a successful MT exam to a better learning outcome in the final test. Therefore, we plot for each student the points of the MT exam and the points for the final exam in a diagram for each year, see Figure 1 and Figure 2.

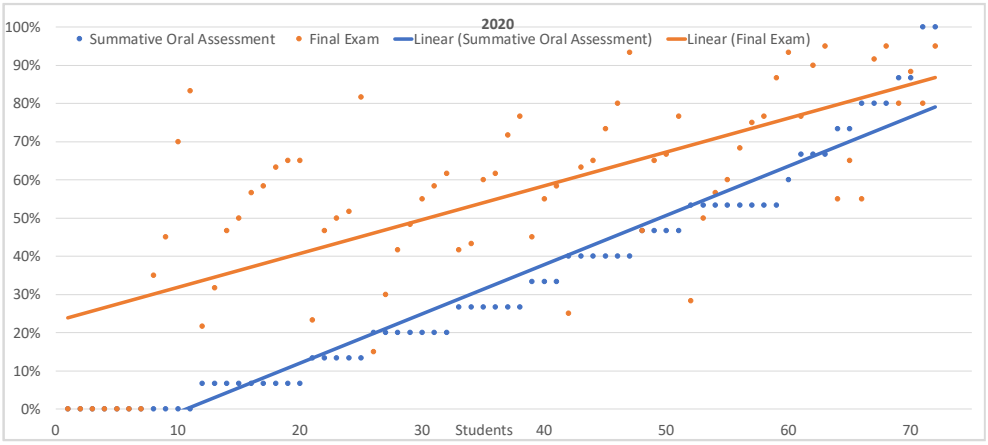

Figure 1: Results of the oral summative assessment and the final exam sorted from lowest to highest for 2020

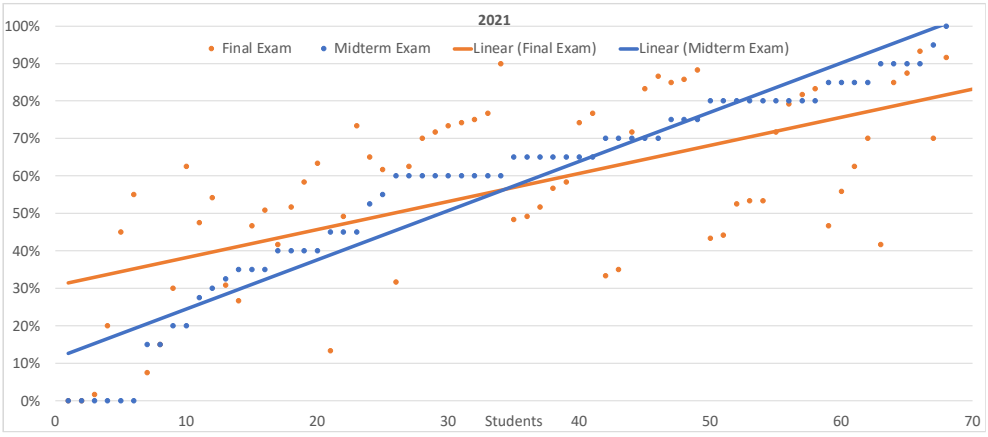

Figure 2: Results of the written midterm and the final exam sorted from lowest to hightest for 2021

The average grades were calculated for the final exams with and without the points accumulated through MT exams. Table 3 shows additionally the pass rate of the courses over four years. The oral assessment was taken at least once by 83 % of the students and about 40 % took part regularly in 2020. The attendance of the MT was 88 % in 2021.

For the comparison of the courses a regular student evaluation is performed for each course plus additional specific questions with respect to the summative assessment and the students' experience with hybrid teaching and pure online teaching as in parallel courses taken by the same students. The survey uses a five point Likert scale. As the student evaluation was scheduled after the final exam, the return rate was quite low: 34 students (23 %). 86 % of the students, who participated in the evaluation, passed the final exam.

3.2 Analysis

Figure 1 and Figure 2 show the correlation of the MT results and the final exam. The data points in both figures are sorted firstly from low to high results of the MT and secondly in ascending order of the final exam results. Comparing Figure 1 and 2 it becomes evident that the effect of the written midterm (Figure 1) is higher on the final grade compared to the oral assessment (Figure 2). This can be drawn from the smaller distance between the linear regression lines in 2021 compared to 2020.

Figure 1 shows that the summative oral assessement has a positive effect on the results of the final exam. The effect is larger the higher the MT points are. This can be concluded from the linear approximation lines being closer together where students had higher points. The first eleven students did not take part in the oral assessment, still two of them had reasonable exam results. Students who got at least 50 % in the summative assessment also passed the final exam and finally, the students with the highest points were the ones getting very good grades in the final exam. In Figure 2 the linear approximation lines of the grades intersect at close to 60 % of the points. The first six students did not take part in the midterm exam but one of them still just about passed the final exam. The students who reached 60 % in the MT exam achieved good grades (> 70 %) in the final exam. Surprisingly we can observe that some students with high MT results did not receive matching results in their final tests.

Table 3 Overview of the received average grades and pass rates of the last four years.

Year	2016	2018	2020	2021
Final Grade [1.0 = best, 5.0 = failed]	3.8	3.7	3.4	3.3
Final Grade with Midterm	-	-	3.4	3.1
Average Grade of Midterm Exam	-	-	3.0	3.1
Percentage of Students passing the exam	63%	64%	76%	82%

As it can be seen from Table 3 the final grades improve about 0.4 compared to the course given before the pandemic. The average grade of the final exam in 2021 is also 0.1 points better than the year before with the oral examination. In the second line of the table the average grade including the MT points improves by 0.3 from 2020 to 2021. It can be noted

that the percentage of the students passing the exam increases by more than ten percent from the course before the pandemic and another six percent from 2020 to 2021.

