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# Understanding the indoor environment and its effects

## – Part 1: Field study of 21 primary schools

This article presents the survey performed in 21 schools based on the integrated analysis approach, to collect information on ‘Stressors and effects’, ‘Preferences and needs’ and ‘Interactions at environment level’, for different situations.



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It is well-known that the environmental conditions in a classroom can affect health, comfort and performance of children [1]. Problems occur even though the guidelines are met, most likely due to the fact that these guidelines are based on criteria that are originally set up for adults, on top of the focus on single factors, which do not consider interactions between them. To gain more insights into the current and potential role of indoor environmental factors on health, comfort and performance of children, an investigation was performed based on a recent introduced research model (Figure 1) [2], comprising of a field study and a series of laboratory studies. Part 1 reported here, describes the field studies performed in 54 classrooms of 21 primary schools in the Netherlands, to collect information

on ‘Stressors and effects’, ‘Preferences and needs’ and ‘Interactions at environment level’, for different situations, by asking children themselves what they experience and need in classrooms to feel and perform well [3]. The SenseLab studies are reported in Part 2 [4].

### Study design

In the spring of 2017, a survey on the health and comfort of school children of group 6 and 7 in 54 classrooms of 21 schools in the Netherlands was performed [3]. From the 54 classrooms studied, 45 classrooms studied had a traditional educational system, and 9 classrooms had a non-traditional educational system (following the educational theory of Jena, Montessori or Dalton).

The survey of the schools comprised of a questionnaire for the children about their health and comfort, preferences and needs; a questionnaire for the teacher about activities they perform to improve IEQ; an inspection of the school and its installations, and the classrooms surveyed using checklists. 1,145 completed questionnaires were collected. It took the children about 30 minutes to complete the questionnaire.

### Characteristics children studied

In general, boys and girls were equally distributed. The average age of the children studied was 10 years and about one fifth wore glasses or lenses, about one third

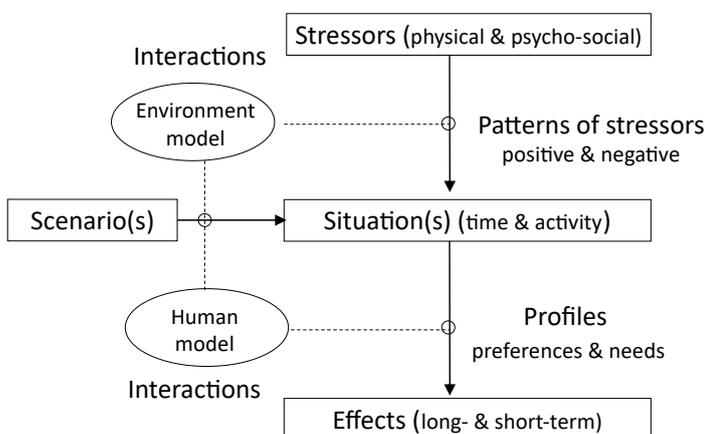


Figure 1. Model for the integrated analysis approach [2].

of the children had someone who smokes at home, and around 52% had a dog, a cat, or a rodent as pet.

At the moment of filling in the questionnaire, 87% claimed to feel good. Most reported diseases (in the last 12 months) were allergy (26%), rhinitis (17%), hay fever (16%) and eczema (16%). The most prevalent school-related health symptoms were headache (17%), sneezing (15%) and itchy eyes (14%) (Table 1). Boys reported these symptoms slightly more than girls.

87% of the children was bothered by noise (mainly caused by children themselves), 63% was bothered by smells (mainly caused by children themselves), 42% by sunlight when shining, 37% by garbage on the floor, 35% (did not like the temperature in the classroom (too cold or too warm) and 34% (experienced temperature changes (Table 2). Girls were in general more bothered than boys.

