Understanding the indoor environment and its effects

– Part 2: SenseLab studies with 335 primary school children

This article presents the SenseLab studies performed with 335 primary school children based on integrated analysis approach, to collect information on 'Stressors and effects', 'Preferences and needs' and 'Interactions at human level'.

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Even though the guidelines for indoor environmental quality are met, problems can occur. To cope with this descrepancy, recently, a new research model was introduced to determine requirements (to prevent negative effects) and preferences (to stimulate positive experiences) for (re)designing healthy and comfortable buildings [1]. To fill and validate this model for children of primary schools, a field study and a series of lab studies were held. The field study was reported in Part 1 [2], while the SenseLab studies with 335 children from 7 primary schools, are reported here. Primary school children from previous studied schools were invited to take part in a series of tests in a semi-laboratory environment (the SenseLab), to investigate preferences, needs and responses to single components (sound, thermal, light and air) and interactions of different environmental configurations more in depth.

Procedure

The SenseLab comprises of four test chambers (one for each IEQ factor: air, light, acoustics and thermal aspects) and the Experience room (a room for integral perception) [3]. 335 children from seven different primary schools visited the SenseLab at 10 days in the spring of 2018. Maximum three groups per day were formed: group 1 started in the Experience room (maximum 16 children), group 2 in the test chambers (maximum four children per test chamber) and group 3 in the Science Centre where the SenseLab is located. After 35 minutes, group 1 went to the test chambers, group 2 to the Science Centre and group 3 to the Experience room. In the Experience room an *exposure study* [4]; and a *workshop* [5] was held, while in each of the test chambers, a test was performed that relates respectively to thermal [6], air (smell) [7], lighting [8] and acoustical quality [9].

Exposure study

To test the main, cross-modal and interaction effects of 36 different combinations of environmental conditions on the evaluation of temperature, noise, light and smell by the children [4], a four-way factorial design (**Figure 1** shows the combination 'All acoustical panel's and with 'soft light on') was applied:

- *With 'all' versus 'fewer' acoustical panels:* creating a different interior, view outdoors and acoustical quality.
- *Two ventilation principles*: mixing and displacement ventilation with a ventilation rate of 600 m³/h to provide 30–40 m³/h per person at 21 degrees Celsius.
- *Three types of led-lighting*: direct, indirect and soft light (setting 100%).
- *Three types of background sound*: no sound, traffic and children talking, both at 60 dB(A).

Figure 1. Set-up in Experience room (with acoustical panels and with soft light on).

The results showed a clear influence of 'fewer' acoustical panels on children's' evaluation of smell, draught and light. More acoustical panels had a positive effect on the children's assessment of sound. Sound type, especially 'children talking', affected the assessment of both sound and smell.

Workshop

To conceptualize design solutions by primary school children to solve IEQ-problems in their classrooms, children participated in a workshop, comprising of two parts [5]. In Part 1, the children were asked to choose an IEQ-problem in their own classroom that they are bothered with, while in Part 2, they were asked to imagine they are an inventor or scientist in 2040 with all resources available and to make a design for the future. Noise-related problems were most frequently reported (58%), followed by temperature (53%), air (22%), and light (16%). Girls reported more problems than boys. 47% of the children proposed solutions related to more than one IEQ-problem. Solutions ranged from existing solutions, such as headphones to protect against noise to far-fetched solutions for example send noisy children away by means of a rocket [5].

Thermal test chamber

A three-way factorial randomized design was used to test the effect of different colours of walls and floor on the thermal comfort and draught feeling in a winter situation (sunlight coming in: heat) and in a summer situation (opening window: draught) [6]. The different classroom situations (colours of walls: red, blue or white; and floor: green, grey or blue) (combination white walls and blue floor is shown in **Figure 2**), were created with Virtual Reality in combination with a construction lamp (simulating the heat of the sun) and a fan (simulating the draught of fresh air).

Figure 2. Virtual classroom with blue flooring and white walls.

A statistical relevant relationship between feeling of draught and feeling of temperature was found, as well as a significant difference in temperature feeling for different floor colours when the wall colour was red in the winter situation.

Air test chamber

The aim was to expose children to different sources of smell (container 1: perfume; container 2: mint leaves; container 3: carpet/MDF/vinyl; container 4: crayons; in **Figure 3**), and to evaluate and identify those sources at individual level with their noses [7]. The possible effect of plants on the reduction and/or production of smells was tested in the CLIMPAQ (number 5 in **Figure 3**). Children found the smell in general more acceptable, when they recognized the smell. In general, children did not like the smell of the building/furnishing materials and in most cases they could not identify the source of smell. The effect of (passive) plants on the perception of smells showed no effect.

