Chapter 1

# Preliminary evaluation of design and construction details to maximize health and well-being in a new built public school in Wroclaw

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**Abstract** The paper presents preliminary evaluation of a design approach and solutions applied in the first sustainable school complex in Wroclaw, Poland. The scope of this paper is focused on health and wellbeing of the occupants. The building completed in the year 2009 is planned for an in-depth POE to start this year – the first such broad evaluation project to be carried out in Poland. Measurements taken already and the feedback from the occupants received so far indicate whether certain design intentions have been met. Selected usability problems that have already occurred are discussed as well as the way the occupants cope with them. Selected details that proved to be successful are also presented. An overview of the process of the building delivery, handover and maintenance is also presented as in the authors opinion it has a major impact on the building's overall performance. The paper concludes that most usability problems are lessons to be learned indicating improvements that can be made in a building's life early stages.

## 1.1 Introduction

Sustainability discourse introduced analysis of a building in its whole life cycle: briefing, design, construction, handover, occupancy and possible demolition (Preisner and Schramm 2012). Well-being and user satisfaction with a building are most influenced by delivery stages in which the actual occupants do not participate. Unless participative design is introduced, everything is decided for the users by the specialists, basing on their knowledge and experience. The evidence for

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participative design being an efficient method for finding successful solutions is growing (Day et al. 2011). On the other hand the benchmarking system and growing amount of viable data from research on building's performance evaluation put designers in a good position to treat many solutions as double checked and "satisfaction guarantee" type. Regardless of the method selected for the design process the user's perspective should be fundamental for a building's performance evaluation, as many claim today (Baird 2010).

This paper analyses the design solutions introduced to enhance well-being and health in a public school complex recently built in Wroclaw, Poland. The solutions introduced are grouped according to a design goal they apply to. The user's perspective is present through the results of a questionnaire survey for pupils, analysis of all the records documenting the defects claimed by the users since the building's opening in September 2009 and semi structured interviews with crucial occupants (head of school, head of preschool, staff representatives, including the building technician responsible for the building maintenance). Measurements of noise and lux levels in classrooms were also taken.

Employment of green features into the analyzed building made the whole delivery process challenging and not fully "as usual", as it was the first school in the region to rely partly on renewable energy sources. Launching a competition for the school's design was the first sign of a 'special treatment', as it is not a daily procedure in Poland. Most school designs are commissioned through tender with the lowest price as the main choice criterion. The construction and maintenance cost for Suwalska school was to be kept at an average Polish level.

## 1.2 The case study building

The 6000-square-meters building accommodates 450 pupils and 100 preschool children. There are 80 employees in the building including: teachers, administration and technical staff. The schools population is divided between two classroom wings with shared entrance lobby, library, sport and dining facilities (see Fig. 1.1). The third wing with a separate entrance is dedicated to the preschool. The dining area serves as a connection point between the school and the preschool. The school is located on a greenfield site at Suwalska Street in a currently developing suburban housing district of Wroclaw.

The process of delivering the building was complex. The major groups involved were the Department of Municipal Development (DMD), Department of Education (DE), the design team, contractors, building authorities and commissioners. The main groups using the building are the school staff, pupils, their parents and local community. Keeping everyone focused on the wellbeing of the building's users as an ultimate objective of the whole process was not easy. Introducing the Softlandings procedures might have improved the process. The brief was to be developed solely between the DMD and DE. Head of the school and local community council representative were invited for presentations on the current

state of design. Though the architects insisted that the future occupants comment on the development of the brief their influence was little. Anna Bac and Krzysztof Cebrat from Grupa Synergia architectural office were commissioned the design in result of presenting the winning competition entry. It included clear signs that the users' well-being and integration of the new development with the local community were among the most important design goals. However, as they admit today, the design was not fully integrated as specialist teams worked parallel with the architect coordinating the whole process. The contractors were selected in a tender process according to the lowest price offered. The commissioning process during pre-occupation stage was under strong time pressure, as the building had to open with the beginning of a school year and no delays were possible. The handover stage did not leave the occupants with full understanding of the functioning of the systems that were to assure both thermal comfort and savings in $CO_2$ emissions. A place for improvements at each stage of the building's delivery results in certain usability problems further described.

