PRE PRINT

MOTIVATION BEHIND PARAMETERIZED EXERCISES

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Abstract

Our study focuses on the motivation behind parameterized exercises considering two aspects: motivation inspired by the effective use of the final product by teachers and students and motivation of the creative process itself to build parameterized exercises in an online environment. The scope of this study is the MSc dissertation of some students of the master course "Matemática para Professores" (Mathematics for Teachers)

Keywords: parameterized exercises, mathematics, motivation, small markup language, MEGUA.

1 INTRODUCTION

A parameterized exercise combines random objects with text containing placeholders where an instance of these objects is placed. In other words, a parameterized exercise is a class of exercises with the same pedagogical objectives for a set of concepts. The variation captured by the parameters not only refers to specific data inside the exercise, but also to the format in which content is presented to the student. To implement parameterized exercises, in this case with detailed answers, we use Sage Mathematics as described in [1].

The authoring of parameterized exercises is a creative process that needs scientific and pedagogical knowledge about the concepts involved in the exercise as well as some programming skills on the software used to produce these exercises.

In a previous study, [2], presenting the same software package and its online environment, we have already suggested that "The authoring of parameterized exercises has been an useful activity both for teachers, who could take advantage of databases of parameterized exercises for preparing study materials, but also for master students that learn by producing new problems."

In this paper our focus is the quest for motivation behind parameterized exercises and we have considered two kinds of motivation (**M**):

- **M1** the motivation inspired by the effective use of the final product by teachers and students, i.e., several online versions of exercises to be practiced by students and materials for textbooks, assessment or diagnosis;
- **M2** the motivation of the creative process itself to build parameterized exercises in an online environment, where students and teachers can collaborate. It's clear that these motivations come from a "connected learning world".

The first kind of motivation, (M1), considers aspects that were already discussed in [3], making an analogy with the R´s from the environmental studies (reuse, recycle, reduce, repurpose, refuse).

The second kind of motivation, (M2), can be seen as the author's intrinsic motivation when creating parameterized exercises. To produce this type of parameterized exercises scientific understanding, pedagogical experience, imagination, and some technical computational knowledge are required.

As our master's students weren't expert programmers, some choices regarding the computational environment had to be considered. These choices are summarized in the next section.

2 COMPUTACIONAL CHOICES

As our work was planned for mathematics' teachers, the open source SageMath library was chosen [5]. This led us to choose the Python programming language, since it is characterized by its simplicity and relatedness to mathematics.

We have chosen LaTeX which is a high-quality typesetting system for scientific documents (used in the majority of mathematics texts) with specific features: an online pdflatex compiler using the MathJAX javascript library [6] mixed with basic HTML, and a kind of tiny domain specific language to help the creative process that we call “MEGUA” which is described in [1].

“MEGUA” was designed to ease the process of programming parameterized exercises, including some features needed to have a step-by-step answer. The master’s students who used it to program exercises, although presenting some difficulties in the beginning, managed to succeed and afterwards they found it simple to use.

Below are some of the key aspects of MEGUA that motivate the production of parameterized exercises:

1 The possibility to choose between multiple-choice exercises and full open question exercises, which is done by including (or not) the tag “<multiplechoice>”.

2 The different sections for text and code. By text we mean the problem statement, the multiple choice items (when it is a multiple choice exercise) and the detailed answer; note that in this section parameters are used, for example:

“Consider the equation $var1 x + var2 = var3$”.

Numerical values will be assigned to the parameters var1, var2 and var3 using Python language and SageMath library, which is described on the coding section. For simplicity, in this section, authors must avoid text.

The simple way of separating text and code was never rejected by “MEGUA” users, who were not experts in coding, as one can focus on the different mental processes of writing an exercise and coding it.

Using Python’s mathematical functions, an author can create an exercise using a general function to which will be assigned a specific function when instantiated. For instance, instead of treating an exercise only for function sine, authors enjoy treating a family of trigonometric functions in the same exercise (ex.: sine or cossine).

Another example is an exercise on the topic “definite integrals”. We may consider both types of integrals, proper and improper, and its existence and convergence, on the same exercise. Although the elaboration of such an exercise is much more complex, the variety of instantiations this exercise generates is enough to create an entire worksheet on this topic.

These features are the ones responsible for adding a high degree of motivational challenge.

Since we have opted by the separation of text and code, we had to choose a mechanism to select families of cases inside the same body of text. The scheme:

```
<showone SomeDecisionVar>
<thisone> text for case 0</thisone>
…. other cases ....
<thisone> text for case N</thisone>
</thisone>
```

In the coding section, the author has to create a code that assigns a value in {0,1,2,...,N} to the decision variable, SomeDecisionVar. The <thisone> tags contain the study cases whenever it is necessary to choose different content for each situation.

3 METHODOLOGY

In the last 5 years, several master's thesis focused on the construction of digital resources to support the teaching of mathematical concepts of Portuguese elementary and high school education. MEGUA was used for the construction of parameterized exercises and, even though the students involved had little programming knowledge, our perception as supervisors was that they were enthusiastic in the construction of the exercises, analyzing carefully the choice of the parameters and the different cases those choices led to.

By doing this analysis, the students consolidate their mathematical knowledge regarding the topics that they teach in their professional scope.

In order to prove our perception, an online questionnaire (Google forms) “Motivation in the conception of the exercise / Motivation in its applicability” was drawn up and asked the alumni for answers. The questions raised were as follows:

1 Did you use "MEGUA" to develop digital resources in your master's dissertation?
2 During the design of a parameterized exercise?
3 Do you consider the material you have produced to be an asset?
4 Give reasons (s) underlying your answer: _____
5 Comments: _____

4 RESULTS

Nine of the master’s students answered the survey and all of them used MEGUA in the construction of parameterized exercises.

