Available online at www.sciencedirect.com

ScienceDirect

IFAC Papers Online CONFERENCE PAPER ARCHIVE

IFAC-PapersOnLine 49-6 (2016) 168–173

HOME I/O: a virtual house for control and STEM education from middle schools to Universities

B. RIERA*, F. EMPRIN, D. ANNEBICQUE***, M. COLAS* and B. VIGÁRIO******

** CReSTIC, UFR Sciences Exactes et Naturelles, University of Reims Champagne Ardenne, Moulin de la Housse, BP 1039, 51687 Reims - France (bernard.riera@univ-reims.fr).*
*** CEREP, ESPE (postgraduate school of professorship and education), University of Reims Champagne Ardenne, 23 rue Clément Ader -51100 Reims - France.*
**** CReSTIC, IUT de Troyes, University of Reims Champagne Ardenne, 9 rue de Québec, BP 396, 10026 TROYES, Cedex, France*
***** REAL GAMES LDA, Rua Elísio de Melo nº 39, Piso 34000-196 Porto – Portugal*

Abstract: This paper deals with the result of a R&D project called "DOMUS" partially founded by the French Ministry of National Education in order to design a virtual house adapted to control and STEM (Science, Technology, Engineering and Mathematics) education, and usable from middle schools to Universities. The result is software called HOME I/O. It is much more a serious game than a simulation tool which has been designed and developed in order to be adapted to the Y generation. This 3-year R&D project (2011-2014) is a fruitful collaboration between CReSTIC lab from the University of Reims Champagne-Ardenne and Real Games, a Portuguese company. The main idea has been to bring a virtual house into the class room, adapted to learners and teachers and suitable for control and STEM interdisciplinary education. With this innovative pedagogical tool, the possibilities of pedagogical scenarios in control and STEM education depend only on teachers' imagination. In this paper, the main ideas which are involved the design of HOME I/O are presented as well as the main features of the software. An experimental stage with 50 teachers from middle and high schools has shown that this kind of tool changes the way to teach and requires new training for teachers.

Keywords: control education, STEM, serious games, Human-Machine Systems.

1. INTRODUCTION

With rapid technological change in industry around the world, it is likely that specific skills demanded in the future will differ from those required in the past. STEM (Science, Technology, Engineering and Mathematics) education aims at teaching Science as a practice in an interdisciplinary way. Control is a field that really spans STEM education. It is why Education, at all levels, is an interesting field for Human Machine System research and applications (Riera, 2009, Riera and Vigario, 2013) (Marangé, 2008). In this paper, we present an innovative pedagogical tool and pedagogic principles that involved its design. The idea has been to create a virtual house called HOME I/O. This software is much more a serious game than a simulation. It is the result of a 3-year R&D project "DOMUS" (2011-2014) partially founded by the French Ministry of National Education, between CReSTIC lab from the University of Reims Champagne-Ardenne and Real Games, a Portuguese company. The idea has been to bring a virtual house into the class room, usable from middle schools to universities, adapted to learners (Y generation) and teachers and suitable for control and STEM education. HOME I/O has been designed by applying a systemic approach of education. For that, HOME I/O enables to study the house from different points of view (automation, energy efficiency, smart home …), as a whole or as a set of subsystems, but taking into account the environment. The possibilities of pedagogical scenarios (i.e. situations, questions, problems) offered by HOME I/O depend only on teachers' imagination.

The first part of the paper deals with STEM and control education. It is shown the analogies between control and STEM education and the importance of a systemic approach in both cases. The second part of the paper deals with HOME I/O and its main features. This part also presents the evaluation stage of HOME I/O with 50 teachers. This study has shown that a tool like HOME I/O modifies teachers' work and requires new training for them.

HOME I/O seems to be a very innovative pedagogical tool and it was awarded with the prize "Le Coup de Coeur" in the 6th Edition of "TROPHÉES DES TECHNOLOGIES ÉDUCATIVES 2014" at EDUCATEC-EDUCATICE in Paris.

2. STEM AND CONTROL EDUCATION

STEM is a curriculum based on the idea of educating students in four specific disciplines — science, technology, engineering and mathematics — in an interdisciplinary and applied approach that is coupled with hands-on, problem-based learning. The literature is intensive about STEM education (Bicer et al., 2015) (Gonzalez and Kuenzi, 2012) (Corlu et al., 2014). Rather than teaching the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world

10.1016/j.ifacol.2016.07.172

applications. The term is typically used when addressing education policy and curriculum choices in schools to improve competitiveness in science and technology development. All young people should be prepared to think deeply and to think well so that they have the chance to become the innovators, educators, researchers, and leaders who can solve the most pressing challenges facing the world, both today and tomorrow. It is necessary to focus on these areas together not only because the skills and knowledge in each discipline are essential for student success, but also because these fields are deeply intertwined in the real world and in how students learn most effectively. STEM education can begin while students are very young, from elementary school to high schools.