**Fig. 1.1** Visualization of the school complex. © Grupa Synergia

## 1.3 The context and the stage of data collection

The building has been occupied since September 2009. In the year 2009 a questionnaire survey for the children of 9-12 years of age was personally distributed and collected by the architects to learn about the reception of selected issues of the school's design. In 2012 it was repeated with the 12-year-olds. A total of 104 questionnaires were collected for analysis in 2009 and 26 questionnaires in 2012. The questionnaire was developed by the architects themselves based on Rittelmeyer's research on children's perception of the school environment (Rittelmeyr 1994). It comprised of one page with 13 questions: 4 open ended questions and 9 closed-ended questions with a possibility to add explanation of the choice made. Table 1 summarizes key findings form the pupils' questionnaire (see Table 1.1). The questionnaires were accompanied by semi-structured interviews with 7 key

representatives of the technical, administrative and teaching staff. The records of all faults claimed by the occupants covering time from the handover to February 2012 were shared with the authors by the Head of School. It became an important source of information on usability issues. The selection of design targets and details introduced is based on an in-depth knowledge of the building's design (Bac 2005) and procurement phases. Further research is planned however and a Polish translation of Probe questionnaire of users satisfaction developed by Usable Buildings Trust, UK is to be licensed and used to compare the building's perceived performance against collected benchmark examples from other countries (Baborska-Narozny 2011). As a part of planned POE research IAQS measurements of $CO_2$ levels, humidity and temperature will be taken. Building's energy consumption is analyzed in a chapter "Comparison of design intentions and construction solutions delivered to enhance environmental performance and minimize carbon emissions of a new public school in Wroclaw".

**Table 1.1** Pupil satisfaction and comfort

| Parameters | Criteria | Nos. of pupils rating this at top of scale (1-7) | |
|---|---|---|---|
| | | 2009 | 2012 |
| Design overall | satisfactory | 92% | 90% |
| Meeting my needs | very well | 85% | 84% |
| Lasting impression | very good | 89% | 91% |
| Safety inside | very high | 79% | 82% |
| Safety outside | very high | 69% | 70% |
| Space use | effectively | 80% | 83% |
| Functional program | adequate | 54% | 59% |
| Comfort overall | satisfactory | 62% | 72% |
| Light comfort overall | satisfactory | 43% | 69% |
| Noise comfort overall | satisfactory | 79% | 80% |

Source: Adapted from Stevenson and Humphris (2007: 42-44)

## 1.4 Health and well-being design targets and solutions applied

To provide an efficient learning environment Anna Bac referred to her precedent research. In her PhD thesis (Bac 2003) she made an insight into various education systems and their influence on school architecture, psychology of child development and perception, psychology of architecture and the presence of schools in urban structure (Posch and Rauscher 1996). The foreseen preferences of future space users were an important design motive. To enhance user's health and well-being through architectural form, functional distribution and materials the following design targets areas were identified:

- *target:* Safety and easy orientation

*design:* distinct division between public and restricted access zones and enabling insight into most spaces, extensive glazing, keeping visual links between inside and outside (see Fig. 1.2). Clear functional disposition with distinct color patterns for different sections of the building to facilitate orientation (see Fig. 1.3).

**Fig. 1.2** The main school hall – keeping visual links between inside and outside

**Fig. 1.3** Clear functional disposition with distinct color patterns for different sections of the building to facilitate orientation. The following colors are used in corridors and classes: space for pupil from classes 4-6 in yellow, classes 0-3 in orange, kindergarten in green

- *target:* Individual character of architecture to induce a feeling of identity of place and community and prevent vandalism

*design*: vivid colors, various surface textures and gloss and not all perpendicular shapes across the outside and inside of the building to prevent bore and enliven the space, custom detailing of selected load bearing structure elements, heater covers.

- *target:* Sharing selected school facilities with the local community. An integration of local community with the school was proposed at the competition stage through inclusion of several public functions into the school: a public library, community club, local community council and a city guard office. The sport facilities were also to be let to local community after school working hours.

**Fig. 1.4** Distinct volumes with separate entrances for different functions shared with local community a) View towards entrance area, b) School and community shared library

*design*: Separate entrance to sport facilities, library and a multi purpose room. The main lobby may also function as a space for public events after the school is closed (see Fig. 1.4).

- *target:* Design adjusted to the child-scale wherever possible

*design:* the complex is no higher than two floors (one floor in the preschool part), windows with external views are designed at eye level in all areas including preschool, appropriate size of furniture was selected.

