Co-design of a serious game for computing education

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Abstract The teaching of computer programming will soon become compulsory in the gymnasiums of the canton of Fribourg. To this end, we are conducting a project to co-design a serious game and an associated pedagogical scenario. This project is carried out according to a design-based research (DBR) involving the collaboration of an interdisciplinary group. In this article, which is based on and extends a recent communication [1], we define the DBR methodology, then analyse the co-design process with the successes and difficulties we encountered. We discuss the factors which facilitated collaboration and ownership of the research by the different members of the group.

Keywords: Digital learning game, Computational thinking, Design-based research, Collaborative research in education

Context

In September 2019 a programming course will become a mandatory part of the curriculum of first-year gymnasium (preparatory high school) students in the canton of Fribourg (Switzerland). The study plan, which is currently being finalized, will require learning the basics of programming. Teachers impacted by this change are therefore looking for adequate educational resources. Set up at their request and their professional association, the present research is part of the one-year PACT (*Playing and Computational Thinking*) project funded by the Hasler Foundation. In this research, we are interested in using and improving an existing JavaScript [2] programming game for teaching programming and computational thinking [3]. This project is carried out following a design-based research methodology (DBR) involving collaborative work among the members of an interdisciplinary group.

Targeted issues

Design-based research (DBR) is a collaborative research methodology with both a pragmatic and a theoretical focus. DBR has four dimensions [4]: 1) to design learning situations and to be contributive; 2) it is carried out in collaboration with practitioners; 3) it is iterative; 4) it is implemented in ecological conditions (in the classroom). The goal is to test hypotheses by putting them into practice, refining them after an analysis phase and testing them again in a second practical application. In this project, the research objective in the field of social sciences is to model the institutionalization phase, and on the computer

science side, to analyze the acceptability, usability and utility of the game. According to Sanchez and Monod-Ansaldi [4], this methodology has the advantage of using already validated theoretical models to design educational resources. It enables monitoring and evaluating the deployment of the solution. DBR involves the collaboration of practitioners, educational researchers and actors such as computer scientists, game and graphic designers. In this context, we are interested in observing the following points that are crucial to DBR: (Q1) What is the nature of the information exchanged? (Q2) Do the actors recognize the skills of the other project members? (Q3) What are the interactions inside the project? (Q4) Does the methodology promote the involvement of participants and their takeover of the project?

Proposed solution

In this project, an interdisciplinary group has been gathering at the Laboratory of Pedagogical Innovation (LIP) of the University of Fribourg for workshops dedicated to the co-development of resources. The group consisted of 13 persons: 6 computer programming teachers from four different gymnasiums, 3 computer scientists (HEIG-VD/HES-SO), 2 educational researchers (UniFR), 1 graphic designer and 1 game designer (freelancers).

The co-design steps in this project are:

1. Identification of the pedagogical objectives to be integrated into the game and the corresponding most common errors made by learners;
2. Identification of the constraints imposed by the pre-existing version of the game;
3. Identification of the target audience and proposals for new game scenarios;
4. Identification of the knowledge progression;
5. Design of exercises for each game level;
6. Identification of game-play traces to be collected automatically for research purposes;
7. Definition of a new graphic design;
8. Development of the pedagogical scenario in which the game will be integrated;
9. In-class test;
10. Feedback, analysis and improvement of the game and pedagogical scenario for the second design iteration.

Throughout this co-design process, we collected traces of all interactions, whether face-to-face or online: meeting minutes, audio/video recordings and numerous email exchanges. We also filled out a questionnaire to evaluate the motivation and satisfaction of the actors of the DBR.

Relevant innovation

The DBR methodology is the first innovation. The collaboration between computer teachers, computer scientists, game designers, graphic designers and educational researchers aims to design, test and analyze the programming learning game and its use in the classroom. One of the objectives is to analyze the acceptability, usefulness and usability of the game.

More specifically to the creation of the programming game, we identify three innovative aspects. 1) This game introduces to the basics of programming. In the creation process, the computer science teachers took

into account the constraints of the study plan as well as their experience as teachers to propose a realistic progression inside the game. 2) During the game, codes written by the players are collected automatically to enable the teacher to monitor each player's activity via a real-time dashboard. 3) Teachers have additional privileges, which allow them to create or modify levels inside the game. The third innovative aspect is related to the use of the game in a school context. This use requires a discussion phase that takes place after the game and is to be carried out with the students. This crucial debriefing phase is called "institutionalization" and corresponds to work on the knowledge activated inside the game and its development in the form of institutionalized knowledge [5]. One of the objectives of this research is to model this institutionalization phase after a game session.

