Students' Usability Evaluation of the FGPE Gamified Programming Learning Environment

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Abstract

Gamified learning environments can effectively support programming education only if their usability satisfies students. Here, we report the results of the usability evaluation of the FGPE PLE, an open-source gamification-supporting web platform for learning programming. The evaluation was based on Lund's USE model and involved students from several countries.

Keywords: Gamified Learning Environment, Usability Measurement, USE Questionnaire

1. Introduction

The programming skill is essential in information systems development yet challenging to master. The inherent difficulties of learning programming escalated in times of forced distance learning. Hence the importance of introducing solutions that could ease this process. One of them is gamification [16]. However, it adds a new layer of abstraction, complicating students' interaction with the programming learning environment, which may hinder its usability.

There is a scarcity of reports assessing the usability of gamified information systems serving the purpose of learning programming. In this work, we address this gap by reporting usability measurements of the FGPE PLE [3] – an open-source gamified programming learning environment – obtained from 181 students from various parts of Europe.

2. Measuring Perceived Usability

As defined by ISO-9241, usability is "the extent to which specified users can use a product to achieve specified goals with effectiveness, efficiency, and satisfaction in a specific context of use" [7]. Whereas effectiveness and efficiency are objective and, as such, can be measured using various forms of user observation or tracking (with dedicated metrics such as time to perform a task or the number of accomplished tasks), satisfaction is subjective. It is typically measured with one of the perceived usability measures based on user surveys.

Two such measures have been in use already since the 1980s: Post Study System Usability Questionnaire (PSSUQ) – and its sibling Computer System Usability Questionnaire (CSUQ) – developed at IBM [8] and System Usability Scale (SUS) developed at DEC [2]. Much later, Lund proposed his USE Questionnaire model [11]. Even more recent measures are UMUX [4] developed at Intel, and its shortened version, UMUX-LITE [10]. Table 1 compares the properties of these five measures.

Table 1. Comparison of Perceived Usability Measures.

Measure	Response scale	Items	Subscales
PSSUQ/CSUQ	7-point	16	System usefulness, Information quality, Interface quality
SUS	5-point	10	– / Usability, Learnability
USE	7-point	30	Usefulness, Ease of Use, Ease of Learning, Satisfaction
UMUX	7-point	4	–
UMUX-LITE	7-point	2	–

Note that although the presented measures differ in the result value ranges, they can all be mapped to the same range for comparisons. Moreover, several studies confirmed that they are correlated highly with one another – see, e.g., [9] and works cited therein.

3. Method and Data Sources

As our goal was to obtain a detailed picture of the perceived usability of the FGPE PLE, the most complex of the five discussed measures – USE has been selected for this purpose. The USE questionnaire consists of 30 items measuring three independent variables – usefulness (8), ease of use (11), and ease of learning (4) – plus one variable – satisfaction (7) – that depends on the other three [11].

The USE questionnaire has been successfully applied to measure the usability of various information systems, ranging from farm management systems [1] to mobile health applications [5] and tourism websites [14], including various types of educational software: from MOOCs [15] to educational games [17].

The questionnaire has been implemented online using Google Forms. As users' different cultural backgrounds may impact usability measurement [6]; the survey was performed on eight

student groups at six institutions in four countries. Each group was approached after spending a considerable time (at least several hours) using the FGPE PLE. Participation in the survey was voluntary, and no incentives were offered for it to the students. The list of surveyed groups is given in Table 2.

Table 2. Surveyed FGPE PLE users groups.

Time	Country	Institution	Group size	Responses
October 2021	Poland	West Pomeranian Business School	<70	19
November 2021	Portugal	ESMAD, Polytechnic of Porto	<50	27
January 2022	Poland	University of Szczecin	<25	11
March 2022	Poland	University of Szczecin	<15	8
May 2022	Italy	University of Napoli Parthenope	<10	6
May 2022	Italy	University of Napoli Parthenope	<150	106
May 2022	Denmark	Aalborg Universitet Copenhagen	<10	1
June 2022	Poland	University of Szczecin	<10	3
		TOTAL		181

4. FGPE Programming Learning Environment

The FGPE PLE provides two distinct user interfaces: for students, who try to solve the programming challenges, and for teachers, who manage the courses and supervise students' progress (see Fig. 1). Here, we only deal with the former, as the latter is a subject of another publication [13].

The students' UI follows a component-driven development approach, whose main components are: **Code Editor**, which allows students to start coding from a skeleton provided by the exercise author and features syntax highlighting, parameter hints, and code completion; **Console**, which presents the results of the code execution and feedback; **Statement Viewer**, which renders the activity statement to present to the student; **Leaderboard**, which displays the usernames and scores of the participants, sorted according to specific metrics and scope; **Push Notification Box**: a small rectangle that receives rewards, leaderboards' updates, and other events from registered GraphQL subscriptions. The teachers' view comprises paginated data tables to consult data and forms to manage games and students. Furthermore, it also allows teachers to check the code submitted by students and the obtained result.

