FACTA UNIVERSITATIS
Series: **Architecture and Civil Engineering** Vol. 10, N° 2, 2012, pp. 179 - 191
DOI: 10.2298/FUACE1202179B

SUSTAINABLE SCHOOLS AS 3D TEXTBOOKS: SAFEGUARDS OF ENVIRONMENTAL SUSTAINABILITY*

UDC 727.1: 502.131.1 =111

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Abstract. *At times when Serbia is planning to invest in improving the quality of learning environments up to a hundred million Euros through School Modernisation Project 2010-2014, describing some of the trends in school buildings design in Western countries is regarded to be crucial. Schools are places where young members of our society are educated. School building design can have a direct influence on the way we assimilate, learn and integrate with other people, and can also affect the way we, as a society, integrate sustainability into our lives. A building is able to teach and convey new ways of materialising sustainable principles. Nowadays many experts claim that 'sustainable school is the most appropriate strategy for renovating educational processes and achieving quality education' [1]. Therefore, this paper deals with some of the aspects of school development in relation to environmental sustainability principles. Each aspect is supported by an example of a contemporary school that included one or more of those principles. Towards the end some of the benefits of approaching schools with environmental sustainability in mind are presented. It is hoped that the results of this article will act as an invitation and stimuli for architects and planners, especially in Serbia, to reconsider their previous practice and start observing school design through the prism of sustainable development.*

Key words: *sustainable school, Serbia, school as 3D textbook*

Received July 10, 2012

* **Acknowledgement.** Paper within the framework of the Project titled: "Innovative intelligent eco - concepts, technologies, materials and constructions in the function of improvement of sustainable development processes in spatial planning, town planning, architectural design and building in natural and built environment". Number TR 036049. Period: 2011-2014. Ministry of Science and Technology Development of the Republic of Serbia

1. CONVERSION. HISTORICAL EXAMPLES.

Global concern for the current condition of our planet is challenging all professions. Therefore, many architects are trying to contribute to finding a proper solution to the problem. Architects, whose job is to plan, draw designs and make great interventions in our environment, are dedicated to adapting their design principles in order to be in harmony with Nature and its postulates. This is the only way they can enable their buildings to live in synergy with their environment. The most important element of sustainable design is to respect Nature and be aware of how precious it is for both our lives and the lives of coming generations. The building design and language should truly reflect the ongoing search for expressing our relationship **with Nature**. Taking this even further, building design can have a direct effect on how we assimilate, learn and integrate with other people, and how we, as a society, integrate sustainability into our lives. A building has the potential to teach and convey the new ways in which sustainable principles materialise.

Dealing with design in this manner allows architects to take the role of educators. Their design is stimulating users to use the space in the best possible way. This aspect of architecture as a profession comes to the limelight when we discuss school design. Schools are places where young members of our society are educated. When architects implement sustainable concepts in school design, alternative energy resources and when they respect the environment, they give a great example to young people. In this way they are actively involved in shaping someone's awareness about global problems.

Furthermore, building design can demonstrate architects' solutions to the growing global problems. Approximately one of five people spends time in educational institutions every day [2]. Those institutions have crucial impact on character shaping, educating and socialising children. Unfortunately, it happens too often that today's school system presents a source of health problems to our children. Schools should provide a healthy environment by avoiding toxic materials, using renewable energy sources, serving organic food, having copious amounts of light, etc. This is the way to help children become conscious people who know how to respect and appreciate the planet Earth and all its resources. Therefore, we should design smart schools that can act as sustainable 3D textbooks, where children do not learn passively, but are actively involved in all processes-energy production, green roof maintenance, recycling, etc.

In the times when Serbia plans to invest up to hundred million Euros, through School Modernisation Project 2010-2014[1], in improving the quality of learning environments, it is seen as crucial that some of the trends in designing school buildings are described. This is also important because some of the newly built schools in Serbia, which were examined by the authors, were built rather poorly. To illustrate this, during a post-occupancy evaluation with teachers and pupils, in one particular school in Serbia, at the beginning of June 2011, the classroom temperature was 25°C due to the lack of proper insulation. Unfortunately, this was not the only sign of problematic environmental conditions. Many pupils, as well as teachers, complained about poorly lighten space (too bright and some too dark), glare and poor ventilation. Hot and stuffy rooms affected everyone's concentration,