Lighting test chamber

Children assessed six school desks table tops (brown, yellow and grey wood and normal, matt and reflective white) (**Figure 4**), under three different light conditions: energizing (650 lux; 12000 K), calming (300 lux; 2900 K), and focusing (1000 lux; 6500 K) [8]; using a two-way randomized design. For all surfaces, the calming light was perceived as the worst and the energizing light as the best (except for the brown wood surface). For the wooden-like surfaces these differences were statistically significant. The children preferred the brown wood under focusing light the best and the brown wood under calming light the worst. For energizing light, grey wood scored the best, while for focusing light, brown wood.

Acoustical test chamber

The effect of reverberation time (RT) on children's cognitive performance (phonological processing), noise evaluation and emotional attitude was studied [9]. Two

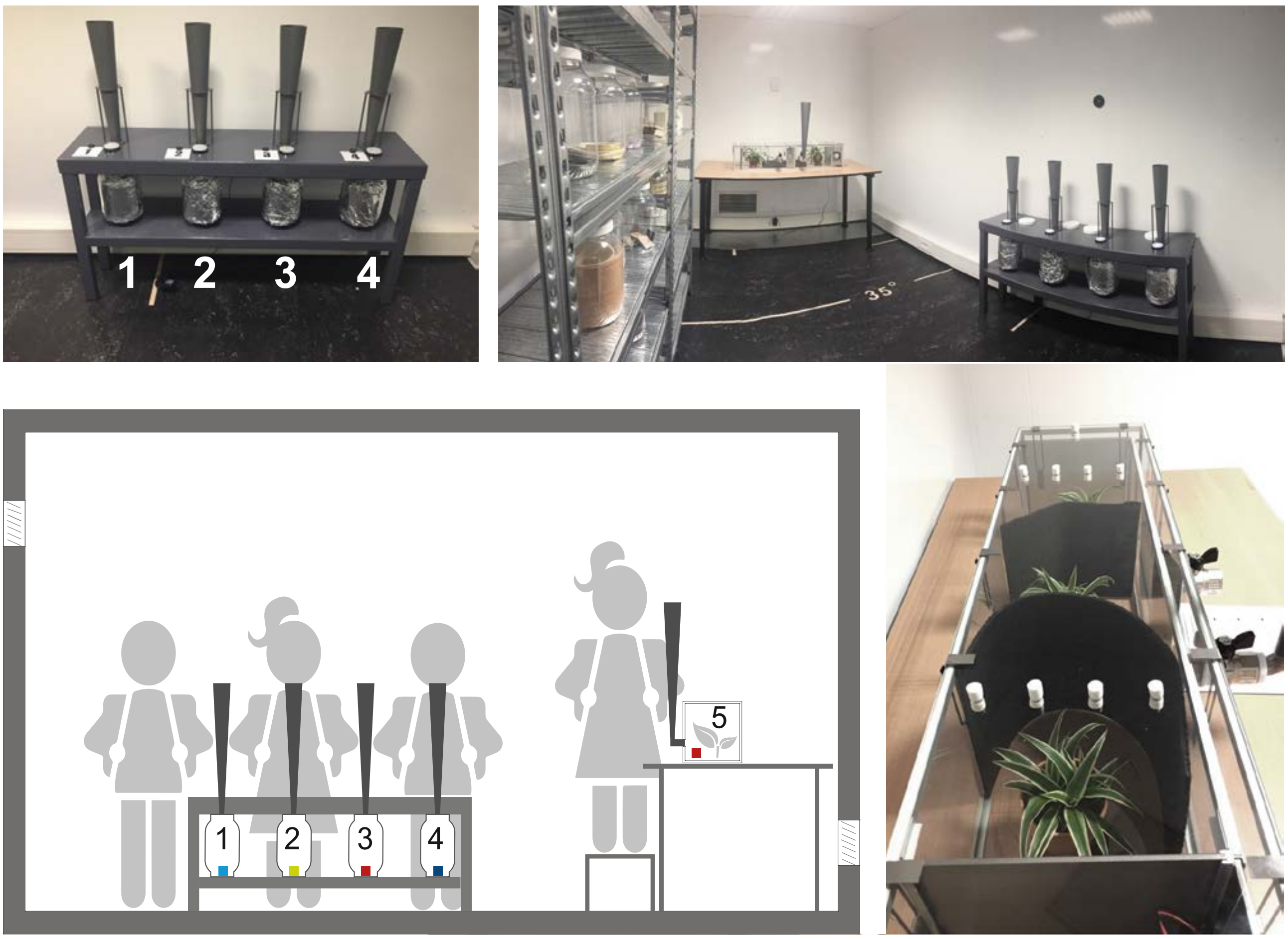
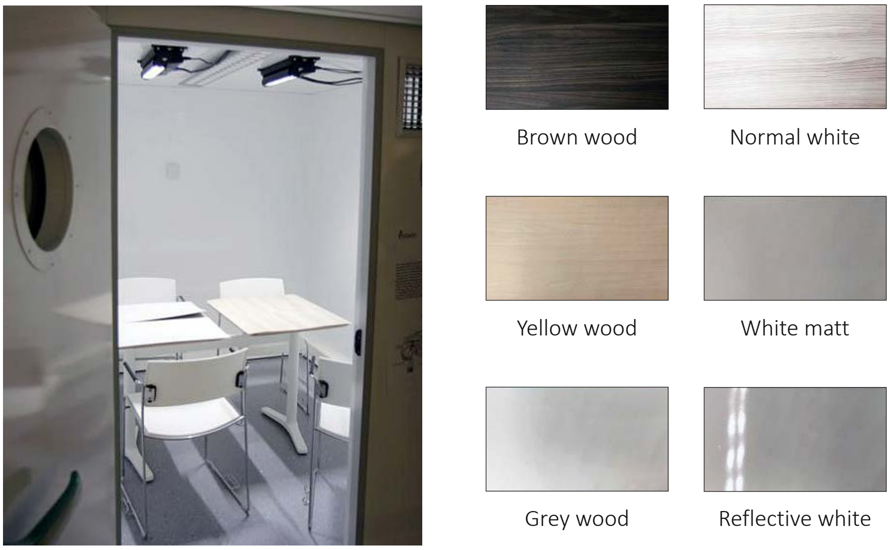


