

Open Source Collection of Gamified Programming Exercises

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Abstract

Computer programming courses are considered difficult. They can be made more engaging for students by incorporating game elements in a process known as gamification. In order to make it easier to facilitate this process in practice, several European universities collaborated in a joint project aimed at developing a framework for application of gamification to programming education. The framework includes the specification of the gamification scheme and the exercise definition format, an open source toolkit for preparing the gamified exercises and an interactive learning environment to present them to the students, and, last but not least, an open source collection of gamified programming exercises. In this paper, we present a work-in-progress on the last element, describing the current contents of the collection and planned directions for its extension.

Keywords: open educational resources, gamification in education, programming exercises, teaching computer programming, e-learning

1. INTRODUCTION

The progress of the ongoing digital revolution depends on the availability of skilled programmers. Their supply is limited, and one of the reasons for that is the difficulty of learning to program, both perceived by students and reflected in the measured average pass rates in comparison to other STEM subjects (Simon et al., 2019). The difficulty often leads to students' disengagement, and, consequently, to dropout.

Gamification, consisting in enriching education with game-inspired elements, has been proven to be capable of counteracting such problems (Ghaban & Hendley, 2019). The practical implementation of gamification to programming education requires several components, such as: an agreed gamification scheme (to provide guidelines to the exercise designers on what gamification elements they can use and define requirements for the supporting software), a standardized exercise definition format (so that the gamified exercises could be exchanged between tools and people), an open source toolkit for preparing the gamified exercises by the designers and an interactive learning environment to present them to the students and handle automatic assessment of solutions submitted by students and processing of gamification rules. The development of such components was the aim of the Framework for Gamified Programming Education (FGPE) project financially supported by the European Union's Erasmus Plus programme (FGPE, 2020). While all above-mentioned components are technically necessary to develop and make use of gamified programming exercises, what the students and teachers actually need are the exercises themselves. For this reason, the FGPE project included the development of 480 gamified programming exercises under open-access license. In this paper, we describe the development and the current structure of this collection as well as present the plans for its extension.

2. DEVELOPMENT PROCESS

The development of the exercises has been preceded with devising the general scheme for gamification of programming education, based on results of a survey of what forms of gamification are appealing to students (Swacha et al., 2019), and defining data format for exercises – actually, two distinct formats were defined: YAPExIL for non-gamified programming exercises (Paiva et al., 2020a) and GEdIL for the gamification data (Swacha et al., 2020).

The development work has been equally shared among the four partners of the FGPE consortium: University of Szczecin (Poland), INESC TEC (Porto, Portugal), Aalborg University in Copenhagen (Denmark), and University of Naples Parthenope (Italy).

The basis for the gamified exercises were mostly non-gamified exercises used earlier for teaching programming by the FGPE partners, some interesting exercises were adopted from existing open repositories, and also some were created from scratch to allow testing of various gamification concepts.

The exercises were developed using the AuthorKit webtool for collaborative authoring (Paiva et al., 2020b). Following the user-centered design principles, from the very beginning, the students were involved in the development of exercises by each of the partners. Initially, there was a problem with testing the exercises, as the software components necessary to run the exercises: the gamification service (Paiva et al., 2021a) and the interactive learning environment (Paiva et al., 2021b) were developed in parallel to the exercises. Later, the testing was bidirectional (exercises were helpful in finding bugs in the software handling them, and vice versa).

3. COLLECTION CONTENTS

Due to different educational needs of the respective FGPE partners, the contents of the collection varies. University of Szczecin developed two sets of exercises, the main

counting 94 exercises supporting a course on Introductory Python, the second with 26 exercises supporting the final exam for the same course. Both Aalborg University and INESC TEC developed one collection each with 120 exercises to be used for supporting education of students at subjects such as Algorithms and Data Structures or Introduction to Programming, which are taught using various programming languages, therefore an effort was made for the exercises to be programming-language-agnostic, i.e., have no elements designed to teach or test knowledge of specific features of specific language, but rather of algorithmic problem solving in general. University of Naples Parthenope developed one collection containing, however, exercises designed for various languages (of which 36 can be most suitably solved in Python, 28 in Java, 28 in C++, 18 in C, 10 in JavaScript) to let students practice different programming languages.

All exercises were developed in two languages of instruction: English and the national language of the respective partner.

The exercises are free to use by any educational institution, as they are published under Creative Commons – Share Alike license. The up-to-date version of the collection is available for download at GitHub (FGPE, 2021).

4. EXTENSION PLANS

Although the FGPE project ended on 31st May 2021, the work on extending the collection continues as a part of the new FGPE Plus project (FGPE Plus, 2021). In the forthcoming year, the collection will be extended with 520 new gamified exercises. While the collection is currently focused mostly on supporting introductory programming and algorithms and data structures courses, the focus of the new exercises will be more on learning how to apply programming in the areas of other subjects. For instance, one of the envisaged

gamified exercise sets is “Machine Learning with Python, Keras, and Tensorflow”.

We also hope that the spread of news about the collection will help involve third parties from outside the FGPE consortium to contribute their own exercises to the open collection and stimulate its further growth.

5. CONCLUSION

The novelty of the presented collection is that its exercises contain embedded gamification-related data. This way various institutions may benefit from application of gamification techniques in their educational activities with a very limited effort.

With the help of the software tools developed in the FGPE project, the exercises can be used as they are in different educational contexts (in-class learning, e-learning, and blended learning). Thanks to the open license, individual exercises can be extracted from the collection and re-arranged into courses prepared by different instructors.

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