[1] Ministry of Education and Science, Republic of Serbia, (no date). Ministarstvo Prosvete i Nauke Republike Srbije. *Program modernizacije škole, zajam EIB. Javni konkurs "Programa modernizacije škola" finansiran iz sredstava zajma Evropske investicione banke*. Online: http://www.mpn.gov.rs/prosveta/page.php?page=315

caused eyesore and even headaches. If we want Serbia to have the 21st century schools, worthy of our children and teachers, which stimulate rather than hinder learning, we must build on already existing knowledge and adapt it to suit local circumstances. Therefore '*sustainable school is the most appropriate strategy for renovating educational processes and achieving quality education'* [1]. In order to accomplish this, schools must be developed by paying attention to all three dimensions of sustainable development: social, environmental and economic one.

Due to the limited length of this paper, the following pages reveal some of the aspects of school development in relation to environmental sustainability principles. Each feature will be supported by an example of a contemporary school that applied one or more of those principles. Towards the end, some of the benefits of approaching schools with sustainability in mind will be described. The explanation of the way the schools should be developed in relation to the social and economic dimension will be discussed elsewhere.

2. Important Points to Consider when Designing Environmentally Sustainable Schools

If we want to have schools that are healthy, comfortable, energy efficient, resource efficient, water efficient, safe, secure, adaptable, and easy to operate and maintain, the following points must be taken into consideration.

2.1. The design process

The characteristics of a sustainable school reflect a mix of environmental, economic, and social objectives. The design process of sustainable schools is fundamentally different from conventional practice. To be the most effective, this process requires significant commitment of design professionals who are supposed to perform the following:

- meet energy and environmental performance criteria,
- design the building in relation to the site and wider community, so that both form a harmonious whole,
- respect and take into consideration natural ecosystem even in case of urban school setting,
- support interdisciplinary collaboration throughout all design and construction phases,
- increase day lighting and maintain high air quality so as to maximise student performance,
- all important decisions regarding design should be integrated during the programming phase,
- the most optimal design should be chosen through simulations and models,
- all decisions should be made taking into consideration life-cost analysis,
- all systems should be easy to repair and use,
- all high performance techniques and materials used should be properly described and documented so that later they could be used and repaired according to the original design intent,
- all the construction operations and later maintenance should be resource-efficient,
- all staff should be properly trained to use and maintain the building adequately

Integrated design means consideration and design of all building systems and components together [2]. It recognises that each discipline's recommendation has an impact on another facet of the building design. In this way both the cost and the building performance could be optimized. Unfortunately, it happens too often that heating, ventilation, and air conditioning (HVAC) systems and lighting systems are not designed simultaneously. All engineers taking part in a project: architect, civil, mechanical, electrical; contractor and all other team members, have their important duties. Very often they carry them out without previous consulting with other members and synchronising all the phases of the project. This leads to oversized systems optimized for non-typical conditions. Even the smallest efforts aimed at collaboration and communication between team members can bring some benefits. Instead of working in isolation, the principles of integrated design allow all team members, gathered from various educational backgrounds, to take the advantage of knowledge from other disciplines. It can also point out areas where trade-offs can be implemented to enhance resource efficiency. Systematic and synchronised integration of all design stages and duties leads to design optimization, almost no redundancy, and decreased possibilities for conflicts [2].

2.2. Site design and ecosystem protection

Site design is a fundamentally important aspect of sustainable design. The choices made during site selection and site planning reverberate throughout the entire school. All aspects of environmental design are affected - from energy and water efficiency to acoustic comfort and environmental impacts. A high performance sustainable school responds to the site. Building placement, orientation, massing, and layout decisions made early in the school design process can profoundly affect the energy impacts of the building [3]. These decisions also bear on the resulting indoor environment since they either capture or lose opportunities for daylighting and natural ventilation. Other implications include acoustic comfort, safety and visual quality. Sustainable school design incorporates natural advantages and features of a site in order to achieve high performance goals of a particular school. In addition, high performance school site and building should “teach” environmental protection concepts**.** Site design should take into consideration opportunities for outdoor classrooms and environmental learning projects.