4.1 About M1

Regarding the first type of motivation presented (M1), all the respondents consider that the material elaborated is an added value, presenting several reasons justifying their response.

It should be noted that only one of the respondents considers that the material developed motivates the students for the mathematics subject. However, the percentage indicating that the digital resources created are a powerful tool to assess students’ knowledge, namely self-assessment, is 88.9%.

The use of the digital resources created in the preparation of class support material, such as exercises or tests, is an asset for 77.8% of the respondents, thus enhancing learning, as mentioned in 44.4% of the answers and allowing to have assessment material to 66.7% of the teachers who responded to the survey.

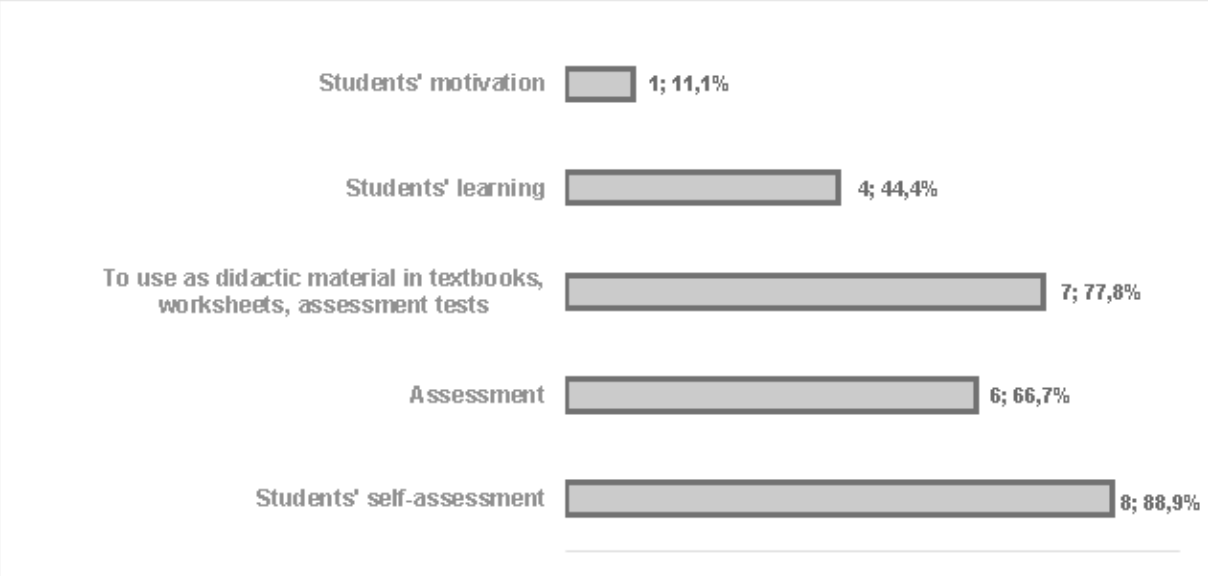

Figure 1: Reasons supporting (M1)

4.2 About M2

To evaluate the degree of motivation in the creation of parameterized exercises, a 5-point Likert scale was used (poor motivation - very motivated). All the respondents felt motivated during the creative process and 55.6% of them very motivated, confirming the perception of their supervisors.

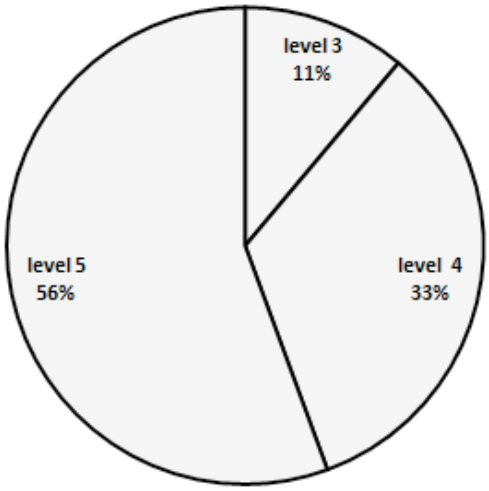

Figure 2: Motivation in the creative process (no occurrences for levels 1 and 2)

Often, when students already mastered the technique of creating exercises, they challenged themselves to create classes of exercises, in other words, a super-exercise where different instantiations led to very different exercises, on the same mathematical concept. This process is also referred to in [4] "the whole class of exercises is authored at once by authoring one highly annotated randomized exercise".

5 CONCLUSIONS

Parameterized exercises have proven to be capable of generating motivation in our MSc students of the "Mathematics for Teachers" course during their dissertation work. They felt motivated while authoring parameterized exercises, using an online environment, where teachers and students can cooperate.

Besides, a unique exercise can generate an instantiation for each student, allowing the assessment of an entire class with different exercises, as well as making them available in online platforms, allowing students to use them for self-assessment.

Eight of the nine respondents scored 4 or 5 (in a 1 to 5 scale) on the item motivation on creating parameterized exercises.

Currently MEGUA databases have hundreds of parameterized exercises on a great variety of mathematics' topics, from the earliest years of elementary education to higher education, with special emphasis on mathematics topics of courses in Calculus for Engineering and Science.

We intend to continue implementing the creative process, by developing new technical functionalities that facilitate the exercise construction process, in order to increase the number of authors and scientific areas.

Another goal is the implementation of classes of exercises generation models, in order to create worksheets from a single exercise, that have a vast set of problems with different levels of difficulty and approaches, but on the same concept.

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