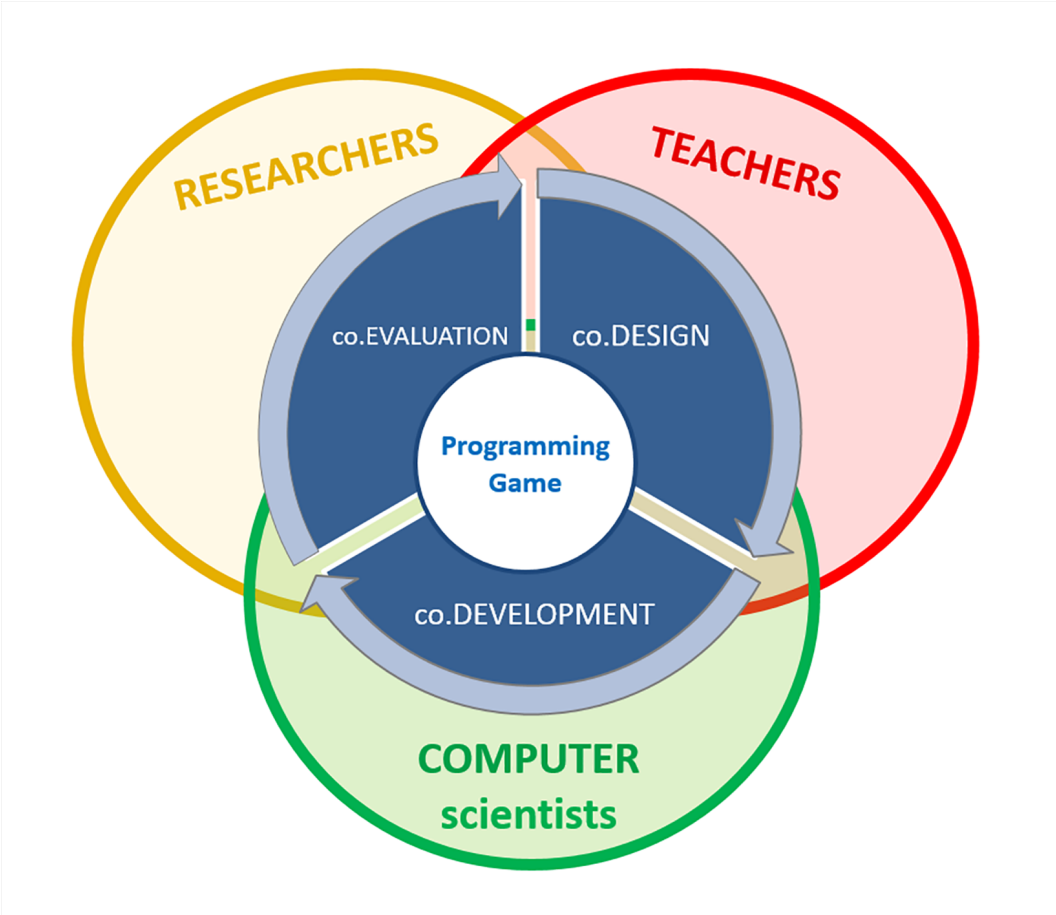

Figure 1 - The serious game at the center of the iterative co-design, co-development and co-evaluation process.

Project outcomes & results

Below we describe the findings for our four research questions.

Q1. During the meetings, everyone was asked to specify his/her work methodology, constraints and reality. This made it possible to take into account different work methods. DBR therefore fosters interactions, both in terms of content to be taught and encountered constraints.

Q2. We observed that the skills of each protagonist were recognized by the other actors. However, difficulties could arise when the needs of some people collided with the constraints of others. The time at hand did not always allow the desired game content modifications to be made, requiring a negotiation process. Another issue arose when research questions started taking more place: it was difficult for some teachers, as they had not realized that DBR is pursued bottom-up. To summarize, the methodology encourages openness and most often allows for negotiation in order to reach a solution adapted to the needs of each party.

Q3. In this DBR process, participants' relative availability seems to have strongly influenced group dynamics, as well as the time that had to be invested.

Q4. During the meetings, each participant is invited to share his or her point of view and contribute to a more effective outcome. Everyone seems to be involved and gives positive feedback on the project. However, some comments made us think that not all the actors had yet taken ownership of the research and sometimes had reservations about the project.

Figure 2 - Screenshot of the resulting serious game.

Conclusion

Our research methodology allowed the design of a programming game encompassing teachers' needs and the reality of the context in which the game is to be used. The resulting solution, the game and the usage scenario, is both a means of teaching and an object of research. The collaborative process is made possible by the participants' differentiated skills. However, success also depends on external factors, such as decisions of educational authorities, over which the team has little control.

Perspectives and Needs

We will shortly finish the design of a completely innovative active pedagogy game scenario and update the game to this end. Also, more sophisticated code analysis tools will be added in order to finely assess the quality of students' solutions to exercises. Programming languages other than JavaScript must be supported, in preparation of future teaching requirements. In the longer term, we would like to implement more software support for the DBR methodology around our serious games platform.

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