Table 4. Evaluation results.

Question	(fully) agree	neutral	(fully) disagree
Q1: HT as teaching method was motivating and stimulating?	77 %	18 %	5 %
Q2: Online teaching as teaching method was motivating and stimulating?	59 %	27 %	14 %
Q3: Has the opportunity to collect points had a positive effect on your learning success?	59 %	27 %	14 %
Q4:Would you like to be able to collect points for future courses that can be counted towards your exam?	90 %	5 %	5 %

The students‘ evaluation results shown in Table 4 are ambiguous with respect to HT, feedback received was from “being glad for face-to-face teaching, I’d do anything to get out of my student digs” to “I prefer the flexibility of online teaching and video recordings.” Compared to pure online teaching (OT), 18 % of the students found HT more motivating and stimulating, compare Q1 & Q2. On the other hand, the students evaluated their own learning success in grades as 2.0 for HT and with 1.9 slightly better for OT. CS101 is the first mandatory course at our faculty with a summative assessment. 90 % of the students agreed or fully agreed (Q4) that they would like to collect points in other courses as well. About 60 % of the students stated that the summative assessment had a positive impact on the learning success (Q3).

4. Discussion and Conclusions

A catalog of revision questions is greatly appreciated by students and a valid measure for collecting points as a summative oral assessment for small groups (less than 15 people). This holds true for online and face-to-face teaching. Our students confirmed this in other subjects that were taught in small groups as well. In larger groups the appreciation for the questions remains but grading is quite difficult with respect to equal treatment and proper tracking of the answers, and therefore consuming too much time during the lecture. In the evaluation of the class most students gave the feedback that the questions helped them prepare for exam while some stated that they didn’t like to interrupt other students or wanted to give answers in front of the whole class.

Figure 1 and Figure 2 show that the effect of the oral assessment is less effective towards a higher final grade than the written MT exam. However, the MT results as shown in Figure 2 reflect just the first six weeks, whereas the oral assessment lasted the whole semester. Thus, collecting more points in the oral assessments requires students to stick further to the lecture objectives. This explains a lower variance for students with superior oral assessment results.

Students gladly took the incentive of collecting points during the trimester to accumulate better final grade as shown by the above 80 % participation at the MT exams and with a strong result in the evaluation. On the contraty Figure 2 shows: the higher the MT grade, the safer the students must have felt to pass the final exam. Students confirmed after the course that they felt safe due to the MT exam and prioritized other subjects in the examination phase.

From before the pandemic years to the lecture given quite a number of factors were changed: The size of the groups, teaching in parallel with two lecturers, the introduction of the summative oral assessment, the written MT exam and hybrid teaching. We found that despite difficult circumstances (pandemic) the average grade of the class improved (see Table 3). We still attribute the improved average grades mainly to the MT exams and revision questions as this was the oral and written feedback from students during the evaluation of the class. Future work may include a more specific analysis of the correlation of detailed problems in the midterm and final exam and a comparison between CS101 and other classes taught to the same group of students at the same time.

References

Crick, T., Knight, C., Watermeyer, R. and Goodall, J. 2021. The International Impact of COVID-19 and "Emergency Remote Teaching" on Computer Science Education Practitioners. *2021 IEEE Global Engineering Education Conference (EDUCON)*, 2021.

Flynn-Wilson, L., Reynolds, KE. 2021. Student Responses to Virtual Synchronous, Hybrid, and Face-to-Face Teaching/Learning. Int. J. of Technol. in Education. 2021;4(1) 46-56.

Gherhes,V., Stoian, C.E., Farcasiu, M.A., Stanici, M. 2021. E-Learning vs. Face-To-Face Learning: Analyzing Students' Preferences and Behaviors. Sustainability 2021, 13, 4381, doi: 10.3390/su13084381

Hehir, E., Zeller, M., Luckhurst, J. and Chandler T., 2021. Developing student connectedness under remote learning using digital resources: A systematic review. *Educ Inf Technol* **26,** 6531–6548 (2021), doi: 10.1007/s10639-021-10577-1

Hunter, W., Haynes, M. and Kim, J. 2021. Dual Teaching: Simultaneous Remote and In-Person Learning During COVID. In Proc. of the 22nd Annual Conf. on Information Technol. Education (SIGITE '21), Snowbird Resort, Utah (US), Oct. 6-9, pp. 111–116

Katalnikova, S., Zagulova, D., Prokofjeva, N., Špakova, A., Ziborova, V., Averin, A. 2021. Forced distance learning in Covid-19: peculiarities of the position of lecturers, students of IT and humanitarian specialties. 7th Int. Conf. on Higher Education Advances (HEAd'21), June 22-23, Valencia, Spain, doi: 10.4995/HEAd21.2021.13057

Lorås, M., Haugset, B. and Trætteberg H. 2021. The Importance of the Campus - A Study on the Effects of the COVID-19 Pandemic in a CS2 Course. IEEE Global Engineering Educ. Conf. (EDUCON), 2021, pp. 160-169, doi: 10.1109/EDUCON46332.2021.9453910.

Riese, E. and Kann, V. 2021. Computer Science Majors' Experiences of Their Distance Education Caused by the COVID-19 Pandemic. IEEE Global Engineering Educ. Conf. (EDUCON), 2021, pp. 393-397, doi: 10.1109/EDUCON46332.2021.9454105.