A School Evacuation Plan after Earthquake for Blind, MDVI and Deaf- Blind Students - Universal Design of Wayfinding and Cognitive Maps Using Multi- Sensory Signs

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ABSTRACT

In this paper we present a plan for evacuation of a school building after an earthquake. The combination of sensory information perceived by multisensory cues (visual, auditory, tactile, olfactory) placed in the school environment provide the blind, visual impaired and deafblind students with the necessary information to locate themselves and maintain orientation while moving. The systematic framework of the presented project is focused on the attendance, perception and interpretation of sensory cues into spatial information; the school environment becomes more accessible, structured and predictable and the perceived multisensory inputs function as a means of orientation and way finding in case of emergency. It is important to ensure that mdvi and deafblind students are trained to evacuate safely the school building in case of an earthquake. Thus, in the school environment permanent multisensory cues are located, which heighten the students' sensory awareness and may help students to orientate themselves and to determine their position in relation to the line path from their classroom to the gathering point outside the building.

1. INTRODUCTION

The learning environment should provide opportunities to students to explore and become aware of their environment. Visual impaired students and deafblind students may need to combine several sensory cues to learn about the environment and maintain their orientation. Thus, they are usually motivated when their environment is enriched with multisensory cues. However, sensory cues (auditory, visual, olfactory, , tactile-kinesthetic-thermal) cannot be useful, unless they are recognized, identified, interpreted and applied by the students to move purposefully. Therefore, the students' functional sensory assessment, due to their heterogeneity in sensory potential, and the structure of the school environment with the throughout chosen multisensory cues, are the project's prerequisites.

Students are instructed to detect the multisensory cues in their route; they interpret their meaning into spatial information and follow them, in order to orientate themselves and move with safety. Using sensory cues, students become aware of where they are and can exercise control over where they wish to go. Moreover, they experience that a route may become predictable, and that following a selected route from a specific point, will lead to a specific destination.

2. MULTISENSORY APPROACH

2.1 The role of Vision in spatial perception

The principle of 'universal design' suggests that sensitive planning and design can yield environments that are equally suited to all people. These point to environmental modifications which may benefit large numbers of people. The human visual system can detect and discriminate between an incredibly diverse assortment of stimuli that may be chromatic or achromatic, in motion or not, patterned or unpatterned, two-dimensional or three, in order to create a visually derived mental "map". However, while the literature on the effects of total blindness increases rapidly, there has been little research into the effects of differing degrees and types of visual impairment on spatial cognition [1]

A person with visual impairment and deafblindness or multiple disabilities has no visual memories of particular spaces and has no direct visual input into the development of spatial understanding in general. Experience of space comes from hearing, touch, smell and movement, and yet he/she can engage in pretty much all the activities that a sighted person can. In research on spatial cognition in blind and visually impaired people, a distinction is usually drawn between 'near' and 'far' space. The former relates to small-scale or manipulatory space: areas that can be explored without changing the location of the body. The latter relates to medium- or large-scale space: areas in which locomotion is required for exploration. In the absence of vision this distinction is very important for the performance of spatial tasks. In small-scale space, where tactile exploration with the hands and arms is used, object locations can be represented relative to one's own body. In large-scale space where exploration involves locomotion, the body must translate (i.e. change location). Consequently, there is a difference between tasks that a response based on a spatial relation which has been directly experienced, and tasks that inquire the inferential of a new relation based on direct experience. The former simply requires some form of spatial coding, while the latter requires that a transformation will be performed on the coded information. Performance in inferential tasks is generally more efficient and reliable when based on external coding, for instance an integrated or 'map-like' representation of a spatial layout.

People with little or no visual ability and deaf-blindness or multiple disabilities tend to code spatial relations in small-scale space by reference to their own body co-ordinates and/or their arm movements during exploration of the experimental space. According to [2], this is because the 'type and reliability of spatial information' available under blind conditions differs from that available with vision, and these differences in the quality of experience generally to organize spatial information by different coding strategies from those that tend to arise from visual experience. Optional forms of coding differ in the types of information selected (e.g., relationships between locations in space or relation of locations relative to the body mid-line) and the coding heuristics appropriate for a particular type of information (e.g., external frame of reference, self-referent, movement).

If external cues are attended to and used, however, performance is generally improved. External cues also become advantageous when the task is very complex, with strategies that use external reference frameworks, such as reading tactile maps or using the Optacon.