A high performance school protects the natural ecosystem by not applying any products and technologies that could pollute or degrade school site [2, 3]. By embracing natural site conditions (possibilities for solar and wind energy production *in situ*) school design is environmentally responsive to the site as it enhances the building's performance. In this way students are provided with the opportunity to see a direct impact of human activities on ecological systems, which turns them into active participants in the process of learning about strategies meant for protecting natural habitats.

A great example of such practice is Sakai Intermediate School, Bainbridge Island in Washington. Much effort was put to protect natural environment. Both building size and sport fields were reduced so that the buffer zone protecting the adjacent wetland and salmon stream could be expanded. Special system meant for separating groundwater and recharging natural wetland was installed. Nowadays, students and community members use their school site to guide tours and teach visitors about special protection features [4].

2.3. Water efficiency

Fresh water is an increasingly scarce resource. Hence, water runoff from the school site should be decreased and controlled, fresh water should be consumed efficiently and grey water should be reused as much as possible. Very simple efficiency measures, such as the ones previously mentioned can reduce water consumption in schools by 30% at least [2].

These measures include water-efficient irrigation systems, storm water management, groundwater management, drainage materials, rainwater collection systems, grey water systems, waterless urinals and efficient (low-flow) terminal devices. The reductions help the environment, both locally and regionally. They also lower a school's operating expenses. While the cost savings may be modest now, since water is relatively inexpensive in most areas, there is a strong potential that these savings will rise over time, especially in areas where water is deficient and gets more expensive. The technologies and techniques used to conserve water, especially landscaping, water treatment and recycling strategies, can be used to help students learn about ecology and environment.

In Anns Grove Primary School in England rainwater harvesting was done in such a way that the connections between the collection, storage and distribution systems were made visible. The system designed in this way is a great opportunity for pupils to learn about water conservation and water cycle in action [5].

2.4. Day lighting and fenestration design

Daylighting is the controlled admission of natural light into a space through windows, skylights or roof monitors. Sustainable school should use as much daylight as possible, especially in classrooms, while avoiding excessive heat loss, heat gain and glare. Access to natural light may be one of the most important attributes of a high performance sustainable school. Daylighting forms the cornerstone of resource efficient, high performance design for schools [6]. Affecting individuals on both conscious and subconscious levels, it provides light to see the work environment, a natural rhythm that determines the cycles of days and seasons, and biological stimulation of hormones that regulate body systems and moods [7]. In addition, it offers opportunities for natural ventilation and, if properly integrated with the electric lighting system, it can provide tremendous energy saving. The advantages of daylighting translate to higher performance in schools. Researches have shown that children achieve significantly higher test scores in classrooms that use daylight than in those that do not, making daylighting one of the best building-related investments for the learning environment [6]. A recent study showed that skylights admitting direct sun (and presumably glare) into classrooms correlated with a decrease in student performance on standardised tests [6].

Some of the benefits of adequate fenestration are:

- improvement of academic performance, evidenced by 13% to 26% higher scores on standardised tests [6],
- energy saving, supported by the fact that properly designed systems can significantly decrease energy consumed by electric lighting (from 30% to 50%) [7],
- better quality of light, connection to nature, which is bolstered by research suggesting that natural views elicit positive feelings, hold interest, and reduce fear and stress [8]. Teachers have reported a reduction in stress levels when they have access to a relaxing view from their classroom [2], improved health and environ-

mental education. Research in Sweden showed that work in classrooms without daylight "*may upset the basic hormone pattern, and this in turn may influence the children's ability to concentrate or co-operate, and also eventually have an impact on annual body growth and sick leave"* [7].

Dena Boer Elementary School in Salida, California installed louvers in the skylight which help controlling the amount of daylight. Classroom windows, apart from providing natural light, are protected by overhangs so direct sunlight and glare could be controlled [8]. The head teacher in the school observes *"the skylights create an open, bright work environment. We just seem to have more room. Visitors say it sure is a pleasant place to come into"* [3].

2.5. Electric lighting

Electric lighting is one of the major energy consumers in schools. Enormous energy saving is possible to achieve by using efficient equipment, effective controls, and careful design. Using less electric lighting reduces heat gain, saves energy for air-conditioning, and improves thermal comfort as the radiant temperature of a room is decreased [6]. In cold, predominately heating climates, reducing the use of electric lighting does decrease heat gain from the lights, which in turn increases conventional energy use for space heating during the winter. However, this increase in heating energy is more than made up for in electrical saving. The design of electric lighting strongly affects visual performance and visual comfort by maintaining adequate, appropriate illumination, while diminishing reflectance and glare [6]. Finally, accessible light and power meters can educate students and faculty about how lighting systems and energy controls work. School visual tasks vary in terms of size, contrast, viewing angle and distance. Many of these activities require close attention for prolonged periods of time.