- *target:* Exploiting the educational potential of the substance of the building

*design:* wherever possible the construction, electrical and ventilation systems are left visible to show how the building functions, porthole windows in most internal doors to allow the children an insight into most spaces including ancillary technical rooms, staff rooms and classrooms (see Fig. 1.5).

*usability issues:* the insight into some of the spaces i.e. head of the school's office, technical rooms is sealed.

**Fig. 1.5** Across the building the construction, electrical and ventilation systems are left visible to show how the building functions. a) Dining area b) Entrance hall

- *target*: All parts of the building wheelchair accessible, sanitary facilities for handicapped users

*design:* no stairs at the entrance areas, internal lift.

*usability issues:* a telephone connection was not included into the brief for the school and thus the school was not equipped with a telephone. In result the lift was not to be commissioned as long as an emergency phone was not installed inside. The problem is not yet solved.
All the above solutions are generally very successful and appreciated by all users. The questionnaire surveys among the children show their satisfaction with the individual character, appearance and functional disposition of the building (see Table 1.1). The school did not suffer from any vandalism acts so far. There are many local community events organized indoors and outdoors. The only claims concern the limited number of outside benches.

- *target: V*isual comfort in day-lit interiors

The use of daylight affects both energy demand as it restricts the need for artificial lighting and also enhances the occupants well being.

*design:* wherever possible all internal spaces are day-lit, including changing rooms adjacent to sport facilities and technical rooms. All classrooms have south facing extensive glazing.

In the preschool area there is a shed roof allowing direct eastern daylight into the rooms and also into half of toilets (see Fig. 1.6). The rest of the toilets receive dispersed light through translucent upper part of partition walls. The partition walls are glazed from 2m up. Thus the need to use artificial light in the toilets is limited.

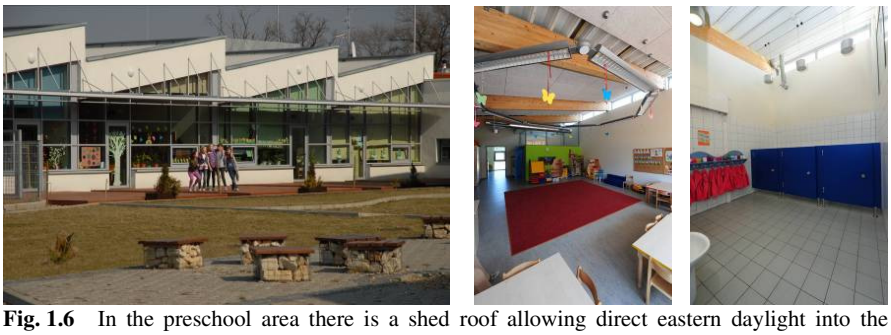

**Fig. 1.6** In the preschool area there is a shed roof allowing direct eastern daylight into the rooms and also into half of toilets. a) the shed roof from outside, b) the natural light penetrating the classrooms, c) the restroom illuminated by natural light

*how it works:* the artificial light in the day-lit toilets is sometimes on even when it is sunny – the lighting scheme needs fine tuning. The modeling of direct light penetrating the interiors, particularly classrooms and sport halls, performed at design stage were insufficient; they proved the exclusion of direct sunlight by fixed horizontal sun louvers on the 20th of June at midday only. Lower angles of solar light were not taken into account. In result in all the classrooms and sport halls glare and over heating became an instant problem. Internal blinds were installed and are in constant use. In the sports hall were the blinds have not been mounted so far the windows are temporarily sealed with paper. Another thing is that shad-

ing by trees was an important aspect of solar protection scheme. As the trees were only planted when the school opened the plan doesn't work yet.

Since the handover the school suffered from faulty functioning of external roller blinds that stay open regardless the weather conditions – they were to react to sun to protect the interiors from overheating and the BMS control was to open them in case of strong wind. A probable cause of malfunctioning is wrong location of the wind sensor. The contractor for the blinds is to solve the problem.

- *target:* Acoustic comfort

*design*: acoustic ceilings Herakustik covering ca. 82 % of ceilings area across the building.

*usability issues:* The section on acoustic comfort requires some explanation. Even though research data shows that the noise in schools reaches a level of 90 dB is it an issue neglected in all school designs to date in Poland (EIAS 2011). Polish building standards do not include requirements concerning the maximum noise level in school circulation areas. In Polish schools the only acoustically protected areas are sport halls. For Suwalska school the architects insisted, opposing the DE, to perform a study of acoustic quality of the design and in result acoustic ceiling were installed across the school. The measurements of noise levels taken in the classrooms with a group of 25 pupils actively participating in the class was 65 dB and when they worked individually it was 46 dB. At the corridor playing at recess children produced noise at the level of 76 dB. The only acoustic problem claimed was the noise from mechanical ventilation.

