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Designing an Individually Controlled System based on children's' perception and preferences of IEQ in a classroom.

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SUMMARY
This paper aims to design an "individually controlled system" (ICS) for children in classrooms based on their preferences and needs. It is well known that a higher satisfaction of indoor environmental quality (IEQ), including thermal, air, visual and acoustical quality, can be achieved by giving occupants control over their local environment. However, knowledge about individual control of IEQ in classrooms by children is still limited. Based on a field survey conducted in in 21 primary schools (54 classrooms with children aging from 9 to 12) in The Netherlands and a lab study performed in the SenseLab (a semi-lab environment at the premises of the TU Delft) of circa 350 children of some of the schools studied, in which preferences and needs of pupils, as well as perception about control of their individual IEQ, were collected, the first prototype of an ICS to improve their local environmental quality will be designed.

KEYWORDS
preference; Indoor Environmental Quality; classrooms; primary schools; individual control

INTRODUCTION

Background:
Many studies have been performed that reveal the impact of IEQ of classrooms, including indoor air quality, acoustical quality, visual quality and thermal quality, on pupils' comfort, health, performance, attendance and well-being (Bluyssen, 2016). Most of these studies just focused on one specific aspect of IEQ, and they have provided lots of persuasive evidences to indicate the negative influence of poor IEQ on pupils. For example, the increase of the indoor CO_2 concentration was associated with a decrease in attendance and an increase in pupil absenteeism (Shendell et al., 2004); pupils in schools with natural ventilation scored lower on a national test compared with students in schools with mechanical ventilation (Toftum et al., 2015); noise can impair pupils' ability to recall and recognition, and aircraft noise was shown to be more harmful than road traffic to long-term memory (Hygge, 2003); and the color combination of indoor surfaces in classrooms was found to have an influence on pupils' perception (Yildirim, Cagatay, & Ayalp, 2015). However, there is still a missing holistic understanding of all aspects together. So, as suggested by Bluyssen (2016), the holistic analysis considering all aspects of IEQ of classrooms should be the emphasis for future research.

Hypothesis:
Over the past decades, with an increasing attention on IEQ, a number of suggestions for improving it have been provided in order to create an optimal environment. However, no matter how high the quality of the environment is, there are always a number of occupants unsatisfied, which is because of individual different preferences. The only way to achieve 100% satisfaction of IEQ is to offer effective personal control (Boerstra, 2010). Until now, there are already some outcomes about the individual control of IEQ in office buildings. For example, Heerwagen (2002) analyzed the effect of individually controlled temperature and ventilation among 11,000 workers from 107 European buildings and found that workers who can control

the temperature and ventilation had higher work efficiency and lower chance of illness and absenteeism. Humphrey and Nicol (2012) observed that given the opportunity to control their environment, office workers would frequently adjust the IEQ conditions at their workstations to enable them to feel more comfortable and perform tasks better. Toftum (2010) also conducted a study about the comparison of occupants' satisfaction in buildings with or without mechanical ventilation, the result of which showed that the more control people have, the more satisfied they feel. The same influences are also expected in classrooms, even though there has been no research yet on individual control over IEQ of classrooms. Based on research on offices, it seems very advisable to bring individual control into the classroom to enable pupils to control their own local environment, which will provide them with a satisfactory learning environment and further improve their comfort and even academic performance.

Objective:

Therefore, this study is being carried out to fill these research gaps: on the one hand, identify pupils' perceptions, requirements and preferences towards the whole aspects of IEQ of their classroom; and on the other hand, design an ICS based on these requirements and preferences. Only after their perception of IEQ are understood, the problems in classrooms that bother them can be found, and only after their preferences are realized, the effective ICS suitable for them can be designed. Based on this background, the objective of this study is to collect pupils' perceptions and requirements of their classroom environment, analyse the relationship between these, reveal the most important factors that pupils consider to influence their school performance, and design a prototype of ICS for pupils of primary schools.

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