Safety Science 73 (2015) 8–14

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Prevention through Design (PtD). The importance of the concept in Engineering and Architecture university courses

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ARTICLE INFO

Article history:
Received 26 November 2013
Received in revised form 27 October 2014
Accepted 10 November 2014

Keywords:
Prevention through Design
Course
Occupational Health and Safety
Degree
Bologna
Construction
Structure

ABSTRACT

Although the concept of Prevention through Design (PtD) is not new, many injuries still occur at construction sites because it is poorly implemented by engineers and architects, or it is not implemented at all. The aim of this paper is to quantify how Prevention through Design is taught in university design or construction courses offered as part of Engineering and Architecture under/degrees in Spain that focus on the construction of concrete structures. Objective and subjective methodologies were used to compare courses from the under/degrees taught in the previous system (Old) and those under the Bologna process. A survey of 454 Engineering and Architecture students was conducted, course lecturers were interviewed, and an objective analysis of the contents of the syllabi in the under/degrees was carried out.

Occupational Health and Safety had a greater presence and importance in the courses under the Old degrees than those created to comply with the Bologna process. Analysis of the contents included in the syllabi showed that although the integration of occupational prevention decreased in construction courses in the Bologna degrees, the number of courses dealing with OHS topics increased, but they did not necessarily include the topic of Prevention through Design. Lack of education and training in Prevention through Design was found in those courses dealing with the construction of concrete structures that were included in the study. The Bologna degrees have not been an improvement in this respect. An enormous effort is necessary to improve the understanding and implementation of the Prevention through Design concept.

1. Introduction

Construction injury rates are an international cause for concern because it is the sector with the highest casualty rates in many countries (Camino et al., 2008; Eurostat, 2013). Consequently, the problem has been investigated by researchers in countries as different as Taiwan (Cheng et al., 2010), Scotland (Cameron et al., 2008) Turkey (Etiler et al., 2004) (Müngen and Gürcanli, 2005) Portugal (Macedo and Silva, 2005), or South Korea (Im et al., 2009). In Spain, injury rates are equally high (Camino et al., 2008; López-Arquillos et al., 2012; Martinez-Aires et al., 2010).

Multiple factors are involved in fatalities and injuries in the construction sector, such as equipment, workers, workplace issues, or project design (Gibb et al., 2006). Of special interest in the area of safety is the concept Prevention through Design (PtD), which improves safety by including it in the design phase itself. A definition of the concept is available on the National Institute for Safety and Health (NIOSH, 2013) website:

"*Addressing occupational safety and health needs in the design process to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, and disposal of facilities, materials, and equipment*".

There are many studies of PtD which conclude that a large percentage of construction injuries could have been avoided or reduced if occupational safety had been considered in the design phase and during the project itself (Weinstein et al., 2005; Behm, 2005; Haslam, 2005; Gibb et al., 2006; Gambatese et al., 2008). Authors such as Behm (2005) and Gambatese et al. (2008) studied the influence of project design on construction worker safety. Their studies analyzed connections that existed between construction fatalities and construction safety design and found that 42% of the fatalities reviewed were linked to the construction safety design of the projects.

In Europe, architects and design engineers are required to implement construction safety in their designs (ILO, 1985), but unfortunately Prevention through Design is often forgotten or not clearly integrated in university Engineering and Architecture

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http://dx.doi.org/10.1016/j.ssci.2014.11.006
0925-7535/

courses. Consequently, many professionals are required to implement a concept that they have not studied at all or only briefly during their academic careers. The absence of PtD during university education could thus be considered as a "hidden" problem, because the related negative consequences are not detected at the university, but will appear during the professional careers of construction Engineers and Architects. This is only part of a bigger problem because, in general, safety-related content is not properly integrated in undergraduate and graduate curricula (HSE, 2009). Changing this is difficult since these curricula are already crowded (Culvenor and Else, 1997).

