Robotics and Virtual Worlds: An Experiential Learning Lab

Barbara Caci¹, Antonella D’Amico¹, and Giuseppe Chiazzese²

¹ Dipartimento di Psicologia, Università degli Studi di Palermo, Viale delle Scienze, Ed. 15. 90128 Palermo - Italy
² Istituto per le Tecnologie Didattiche di Palermo, Consiglio Nazionale delle Ricerche, Via Ugo La Malfa, 153, 90146 Palermo - Italy
{barbara.caci,antonella.damico}@unipa.it, giuseppe.chiazzese@itd.cnr.it

Abstract. Aim of the study was to investigate the cognitive processes involved and stimulated by educational robotics (LEGO® robots and Kodu Game Lab) in lower secondary school students. Results showed that LEGO® and KGL artifacts involve specific cognitive and academic skills. In particular the use of LEGO® is related to deductive reasoning, speed of processing visual targets, reading comprehension and geometrical problem solving; the use of KGL is related to visual-spatial working memory, updating skills and reading comprehension. Both technologies, moreover, are effective in the improvement of visual-spatial working memory. Implications for Human-Robot Interaction and BICA challenge are discussed.

Keywords: Educational robotics, cognitive skills, academic performance, human-robot interaction.

1 Introduction

Educational robotics is one of the most challenging research area in the domain of Human-Robot Interaction (HRI), and is eligible as one of the best practical domain for the BICA challenge [1; 2]. In the constructivist framework [3], robotic and virtual interfaces are considered powerful tools for learning concepts about Mathematics, Computer programming, and Physics [4], for improving visual-constructive abilities, reasoning and problem-solving skills [5; 6] and for enhancing narrative and paradigmatic thinking [7]. Both LEGO® robotic kits and KGL allow children to build robots or agents able to act goal-oriented behaviors, such as to direct themselves toward a light, avoid obstacles or move inside a maze, and so on.

Using LEGO® robotic kits, children build the body of the robot assembling motors and sensors (e.g., touch, ultrasonic, or light) with the brain of robot, a programmable microcontroller-based brick (NTX). Then, they may program the mind of the robot using an object-based interface inspired to Logo, and based on if-then rules. However, LEGO® kits are limited in the kind of behaviors that subjects can design and program.
A more extensive programming practice is offered by the recent Kodu Game Lab (KGL) [8], a 3D virtual stage for the creation of virtual worlds, in which children can define more complex behaviors, movements and interactions with characters and objects using similar programming rules [9]. Using KGL children may design virtual environments, defining terrain scenarios and adding mountain, volcanoes, lakes, and so on. Then, they may enrich the environment by adding funny characters (e.g. Kodu, cycle, boat, fish), environmental elements (trees, apples, rocks clouds), paths (streets, enclosures, walls) and city elements (houses, factories, huts, castles) and, finally, they may assign specific behaviors to some of the elements, generating an interactive virtual world. Although the literature about KGL is quite recent, first experiments on use of Kodu have shown that its visual programming language is particularly easy to use also for novice students [10], compared to textual language models used by Alice [11], Greenfoot [11] and Scratch [13].

Starting from this theoretical framework, an experiential learning laboratory (32-hours) involving children was designed with a twofold goal: to study some of the cognitive and academic abilities involved in building and programming robots/agents; to measure the effectiveness of the laboratory in the enhancement of the same cognitive and academic skills.

2 Method

2.1 Participants

The study involved 59 students of 11 years of age, attending an Italian Secondary School, that were casually assigned to experimental (F =14, M=22) and control condition (F=15, M=18). Children of the experimental group (EG) followed the laboratory described below; children of the control group (CG) followed the regular school activities.

2.2 Materials and Procedures

A pre-post test design was adopted. During the pre-post test phases the cognitive abilities and academic performances of EG and CG were measured using:

— eight syllogistic and conditional reasoning tasks, drawn from the Automated System for the Evaluation of Operator Intelligence [14].
— the PML working memory battery [15], aimed at measuring phonological and visual-spatial working memory, executive functions (shifting, updating, inhibition), rate of access to long term memory and speed of processing.
— the MT Reading Comprehension tasks [16] requiring children to read a narrative and an informative passage and to answer to 15 multiple-choice questions for each passage.
— two arithmetical problem solving tasks and one geometrical problem solving task.