Figure 3. Pictures of air test chamber set-up.

series of listening tests and evaluations were performed in chamber A (untreated: RT=0.33 seconds) and chamber B (acoustically treated: RT=0.07 seconds) respectively (see **Figure 5**), while at the same time one of seven background sounds (45 dB or 60 dB traffic noise, 45 dB or 60 dB children talking, 45 dB or 60 dB music, or no sound) were randomly played. The positive effect of the acoustical treatment was demonstrated by the statistically significant difference of children's sound perceptions between the acoustically



a *b*

Figure 4. a. Set-up light experiment b. Six types of surfaces: from top left: brown wood, white matt, yellow wood, normal white, reflective white, grey wood).

Acoustically treated chamber B

Reverberation time: 0.33

Untreated chamber A

Reverberation time: 0.07

Figure 5. Treated and untreated chamber.

treated chamber and the untreated chamber. However, especially with the 'children's talk' as the background sound, overtreatment seemed to have adverse effects on children's performance. Children preferred the acoustically treated environment when there was a background sound.

Findings

From the exposure studies and the workshop held in the Experience room, the following can be said:

- Interaction effects of different IEQ-factors seem to take place at human level.
- Sound type, especially 'children talking' affected the assessment of both sound and smell, indicating that children are perhaps pre-conditioned in their response by hearing children talk.
- Children were very able to provide problems and solutions for IEQ-problems at different levels (building, classroom, desk, child etc.).
- Girls reported more problems than boys, which is possibly related to a better recollection of negative feelings towards those problems in their classrooms.

The tests in the different test chambers (thermal, air, light and sound) showed that:

- When the wall colour was red in the winter situation, a significant difference in temperature feeling for different floor colours was found.
- The smell was in general assessed more acceptable, when the children recognized the smell.
- Different surfaces most likely require different types of lighting, and vice versa.
- When there was a background sound, the acoustically (over)treated environment was preferred by the children.

Conclusion

Both the field (reported in [2]) and the SenseLab studies with the primary school children were an attempt to fill and validate the newly introduced research model [1]. The outcome of both studies confirmed the need for this model, and the need for more studies to determine requirements (to prevent negative effects) and preferences (to stimulate positive experiences) per scenario (e.g. schools, homes, offices) and situation (for example traditional and non-traditional). Interactions at environment and human level need to be explored, as well as patterns of stressors for different profiles of occupants. ■

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