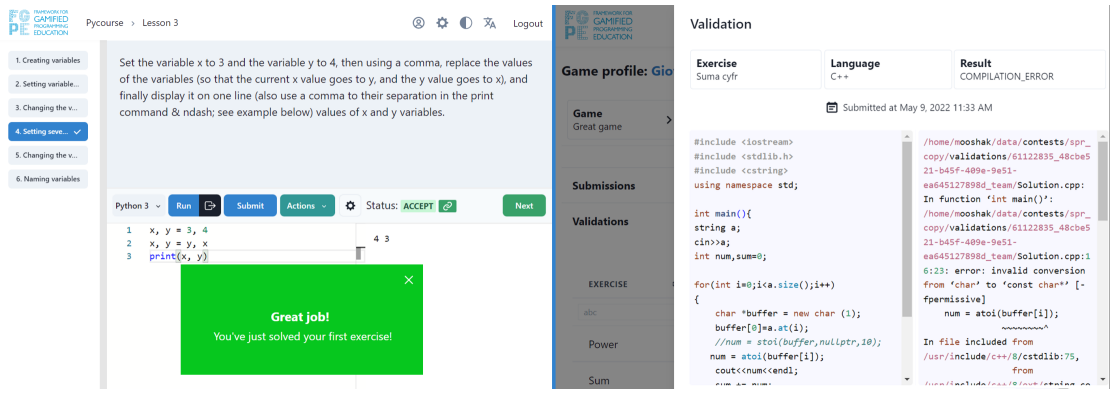

Fig. 1. Exemplary screenshots of the FGPE PLE, with students' (left) and teachers' (right) views.

5. Results and Discussion

Figure 2 depicts the results as heatmaps for each respective variable. Each row refers to one question and shows the average, standard deviation, and the respective share of answers from "strongly disagree" (1) to "strongly agree" (7). Following Nielsen [12], mean and median have been calculated for each variable. Both the obtained mean (respectively 5.175, 5.207, 5.459, and 5.122) and median (5, 6, 6, and 5) scores indicate that FGPE PLE's usability has been evaluated positively by the surveyed students. We can therefore conclude that FGPE PLE provides good enough usability to warrant its practical application to programming education. The measured distance to the perfect score is not slight, though (1.772 on average), which encourages further work to improve FGPE PLE's usability.

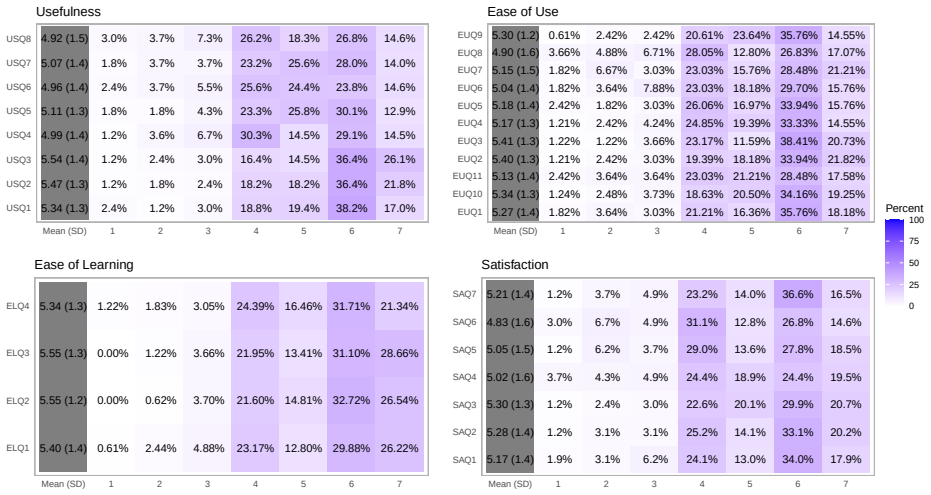

Fig. 2. Results of the USE questionnaire.

The FGPE PLE results are in between those reported in the literature: inferior to Bagh-Learn [17], a mobile game-based learning application for computing education, evaluated on average at 6.12, 6.00, 6.19, and 6.52 for usefulness, ease of use, ease of learning, and satisfaction, respectively, and superior to the OpenLearning MOOC [15], evaluated on average at 3.50, 3.55, 3.57, and 3.50.

6. Conclusion

Low usability can hamper the advantages of enriching learning environments with gamification. Here, we investigate this problem in the case of FGPE PLE, an open-source, language-agnostic gamified platform for learning programming.

By administering the USE questionnaire to 181 students using FGPE PLE, we could evaluate its perceived usability in the four aspects of usefulness, ease of use, ease of learning, and satisfaction. For each of them, the average measurement was between 5 and 6, which denotes a positive evaluation, but indicates that there is still room for improvement (as the perfect score is 7), which is a valuable signal for the developers of this and similar platforms.

The presented results have, of course, their limitations, the main of which is that the selection of survey participants was not random but based on their availability.

Our envisaged future work will be to perform a similar evaluation on commercial gamified programming learning environments to check whether there is a usability gap between open-source and closed platforms.

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