Control engineering courses as all technical courses in the broad sense require the transfer of knowing and know-how to learners. Usually, courses are divided into theoretical courses, exercises, and practices. Control engineering training requires an interdisciplinary and applied approach that is coupled with hands-on, problem-based learning, similar to the STEM approach. In addition, as STEM education, control education requires the use of systems coming from the today life. STEM and control education requires the use of systems having similar requirements:

- The technical system has to be adapted to the teacher's objectives which are linked to the learner's level and to the curriculum.
- To keep a global perception of the technical system and its environment. This point aims at always considering the system having to be studied as a whole with its environment.
- To allow making errors in order to learn from errors (Boy, 1996).

One can notice that some points are contradictory. For instance, real equipment seems interesting but requires proper integration in training applications. That also can require considerable room and regular maintenance, which has important costs and requires qualified people; last but not least, most applications of interest tend to be risky for the inexperienced students who are trying to making them work. Software simulation can help a lot in this subject. In fact, computer based simulation can be a risk free, affordable and easy to replicate training platform. In the specific case of industrial control and automation education and training, software simulations recreating industrial plants can replace physical target systems (Callaghan et al., 2009). This "synthetic" approach makes possible to get an inexpensive training environment that does not present any risk of injury to man or damage to machines. Whilst synthetic (or virtual) training scenarios are not new – for instance flight simulators are being used for decades in professional training (Menendez and Bernard., 2001) – modern technology, most derived from computer games, is making them very realistic, low cost and increasingly easy to use and integrate with external devices. Moreover, computer games are also enabling the creation of "synthetic" or "simulated" environments from where scientific research, education and training, career development and life-long learning are possible and effective. Thus, computer games technology is getting an increasing importance in the development of valuable professional tools for scientists, engineers and educators. Video games can be a great tool, really adapted to control and STEM education (Mayo, 2009) (Arango et al., 2008) (Riera et al., 2009). It is with this objective that CReSTIC lab from the University of Reims Champagne-Ardenne and Real Games, a Portuguese company, performed in a 3-year R&D project (2011-2014) bringing a complete "virtual" house, called HOME I/O, into the classroom for control and STEM education. The idea was to design an innovative pedagogical tool. HOME I/O can be freely downloaded at www.realgames.pt.

3. HOME I/O: A VIRTUAL HOUSE FOR CONTROL AND STEM EDUCATION

HOME I/O is real time simulation software (Fig. 1) of a smart house and its surrounding environment, designed to cover a wide range of curriculum targets within Control, Science, Technology, Engineering and Math, from middle schools to universities. This project was supported, in testing and evaluation phases, by CEREP lab, the National Resource Network (RNR) in Technology and Academic Delegation to digital (DAN) of the rectorship of Reims.

3.1 Why a virtual house?

Home automation is a growing trend that is becoming more and more popular and affordable every day. Today this term is rather replaced by smart house. It is used in electronics technology, automation, IT and telecommunications to ensure safety functions (alarms, cameras and remote monitoring), living comfort (automation and job scheduling daily, remote control, home care ...) and energy management (optimization of heating, lighting ...). The operating principle of a home automation system is to centralize the control and monitoring. Unlike previous wired solutions often very expensive, home automation box uses the power of Internet and wireless. With or without subscription, they allow open use and can be controlled from a computer, a smartphone or a touch pad. Installation is very simple, and takes just a few minutes by a non-expert user. Home automation is currently booming with this democratization. The applications are numerous, and this new market, which has many links with that of connected objects, interest a lot ISPs, game console manufacturers or chains of consumer stores.

The idea to simulate a house was to offer to kids, students and learners a system from the today life that they can use to raise awareness about energy efficiency, change behaviors and learn about new technologies. By giving the possibility to modify the environment and the level of automation, it becomes possible to have one numeric tool usable from middle schools to universities.

3.2 Why a serious game and not only a simulation tool?

Young people have changed. Y generation spends more time in front of a console or a computer screen than watching television. Video games are fascinating and probably inescapable, attracting kids to consoles as bees to honey. In one way or another, video games have impacted many kids' lives during the last decades, and presently, playing computer games is a favorite leisure activity for most young (and not so young) people (Magalhães et al., 2011). Whilst recreation