To investigate the cognitive maps of people with visual impairment and deaf-blindness or multiple disabilities the construction of models is widely used. More common have been direct (re)production of a route, distance or direction by walking, distance estimation or direction estimation using some kind of pointer.

The information about the structure of external space, which is so accessible in vision, must be substituted via touch and or hearing. How this is to be done effectively is not straightforward. Millar stresses the importance of building on the information and coding strategies currently available to a blind child, and progressively integrating new sources of reference information with these existing ones; simply exposing a child to a new source of information which is rich in external cues (e.g., an electronic device, or an acoustically rich room) may not automatically cause the child to adopt a new coding system [1, 3, 4].

2.2 Tactile maps in spatial perception

In the case of children with visual impairment and deaf-blindness or multiple disabilities knowledge about the spatial structure of an environment could be acquired from a tactile map. Tactile maps might be an ideal means for emphasizing external frameworks in the environment, which are not readily apprehended by direct experience alone. Spatial knowledge may be optimized when tactile maps are used in conjunction with direct experience of the environment, supporting Millar's [3, 4] recommendation that new strategies should be integrated with existing ones. Individual differences in tactile mapping use may be accounted for by differences in strategies used to acquire information from the maps, and it may be possible to train poorer map readers in more effective strategies. Tactile maps are still little used in practice, both in the classroom and in the outside world. Educators do not always have the time or resources to keep abreast of the latest developments in research. Furthermore, there is very little in the way of standards for the design and construction of tactile maps; practitioners make use of the resources they have to hand, and as a consequence, may find themselves reinventing the wheel. Closer links are clearly needed between the research and practitioner communities.

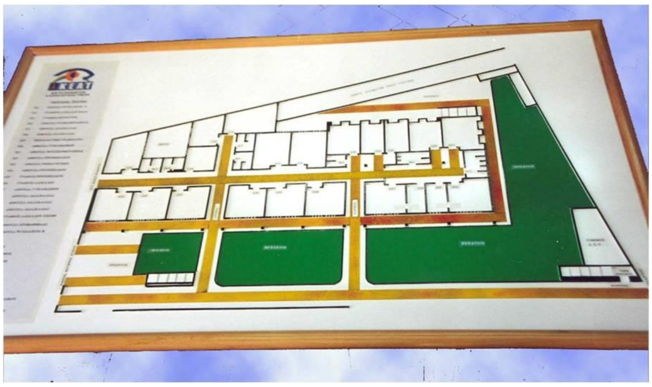

Figure 1. Tactile map of the school.

The emphasis here is on the structure of the built environment to produce a plan of a school campus using model buildings and multi-sensory (tactile, olfactory, visual and hearing) signs, creating an evacuation plan in case of an earthquake. The project includes the performance of students with visual impairments and deaf-blindness or multiple disabilities is correlated with their level of independent mobility in order to keep track of their position relative to a number of landmarks as they move or imagine moving through an experimental layout of visual, olfactory, hearing and tactile signs. Tasks involve spatial memory (e.g., reproducing angles or distances) and spatial inference (e.g., short-cutting, inferring crow's-flight directions). The project follows the guidelines of the "Draft Action Memorandum for the Management of Earthquake Risk in the School Unit (2014: 11)" of the Earthquake Planning and Protection Organization (EPPO) [5], in case of an earthquake.

Thus, the use of tactile maps plays a key role in orientation and mobility. Specifically, in this project we will give great emphasis on the manner through which blind people utilize their sense of touch, in order to be able via tactile maps, to draw in their minds a picture representing a specific area (in our case, school environment)[6]. The aim is to be able to orient themselves in case of an emergency, such as an earthquake evacuation.

According to certain surveys, children with blindness who are taught and briefed with the help of a tactile map, are effectively able to create a comprehensible image of the surrounding space, since tactile recognition is based on the process of the entire object, or parts from it, and in the creation of such image [7]. Via tactile maps, blind user is being taught, briefed, oriented and able to move. This last ability that they provide is the main reason of their existence. The blind user obtains a total perception of the surrounding space, understands the relative position of certain objects in the area, is able to calculate distances, to program - draw routes and to move without the risk of being disoriented [8].

In order one to create a tactile map, as with every other tactile training material, certain specifications are necessary to be followed, for it to be simple, concise and recognizable from the previous knowledge and experience of the specific area, of the child. According to [9], the elevated characteristics of a tactile map in conjunction with the texture affect both the accuracy and the speed of recognition of the map characteristics. As a result the user in case of an emergency can move and evacuate the area even faster.

