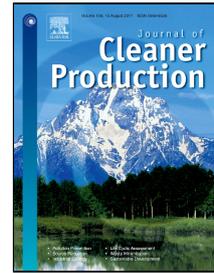


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# Infusing Sustainability into Software Engineering Education: Lessons Learned from Capstone Projects

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## Abstract

Sustainable development (SD) has become a millennium challenge for humanity. It has boosted the integration of sustainable, sound practices across different fields (e.g. e-participation, smart transportation, sustainable agriculture). Information and Communication Technologies (ICT) have strongly supported social transitions in becoming more sustainable and participative over the last two decades. Integrating multi-disciplinary sustainability concepts into the higher education of computer scientists is important in that this ensures that future ICT endeavours will take sustainability concerns into account. This article describes four capstone projects developed by students from the Erasmus Mundus Master Course in Pervasive Computing and Communications for Sustainable Development (PERCCOM), who were enrolled alongside regular students in a traditional software engineering course held at the Lappeenranta University of Technology. The coursework was part of a research project called Green.Citizen@ICT, which aims at investigating the use of ICT and software services for infusing sustainable habits in citizens through the development of applications for SD. This study demonstrates how a sustainable development focus can be integrated into a traditional software engineering course. The goal of this article is to enhance understanding of the integration of sustainability into software engineering education, by providing a detailed example of a master course in which this took place. This course supported the development of ICT competences for building cleaner, greener, and more resource- and energy-efficient cyber-physical systems, while addressing the social and environmental dimensions of sustainable development.

**Keywords:** Sustainable development; ICT; Software Services; Green.Citizen@ICT; PERCCOM; Educational Initiative.

## 1. Introduction

The concept of sustainable development (SD) has been continuously evolving ever since the 1960s, referring 1) to only ecological conservation management in the 1960s, 2) to incorporation of human development in the 1970s, 3) to integration of economic progress (based on sustainable agriculture) in the 1980s (Brundtland et al., 1987), 4) to participatory governance as the norm in the 1990s (United Nations, 1992), and 5) to recognition of the multidimensionality of the term (social, economy, and environment) in the 2000s (United Nations, 2015, 2005). Sustainability and sustainable development have become the megatrends of the millennium. News headlines and scientific reports emphasize climate change and the severe consequences of it. However, ways for addressing and preventing it remain under discussion. In this context, education at all levels has been highlighted as key to achieving long-term sustainable efforts in designing a sustainable future (Cortese, 1997). Sustainability and sustainable development can be understood and approached from different perspectives. Environmental / ecological, business / economic and social perspectives are the most used. Recently also technological and individual, as opposed to society, perspectives have been proposed. In this article we stick on the original ecological, economic and social perspectives on sustainability while analysing the sustainability education.

Education for sustainable development (ESD) has been proclaimed during the last three decades by several international declarations as being essential to promoting responsible and sustainable conducts of societies (UNEP, 1972; UNESCO, 2014; United Nations, 1992). To design a longstanding sustainable future, certain mind-sets must be changed towards embracing more participative and collaborative cultures, where human activities sustain rather than degrade our natural environment. Education at all levels is the means to achieving such a transition (Arevalo, 2010; Barth et al., 2014; Lozano et al., 2013).

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