Programming course for health science as a strategy to engage students during the coronavirus pandemic

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Abstract

Programming is an important skill for different areas of knowledge. While in the past, programming skills were much more related to fields of computer sciences and engineering, today, professionals from different areas benefit from the ability to write codes for different applications. Furthermore, programming stimulates logical thinking, which impacts other personal abilities. Health science students have limited exposure to programming during their studies. Aware of this and considering the prolonged time in social distancing in Brazil due to the SARS-COV2 pandemic in 2020, we organized an outreach course dedicated to teaching introductory concepts of programming for health science students. The activity was developed fully online using the Zoom web conference agent, lasting 12 wk (8 synchronous classes, 15 synchronous hours in total), and attended by 27 undergraduate and graduate students from two different universities. A collaborative problem-based learning and group-learning methodology were developed through asynchronous homework and mainly online synchronous activities. In this article, we describe our approach and provide some suggestions for replicating the course in other universities. We observed that the activities of the outreach course improved programming skills and confidence for most of the students. More importantly, it piqued their interest enough to motivate them to continue to practice writing and testing their programs. We concluded that an outreach course dedicated to programming promoted improvements in programming skills in health science students. Furthermore, the program was an opportunity to keep the students active in science while working from their homes during the pandemic.

higher education; problem-based learning; remote learning; remote teaching; teaching

INTRODUCTION

Public institutions are responsible for up to 95% of all Brazilian research published (4). Following the appearance of SARS-CoV2 in Wuhan, China (5), which has spread globally during 2020, Brazil now ranks second for the most people infected (~3.5 million people in August 2020) and deaths (>150,000), with the United States ranking first (6). The coronavirus disease (COVID-19) pandemic caused a drastic reduction in the activities at Brazilian public universities (2). In this particular case, the Federal University of Pampa stopped teaching activities in March 2020, and by August, the undergraduate classes still had not returned, even in the online modality. Online classes for undergraduate students started in September. Although graduate students were able to continue their courses, with their classes quickly migrating to online learning, there were significant delays in the development of research projects and no possibility of beginning new Master’s degree or Ph.D. projects. Unfortunately, the timeline of these projects and scholarships continues to trigger anxiety in students and supervisors, especially due to stay-at-home orders, quarantine, limited information or technology background, and hardware and software skills to work from home (7–9).

The interest in learning new things and developing more about a topic, with recognized limitations, increased among those students who were able to continue their activities from home under the remote supervision of professors and through collaborative work with colleagues. When considering activities that are part of research development, programming skills are important. These skills provide the possibility to further explore databases, which can be an alternative option to adapt research projects, the experimental phases of which had stopped in 2020. However, programming is considered a difficult task for both undergraduate and graduate students in Brazil (10). Programming is not part of regular graduate and postgraduate studies in areas such as health sciences. However, in the human movement sciences (e.g., kinesiology, biomechanics, and neuromechanics), it is often required for data collection, signal processing, and statistical...
analysis of large data sets. Therefore, the understanding and capacity of programming can facilitate academic development, save time, and enable students and professionals to be independent in carrying out these different analyses, though sometimes limited because of the high-cost of commercial software.

In this context, education and science appear to be the milestones to providing opportunities in a world that demands working from home (11) during the COVID-19 pandemic (5). To engage students in activities during the pandemic and develop an online-based outreach program, we developed a programming course for undergraduate and graduate students during the COVID-19 pandemic in 2020. In this article, we report our approach to developing this activity, the impact of the course on programming skills, and knowledge of the students participating in the online and offline methodology we developed during 12 weeks.

## METHODS

### Participants and the General Framework of the Activity

The programming course lasted 12 wk (18 synchronous hours, ~1.5h of synchronous activities per week) from March to May in 2020. The activities were fully performed via videoconference using a web conference agent (Zoom Video Communications, Inc.). The course was planned to enroll 25 to 30 students who were interested in learning programming. The activities were advertised online for students who had previous experience with laboratory activities and remained active working from home. After the advertisement, 27 students from two universities were interested in the course. There were no prerequisites regarding the participants’ background knowledge to attend the course other than being a health science student, having a computer with access to the Internet, having a demo version of MATLAB software installed, and being motivated. The 27 participants had a background in health sciences (physiotherapy and physical education): 10 of them were undergraduate students, and 17 were graduate students; 18 were women and 9 men, whose age ranged from 20 to 36 years. A collaborative, problem-based learning and group-learning methodology (cooperative learning) were developed through homework and online activities. The number of participants was limited in order to provide a better environment for the close participation, and also because the activities involved only one tutor.