A good technique for better understanding of a tactile map is through real-time experience. When referring to a real time experience we basically mean the physical transfer, initially of the students of every individual class and then the students of the entire school unit, with the tactile map on their hands, to the same area depicted on the map. The aim of this technique is for each student independently, to locate tactile information (specific marks) which are vital to spot in case of an emergency (earthquake), to assist him/her to orient and move to safe location. The teacher may ask the students to navigate in a real course in the drawn area (evacuation course) and periodically ask them to locate their accurate position on the map. In case of any students being disoriented, the teacher must give the correct guidelines to reorient the students using information from the map [10].To conclude we should all bear in mind that blind children primarily navigate with mental maps. It is often a long and difficult process to learn a place, a task that becomes even more difficult under the presence of large numbers of people (as it could happen in the case of a general building evacuation exercise due to an earthquake). Most of the difficulties encountered are due to the fact that blind individuals learn places, like others may learn other physical skills. Just as a child learns how to ride a bike in a day, it requires repetition and rehearsal for a blind child to learn enough about an environment to allow him/her to navigate completely in them [11].

2.3 Hearing and spatial understanding

The distance senses (vision and hearing) have an exceedingly important role in the perception of spatial concepts. In particularly, vision is the most equipped human sensory modality, which provides precise and extensive spatial information and serves the integration of spatial information from all sensory sources (auditory, tactual). The students with visual impairments may confront with difficulties in conceptualizing spatial information. [5]..

In the wider natural and social environment uncontrollable, consistent sounds are entitled. As a result children practice little control over all these auditory inputs. Only when someone starts to group the sounds and develop selective listening and perception, succeed in calling attention to useful and meaningful sounds. Even though, a sound carries information about the spatial location, but it may consists of an ineffective cue of spatial structure. [12, 13]

Sounds, in general, consist of a valuable mean of information for people with visual impairments to identify and localize sounds, to echolocate, to take direction from a sound (sound tracking) and make time and distance judgments. [14, 15].

Attending to a sound visually impaired students can specify the persons present in a room, detect what is happening in a place. Furthermore, sounds can provide direction, since persons with visual impairment are helped to know where they are [16, 17].

It is noticeable that in the case of students with visual impairments and multiple disabilities or deafblindness, the sense of hearing depends on the amount of hearing potential and its usefulness to the child and on whether the child is using a hearing aid [18]. For the children who have difficulty in detecting environmental sounds, the use of vibrotactile devices may be helpful, since these devices transform the sound into vibration. In parallel the student learns to distinguish the sounds by their duration, intensity and rhythm [14].

It is worth mentioned that listening skills are not developed naturally in students with visual impairments. It is needed a constant program of systematic instruction and intervention. Part of the program is to encourage the child with visual impairments to interact with the surroundings and interpret the sounds and every hearing stimuli perceived [16, 19]

Alsop underlines the five phases of sensory integration to meaningful information as follows: tolerance, awareness, recognition, integration and application. The tolerance of sound is an important factor, since many students avoid to listen and “tune out” (p. 188). In this case, students should be encouraged to listen to sounds and facilitate the process by connected a sound to another stimuli (light or vibration). The assistance of vibration and light referred to a sound may help and encourage sound awareness [18]

In addition two important auditory skills related directly to orientation and mobility are referred to sound localization (identifying where a sound is originated) and sound discrimination (the ability to differentiate between sounds) [18].

Auditory perception is of great importance to the visual impaired students in movement, orientation and independent travel, since they may often locate and detect large objects, halls, corners and integrate spatial information through the reflected sound on these areas. Thus, it is emphasized the importance of sound perception. Students should be systematically trained in both sound perception as a means of orientation and safety, but also in sound discrimination of sounds suggesting danger and emergency, as means of survival [20, 21]. Children with sensory impairments may be encouraged to orientate themselves by musical prompts, auditory cues and even following the educator's voice to move independently [22, 23, 24 and 25]

2.4 Auditory Stimulation

The school environment may be enriched with sensory cues in order to help in understanding and building of a spatial map. More specifically, sound edges would provide information since they create sound shadows and give shape to the room. In parallel, when the sound environment has some sound sources (ticking clocks, mobiles or wind chimes, bead curtains in a doorway, contact bells on doors), encourages the children to orientate themselves. [26, 27].

In adapting and changing an environment to an accessible, predictable, safe place, it is important to examine the factors that help or impede children with visual impairments. One area of assessment refers to sound, which may provide information about the natural and social environment, but in the mean time may become devastating and tiring. The sound quality could be improved when the environment is enriched with clear distinguishable sounds and when fixed sounds are selected to provide direction. It is important to teach visual impaired students how to listen to the chosen sounds, how to use them and how to explore and distinguish them. [18, 26].

