Chapter 44
Using ICT in STEM Education: A Help or a Hindrance to Student Learning?

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ABSTRACT

The aim of this paper is to examine the use of digital technologies in Science, Technology, Engineering, and Mathematics Education (STEM). We will discuss the effectiveness of the teaching-learning process in terms of the elements that could possibly promote learning with the use of Information and Communication Technologies (ICT) in STEM education. This will be done, first, by taking a learner-centred approach to an activity that students carried out using ICT to performing a task set by the teacher (cognitive engagement in the task, motivation, nature of knowledge built). The aim was to understand how ICT could be a cognitive aid for the student. Second, a teacher-centred perspective to the development of prescribed tasks (form, knowledge carried by the task) was used to identify how ICT can be adapted to aid student learning in STEM education.

INTRODUCTION

Huge financial support has, for several years, been provided by states, institutions, and communities in the deployment of information and communication technology (ICT) for education (OCDE, 2015; Pedro, 2012). These massive investments in ICT aim, on the one hand, to prepare children for the future evolutions in technologies and society, specifically in our contemporary context of globalisation and the development of a knowledge society. On the other hand, there is the idea that due to a massive increase

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in their potential, digital technologies offer increasingly important possibilities for supporting student learning, assisting teachers in their mission, or even replacing the teachers. Because digital technologies symbolise progress, and thus the necessity to prepare students for the future, these policies have a dual aim: to learning with ICT and to learn about ICT.

Science, Technology, Engineering, and Mathematics (STEM) frequently deal with all new technologies, including, specifically, digital technologies. It is easy to see this from many stages of this long tradition and people are likely to remember the different approaches in the 1970s with tools such as Lego-Logo, Fishertechnik, or any others. At the same time, there has been considerable pedagogical innovation that includes using a problem solving approach, a project based approach, and, more recently, an investigation based approach. Although some of these research findings show that these pedagogical innovations are somewhat effective from the point of view of student learning, Connor, Karmokar and Whittigton (2015) consider that the most significant element of all these approaches is that of a student who is active in his or her learning. So, for these authors, problem-based learning is a subset of inquiry-based learning, and inquiry-based learning is a subset of active learning. If some research suggest the relative efficiency of inquiry-based learning (Lazonder & Harmser, 2016), these authors also raise the question of what type of guidance is adequate in order to promote students' learning in such an approach. For Kirschner, Sweller and Clark (2006), inquiry-based instruction induces a heavy cognitive load for the learner by imposing a search for a problem-space that may then be an obstacle to learning. Therefore, for these authors, it is necessary to provide the learners with specific guidance to help them to learner efficiently in processing the information of the problem-space and, thus to enable them to learn by reducing the cognitive load imposed by the different tasks.

Many combinations of ICT and pedagogical innovations have marked the development of STEM in recent years. However, their effectiveness has never really been studied and it impossible to say which one impacts the other. This hierarchy is mostly due to the advantages of ICT and the development of a number of applications. In many cases, these applications are presented (by authors, editors, producers, etc.) as the best way for facilitating learning. A number of studies published in scientific journals pose this efficiency as evidence that is based on the satisfaction of actors, teachers, and students. Such studies respond to the question of the attractiveness of new pedagogical organisations. The students can be satisfied by ICT, but this interest decreases at the same time as their use increases in their environment. This satisfaction says nothing about the learning efficiency. A lot of questions are still open: what and how they learn? If they learn, whether this is due to: ICT, the pedagogical organisation, the interactions between teacher and students and others?

All the above questions are relevant for assessing the policies around the massive deployment of digital technologies, as well for understanding the efficiency of the pedagogical organisations (with or without ICT), and for appreciating the cognitive development of students. These three levels cannot be reduced to a simple satisfaction evaluation and the results can differ from one to another. In other words, people suppose that ICT can support and enhance learning. For example, in the presentation of the UNESCO project entitled "Enhancing teacher education for bridging the quality gap in Sub-Saharan Africa" [UNESCO, 2014] it is clearly written that the use of ICT enhances student learning and improves the quality of instruction. Nevertheless, analyses show that there is no evidence of this, and thus the role of the digital technologies in facilitating learning remains to be demonstrated (Michko, 2007). The present chapter presents some elements of the debate around ICT from the point of view of the efficiency of learning.