It is crucial that we take in consideration critical visual tasks common to all school environments such as writing, reading printed material or the one in digital form, doing artwork such as painting, drawing, sports practicing, doing work in laboratories, preparing food, acting, doing work in wood and metal workshops, etc.. All of these activities require specialised lighting equipment and design. In the process of electric lighting design special attention must be paid to the quantity and quality of light, lighting control flexibility Switches Occupancy Sensors, Time Controls Energy Management Systems, Manual Dimmers, Photosensor controls and Occupant education [6]. Integrating this with HVAC systems and day lighting will optimise school operational costs.

Ross Middle School in Ross California incorporates myriad of high performance electric light features. Throughout the school there are dimmers and photo sensors installed so that electric light can be adjusted to daylight. Moreover, pendant luminaries with direct and indirect light provide light at foot-candle level. Only this strategy can reduce energy consumption for electric light up to 60%. [9] Since electric lighting can contribute from 30% - 50% of total energy consumption in a school, the architect of the school hopes that the school will use this strategy to raise children's awareness about how buildings use energy and affect environment [9].

2.6. Efficient HVAC systems

Heating, ventilating and air-conditioning necessary for the comfort and well-being of students, staff, and visitors is provided with a school's HVAC system. To ensure maximum operating efficiency, the higher performance HVAC system must be of a right size and in accordance with the school building demands, use efficient equipment and provide opportunities and controls for boosting the performance of the system [10]. As the HVAC systems are considered to be the largest consumers of energy in the school a proper design can have a huge impact on savings in the school's operating budget. This could be achieved by fulfilling the principles of integrated design and developing and designing HVAC systems alongside all the other systems necessary in the school. If we want HVAC systems to have optimum performance we have to perform an accurate estimation of the building enclosure efficiency, pay careful attention to shading, exploit possibilities for natural ventilation and consider the radiant temperature of surfaces. This will result in decreasing the costs of the system itself, less energy consumption and efficient operation over time. Properly designed, installed, and operated HVAC systems and controls minimise these issues as well as provide a key component of the "buildings that teach" theme. Automatic control of multiple pieces of HVAC equipment and other systems may be integrated by using computerised systems such as energy management systems (EMS), energy management and control systems (EMCS), building management systems (BMS), or building automation systems (BAS) [10]. The added expense and complexity may be justified by the equipment optimisation and increased convenience of maintenance possible with such a system. These systems generally perform three functions: equipment on/off control, space temperature control, and equipment status monitoring. A single system can control lighting, security, central plant equipment, and space conditioning equipment.

In Newport Mesa High School, Costa Mesa, California high efficiency heat pumps were combined with natural ventilation in each classroom. The system can be controlled in each of the classrooms so that the optimal conditions for teaching and learning could be maintained at all times. The teachers and pupils in the school today know how to sue the system and exploit the system most efficiently [14].

2.7. Building enclosures

"*The building enclosure (walls, roofs, floors, and windows) of a high performance school should enhance energy efficiency without compromising durability, maintainability, or acoustic, thermal, or visual comfort*" [3]. Energy efficient building enclosure is supposed to control moisture, insulation, shade, glazing, thermal mass, air leakage, thus reducing operating costs in a school and minimising a potential negative impact on the environment. Many of applied techniques: high performance glazing, shading devices, lightly coloured surfaces, could be part of three dimensional textbook that can easily be used in teaching in a school as an instructional aid.

Designing the school building enclosure or envelope requires much reasoning and assessment. The materials, both indoors and out, must be durable, resistant to water damage and vandalism, easy to clean, and inexpensive. Integrated approach where all the parts of a building are considered together and designed to interact with each other is the key to building enclosure optimisation. Today on the market there are already available tools that can help us do [11, 12, 13].

In Ballifield Primary School in England Prue Chiles Architects (PCA) used recycled newspapers as insulation material. Building on the idea of a school as 3D textbook they cleverly installed transparent part of the wall where inside insulation could be seen [15].