2.5 Olfactory cues as landmarks

The human sense of smell has long been underestimated, because the sensitivity is often lower than that of animals [28]. However, recent research has shown that people have really sophisticated olfactory capabilities [29], meaning that although the sense of smell is less important to people than to many other animals, it is nonetheless a highly developed and sophisticated sensory system. According to previous studies, smell can cause newborn babies' orientation and movement towards their mother's scent [30, 31].

Based on these findings it would be interesting to detect the extent to which blind people utilize their sense of smell, in order to imprint in their minds olfactory maps targeting at space orientation in case of emergency because of an earthquake. Nevertheless, according to the US National Fire Protection Association [32], in the case of an urgent evacuation of a building, no special plan is required for people with partial or total vision loss, since they can use their hearing to orient themselves in space. At this point, however, emphasis should also be put on the sense of smell for a multisensory approach for such a situation.

Based on neurosciences, smell creates powerful memories, thus, it is printed indelibly and not forgotten if repetition occurs with the specific olfactory stimuli. More particularly, the sense of smell is connected to memory and emotion more than any other sense. Memories associated with the smell stand out because they combine precision with emotional load, a correlation that ranks olfactory information to the most basic information in relation to memory. Olfactory cues are superior not because they raise accurate memories, but because the prominent importance of emotional memory makes memories seem more real [33].

An odor can retrieve a flood of memories, can influence people's mood and even affect their work performance. Because the olfactory bulb is a part of the limbic system of the brain, an area so closely associated with memory and emotion, a smell can recall memories and powerful responses almost instantaneously, helping, thus, quite often a person to orientate him/ herself in space.

Brown [34, 35] refers to the existence of "archive odors" in the child's mind. This explains why odors directly cause strong feelings in regard to old events and strong feelings about people [36, 37, 38]. This can be the basis of an educational program, during which the teacher can make use of pleasant odors for the students in order to prepare them to stand for the acquisition of knowledge.

Without any explicit awareness, people link emotionally meaningful situations to them with odors and retain them in an implicit memory that renders them up (usually involuntarily) when those odors are encountered again [39]. An odor can retrieve a flood of memories to influence people's moods and even affect their work performance. Moreover, it may be used as a basis for creating olfactory maps for orientating themselves in the city [40], as well as for improving orientation skills development in general [41]

Data from the previous researches will be used in order for students with partial or total loss of vision, deafblind students or students with multiple disabilities to improve their action planning after a probable earthquake.

3. THE PROJECT DESIGN

3.1 Participants

At this point, an experimental project will be conducted, in order to investigate whether schoolchildren can detect through odors the escape route already set, in case of an earthquake. Regardless where the children are (e.g. classroom, hallway, bathroom, gym, etc.), they should have the ability to orient themselves in space via a strong and distinct odor providing them with a cue, and head to the correct exit, reach the correct spot of assembly and thus, the building can be properly evacuated.

Participants will be all of the students of the special kindergarten, the special school for the blind and deafblind and the project will take place in the school. The estimated duration of the project will be approximately 3 months.

According to EPPO [5], in case of an earthquake, if "there are no available people at the school unit having as task the exclusive responsibility to support the disabled, during the post-earthquake period, members of the teaching staff of the school who had no teaching duties at the time of the earthquake and the administrative staff of the school constitute the support group for the disabled person. Thus, everyone should know the actions specified in the plan of the school to support the disabled person." This plan is not considered functional at all as to the under research case is concerned, since it refers to three Special Schools for the Blind and Deafblind students, where the ability to provide assistance for a handicapped child by an adult is not always possible, since, according to L.2817/2000, 5-8 students with disabilities can be placed in classes at Special Schools and in some exceptional cases 3 students with disabilities, according to L. 3699/2008.

Therefore, the existence of an alternative plan of actions for managing a possible earthquake in the premises of a Special School is imperative and in this case the sense of smell will be used as mentioned above.

More specifically, two groups of students will be sorted out, based on the position of their classroom in the school building, in relation to the two exits to be set. They are Group A and Group B (see Table 1). Group A is asked to come out from Exit A, whereas Group B is asked to come out from Exit B. It would be an omission if it was not mentioned that two different, distinct and strong scents will be chosen, one for each exit in order to avoid possible confusion on behalf of the children (e.g. potential air drafts on escape routes).

