Grading of Project-Electronic Courses in the Pre-COVID, COVID, Hybrid, and After-COVID Semesters

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Abstract
Providing consistent and fair grading of the student's work during a semester is never a simple task. Consistent and fair grading becomes even more complicated when the course organization is changed. This contribution explores the practical experience of teaching three electronic courses: "Electronic Instrumentation", "Real-Time Digital Signal Processing" and "Image processing". Before 2020 above courses were provided by using what our days can be called “normal” (pre-COVID) logistics: in-class frontal lectures, laboratories, home works, and hardware-based projects to be presented physically in class. Then, during a number of semesters, different variants of “COVID logistics" were used. Later “HYBRID” logistics was used (some students still can work from home), whereas the last semester was a gradual return to “After-COVID” logistics – which is supposed to be close to the original “normal” logistics with some modifications. Obviously, most changes are in the hardware-based assignments. In order to make grading as consistent and fair as possible, detailed Excel Grading Tables were created for each assignment. Those tables contain numbered lists of requirements including their weights in the grade of this assignment and numbered lists of errors typically made by students. To make grading time-efficient for educators, short numerical codes are used to point to the specific error in the relevant list. This technique makes grading transparent to the students. Additionally, reference to the detailed description of the student’s error prevents many baseless student grade appeals.

Keywords: STEM, Cloud-Based Education, Project-Based Course, Consistent Grading

Introduction

This contribution summarizes the practical experience of grading three project-based electronic courses: Electronic Instrumentations, Real-Time Digital Signal Processing (RT-DSP), and Image Processing in different semesters: Pre-COVID, COVID, Hybrid, and After-COVID.

The course Electronic Instrumentation is a basic electronic course provided in the electronics department. It is provided after students learned the fundamentals of analog and digital electronics. In the frames of this course, students learned the structure and usage of simple sensors and actuators used in laboratories and industry. In some universities, this course contains frontal lectures, exercises, and laboratories. In Braude College, this course has no laboratory. Instead, pair of students get a specially prepared kit containing an Arduino UNO R3 board with a shield, containing a small matrix, and a set of 37 sensors and actuator modules. By using a set of color wires, students can assemble on small matrix prototypes of the typical electronic instrumentation systems. Important, that those kits enable students not only to build prototypes at their homes but to use their laptops to program the Arduino board. By using programming, students can create advanced projects by using simple and inexpensive components from the kit.

The course Real-Time Digital Signal Processing (RT-DSP) is "*a hard-to-learn course*" for advanced electronics students. It is provided after students of the electronics department learn basic math and physics (including complex numbers and Fourier Transform) and after they have learned basic analog and digital electronics and basic programming (preferably C language). In the frames of RT-DSP students learned the following items: how to make the acquisition of analog voltage signals from different sensors (for example, from a microphone), how to use ADC (Analog to Digital Converter) to convert analog voltage signal to digital signal (sequence of numbers that can be stored in the electronic memory), how to use microcontrollers to do an acquisition, how to process digital signals practically (for example clear human speech from the street noises), and how to do all above fast enough by using specially designed microcontrollers. "Fast enough" in the content of RT-DSP means: in accordance with exact timing criteria described in technical terms for the specific application.

RT-DSP course can be considered as a "pedagogic challenge". It is assumed, that in the frames of this course, students must fortify the theoretical basis learned in the prerequisite courses, and learn on a higher level a set of classical DSP algorithms (like filtration by convolution and by using FFT [Fast Fourier Transform]). Then, students learn advanced RT concepts: timers, hardware interrupts, ring buffers, dual-buffer techniques, and Q-Numbers. It is clear, that learning a "theory only" is not enough for the modern electronic engineer. To make learning closer to the real-life work of the electronic engineer, students, instead of working in the dedicated laboratory, uses a development board "EasyPic Fusion V7." As in the case of the kits for the course Electronic Instrumentation, students get this board with an additional Arduino DUE board. Then, they can program above board by using their PC and/or laptops to test basic and advanced RT-DSP algorithms at their homes. By doing this students achieve minimal practical experience: how to implement classical DSP algorithms by using advanced RT concepts while using real electronic components and development boards, and by using modern software development and simulation tools.

The course Image Processing is another example of a classical course provided in the electronic departments. Our days, we have a huge number of digital cameras in laboratories, hospitals, factories, on the street, and at home. Students must learn about the basic design and properties of digital cameras and how to write software that can process images by using classical image processing algorithms in order to enhance digital images and analyze their content.