### Two situations: Traditional vs. non-traditional schools

Classroom-related comfort complaints and Classroom-related health symptoms were evaluated for both the traditional and the non-traditional school children by respectively the Personal Comfort Index (PCI) based on 7 complaints: thermal discomfort, temperature changes, wind/ draught, smells, noise, sunlight and artificial light; and the Personal Symptom Index (PSI) based on nine symptoms: dry eyes, itching or watery eyes, blocked or stuffy nose, running nose, sneezing, dry throat, difficulty breathing, dry, irritated or itching skin, and headache. So, for each child it was calculated for how many of the complaints and symptoms they were bothered with. The average PCI-7 for all school children, for school children from traditional schools and for school children of non-traditional schools,

was respectively 2.76, 2.87 and 2.24 (Figure 2a). The average PSI-9 for all school children was 3.97, for the children going to non-traditional schools 3.69 and for school children of the traditional schools 4.02 (Figure 2b). The differences between the traditional and non-traditional schools were statistical relevant, indicating that children of non-traditional schools had on average less symptoms and less complaints than children from traditional schools.

Table 1. Symptoms at least once every 2-3 weeks (related to indoor environment).

Symptom	All [%]	Girls [%]	Boys [%]
Dry eyes	6.7	5.7	7.6
Itching or watery eyes	14.1	12.8	15.4
Stuffy nose	10.4	9.9	10.9
Running nose	9.3	11.7	7.1
Sneezing	15.3	15.0	15.6
Dry throat	11.6	12.9	10.3
Dry, itchy skin	7.4	8.0	6.8
Headaches	17.0	15.9	18.0

Table 2. Complaints about the indoor environment.

Complaints	All %	Girls %	Boys %
I do not like the classroom	15.9	16.4	15.3
Thermal discomfort at this moment (too warm/cold)	34.9	34.7	35.1
Bothered by temperature changes	34.0	31.4	36.6
Bothered by wind/draught	7.3	7.8	6.9
Bothered by smells	62.7	67.0	58.6
Bothered by noise	86.6	91.0	82.2
Bothered by sunlight when shining	41.8	43.2	40.4
Bothered by artificial light when on	11.3	11.3	11.3

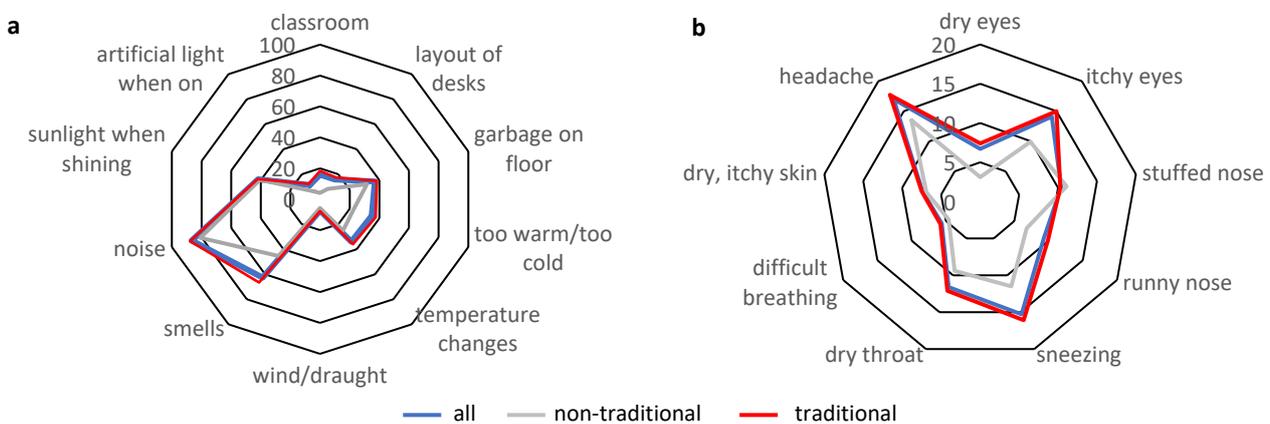


Figure 2. Percentage of children a) with complaints about classroom conditions and b) with symptoms every day or sometimes at school, that went away when not at school.