2.8. Material efficacy

Material efficiency here refers specifically to two overarching goals:

- waste reduction, including construction and demolition source reduction, reuse, and recycling; and
- the use of building products that are produced taking into consideration conservation of raw materials, use of recycled content products, conservation of energy and water, that are reused or salvaged, or that can be recycled or reused at the end of the building's service life.

Addressing these goals provides significant environmental benefit. Buildings account for 40% of many processed materials used (such as stone, gravel, and steel) and 25% of virgin wood harvested [16]. Unfortunately this results in destruction and erosion of the landscape, deforestation, the lost of biodiversity, air and water pollution, toxic runoffs and a myriad of other problems. When considering recycled content products or other materials-efficient products their effect on acoustic, visual, and indoor air quality must be considered. Using certain recycled products may conflict with goals for long-term materials efficiency, since a product's recycled composite may be difficult to recycle. Products that unnecessarily complicate operation and maintenance procedures should be avoided, and the custodial staff should receive proper training on how to upkeep the products. By clarifying this to students and teaching them through school building and later exploitation process, they can understand the role of waste reduction in protecting the environment.

Here again Ballifield Primary School is an excellent example. The key focus of the whole design process was using environmentally sustainable materials as possible. One of the architects of the PCA team explains "*Natural carpets and linoleum flooring were employed to help reduce the chemicals that children come into contact with. A brightly coloured worktop made from recycled plastic bottles was used in the wet area, showing the importance of recycling and how fun the results can be*." [17].

2.9. Renewable energy systems

Using renewable energy systems for part of a school's required energy load is highly recommended. As demand on fossil fuel reserves and the existing electricity grid increases, a growing number of countries are facing energy shortages and skyrocketing utility costs. The problem will continue to worsen as the World's energy needs are expected to grow by 33% during the next 20 years [3]. Renewable energy can help fill the gap. Renewable energy sources not only release less pollutants into the environment than traditional energy sources, but they save school districts money in the long term while also serving as valuable teaching tools for students and faculty.

Renewable energy technologies are often referred to as "clean" or "green" because they produce few, if any, pollutants. Burning fossil fuels, however, sends greenhouse gases into the atmosphere, trapping the sun's heat and contributing to global warming. Unlike fossil fuels, renewable energy resources are abundant. Every day, more energy

falls on the Earth than is used in an entire year. Wind power is an increasingly common renewable energy source. Depending on the wind resource, a small wind electric system can lower electricity bills by 50% to 90%, prevent power interruptions, and is non-polluting. A wind energy system can also be a good teaching tool [3]. Geothermal power may be one of the lesser known renewable energy sources, but it is growing in popularity. Using passive heating and cooling, solar thermal hot water systems, solar pool heating, wind, geothermal heat pumps and photovoltaics will not just lower school operating costs, but it will contribute to making this planet a better and healthier place for living.

Toilets at Earlham Primary School, Forrest Gate, in England made by PCA are designed to stimulate pupils to explore various environmental problems. Electricity is produced by solar panels and water is harvested for flushing the toilets. All of this is shown on the diagrams that can be found at the entrance of the toilets. They explain water and electricity usage and incorporate readouts so that pupils can constantly monitor consumption of water and electricity [18].

2.10. Recycling systems and waste management

Neither recycling systems nor waste management systems, such as composting, require extensive design accommodations. However, paying attention to these issues during the design process, rather than after, can minimise waste streams and lower disposal costs, conserve natural resources, and provide an educational opportunity for students as well as teachers and administrators.

Once the site and building accommodations have been made for these systems, students can design and manage the programs as part of science or math curriculum. Paper, plastics, glass, and aluminium, as well as composting can become a part of the school's daily education program. For both, a comprehensive recycling and waste reduction plan is recommended. However, recycling and waste management should begin long before the building is occupied. Environmental goals should not be compromised during high performance school construction.

East Clayton Elementary Public School from Clayton in North Carolina organised great action where school children had a task to collect old jeans. Afterwards those jeans were recycled and used as insulation material [19].