This course contains frontal lectures, exercises, and a laboratory. Before 2020 a dedicated laboratory room was used to provide laboratories. By using the equipment of this dedicated laboratory, pair of students use digital cameras to grab images and develop software that can process those images. Then, expensive equipment must have been used: Silicon Graphics workstations, still experimental digital cameras. In 2005, expensive Silicon Graphics workstations were replaced by inexpensive PC with Windows OS. MS Visual Studio 2005 was used to write image processing assignments by using C/C++ language. The goal of the educator then was to monitor students' activity during the laboratory and assist in solving technical problems. Grading was "plain, instant, and simple". The educator's job was to check manually written paper reports prepared during the laboratory and ask a number of questions in case of need.

Starting in 2015 laptops became inexpensive – hence, most of the students started to use laptops and bring them to campus. Simple for inexperienced user Windows OS became the default OS installed on most PC and laptops. MS Visual Studio becomes free for non-commercial use. An inexpensive WEB camera became a default for every laptop. High-speed Internet became always available. As a result, nearly any computer class can be used to provide Image Processing Laboratory. But, many students prefer to use their laptops. Then, the need for the specialized Image Processing laboratory room has become obsolete. Grading still was "plain, instant, and simple". An educator then checked computer-based reports prepared during the laboratory and ask a number of questions in case of need.

The next step was to evaluate the quality of the student's work in the laboratory by grading their reports and the code. Effectively, those reports can be prepared at any place and at any appropriate time – just some deadlines to send reports must be set. In this situation, "strong monitoring" of the student's work in the laboratory time became obsolete.

Speaking practically: even before "The COVID-19 semesters," Image Processing Laboratory was provided by using Gmail cloud services. Laboratory still was provided in the dedicated room at the dedicated time slot. During this time slot, an educator answers the specific student's questions, but students no more printed their reports – they mailed them to the educator by using the special time-effective format. Grading became dependent mainly on the quality of the student' PowerPoint reports and the code written.

The yet next step was to grade the reports by using clearly described criteria. Practically, detailed Excel forms were created. As a result, while using cloud services, it was possible to provide the Image Processing laboratory practically in the same way in different semesters, while the grading criteria were not changed significantly.

The approach to using specially designed Excel tables, containing clearly defined requirements to work to be done with fixed maximal grades was naturally expanded to all three courses long before the time when COVID-19 restrictions were imposed. Practical details of this approach will be described in the following sections.

Literature Review

Courses Electronic Instrumentation and DSP are classical courses for the electronic engineer, hence many articles were dedicated to the details of teaching these courses. Many educators believe, that working with real electronic components (like amplifiers, microcontrollers, ADC, and DAC) is a must for a course of that kind (Nikolic, 2015). Some educators use only mathematic tools to demonstrate usage of the typical DSP algorithms: "A substantial amount of effort from the teacher is required to deliver mathematical and algorithmic concepts", hence "specially designed Windows Store App can be used as a teaching aid for an introductory undergraduate DSP course" like "linear convolution, circular convolution, radix-2 Fast Fourier Transform (FFT), and Finite Impulse Response (FIR) filter design" (Diya, 2017). The above authors use non-electronic software emulation of a "hypothetical 16-bit floating-point digital signal processor, with a simple instruction set." Modern software-based electronic simulators are an advanced tool. The results of their work are very close to the operation of real-life systems. This is why many educators started to use dedicated electronic simulators and software tools (like LabView) for electronic courses (Yi, 2005). Some educators promote the "remote laboratory" concept. In the frames of this concept, students remotely operate specific electronic equipment positioned in the "normal" electronic laboratory. (Auer, 2000). Taking into account that the DSP course contains a lot of sophisticated math, and, thus, is not simple for many students, many educators promote "project-based" learning (Hoffbeck, 2012).

Grading of the student's projects in the "normal" semesters was plain and simple. COVID-19 significantly changed the organization of many courses, including organization of the electronic courses. In many countries it was found that a significant number of students "perceive a paradigm shift in their learning experience before and after COVID-19" and that a significant number of students had faced "numerous challenges during the COVID-19 online learning, affecting their academic performance" (Acheampong, 2023). Many educators observed "inflation of the grades" as a result of the changes in the course organization. For example: "The increase in grades can be explained by the effort of instructors who are accustomed to face-to-face settings. When they suddenly switch to distant education, they might try to grade higher to compensate for the unforeseen negative circumstances" (Karadag, 2021).

This contribution is attempting to analyze the efforts and practical changes in the course's organization that were provided to prevent significant changes in the grading of the three project-based electronic courses.

