Educational building safety

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Abstract. The article proposes a crime prevention approach to create educational environment and particular buildings. The author explores a structural and architectural type of the educational facilities, presents some examples of these objects, identifying the main problems associated with the protection of educational buildings from criminal activity and defines the features that help to improve the safety: strong links between the building and its surrounding, establishment of semi-public and semiprivate areas, or the buffering zones, visual transparency and simplicity of communication. The author describes modern examples of schools designed with built-in security measures. Crime prevention through environmental design accepted as a structural model of educational buildings. Contemporary safety critical research were reviewed. Subsequently, the architectural, landscaping, and planning means of protection are proposed.

1. Introduction
This type of building has common and special problems related with safety. Criminal problems includes vandalism, undesirable activities, unwanted visitors, ineligible access to some areas assigned to teachers and personnel only. Other problems are separation of inner and outer spaces purposed to different groups of people and personnel and appointment of altering paths.

The goal is to find the common way to create safe educational space by means of architecture.

We can follow to next particular objectives:
- to learn historical basis of creating defensible space;
- to overview some examples and to extract some facilities provides safety;
- to define the sequence of steps that can help architect to control the school environment.

Surveillance principle should be provided with survey points, for example, galleries, transparent communications and balconies. Educational buildings needs high visibility of its public spaces, where emerges the undesirable activity. Control points includes guard post, entering points, comfortable watching points located in the common spaces and classes.

2. Connection between the safety and architecture
Safety is provided in accordance with proposed hierarchy of defence levels that can be seen in any building and architectural means and methods. We can extract a variety of schemes with which hierarchy of defence levels can be constructed. These schemes describes methods of arrangement and forming of inner spaces and relations between them in any building. They emphasizes safety and surveillance provided by capable guardians [1].
2.1. Safety problems
According to R. Atlas’ research school buildings and their sites have a set of specific problems. Architectural environment affects children’s behaviour. Typical problems with safety and surveillance of schools are: school site boundaries are not defined or poorly defined; playgrounds and gathering places are away from the observation; site and building structure produces blind spots; pedestrian sidewalks intersect with transport; trees are obstacles on a sightline between observation points and significant gathering places; service zones are available to students; restrooms and toilets are unobserved [2]. The list of indicators that describes percentage of victimization of students at school and their perceived security reveals that school environment affects students behaviour [3]

2.2. History of researches
“Crime Prevention Through Environmental Design”, a book by C. Ray Jeffery [4] describes a special approach to the creation of safe educational environment. The author took into account the architecture and modern theory of learning that was based on the behaviorism theory. The author had an experience with a rehabilitative project in Washington, D.C. He learns how to make safe, clean and unvandalised educational facility with the architectural methods and means. According to Ray Jeffery, these means are involved in the formation of positive and negative impressions. He pointed out that the physical environment can influence the decision-making of a potential offender [5].

An example of modern research on a safe school environment is the Kunstle, Clark, and Schneider’s “Florida safe schools design guidelines”. This study shows the results of surveys on the most important problems of school buildings and typical crime problems. These problems were fighting, larceny, theft and vandalism. They also found that inner and outer school space contributes to the perception of the school as safe or vulnerable. The survey describes an algorithm of steps that helps to increase security and reduce vandalism and a few tips related to the safety of the site, exterior and interior, furniture and equipment [6].

3. Architectural approach
3.1. Safety schemes
Architectural safety approach accenting social hierarchy and basic function of inner control. We can call it "differentiation of space". This approach can be used in the public buildings with various groups of users, to which educational buildings and complexes can be attributed. The approach establishes with isolation of functional areas of building and relations intended for different groups of users: employees, students and other. These objects are distinguishing from others by high surveillance, visual connections with outer spaces and building site and inner common spaces. As educational buildings usually has its own campus or large site, it needs good visual permeability, strong arrangement of different safety levels, access control and others. Organization of different functional areas on the site realizes with arrangement of architectural objects that divide outer space.

The safety schemes, as to said, defines inner space safety layout. The arrangement of inner spaces should follow the ranking by level of required defence. There are following types of inner defence structures:
- traditional scheme with different permeability of inner filters and barriers as it was suggested by Christian Norberg-Schulz (he divides all architectural elements into four groups: filters, barriers, connectors and switchers) [7];
- extraverted building, uncovered outside with transpired walls and other barriers;
- introverted building, integrated with central common distributing space (halls, atriums, wintergardens etc);
- oriented building, developed according to one or two axis.
3.2. Safety principles and layers of defence

According to CPTED theory, the next principles of creating safe architecture are common for all types of building including educational:

- Access Control
- Natural Surveillance
- Territorial Reinforcement or Integrity
- Maintenance [8, pp 7-8]

These principles should be applied during the projecting process. They influence architecture, site and building design. Even the action steps for personnel include instructions on how to create an environment that encourages parents and other adults to observe what’s happening and to participate [9].

