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Board 55: (Work in Progress) Adapting the First Programming Course for Undergraduate Students of Mathematics Major

Dr. Maristela Holanda, Texas A&M University

I am a visiting professor at Texas A&A University. I am professor at University of Brasilia, Brazil. My research areas are databases and Computer Science Education.

Dr. Dilma Da Silva, Texas A&M University
Raquel Carneiro Dörr
Fernanda Macedo de Sousa

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Abstract. Computing is everywhere, and the first programming language course, generally called CS1 (Computer Science 1 course), is usually taught by departments of Computer Science to undergraduate students majoring in various subjects. However, the high failure rate in these introductory programming courses is an issue that challenges several universities. In this context, this work-in-progress presents an intervention proposal focused on the class for students majoring in Mathematics. In conjunction with the Department of Mathematics, a CS1 course has been created with adaptations to the course content for the context of Mathematics. The initial validation, performed on mathematics undergraduate students, showed good initial results.

1. Introduction

The first programming course, commonly called CS1 (Computer Science 1), is a recurrent research topic in the literature, with at least 50 years of study [1] and more than a thousand articles on the subject [2]. Subjects covered in this topic range from forms of assessment to teaching techniques, as well as student engagement and behavior [2,3]. Among the topics studied, the high failure rate in this discipline appears as a difficulty in universities worldwide [4]. Other papers on CS1 present challenges in teaching the first programming subject [5, 6, 7].

Many undergraduate majors have CS1 as a mandatory course in their curricula. This course is usually taught by the Department of Computer Science, with the same content for all majors. Computing is embedded in different areas of knowledge, being important for many majors that are not computer science or computer engineering. At the same time, it may be difficult for a department of Computer Science to customize CS1 courses to the needs of specific majors.

In this context, this work-in-progress report presents the experience from the Department of Computer Science (DCS) and Department of Mathematics (DMAT) at the University of Brasilia (UnB), in Brazil, on the elaboration of a CS1 course adapted for the profile of undergraduate mathematics students. This major was chosen because of this offering's high failure rate. The experience took place in early 2021, still in the pandemic period, when remote teaching remained the sole mode of delivery.

This paper is divided into the following sections: Section 2 details the methodology used in this study, Section 3 shows the results and the validation of what was developed, and Section 4 presents the limitations. Finally, Section 5 presents the conclusion and the planned continuation of the work.

2. Methodology

The first step towards the development of this research was formating a working group composed of instructors from the DCS and DMAT departments, as well as undergraduate and graduate students from both departments. The general coordination of the group was carried out by a DCS professor, and the coordination of mathematics students was carried out by a mathematics professor.

The University of Brasilia's CS1 course has its structure deployed in the Virtual Learning Environment (VLE) Moodle [8] with the Coderunner plugin, an automatic programming corrector [9]. Moodle and Coderunner are open platforms, and Coderunner can be used for different programming languages. The course consists of material presented in slide format, accompanied by audio explanations, in addition to indications of book readings and, finally, lists of exercises to assess learning. This format stems from the need for remote emergency teaching due to the Covid-19 pandemic after March 2020. Currently, with face-to-face instruction, the structure created in the Moodle platform continues to be used. As an initial step, the working group started adapting the course through the lists of exercises.

The exercise lists are made up of ten exercises with varying difficulty levels. Initially, to create new lists of exercises, the DCS group analyzed the questions that already existed in the course's question database, considering the complexity of the questions and whether the theme was related to Mathematics. Then, based on the book by Saha [10] "*Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More!* ", other questions were created. At the end of the first review, 38 questions were retained, of which two were edited for a better fit. To complete the ten questions in each of the seven lists, 32 new questions were created. The subjects dealt with in each list are:

- List 1 - Variables and Expressions;
- List 2 - Decision Structure;
- List 3 - Repetition Structure;
- List 4 – Functions;
- List 5 - Strings;
- List 6 - Lists; and
- List 7 - Tuples and Dictionaries.

After the first version of the question database with adapted exercise lists for mathematics was created, it was reviewed by DMAT students' and instructors' workgroup. The review process took place as follows. First, the DSC group shared a document with all the questions on Google Docs. The DMAT group then commented on the document itself; these comments related to mathematical concepts and the understanding of the statements and contained suggestions to improve the contextualization of the questions.

From the suggestions given by the DMAT, the DCS group made the corrections; this process was repeated until a consensus was reached between the two groups. This process took approximately six months, with different reviewed questions. Finally, after the last review process, of the total of 70 questions, 33 new questions were created, 13 were edited, and 24 remained from the original bank of questions.

3. Initial Results

The undergraduate students enrolled in the course for Mathematics majors offered in the first semester of 2021 were invited to participate in the validation. The pandemic introduced significant delays in the academic year calendar, so students were contacted in July 2021 when still in the midst of taking courses corresponding to the first 2021 semester. To facilitate this preliminary validation, the exercise lists were limited to containing only two new questions, randomly selected by the platform for each student. For the same reason, the trials were restricted to the first three exercise lists since they comprised the contents the students had studied in the subject up to the time of the trial.

Volunteers completed a perception form, based on [11] and [12], involving questions regarding student motivation and satisfaction. There were 56 students registered in the course. Of these, 15 completed all exercise lists, and 11 students voluntarily answered the perception form.

In the statements, “Solving questions contextualized to Mathematics makes me realize the importance of the discipline for the major”, “Solving questions contextualized to Mathematics motivates me to study programming” and “I feel more willing to work on a question with a Mathematics context than other questions”, the average of students who show agreement at some level is 69.7% while the average of disagreement in some degree is 24.3%. It is noteworthy that the statement “My performance improves when I know exactly what the objective of a computational problem is ” had 72.7% of total agreement and 18.2% of partial agreement. However, 9.1% strongly disagreed.

In order to collect other suggestions and comments regarding questions adapted to Mathematics, the perception form included the following open-ended question: “Any suggestions or comments for questions adapted to Mathematics?” The following comment was informative:

> “I really liked the questions presented because they are simple and complete. It is difficult to sort out the subject lists, because they are confusing and long. This discourages me a lot. If the official lists were similar to the trial lists, I believe my performance in the subject would be better. I was able to learn a lot from the trial and even finished everything in advance.”

4. Limitations

This is a work in progress with the focus only on the exercise lists; the rest of the course material was not customized to the target audience. The analysis of the results was based on the views of Mathematics undergraduate students enrolled in the course, and participation was limited to 11 volunteers from the 56 students registered in the test environment. The collection was further hampered by the COVID-19 pandemic, as 100% remote teaching had a detrimental effect on communication with some students. In addition, the exercise lists were available over a period of two weeks in the middle of the academic semester. That is, it was not possible to accompany the students throughout the course, which prevented the assessment of other newly developed lists of exercises.

5. Conclusion

This work-in-progress report presented an educational intervention for teaching the first programming language to mathematics undergraduate students in a customized way. This course is taught by instructors from the Department of Computer Science. The intervention was carried out by a group of instructors and students (undergraduate and graduate) from the Departments of Computer Science and of Mathematics at the University of Brasilia.

The first stage of the project was to work on the lists of exercises in the programming environment of Mathematics students who are currently using Moodle with automatic correction by Coderunner autograder. The idea of the exercise lists is to be adaptable to the student's profile in order to motivate students to carry out the exercises. This stage was evaluated by mathematics students in the first semester of 2021 with a good evaluation by the students.

As future work, it is intended to validate this contribution throughout the semesters to measure its impact on student learning, make the same customization for other majors, and track student learning.

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