Lectures and Exercises of three courses in a "normal" and in a COVID-19 semester

Common elements of the three Electronic courses are frontal lectures and exercises. In a "normal semester", lecturers of obligatory basic courses (like math and physics) still use markers and white-board. At the same time, the majority of lecturers of "electronics elective courses" uses pre-written PowerPoint presentations and projectors. Only a small number of lecturers require obligatory presence in the lectures.

When COVID-19 restrictions were enforced, lecturers were asked during 3 days to propose an "alternative". It so happens that, "the alternative to normal life" in Israeli schools and universities was prepared and tested long before: periodically lecturers and students are forced to remain at their homes in "shelter rooms," and use ZOOM to provide lectures.

Hence, there were nearly no problems with the frontal lectures. Those days some students have had low-speed Internet. In that cases, they were permitted to switch off their cameras and microphones.

Exercises of the above three courses are mostly provided by using pre-prepared PowerPoint presentations. Additional software is used to demonstrate practical elements. For "Image Processing" exercises "MS Visual Studio" is used. "Arduino IDE" is used for "Electronic Instrumentation." "MikroPIC C" is used for "RT-DSP."

As in the case of Frontal Lectures, there was no problem to use ZOOM services to provide exercises nearly as in the 'normal semesters."

Changes in the Laboratory organization

The real challenge was in the change in the organization of laboratories. Solutions were different for the above three courses. In the end, assignments were practically the same in the "normal semester", in the "COVID-19 semester, in the "HYBRID semester," and in the "Normal Again Semester". This became possible because of the fast progress in the way how computers and cloud services are used our days.

In the case of the Image Processing course, changes were minimal. Practically the same grading tables were used in all the semesters. Important point was to formulate assignment requirements in a clear way. For example, requirement #1 in assignment #11 was formulated as: "Put YOUR resulted image "grayImage11.bmp" and add a short comment of what the educator is expected to see". In this case, the student was forced to add some text describing created test image in scientific terms. Requirement #4 was written as: "Proof that the function "AddGrayRectangle" works as described (use scientific tools)". Again, it was not enough to write the code of the function "AddGrayRectangle", it was necessary to provide solid proof. The grading policy was clear and simple. Every requirement has a maximal grade of 2 points. "Two-point grading" makes possible fast and simple evaluation and grading: '0' – not done; '1' – done but not exactly as required, '2' – done as required. To make this process really fast and simple two-monitor configuration was used. One monitor presented the table with requirements, whereas the second monitor presented the student's report. During the years, student's errors were systemized and a "typical numbered error' list was compiled". The educator in several seconds can evaluate: whether a specific requirement was properly done. Any appeal of the student concerning grade now can be checked in a fast and simple way: "done as required"/"not done as required". This enables fair and consistent grading for the Image Processing Assignments. In the comment to the relevant cell in the grading table, it was necessary only to add the "number" of the specific error. The "price" of every error was obviously the same for all pairs of students. Usage of the numbered list of errors effectively minimized the number of student appeals for the one-digit number of appeals.

In addition to the laboratory assignments, students were asked to do two micro projects: MP1 and MP2. In the "normal semester", students presented their work physically in class. During the "COVID-19 semester presentations were provided by ZOOM. In the "HYBRID semester" – some students were physically present, whereas others were at their homes. It was proved that using high-quality cameras and microphones for the ZOOM sessions makes cloud-based presentations nearly the same as in a "normal semester". (HI-RESOLUTION option was set). In the case of Micro Projects grading was different for the different requirements. For example, simple requirement #2 of the Micro Project #1 (Provide the description of the algorithm including a description of Input Image(s), algorithm' parameter(s), Output Image(s)/value(s); write what exactly must the algorithm do with input images – what is/are expected output(s)) – has the maximal grade of 1 point. However requirement #3 (create a detailed block chart of the algorithm(s) including all algorithm functions, parameters, input/output/temporary arrays by using the same names as in the code) – has a maximal grade of 6.

All assignments are now stored in the cloud (Gmail service was selected). Then, by comparing the level of students' presentations and the complexity of the code during "COVID-19" semesters with those of "normal" semesters, it can be stated that the level of the presentation and the level of the code' complexity were not significantly changed. This conclusion justifies practically the same typical grades for the different semesters.

For the courses Electronic Instrumentation and RT-DSP, the situation was not simple as in the case of the course Image Processing. In the normal semester, real electronic components were used to implement the assignments. Unfortunately, when COVID-19 restrictions were enforced, it was too late to distribute the kits. After short tests, the TinkerCad simulator was selected as a proper alternative.