### Multivariate analysis for traditional classrooms to find patterns

Multivariate analysis was performed for the 949 children of the 17 traditional schools, to find patterns of stressors: associations of building-related indicators with occupant-related indicators [3]. The analysis showed that a child at a school in the suburbs had fewer symptoms than a child at a school in a village (in a rural area). A child in a classroom with radiators below windows had more symptoms than in a classroom with floor heating, or in a classroom with air heating as an important way of heating the classroom. Both findings can indicate the presence of air pollution, either caused by inefficient cleaning or inefficient maintenance of the components of the building services. The presence of a solar shading device that hampers ventilation/opening window also increased the number of symptoms, which might indicate inefficient ventilation when required. Furthermore, it was seen that a child in a classroom with mechanical assisted ventilation (no mechanical supply) had more comfort complaints than in a classroom with natural ventilation. A classroom with a dark coloured window frame caused more complaints than a light coloured one, as did laminated flooring vs. synthetic smooth flooring material. Also, vacuuming the classroom floor less than once a week vs. more than once a week increased the PCI.

### Actions of teachers to improve IEQ

The frequency of teachers' actions to improve IEQ in classrooms (such as turning on/off lights; lift/lower shades; close/open windows; etc.) was studied to get more insight into the impact of teachers' actions [5]. The percentage of teachers who performed the actions to improve the IEQ in classrooms at least once per day (Figure 3) was related to primary school children's comfort perceptions in classrooms. From the comparison was concluded that those actions hardly had an effect on how the children felt. The teachers could not fulfil every child's needs, even though teachers' actions did relate to the child's requests. Two reasons can be put forward: 1. Not all children have the same needs; which makes it is impossible for a teacher to satisfy each child. 2. A certain action can improve the conditions for one child, while for the other child the same action can cause a problem.

### Clustering school children to identify profiles

Using two-step cluster analysis, six clusters (profiles) of children based on their comfort perceptions and the importance of environmental factors were identified [6]

(Table 3). The children were asked to rate the importance of 10 indoor environmental factors to their school performance (including feet temperature, air temperature, chair temperature, scent, fresh air, light on desk, light on board, hearing teacher, outdoor sound, indoor sound) on a scale from 0 to 10 (10: very important; 0: not important at all) (Figure 4a). Children thought that 'Hearing teacher' had the most important impact on their school performance (8.6). The second and third most important factors were 'Fresh air' (8.0) and 'Air temperature' (7.4).

Table 3. Six profiles of children (adapted from [6]).

Profile	Most bothered by	Important
Sound	Noise	Noise indoors and outdoors
All	All	All
Smell and sound	Noise and smell	Understand teacher and fresh air
Thermal and draught	Draught and temperature	Draught and temperature
Light	Artificial and sunlight	Light at desk and (smart)board
Nothing	Hardly anything	Nothing