### Course Design

The course included theoretical classes (considering topics of descriptive statistics concepts and basic biomechanics) and practical assignments (programming based on statistical problems, but also other assumptions related to file loading and management of data sets). A friendly environment was ensured during the online meetings, where students could ask questions at any time, report their difficulties, and also meet in small groups for additional hours of study. The tutor always used part of the time to hear from the students about the feedback to the tasks and coaching them during the online meetings. All online learning activities occurred in a common room meeting, and the MATLAB software was used for the examples (Mathworks; see Fig. 1 and Table 1); the course was projected in real time on the computer of each participant, while each one was working with software at home. The total number of hours dedicated to the course may have varied among the participants. However, we ensured that all participants completed at least 15 synchronous hours of online study during the 12 wk. We sent regular messages to the student to motivate them to join the online session using a WhatsApp group. Additional asynchronous hours were added according to the tasks assigned to the participants, so they could return to the programming interface later to test the concepts through practice.

### Contents

The topics covered included the MATLAB programming interface, commands for data loading, matrix concepts, algebra, one- and two-dimensional plotting, exponential prediction, linear equation system, basic trigonometric, functions, correlations, multiple correlations, programming loops (while-end, for-end), conditions (if-end, if-else-end, if-else, if-end), and nonlinear equation problems considering the human knee dynamometry test (Fig. 1). Open databases available online were utilized for practicing, such as the governmental statistics for the COVID-19 pandemic. Slides were used to show the illustrations and concepts, and they were made available to the participants. The topics were promoted in a “hands-on” mode. Each meeting had a problem to be solved for which the solution required skill development. For each problem, the tutor gave time to the students to find solutions and critically discuss the programming strategies. The participants were always encouraged to ask questions during the activity and share their MATLAB screen to suggest the solutions or discuss the errors.

### Course Assessment

We did not conduct a formal assessment using quantitative tests. Despite the pandemic causing high stress and fear in our society, it is difficult to assess programming performance. The participants had different levels of knowledge, and we considered it more important to identify how the outreach course helped the participants to better understand the programming. Therefore, when the course was finished, we requested their self-report about how the course helped them to keep active and learn new things during the pandemic, as well as what were their impressions about programming after the course. The information was collected after the course using an online anonymous form (Google Suites tools) that included 18 questions about their programming abilities before and after the course, the importance of learning these tasks for their professional activities, the general quality of the course, and their impressions of the online format of the course. These data are presented descriptively, including frequency analysis. We also invited the participants to write short comments about the course. To compare differences between the proportions, we used the nonparametric test $\chi^2$ or binomial test when cases were <5% of the total sample. An $\alpha$ value of 5% was used.
RESULTS

Before the start of the course, most participants acknowledged they had some previous knowledge of programming (78%; $P = 0.007$) and had used the MATLAB software before (93%; $P < 0.001$). Participants also reported the capacity to run programming routines written by someone else (78%, $P = 0.007$), but anyone could create a routine by themselves (100%; $P < 0.001$; Table 2). After the outreach course, most of the participants reported that they could run routines created by others and by themselves (67%; $P = 0.125$). Regarding the new skills, 85% of the participants reported that they could create a routine from the start in MATLAB ($P < 0.001$). All participants said they had learned new things about

Figure 1. Timeline of the online learning skills developed during the course.

Table 1. Meetings progression and skills promoted

| Week | Activity                                                                 | Skills                                      |
|------|--------------------------------------------------------------------------|---------------------------------------------|
| 1    | Familiarization with the software; practice of mathematical operations; quadriceps force estimation problem | Logical thinking skills; writing skills       |
| 2    | Quadriceps force estimation discussion; practice of data importation; practice with matrix algebra; vector and matrix problems creation from data | Logical thinking skills; writing skills; problem resolution skills |
| 3    | Vector and matrix problems creation from discussion; plotting from matrix practicing; plot analyzing; prediction problems from time series | Logical thinking skills; writing skills; problem resolution skills |
| 4    | Prediction problems from time series discussion; optimizing the quadriceps force estimation problem; writing the first routine; writing a routine to estimate quadriceps force | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 5    | Writing a routine to estimate quadriceps force discussion; developing commands of matrix algebra; plotting two-dimensional graphs; broadcasting a matrix problem | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 6    | Broadcasting a matrix problem discussion; knowing MATLAB commands; basic command routine problems | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 7    | Basic command routine problems discussion; mathematical functions analysis; writing a statistical function problem | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 8    | Writing a statistical function discussion; analyze a COVID-19 database; descriptive statistics from world COVID-19 database problem | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 9    | Descriptive statistics from world COVID-19 database problem discussion; optimization of quadriceps force estimation with multiple-factor problems | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 10   | Optimization of quadriceps force estimation with multiple-factor discussion; loop structures knowledge and practice; quadriceps force estimation using loop writing problem | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 11   | Quadriceps force estimation using loop writing discussion; multiple importation of data using loop problem | Logical thinking skills; writing skills; problem resolution skills; critical thinking |
| 12   | Importation of multiple data using loop problem discussion | Logical thinking skills; writing skills; problem resolution skills; critical thinking |