It is important to consider the impact of the changes introduced by the Bologna process, which was devised to create a European Higher Education Area by 2010. Bologna is a process launched in 1999 by the Ministers of Education and university leaders of 30 European countries. The objective of the process is to allow national systems and universities to maintain their diversity and, at the same time, improve transparency between higher education systems, as well as implement tools to facilitate the recognition of degrees and academic qualifications, exchanges between institutions, and mobility. Taking part in the Bologna process is a voluntary decision made by each country and its higher education community to endorse the principles underlined in the European Higher Education Area. Bologna process was meant to strengthen the competitiveness and attractiveness of the European higher education and to foster student mobility and employability through the introduction of a system based on undergraduate and postgraduate studies with easily readable programmes and degrees. The process has produced profound changes in the curricula of many university courses in different countries, including Engineering and Architecture courses with the aim of improve the degrees' contents, but the impact of the cited changes in the PtD contents of the courses, has not been evaluated previously.

Research on the occupational health and safety courses (OHS) provided by universities do exist in the literature (Heinrich, 1956; Nolan, 1991; Grossel, 1992; Senkbeil, 1994; Phoon, 1997; Hill and Nelson, 2005; Arezes and Swuste, 2012; Cortés et al., 2012), but specific studies on the presence of PtD in courses and attempts to quantify their impact on the design and construction of concrete structures in Engineering and Architecture programs have not been found.

The aim of the current study is to quantify how the Prevention through Design concept is taught in university undergraduate and graduate courses offered in Engineering and Architecture programs in Spain for the design or construction of concrete structures. Opinions from students and lecturers and an analysis of academic programs will be used for this purpose.

2. Material and methods

The study was divided into three stages.

(1) Identify and select a sample of the Engineering and Architecture courses that focus on the design or construction of concrete structures.
(2) Use a questionnaire to collect and analyze the perception of the students taking the university courses selected in stage 1.
(3) Analyze the safety-related content in the syllabi from the courses selected, and the safety issues discussed in the rest of courses that make up the under/graduate degree.

2.1. Data collection

During the 2010–2011 academic year a total of 212,466 university students were enrolled in one of the 718 Engineering or Architecture under/degrees available in Spain (MEC, 2013; INE, 2013). It is important to note that the European Higher Education Area was launched in 2010 as part of the Bologna process. More competitive and more attractive under/degrees were created for both Europeans and students and scholars from other continents under this more compatible and comparable framework.

At present, university students can be divided into two groups depending on their academic itinerary. Students studying degrees approved before the Bologna process, (Old degrees (OD)) and those whose degrees were created during the Bologna process to create the European Higher Education Area (Bologna degrees (BD)). Although the number of students in both is currently similar, the future distribution of the students will be quite different. The Old degrees are in the process of being phased out and the number of students is therefore declining. At the same time the Bologna degrees are being rolled out to substitute the Old degrees and the number of students is on the rise.

In the same period, 50,996 students concluded their under/degrees and of those 39 per cent (20,086) were building or civil construction under/degrees [Architecture, Civil Engineering, Building Engineering, and Industrial Engineering] (MEC, 2013). In order to obtain the opinion of future construction professionals, 12 courses related to design or construction of concrete structures from 8 different under/degrees at three different universities were selected (6 courses from four different Old degrees and 6 courses from four different Bologna degrees). The selection criteria used was that the course be part of a building or civil construction under/degree and that the syllabus must include the design or construction of structures.

From the selected construction courses 454 students were surveyed in-situ using a questionnaire during a lecture on theory. 432 students correctly completed all of the items on the questionnaire and thus the response rate was 95.15%. Distribution of the answers is provided in Table 1.

Based on the population studied and the sample collected the results obtained from the questionnaires had a confidence level above 95%, and a margin of error under 5%.

2.2. Questionnaire design

A Likert-scale questionnaire (Likert, 1932) was designed to collect the opinions of the students in the sample since these scales have been shown to be a very useful tool in previous papers on occupational health and safety in construction (Meliá et al., 2008; Gittleman et al., 2010; Ismail et al., 2012). The questionnaire was designed to be simple and short. It contained 15 items grouped into three categories:

(1) Questions related to the student's general education and training on Occupational Health and Safety issues.
(2) Specific questions regarding the influence of Prevention through Design in the courses.
(3) Questions about the present value of occupational safety and Prevention through Design in the labor market.

Respondent were asked to evaluate each item from 1 [Strongly disagree] to 5 [Strongly agree].

2.3. Statistical tools

A variety of statistical tools were used on the academic programs and the questionnaire results. For the academic programs the frequencies of specific keywords related to construction projects and safety were analyzed. Statistical tools such as the median test and the Kruskal–Wallis test were applied to the questionnaire