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Innovative design of an educational physical simulation tool for investigating energy consumption in buildings for enhancing public engagement

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Abstract

Reducing carbon emission and energy consumption in buildings is becoming an important priority on global level. Buildings consume significant amount of energy for heating or air-conditioning in most countries. The drive to enhance the understanding of building insulation and its effect on energy use, is critical for improving public engagement to achieve reduce carbon emission towards more sustainable future. This paper presents the design and the development an educational and research simulation tool to study and understand the thermal performance and energy efficiency of buildings. The novel design includes small-scale multi-layered model of buildings where insulation layers can be added to or removed from the building model in a modular and interchangeable manner to allow changes to the thermal performance. The results show that this novel model will provide a new educational tool to enhance the understanding of energy consumption and insulation in buildings. The design can be used to engage the young generation regarding building insulation and energy efficiency. It also could provide an advanced research and teaching tool for energy in buildings, instrumentation and infrared thermography.

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Keywords: Building enegy efficiency; simulation; educational tool; Building energy consumption; Thermal performance; Innovation.

Introduction

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There is a need to improve public understanding and engagement towards energy conservation and sustainability, particularly in buildings. Moreover, teaching students and researchers on the effect of insulation and other changes in building features on energy consumption is becoming essential to improve scientific knowledge and public engagement. Currently there is a lack of useful educational tools in this field which is related to enhancing the understanding of the effect of altering the building envelope to improve the energy performance and thermal efficiency. Energy consumption in buildings in the EU accounts for about 40% of the total energy consumption [1]. According to the EU Directive 2010/31, the EU has a goal to reduce energy consumption and carbon emissions by 20% by the year 2020 [2]. The directive also emphasises that all new buildings have to be nearly zero-energy buildings by the same time frame.

However, many countries around the world have an old stock of houses that will still need improvement. To engage the public in this process, they need to understand the benefits of insulation to their quality of life, particularly in relation to their building temperature and financial savings. Thermal insulation is one of the most important factors that enhances the energy performance of buildings. With improved insulation, new and renovated buildings will provide an acceptable level of energy conservation. Significant research has been done in this area. For example, Al-Habaibeh et al. [3] has presented a case study of an existing university building, where the insulation has been improved, mainly by adding an internal doubled glazing. The study shows the thermal images of the building from 2005 before the renovation and from 2010 after the improvement, which demonstrates very clear improvement in the thermal insulation performance. Kim et al. compared the impact of adding insulation on energy consumption in cold and hot climate in USA. Computer simulation tool has been utilised to test the building under two different climatic conditions: cold climate in Michigan and moderate-humid climate in Florida. The results show that adding insulation in cold climate is highly recommended to reduce the energy required for heating in winter, but the insulation might not be effective in moderate weather conditions [4]. Tettey et al. [5] have analysed the implications of five different insulation materials on the primary energy use and CO_2 emission and the results show difference in insulation capability between 6-7% in relation to primary energy use. Other research work, has assessed the life cycle impact of different flooring materials in buildings [6] and the external wall thickness of expanded polystyrene on the life cycle saving, life cycle total cost and payback period [7]. Composite materials as insulation have also been found to be effective [8]. The implementation of mandatory insulation in New Zealand since 1978 shows higher internal temperature and decreasing energy consumption [9].

One of the issues is that it is normally difficult to engage the public in the insulation process and most of the research work stays within the industrial and academic sectors. Some attempts have been made to encourage the public and improve their engagement. A research presented by Goodhew et al. [10] has investigated the behavioural effect of visualisation of heat loss from residential homes and the consequences for energy saving using infrared technology. Using infrared images, the study enabled householders to see how the heat escapes from their homes in order to study the eventual motivational impact on behavioural energy conservation. The research concentrates on the ability to encourage residential energy saving measures through such visualisations. The results show potential energy conservation by using the demonstrated visualisation technology.