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Table 2. Self-reported outcomes before and after the programming course

| Before the Course                                                                 | Percentage  |
|-----------------------------------------------------------------------------------|-------------|
| Were you able to create routines in MATLAB?                                       | Yes: 0%; No: 100%** |
| Were you able to run ready-made routines (created by someone else) alone in MATLAB? | Yes: 77.8%; No: 22.2%* |
| After the Course                                                                 | Percentage  |
| Feelings of conformity with programming:                                         | Comfortable: 66.7%; No feelings: 33.3%; Dislike: 0% |
| How do you feel about programming now?                                            | Until the end: 33.3%; I stopped: 66.7% |
| Attending during the pandemic:                                                    | Yes: 74.1%; No: 18.5%; I don’t know: 7.4%** |
| Did you attend the course until the end or did you stop halfway?                  | Yes: 66.7%; No: 0%; I was able to run before: 33.3% |
| Was it good to take a pandemic-time programming course?                           | Yes: 85.2%; No: 14.6%; I was able to create before: 0%** |
| Performance and skills improvements:                                              | Yes: 100%; No: 0%** |
| Did the course during the pandemic help to improve your data-processing performance? | Yes: 67%; No: 0%; I was able to run before: 33.3% |
| Do you feel able to run ready-made routines (created by someone else) alone in MATLAB? | Yes: 51.9%; No: 48.1% |
| Do you feel able to create routines in MATLAB?                                     | Yes: 100%; No: 0%** |
| Do you believe that the participation in the course improved your programming knowledge? | Yes: 51.9%; No: 48.1% |
| Online methodology assessment:                                                    | Yes: 59.3%; No: 40.7% |
| Do you believe that participating in a course like the one you took is enough to prepare you for using MATLAB? | Yes: 100%; No: 0%** |
| Do you believe learning through a face-to-face course of the same duration would lead to the same learning as online? | Yes: 51.9%; No: 48.1% |
| Extracurriculars:                                                                 | Yes: 100%; No: 0%** |
| Do you think the University should offer programming courses for students from different areas of knowledge? | Very good: 59.3%; Good: 40.7%; Regular: 0%; Bad: 0%; Very bad: 0% |

*χ²-test: P < 0.05. **χ²-test: P < 0.001.

When we planned the course activities, we were afraid that the online format would limit student experience, which is not new for online teaching (3). However, our findings showed that this kind of activity could be developed in an online format with a high acceptance among health sciences students. We found that the activities part of the course were rated as good to excellent by all participants, which is in agreement with the assessment of online teaching activities by health students (12). Importantly, we found that students developed new skills, and the course permitted practice with these new capacities. We found that 85.2% of students reported being able to create a programming routine after the course, while no one could do it before the course. We also consider that skill acquisition influenced the reports of being comfortable with programming after the course. The ability to create programming routines after the course programming courses for students from different areas of knowledge (100%; P < 0.001) (Fig. 2).

The quality of the course was rated as “good” by 41% and “very good” by 59% (P = 0.438) of the participants. We also verified whether the online setting caused discomfort for the participants. We found that 67% of the participants felt comfortable programming, and 33% did not have any particular feeling regarding programming (P = 0.125). When asked if the outreach course could lead to better results if delivered in a face-to-face format, most of the participants believed that similar outcomes would be achieved despite the outreach activity being online or face-to-face (59%; P = 0.441; Table 2).

Most of the participants were unable to fully follow the course classes until the end (67%; P = 0.125). The main reasons for not completing all classes were insufficient time (62%), followed by factors associated with COVID-19 (25%), and the course being difficult to follow (13%). However, most of them (93%; P < 0.001) reported that it was good to take a programming course during the pandemic (see Table 2).