Besides CPTED, there are guidelines and crime prevention handbooks developed by local and state security departments. Buildings and Infrastructure Protection Series includes Primer to Design Safe School Projects in Case of Terrorist Attacks and School Shootings that establishes layers of defence. It consists of building and nearby areas. Primer consists of five chapters. First, it describes the process of threats, vulnerabilities and risk assessment and gives guidelines of risk seduction. The second describes how to design school site in accordance with all security demands. Important features are standoff distances, vegetation, the terrain of the site and school building accommodation.

The basic approach to site security design promoted in this primer is the concept of layers of defense. These are multiple consecutive layers of protective measures deployed in concentric circles around a school. They start from the outer perimeter and move inward to the area of the school building with the greatest need for protection. The third chapter reviewed some shootings incidents and how to prevent them, the fourth - blast threats and how to prevent building damage from external and internal explosions and the fifth considers chemical, biological, and radiological threats [10].

Contemporary research shows the relationship between crime prevention principles and student victimization. This investigation reflects agreement with principles that were associated with higher scores on student perceived safety and lower scores on most of the verbal and physical abuse perpetration items as well as student perceived risk, and missing school out of concern for safety in the past 30 days [11].

**Figure 1.** Introverted, extraverted and oriented schemes.
Figure 2. School site perimeter is fenced and the inner space is the second layer of defence.

Specific design objectives of school protection are [12]:
- Access control
- Surveillance, architectural (provided by physical design) and mechanical (CCTV)
- Design and construction
- Territorial awareness
- Image of the place
- Work with users, police and community: social interaction, community awareness, capable guardians etc.

A term ‘capable guardian’ describes people who can deter crime through their presence at the target area or watching it [13].

3.3. Contemporary safe schools architecture

Contemporary researches and successful studies proves the importance of interaction between architects, engineers and school employees. Last studies specifies the meaning of regular update school safety plans, teacher safety trainings, creating a school safety team and a complete emergency response plan [14].

Let's consider some modern examples of school reconstruction.

Niles West High School is arranged with exterior glass wall that maintains surveillance. It opens clear view to the main entrance and central distribution space (entrance hall). Transparency of the interior layout helps staff to observe and control inner and outer space and students ‘activities [15].
Figure 3. Niles West Commons School exterior.

Despite these measures school still needs safe routes for parents and students [16]. Other example is Sandy Hook Elementary School where occurred an incident with mass shootings of schoolchildren [17].

Figure 4. Sandy Hook School scheme: large, medium and small common spaces that helps to observe.

Natural surveillance, territorial reinforcement and access control principles are integrated in the building layout so imperceptible that users of the school space don’t see them. Natural surveillance provided from the all sides of school site. It is bordered by a forest and a wetland from the back and sides. These features are natural obstacles and a man approaching from these directions will arouse suspicion. Main route in the front of the school divides different groups of visitors. Separate entrances are provided for staff, students and teachers. A moat along with the facade represents at the same time old and new reinforcement feature, and three bridges are under control [18].

Standoff distance allows to observe anyone approaching the school and to prevent possible attack [19]. Windows are often perempted as a vulnerability. In this school they are integrated in the building structure so that they allows to control the entrance lobby and inner courtyards where children play and learn outdoors. A whole system of inner recreations, corridors, galleries and halls for observation was created. Another safety feature of the space is the hardened lower parts of the doors and partitions in classrooms so that in case of attack students can shelter unseen by someone in the corridor.
The last example of a safe educational space is the Early Learning Center in the 59 district of the Massachusetts, an US state. This project wins an award among Illinois public school districts [20]. Building layout includes workshops, gathering spaces, art spaces and sensory gardens. Building structure encourages interaction between children and promotes surveillance by its light-filled corridors. Large windows in the corridors also enables supervision under outer gathering places and playgrounds.

Figure 5. Early Learning Center interior: a central corridor filled with light.

4. Conclusion
The school environment is in a constant need for new impulses to develop, and the educational buildings that actively involve safety principles and all the citizens in their actions, can be such impulses. Extraversions depend on the function of a building and people’s will to self-organize and participate in the provision of security. The common fear of outer attacks has caused the creation of fortresses, surrounded by high walls, but the new approach makes it possible to avoid the fortress effect.

Security is often imagined by architects to be a necessity that disables openness and visual permeability, but often this sacrifice is meaningless. In our time, the idea to reveal the school building to the outside and create interaction between the external and internal environment becomes more widespread. When the traditional urban block or complex development create single, detached objects, extroverted buildings grow deeply into the urban system, allowing to cross their covered streets, open first floors and other elements of intersection of spaces.

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