2.11. Transportation

Careful site planning can help promote alternative transportation. Locating the site close to public transportation and offering bus service will help reduce the automobile-related congestion and pollution. Even if the school location has already been selected, the site design can include features to encourage students, staff, and parents to leave their cars at home. Incorporating a network of safe walkways, bike paths, and carpool and vanpool locations into a school design can reduce local traffic congestion, minimise busing costs, and reduce air pollution [2]. Incorporating natural gas, biodiesel, methanol, or electric vehicles in a district's existing vehicle fleet can help to reduce fuel costs, reliance on foreign oil, and harmful emissions contributing to reduced operating and maintenance costs. The reduced cost of fuel will largely depend on individual state incentives and regional pricing of fuels.

3. BENEFITS OF APPROACHING SCHOOL DESIGN WITH ENVIRONMENTAL SUSTAINABILITY IN MIND

Putting all our efforts in implementing everything previously mentioned in school design we will be able to provide all the schools with healthy environments, good quality of internal air, thermal, visual and acoustic comfort and increased safety and security.

3.1. Health and internal air quality

Internal air quality significantly impacts the health and performance of children, teachers, and staff. A high performance sustainable school should provide superior quality of indoor air by: eliminating and controlling the sources of contamination; providing adequate ventilation; preventing unwanted moisture accumulation; and implementing effective operation and maintenance procedures [20]. Sometimes the concentration of pollutants in a building may be two to five times higher than outside levels. Children are particularly vulnerable to such pollutants. Maintaining a high level of internal air quality is therefore critical for schools. Failure to do so may negatively impact student and teacher performance; increase the potential for long and short-term health problems for students and staff; increase absenteeism; accelerate deterioration; reduce the efficiency of the school's physical plant; create negative publicity; and create potential liability problems.

To eliminate or control contamination materials that are low emitters of substances such as volatile organic compounds or toxins should be selected. Some of these building materials may be unfamiliar to custodial staff, so the training for the staff should be provided, durable products should be selected, and products that unnecessarily complicate operation and maintenance should be avoided. Any material can affect the acoustic and visual quality of a school. Where there is superior air quality and thermal comfort, where children are not exposed to chemicals and toxins, there are lower asthma and allergy rates and sick leave days are reduced as well [21].

3.2. Thermal comfort

Thermal comfort is important for student and teacher performance. Hot, stuffy rooms or cold, drafty ones reduce attention spans and limit productivity [2]. They also waste energy, adding unnecessary cost to a school's bottom line. Excessively high humidity levels can also contribute to mould and mildew. Thermal comfort is primarily a function of the temperature and relative humidity in a room, but air speed and the temperature of the surrounding surfaces also affect it. Sustainable school should ensure that rooms and HVAC systems are designed to allow temperature and humidity levels to remain within the “comfort zone” at all points in an occupied space.

Thermal comfort is strongly influenced by how a specific room is designed (for example, the amount of heat walls and roof gain or lose, the amount of sunlight windows let in, whether the windows can be opened) and by how effectively the HVAC system can meet the specific needs of that room. Balancing these two factors, room design and HVAC system design, is a back-and-forth process that continues throughout all the stages of developing a new facility. In a high performance sustainable school, the process ends with an optimal blend of both components: rooms configured for high student and teacher productivity served by an energy-efficient HVAC system designed, sized, and controlled to maintain thermal comfort under all conditions [3].

3.3. Visual comfort

"*Performing visual tasks is a central component of the learning process for both students and teachers*" [10]. By carefully integrating natural and electric lighting strategies, by balancing the quantity and quality of light in each room, and by controlling or eliminating glare, we can enhance and not hinder learning and teaching, and in that way create a rich visual environment. Writing on and reading from various printed and digital media is a visual activity in which students are engaged for most of their time in a school. During these processes they constantly have to adjust their vision. If there is a glare, or poor quality lighting, it can severely impact the student's sight and ability to learn and enjoy learning. Learning environment that takes this into consideration, has various types of good quality lighting, and can provide comfortable and productive environments where both students and teachers love to learn.