Considering the feedback received, here are some of the positive comments received: “The course was excellent, and the didactic posture helped a lot. I would like to repeat this course in the future.” “Great didactic.” “I wish all the previous courses I took were like this one.” “The real-time contact to ask questions and solve doubts helped me a lot.” “I believe the online format helped in focusing on the program tasks and the tutor’s advice.” On the other hand, as students considered that this outreach course could also have the capacity to improve their academic knowledge, there were some recommendations for a future edition, such as “I think that at least some face-to-face sessions would be valuable.” “Perhaps meetings of shorter duration could help to focus attention.” “I left the course because my computer ended up not able to load the files and run the codes.” “As the course was online, it could be recorded so the participant could watch the lecture again.” “The course could also include the possibility to apply the lectures to solve some personal problem with data processing for the students.” These comments will help improve future versions of this activity and better plan on the limitations of time, computer resources, and solutions to specific data-processing problems.
suggested that students developed logical thinking (enabled better structure and organize information and developed reasoning capability), problem resolution skills (deductive and inductive reasoning, and hypothesis creation), writing skills (structuring, organizing, and ranking variables and commands), and critical thinking (reflection and re-test of results). However, we are unable to establish whether the feeling of satisfaction relied on the experience during the COVID-19 pandemic, that is, the comfortable sensation of doing something while many students stopped all academic activities. More than two-thirds of the participants considered they felt good and had a greater understanding of programming after the outreach course, despite the barriers that programming imposed on health care students (10).

Positive emotional states have an important influence on student learning and performance (13). Therefore, the tutor must always promote a friendly atmosphere, that is, asking students about their condition and motivation to perform the activity, calling students individually by their names, and coaching them. We believe these are always good practices in the classroom, and the online modality also permits us to promote it, making the classroom more comfortable. These practices may also influence the report of positive approach toward programming after the course. In the beginning, participants stated that they could not write a program routine alone, but at the end of the course, most of them felt they could do it. This is an achievement, as programming courses are difficult to conduct even in a face-to-face configuration (10). In assuming this activity could be a fully online outreach activity, the organizers welcomed these outcomes.

The students’ appreciation will also motivate the development of outreach activities dedicated to the student community. Although this activity was dedicated to higher education, we consider that it is possible to replicate the activity for high school students as well. It is difficult to learn all the concepts and acquire all skills for proficient programming in short courses. However, the participants felt that they obtained important knowledge. These conditions may pique their interest in practicing programming skills after the course, which could influence their research activities. The students participating in the outreach course were working daily with scientific activities involving large extensions of data analysis. We hypothesize that when the students identify a utility in their days for the activities performed in the outreach course, they increase their enthusiasm and engagement with the proposed activities (13). We considered that an important factor contributing to the success of this outreach course was the configuration of the activities in a format of “hands-on,” “learning-based problems,” which is known to increase student engagement (3, 12, 14). We also conducted the course in a rhythm that tried to engage the students by asking for frequent feedback, just as other health science areas have discussed frequent feedback as a positive teaching tool to produce more active learning when online teaching is used (1).

Another possible factor accounting for the success of the course was that all participants were students enrolled with research in topics such as biomechanics, kinesiology, and neuromechanics, which involve numerous numeric data provided by laboratory experiments. These assessments include kinematic (e.g., angular and linear distances, velocities, and accelerations); kinetic (e.g., strength, torque); and electromyography (e.g., muscular myoelectric activity) assessments during the performance of different movements and postures (e.g., daily life movements and sports movements). In this sense, programming tools can help them to speed up the data processing, aiming to provide the results of research quickly or making quickly available the results of a patient’s assessment.

Finally, our programming activity was designed to stimulate problem resolution skills, logical thinking skills, cooperative learning, writing skills, and knowledge transfer skills (Fig. 1). Nevertheless, there were limitations and barriers to this course, as commented by students. These included the excessive time of classes, inadequate hardware (computer), not...
having recorded the classes to watch again if necessary, and the non-use of individualized data sets (the data used in the classes were general data, not collected or calculated by each student). Most of these barriers have been described to affect the development and implementation of online learning in medical education (15). In particular, structured time is necessary to maintain attention and enhance learning. One of the students reported computer problems, which generally may limit student learning. Not recording the classes may limit a deeper understanding during asynchronous study, and the lack of application of students’ own data may cause some degree of difficulty in understanding the data used.

## CONCLUSIONS

We developed an outreach course to teach programming to health science students. Programming is an unusual topic for health science students in Brazil, and generally, students regard it unfavorably due to the complexity and need for a mathematical background. With the development of this activity, we found students reporting positive responses after being exposed to different activities for programming practice. From the participant’s feedback, it was possible to observe that the course helped them develop new skills during social distancing in the COVID-19 pandemic, including the ability to generate programming routines. We believe that our course is an important didactic tool to improve students’ abilities during the pandemic and may motivate their interest in developing further skills in programming.

## DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

## AUTHOR CONTRIBUTIONS

F.P.C., C.I.F., E.C.G., and M.R.K. interpreted results of experiments; F.P.C., C.I.F., E.C.G., and M.R.K. drafted manuscript; F.P.C., C.I.F., E.C.G., and M.R.K. edited and revised manuscript; F.P.C., C.I.F., E.C.G., and M.R.K. approved final version of manuscript.

## REFERENCES

1. Ahmed S, Zimba O, Gasparyan AY. Moving towards online rheumatology education in the era of COVID-19. Clin Rheumatol 39: 3215–3222, 2020. doi:10.1007/s10067-020-05405-9.
2. Caetano R, Silva AB, Guedes ACM, Paiva CD, Ribeiro GDR, Santos DL, Silva RD. Challenges and opportunities for telehealth during the COVID-19 pandemic: ideas on spaces and initiatives in the Brazilian context. Cad Saude Publica 36, e00088920, 2020. doi:10.1590/0102-311x00088920.
3. Cravener PA. Faculty experiences with providing online courses. Thorns among the roses. Comput Nurs 17: 42–47, 1999.
4. Leal F. COVID-19 is a wake-up call for Brazil’s universities [Online]. University World News [July 25, 2020]. https://www.universityworldnews.com/post.php?story=20200724000221821.
5. Harapan H, Itoh N, Yufika A, Winardi W, Kemas S, Te H, Megawati D, Hayati Z, Wagner AL, Mudatsir M. Coronavirus disease 2019 (COVID-19): A literature review. J Infect Public Health 13: 667–673, 2020. doi:10.1016/j.jiph.2020.03.019.
6. Worldometer. COVID-19 coronavirus pandemic: reported cases and deaths by country, territory, or conveyance [Online]. Worldometer [August 22, 2020]. https://www.worldometers.info/coronavirus/.
7. King DL, Delfabbro PH, Billieux J, Potenza MN. Problematic online gaming and the COVID-19 pandemic. J Behav Addict 9: 184–186, 2020. doi:10.1556/2006.2020.00016.
8. Lopez-Leon S, Forero DA, Ruiz-Diaz P. Recommendations for working from home during the COVID-19 pandemic (and beyond). Work 66: 371–375, 2020. doi:10.3233/WOR-203187.
9. Schuch FB, Bulzing RA, Meyer J, Vancampfort D, Firth J, Stubbs B, Grabovac I, Willeit P, Tavares VDO, Calégaro VC, Deenik J, López-Sánchez GF, Veronese N, Caperchione CM, Sadarangani KP, Abufaraj M, Tully MA, Smith L. Associations of moderate to vigorous physical activity and sedentary behavior with depressive and anxiety symptoms in self-isolating people during the COVID-19 pandemic: a cross-sectional survey in Brazil. Psych Res 292: 113339, 2020. doi:10.1016/j.psychres.2020.113339.
10. De La Fuente CI, Machado AS, Kunzler MR, Carpes FP. Winter School on eEMG signal processing: an initiative to reduce educational gaps and promote engagement of physiotherapists and movement scientists with science. Front Neurol 11, 2020. doi:10.3389/fneur.2020.00509.
11. Rashid H, Ridda I, King C, Begun M, Tekin H, Wood JG, Booy R. Evidence compendium and advice on social distancing and other related measures for response to an influenza pandemic. Paediatr Respir Rev 16: 119–126, 2015. doi:10.1016/j.prrv.2014.01.003.
12. Maćzniuk AK, Ribeiro DC, Baxter GD. Online technology use in physiotherapy teaching and learning: a systematic review of effectiveness and users’ perceptions. BMC Med Educ 15: 160, 2015. doi:10.1186/s12909-015-0429-8.
13. McConnell MM, Eva KW. The role of emotion in the learning and transfer of clinical skills and knowledge. Acad Med 87: 1316–1322, 2012. doi:10.1097/ACM.0b013e3182575d52.
14. Sayyah M, Shiribandi K, Saki-Malehi A, Rahim F. Use of a problem-based learning teaching model for undergraduate medical and nursing education: a systematic review and meta-analysis. Adv Med Educ Pract 8: 691–700, 2017. doi:10.2147/AMEP.S143694.
15. O’Doherty D, Dromey M, Lougheed J, Hannigan A, Last J, McGrath D. Barriers and solutions to online learning in medical education—an integrative review. BMC Med Educ 18: 130, 2018. doi:10.1186/s12909-018-1240-0.