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Innovative concept of an educational physical simulation tool for teaching energy consumption in buildings for enhancing public engagement

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Abstract

Buildings consume significant amount of energy for heating or air-conditioning in most countries. Therefore, educating the public and young generations to enhance their engagement and encourage them to reduce carbon emission and energy consumption in their daily life is becoming essential worldwide to drive continuous improvement towards more sustainable future. This paper presents an innovative educational tool to simulate energy performance and its use in educating university students and teaching school children about the subject. The paper outlines the developed educational tool and presents its benefits via two detailed case studies, with wide and diverse level of knowledge and learning outcomes. The educational technology includes a small-scale multi-layered model of buildings where insulation layers can be added to or removed from the building's envelop to influence energy performance. Qualitative and quantitative research has been conducted. The results show that the technology is capable of engaging the young generation and to help them to understand the thermal performance and energy efficiency of buildings.

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Keywords: Building energy efficiency; simulation; education; innovation; thermal performance; public engagement.

1. Introduction

Currently, it is becoming necessary to improve public understanding and engagement regarding energy conservation and sustainability, particularly in the building sector. Additionally, educating pupils,

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students and researchers about the impact of insulation and further modifications of buildings on building energy consumption is becoming a central activity to expand scientific knowledge, public engagement and awareness in this field. This will allow them on the long term to take the right decision regarding energy saving measures. Today, it seems there is a substantial lack of appropriate educational tools in this area of research, which could contribute to improving the understanding and the impact of the building envelope on the energy efficiency and thermal performance. Energy consumption in the building sector in the EU stands for about 40% of the total amount [1]. The EU directive 2010/31, has a goal to cut down energy consumption and carbon emissions in the EU by 20% by the year 2020 [2]. The directive also highlights that all new buildings have to have nearly zero-energy buildings standard by the same period.

Many countries around the world with an old stock of houses are facing a big challenge to improve the energy performance of their existing buildings. To enhance the public engagement in this process, people need to understand and appreciate the benefits of adding insulation to their buildings, mainly in relation to the indoor comfort temperature and financial savings. Thermal insulation is an essential element that improve the energy performance of buildings. By adding insulation, new and renovated buildings will offer an acceptable level of indoor temperature and energy conservation. Today, there is significant research available in this area. Al-Habaibeh et al. [3] has published a case study of a renovated university building, where the insulation performance has been improved, particularly by adding an internal doubled glazing to the windows. The study provided thermal images of the building before and after the deep renovation. The image comparison demonstrates very clear improvement in the thermal insulation performance of the building. Hilliaho et al. [4] has investigated the impact of added glazing on balcony's indoor temperature, by the monitoring of 22 balconies in Finland for about 10 months period; the results showed that the glazed and unglazed balconies had higher temperature than the outside air by 5.0 ºC and 2.0 ºC respectively. Yousefi et al. [5] has investigated the impact of occupant behaviour on energy performance of building envelopes via simulation using occupants' data, the study emphasises the importance of occupants' engagement and the user selection of envelope materials on energy performance. A study by Aditya et al. [6] has analysed the research and benefits of building insulation in literature. It has found that one of the most effective ways of energy conservation is building insulation. It has been found to offer significant savings in the residential, commercial and industrial sectors. A study [7] has investigated the effect of strengthening the external insulation level on energy consumption for heating and cooling in buildings with various internal heat gain levels in Seoul, South Korea. It has found that the thermal insulation should depend on whether the building is envelope-dominated or internally dominated to decrease the building heating and cooling energy requirements. Another study has examined the change in outdoor temperature in Cameron and its effect on the indoor climate of buildings [8]. The research has suggested that the thermal insulation technology can be one of the leading methods for reducing energy consumption in new buildings. However, careful evaluation is needed for selecting the right thickness of the insulation material due to high insulation costs. Investigation of expanded polystyrene with specific thicknesses evaluated as optimum material for external wall based on the life cycle saving, life cycle total cost and payback period [9]. The mandatory insulation regulation in New Zealand since 1978 has resulted in higher internal temperature and decreased energy consumption [10].

The engagement of public in the insulation process is a big challenge, and the research work in this area is still limited at industrial and academic levels. Some efforts have been made to encourage the public in building energy conservation and improve their engagement. A research presented by Goodhew et al. [11] has explored the behavioural effect of visualising the heat losses from residential homes and its