- *target:* Assuring thermal comfort and good indoor air quality

*design:* Two ground source heat pumps serve as a heating source to the building, one providing the preschool with space heating and domestic hot water and the other pump serving the school premises. The total heating capacity of the source is 187 kW. Ground heat exchanger comprises of the 26 vertical piles providing 140 kW maximum. Additionally, solar collectors are used to supplement hot water generation. Space heating distribution divided into 5 zones, all equipped with variable speed pumps and radiators with thermostatic valves. Each zone has a heat meter connected to BMS. The building is divided into 5 ventilation zones. Supply ventilation provides minimum $25m^3/h$ per person and is controlled in function of programmed occupancy schedule and door locks. All parameters of the building controls can be defined in the BMS. The return air path is arranged via transfer grilles into the corridors and to the air handling units (AHU). All AHUs are equipped with the plate heat recovery units and air source heat pumps, which control supply temperature and recover the heat from rejected air. Excellent acoustic performance was to be achieved by lowering the air velocity in the ducts below 5m/s and by applying noise attenuation in the AHUs.

*usability issues claimed*: A problem claimed by all interviewees is low personal control of mechanical ventilation. The manual control for each classroom is possible at the hight of over 2.5m and requires a screwdriver and assistance of technical staff. In result the teachers experiencing a problem tend to cut the MV off and

open the windows rather then try to adjust the air flow rate. In the summer achieving comfort temperature in the classrooms requires a maximum air flow rate that causes disturbing noise. The temperature in the dining area and sport halls falls down to 13ºC when the outside temperature drops below -10ºC. The problem is yet to be solved. MV in the kitchen was not working and there was no user guide to control it. It took a few months to solve the problem. In the server room the designed air exchange was too little and the equipment overheated. Local air conditioning was introduced to solve the problem. Due to frequent short power outages the mechanical ventilation units are faulty. Precise measurements of air temperature, moisture and $CO_2$ level are yet to be taken as a part of a planned POE project.

## 1.5 Other usability issues

Most of the usability problems reveal some weaknesses of the building's delivery process. Initial lack of coordination of public transport stops location and pedestrian crossings with the new school's site is one of them. The improvements made were a result of the official complaints of the school community.
Some faults, particularly the rising damp and penetrating damp, are the result of basic faults at construction stage that could have been easily avoided. They are now very difficult to repair and if persisting present danger to the occupants health. Minor faults with exterior plaster and fitting of sinks were gradually repaired. Roof leaks are almost all repaired, only one problem spot remaining. The other group of faults that influence the usability of the building are most likely the result of installing cheaper equivalents of various elements instead of the ones designated in the design or the cheapest elements available if there was no precise specification. Lack of warm tap water is one of the issues claimed by all users interviewed as the most inconvenient and still not answered; using different than specified heaters are the most suspected reason behind this problem and checking that out is the next step. Solar collectors for water heating were installed in the preschool. Initial lack of their fine tuning was responsible for heating tap water in the preschool up to 80ºC. This problem was efficiently solved. Unlike repeating problems with doors and door-locks.

Other issues seem to be a result of lack of efficient communication between DE and the school staff. On request of the DE shower taps for sport facilities were installed as fixed to the wall with no individual adjustments possible. The water was spilling in all directions. The time limit set for three minutes was perceived as too short. The DE refused to agree to change the wall mounted tabs. In result the showers are locked and out of use.

## 1.6 Conclusions

The school's design and landscaping proves to be very much appreciated by its users. The building is not free from faults however and that causes certain problems with its usability. An in depth post occupancy evaluation is planned to be performed this year. The planned POE is to become the first element to build a benchmarking system that would enable comparison and evaluation of what has been built. Seeking the reasons behind certain usability problems shows area for improvements in a public building's delivery process and maintenance.

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All pictures made by Grupa Synergia.

**Acknowledgments** The authors would like to thank the head of the school at Suwalska Ewa Glinska for her co-operation and support to research activities concerning the building. The authors would also like to thank all the other staff and pupils who kindly gave their time for interviews or completed the questionnaires. The authors would like to express their deepest gratitude to prof. Fionn Stevenson from the University of Sheffield for sharing her knowledge on POE and BPE research.