Coding and environmental education: a game to trigger knowledge acquisition

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Abstract — **The use of video games as an educational tool is gaining in popularity. The concept of serious games, which combine playful elements to foster learning, has been widely proven to be addictive. The ability of serious games to improve problem-solving, promote the acquisition of knowledge and skills, and foster involvement and motivation are key elements that make them effective educational tools in various fields. The contribution presents the prototype Dorobot, a serious game developed with a dual purpose: to improve students' programming and problem-solving skills and in the meanwhile to promote awareness of environmental sustainability. The game is addressed to students in early grades of secondary schools and the pilot study yielded encouraging results regarding user appreciation and effectiveness in learning acquisition.**

Keywords—serious games, environmental education, coding, problem-solving

I. Introduction

In an increasingly complex and dynamic world, where technologies are advancing rapidly and interconnections between individuals are becoming increasingly important, soft skills or transversal competencies play a key role in adapting and thriving. From an educational standpoint, the acquisition of these skills is crucial for achieving success in personal and professional life, and high school can be the right time to encourage and prepare students for entry into the world of work. [1]. Among soft skills, problem-solving can be addressed by providing basic informatics concepts. Different actions have been taken to spread digital culture education and to boost problem-solving acquisition. The European Digital Competence Framework for Citizens [2], for instance, has set out some guidelines to equip citizens with the skills and competencies needed for the new society. To support the acquisition process, games have proven to be successful. Understanding the importance of active engagement and practical context is rooted in the awareness that games, by harnessing motivation and involvement, can be a powerful driver of learning. A growing body of empirical data supports the theory that games and simulations, named serious games, can promote and enhance knowledge in a wide variety of educational contexts: medical [3], disaster mitigation [4], cybersecurity [5], in corporate [6], and so on.

In the field of informatics and for the development of computational thinking and programming skills, games can provide a stimulating and engaging environment. Players acquire new knowledge by actively practising problem-solving. Engaging with the experiences presented, players are encouraged to think critically, analyze situations, identify and evaluate available options for problem-solving, and make decisions. In the field of sustainability education, serious games can motivate and engage players both emotionally and cognitively, help them to reflect on complex environmental phenomena, and facilitate their understanding [7].

In this context, the research aims to combine serious games, coding, and environmental education to promote learning. In particular, the article presents Dorobot, a prototype serious game in which players will acquire coding skills in scenarios aimed at enhancing environmental awareness. Although there are several serious games that, through an interactive and engaging approach, integrate coding instruction with awareness of environmental issues, Dorobot has two added values compared to other solutions: first of all, it is addressed to students aged from $13-17$ and, secondly, it uses programming in pseudocode. Moreover, it is in Italian, so it can be easier to apply in Italy.

II. The Game Dorobot

The serious game "DOROBOT" has been designed to foster awareness of environmental issues and the acquisition of problem-solving and coding skills. Dorobot uses pseudocode to easily acquire programming skills. To achieve this, a minimal number of constructs and a graphical environment have been introduced to guide the user's choices. This is to allow the user to focus on defining algorithms in pseudocode. As the levels progress, the user will also need to refine his problem-solving skills as s/he faces new challenges. By participating in these challenges, they will be prompted to reflect on the importance of environmental care and enhance their skills in the field of waste sorting. No previous programming knowledge is required to use the game. The game genre is a top-down puzzle game, where missions consist of logical and/or strategic puzzle challenges. The player's goal is to help Dorobot clean up the environment. The game is structured into four levels. The difficulty of individual levels rises gradually: the first levels will be simpler and will be used to familiarize players with the controls, requiring only a few lines of code. As the game

progresses, the difficulty and complexity of the missions increase, requiring the user to spend extra effort in defining the correct instructions to be given to the robot. Each level is organized into missions, each of which requires the use of skills, i.e., the instructions, from the previous mission. This way, skill acquisition is guided incrementally.

For each mission, the user writes pseudocode in DoroCode to solve the mission. An interpreter created within the serious game allows the bot to move on the screen and provides visual and auditory feedback at the end, signalling whether the mission has been completed. Even when syntax errors are detected, or incorrect language usage, a message is provided explaining the error (Fig. 1).
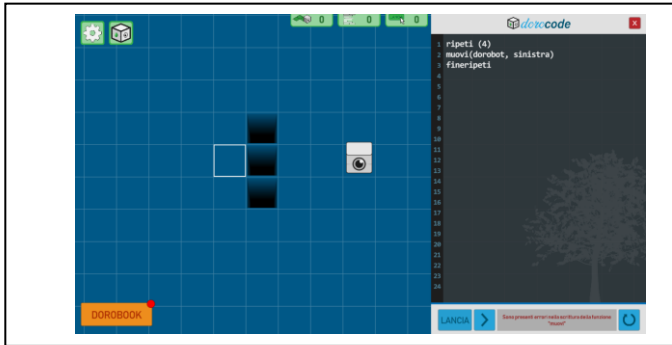

Fig. 1. When a syntax error occurs, the interpreter gives feedback to attract the player's attention. In this case, the feedback suggests to correct the "move" instruction that is wrong.

Along with the mission completed message, feedback on the quality of the code created will be provided using stars, which will colour proportionally to it. Quality will be measured in terms of the number of lines of code created to complete the mission. In addition, whenever the player needs hints on instructions and commands, the Dorobook, the pseudocode manual, is always available in the main game window. It provides all the information about the game and the instructions (Fig. 2).

Fig. 2. Dorobook the pseudocode manual to help the player during the game. In this picture, the information about the instruction "move" is given.

III. Conclusions

With the acceleration of digital transformations and the increasing need for ecological awareness, this study aimed to explore the potential of serious games for the development of soft skills combined with the promotion of environmental awareness. The data collected in a first pilot study confirms and highlights how serious games can be an extremely useful tool in the field of education. Furthermore, engagement and cognitive load were studied, and the satisfactory results obtained show that some game levels, although perceived as challenging, allow users to feel positively rewarded when they complete the level with the highest score. Therefore, it can be stated that the combination of the immersive experience linked to the theme of environmental sustainability, along with the active promotion of computational thinking and problem-solving, can represent an excellent opportunity for the education of individuals who are aware, technologically competent, and capable of addressing the complex challenges of the contemporary world. Finally, it is important to emphasize that, considering the effectiveness of serious games depends on their design and implementation, they must be designed with clear educational objectives and provide an engaging environment to maximize user engagement. It is believed that a broader reflection on the optimal design of these games, as well as their long-term impact on individual education, is desirable.

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