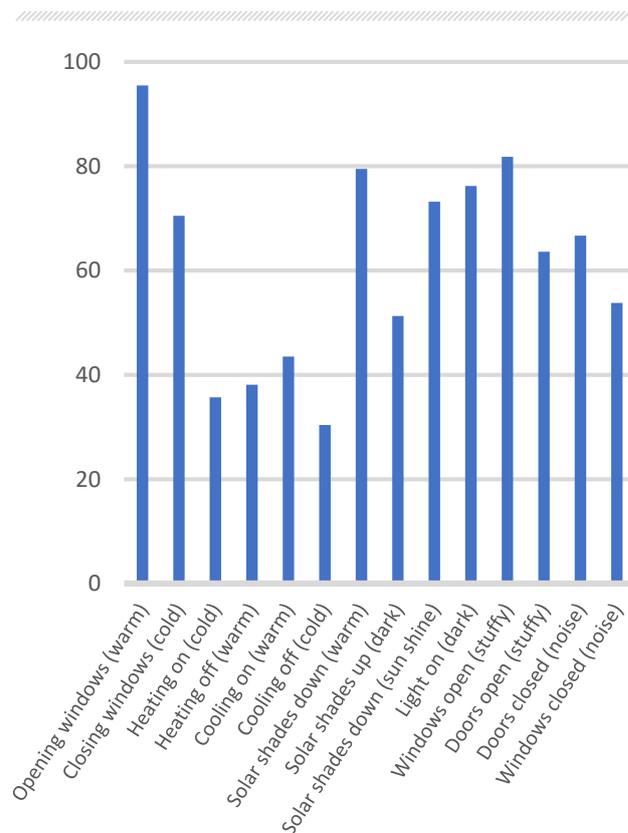
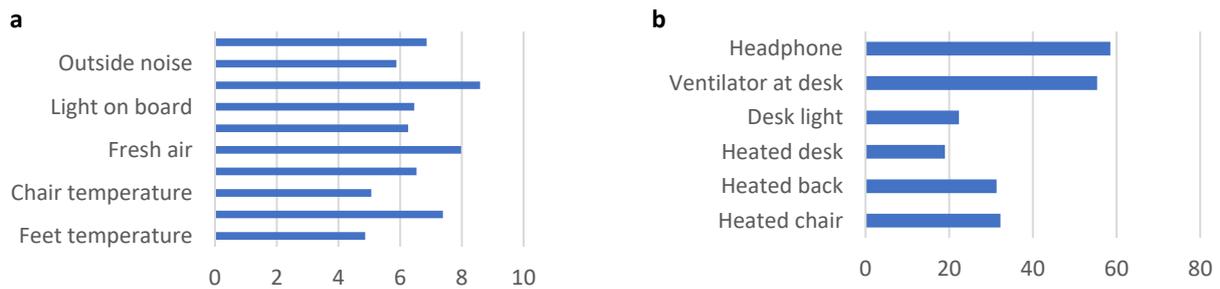


Figure 3. Percentage of teachers who performed the actions asked by children to improve the IEQ in classrooms at least once per day. The reasons for the actions are given in the parenthesis (Adapted from [5]).



**Figure 4.** a) Importance index of indoor environmental factors; and b) Preference for six ICDs (%) of children from traditional schools (adapted from [6]).

The children were also asked to give their preference for an ICD (individual control device), including a heated chair, a heated desk, a heated back, a desk lamp, a personal ventilator and a headphone (Figure 4b). The most preferred device, according to the children's answers, was 'headphone'. Almost 60% of the children in a classroom indicated that they wanted to have a headphone, followed by the 'ventilator at desk' indicated by 53% of the children [6]. The 'headphone' complied with the 'hearing teacher' importance index, while the 'ventilator at desk' corresponded to the second and the third highest importance index of 'Fresh air' and 'Air temperature'.

## Main Findings

The field study of the 21 primary schools, resulted in the following main findings:

- Boys in general reported more symptoms, while girls reported more complaints.
- Main complaints were related to noise and smell (produced by children themselves).
- Different situations (traditional vs. non-traditional schools) resulted in statistically different health and comfort effects: children from traditional schools had more complaints/symptoms than children from non-traditional schools.

- Patterns of stressors (ventilation type, solar devices hampering opening windows, heating system, window frame colour, floor material and vacuum cleaning frequency) were associated with health and/or comfort by applying multivariate analysis.
- Children differed in needs and preferences and were clustered in clusters with different profiles using 2-step cluster analysis.
- Teachers could not fulfil each child's needs in a classroom with the possibilities that were available to change/adapt the indoor environmental conditions.

## Conclusion

The outcome of the field study confirmed the need for the newly introduced model [2] (Figure 1) and the need for more studies with primary school children on their preferences, needs and responses to single components (sound, thermal, light and air) and interactions of different environmental configurations as reported in Part 2 [4]. ■

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