Advertisement of the TinkerCad claims that: Tinkercad is a free, easy-to-use (really easy to use) web application (no need to install) that equips the next generation of designers and engineers with the foundational skills for innovation: 3D design (not used in three courses) analog and digital electronics + some microcontrollers, and coding. The community of Tinkercad is ~ 35 million users. Tinkercad is used by many educators for simple school projects. Hence the question was: whether Tinkercad can be used to create sophisticated algorithms learned in the frames of the Electronic Instrumentation and RT-DSP courses.

The answer for the course Electronic Instrumentation was: yes, the assignments that were designed for the real electronic sensor and actuator modules from the kit can be implemented in the TinkerCad practically without changes – because most of the components were found at the TinkerCad palette of electronic components, and the code in the simulator was 100% compatible with the code used to program real Arduino Uno R3 board.

Cloud-based reporting technique (practically the same as with the course Image processing) makes it possible to evaluate the quality of students' work without physical meetings – by grading GMailed reports containing links to the simulations. Additionally, students were able to demonstrate the operation of their simulations by using the "share screen" feature of ZOOM. An additional challenge was to ensure that all students really build and test what was asked to do in the frames of assignments. This is why students were asked to fill a number of tables documenting all steps of the execution of the assignment. It was obvious that a simple copy-paste technique would be immediately revealed.

As the answer to "Students difficulties during COVID-19 semesters", students were permitted to send up to 3 versions for Home Work #1 and for Micro Project #1. The goal of this policy was to motivate students to do "decent work" while learning "the rules of good reporting". Only one version was permitted for Home Works #2 and #3 and Micro Project #2– because students already know the rules and requirements.

For the course RT-DSP it was found that the cloud-based reporting technique, developed for other electronic courses, can be used for remote reporting and grading of the student's RT-

DSP assignments with minor modifications (Kosolapov, 2019, 2022). When simulation became the only possible option, students, as proof of execution, added to their report screenshots of the simulation's screens instead of adding photos of the working system. Additionally, a link to the working stimulation must be added to the first page of the PowerPoint report, so that the educator was able to check remotely all the details: how exactly students executed specific assignments. Unfortunately, the current version of TinkerCad supports only an extremely simple Arduino UNO R3 board. The small size of the RAM limits the size of data that can be processed. However, considering that Arduino UNO R3 has timers and hardware interrupts, and supports direct operation, it was found that most RT-DSP algorithms (like ring buffers, filtration by convolution in the TD and by FFT at FD) can be implemented by using TinkerCad.). Important that Tinker Cad can simulate as analog as digital electronics. Hence Arduino UNO R3 can be programmed by writing standard C code by using integrated into TinkerCad an Arduino simulator. An educator can see the code and check its execution, including graphs of the signals created by the Arduino simulator. Still, the C-code, in that case, was significantly different that the code for the MicroC compiler so that it cannot be stated, that the complexity of the code is the same in both compilers.

Providing courses in the Hybrid semester

It so happens that semester 2021-10 – 2022-03 was started as an online semester, but after three weeks, it became a hydride semester: lectures, exercises, and Micro Projects presentations were provided in-campus, but students had the right to stay at home and continue to use cloud services including ZOOM and Email. In the “normal” semester students were required to present in-class Micro Projects However, with the non-strict presence rules of the hybrid semester, a plurality of situations was created: for example, one student of the pair was physically present in class during the presentations, whereas the second student participated by using ZOOM. This situation created a number of logistics problems, and, thus, some logistics changes needed to be done in order to ensure fair and non-biased grading, as for the students who were physically present during the lectures, exercises, and presentations, as for the students who participated remotely. In any case, in the frames of the three courses, the number of assignments was the same as in other semesters.

Results and Conclusion

During 10 years, different variants of this time-effective cloud-based logistics for the different electronic engineering courses were tested. Some results were published before and reported at a number of international conferences. There were no drastic changes as in the level of the student’ reports, as in their final grades for the three electronic courses. In the semesters when student pools were provided, grades provided by students for this course were in the range {4.23...4.94} (by using a 1-5 scale) and were in most cases 0.5 higher than the mean department’s course grade. In the written comments, most of the students’ remarks were positive, and, the median grade for this course in most of the semesters was 5.0 (of 5). It is assumed that by analyzing the results of the last student pools (still not available), more conclusions will be drawn, and some modifications in the logistics will be provided.

And, some technical conclusion: TinkerCad simulation was found extremely useful for the goals of two courses: Electronic Instrumentation and RT-DSP, hence it will be used in the AFTER-COVID semesters.

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