3.4. Acoustic comfort

Parents, students, teachers, and administrators are increasingly concerned that classroom acoustics are inadequate for proper learning [3]. Students' concentration can be hampered by various types of noise: the one from outside such as from vehicles, nearby corridors such as loud conversation and walking, neighbouring classrooms because of inadequate sound insulation, from mechanical equipment such as the one from HVAC systems, and even the noise produced within the classroom that reverberates if it is not properly absorbed. Exerting to hear in environments with poor acoustic characteristic is the same as exerting to read and write in poorly lit environments. Increase of stress, poor concentration and impaired learning are just some of the consequences. This has an enormous negative impact on younger children who still have not reached their teens as their ability to sort meaningful sounds from noise is not fully developed, the ones who are not instructed in their second language and especially the ones with hearing impairments [7]. Although little consideration has historically been given to acoustic design in classrooms, as opposed to lighting and ventilation, this situation is beginning to change. The information and tools needed to design classrooms for high acoustical performance now exist [22]. They can be used to ensure that newly constructed classrooms are acoustic environments that enhance and not hinder learning and teaching.

3.5. Security and safety

Safety and security have become critical concerns of students, teachers, and parents. A high performance school should create a safe and secure environment by design. Opportunities for natural surveillance should be optimised; a sense of territoriality should be reinforced; access should be controlled; and technology should be used to complement and enhance, rather than substitute for, a facility's security focused design features [2]. Crime and vandalism, and the fear they foster, are problems school populations have been facing throughout the world. Although better buildings alone cannot solve these problems, they can be powerful factors in helping reduce crime and other antisocial behaviour.

Security-based design strategies will influence a school's basic layout and site plan. If properly integrated from the beginning of the development process, these influences will complement and enhance other high performance design strategies used in the facility.

For example, day lit classrooms can "share" their natural light with adjacent corridors through windows or glass doors provided primarily for surveillance purposes. This "free" natural light can, in turn, be used to offset the need for electrical lighting in the corridors. Security technology strategies will not strongly impact other systems in the school, unless they are incorporated into a comprehensive automated control system for the whole facility.

4. CONCLUSION

To conclude, two great English architects and theoreticians, John Ruskin and William Morris, in the 19th century said that architecture represents the state of society in certain moments. Today, two centuries later, I could not agree more. Looking at the current condition in regard to school building design in Serbia, it is clear that we have much more to do. By using outdated school building standards and by applying "copy-paste" methods while designing schools in the same way we did fifty years ago, we are not just harming the local environment, but we also seriously affect the quality of learning experience, and the quality of pupils' and teachers' life in schools. Architects are in a great position to contribute to improving the quality of learning environments by initiating the revision of the school building standards and by incorporating some of the already existing knowledge in their practice. In this way they will not just improve the quality of school buildings, but the quality of education as well.

This is why high performance sustainable schools, designed as 3D textbooks are important in shaping the youth's consciousness about sustainability as a general life concept. Until we in Serbia do not update our school building standards, and incorporate sustainable design principles, we will not be able to do so. Today's children are tomorrow's people, who, I hope, will be more environmentally conscious than we are today. It is our duty to help them along this way.

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ODRŽIVE ŠKOLE KAO TRODIMENZIONALNI UZORI: ČUVARI EKOLOŠKE ODRŽIVOSTI

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U trenutku kada Srbija planira da investira sto miliona evra u poboljšanje kvaliteta prostora za nastavu kroz program "Modernizacija škola 2010-2014", izuzetno je važno opisati neke od trendova projektovanja škola u zapadnim zemljama. Škole su ustanove u kojima se najmladji članovi našeg društva obrazuju. Dizajn zgrada može imati direktan uticaj na asimilaciju, učenje i integraciju sa ostalim članovima društva, kao i na način na koji mi kao društvo integrišemo principe održivosti u naše živote. Objekti imaju potencijal da nas nauče novim putevima kojima se održivi principi ostvaruju. Mnogi eksperti danas tvrde da su "održive škole najprikladnija strategija za obnavljanje obrazovnog procesa i postizanje visoko-kvalitetnog obrazovanja" [1]. Iz tog razloga u ovom radu će se razmotriti neki od aspekata razvoja škola u skladu sa ekološkim principima održivosti. Svaki aspekat biće ilustrovan primerom savremene škole koja je bazirana na jednom ili više održivih postulata. Pred kraj rada značaj i korist ovakvog načina projektovanja biće objašnjeni, u nadi da će delovati kao poziv i stimulans arhitektama i planerima, pogotovo u Srbiji, da preispitaju svoj rad do sada i počnu da posmatraju projektovanje škola kroz prizmu održivog razvoja.

Ključne reči: *održive škole, Srbija, škola kao trodimenzionalni udžbenik.*