Group A	*Group B*
Kindergarten for the blind Primary school for the deafblind students DB Preliminary class of the Primary School for the Blind (MDVI) 2nd class of the 5th grade of the Primary School for the Blind (E_2)	2nd grade of the Primary School for the Blind (B) 1st class of the 4th grade of the Primary School for the Blind (D_1) 2nd class of the 4th grade of the Primary School for the Blind (D_2) 1st class of the 5th grade of the Primary School for the Blind (E_1) 6th grade of the Primary School for the Blind (F)

Table 1 Groups of students in case of an earthquake.

4. STAGES – PILOT STUDY

In the beginning, students were individually exercised in extracting information from visual cues, tactile maps and in particular the map of the school. Then each student individually was exercised in identifying auditory and olfactory sources. In order to review the implementation difficulties in the evacuation planning, we designed a pilot study, where 8 students participated, one from each classroom and school: students from 1st, 2nd, 4th, 5th, 6th, mdvi student, nursery student and deafblind student. Finally, a simulation of evacuation of the building will be conducted with simultaneous presence of auditory and olfactory landmarks/indications, where all students from all schools will participate.

4.1 Fisrt Stage: Visual Stimulation

Among the students with visual impairments participated in the pilot study, some may be facilitated from visual cues in their effort to orientate themselves and move in the building. Therefore, flashing arrows, highly contrasted were placed on the floor(see fig.2). These arrows indicated the route to the school way out. Students were practiced to detect the flashing arrows and practiced in following them in order to evacuate the building. They were guided from their educator individually to detect and follow the flashing arrows. Additionally, they exercised the arrows detection in differentiated light levels culminated from day light, glare, intense internal light, controlled internal light and shadow to dark in order to become prepared for every possible lighting condition that they may be asked to evacuate the building in safety.

Figure 2. Flashing arrows.

Almost all students succeeded in following the directions provided from the arrows, since the arrows had the appropriate size and the contrast made them perceived. Difficulties were reported from a student with retinis pigmentosa and congenital cataract, who could see the arrows' color, but wasn't able to distinguish the shape; and therefore, couldn't follow the indicated path to the exit. Instead of using separated arrows, it was proposed a continuous flashing line on the floor, which proved more clear and helpful.

4.2 Second Stage: The use of tactile maps

A tactile map of the schools' indoor areas was constructed. The students were individually exercised in reading and extracting information from the tactile map. They were encouraged to find their class in the map and trace the route from their class to the way out (see fig.3). In parallel, the students, guided from their educator, traced all the important places in the school area and all the possible places that students may be found when the earthquake happens (classroom, wc, reception hall, corridor, school exits…). Then, students were asked to follow routes on the tactile map from different spots to exits A and B. In this way and in correlation with experiential experiences they understood the school's structure, they extracted accurate spatial information from the tactile map and estimated the scaled distances. Most of the students practiced individually the steps described above, succeeded in creating mental maps and mental routes, which enabled them to evacuate the school with safety and accuracy. It is noticed that it was rather complicated and difficult for mdvi students and students with difficulties in spatial awareness to find the routes on the tactile map and quite challenging to memorize these routes, advance them in mental maps and follow them in the school areas, in order to find the exits. Therefore, at the following stage, the hearing channel is empowered.

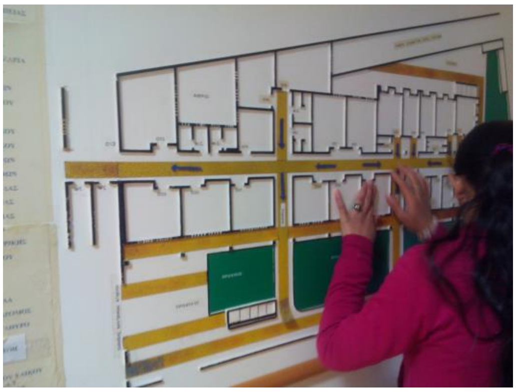

Figure 3. Tactile exploration.

4.3 Third Stage: The use of Directional sounds

In the case of emergency (earthquake) students with visual impairments, multiple disabilities and deafblindness may be benefited from a well structured multi sensory environment strengthened with sensory cues. More specifically sound cues will help students to understand the emergency situation (alarm) and orientate themselves in the building and get to the safety point of gathering.

The National Fire Protection Association [27], suggests the use of "directional sound". It is noticed that traditional fire alarm systems usually just notify students but not necessarily guide them. "Directional sound is an audible signal that leads people to safety in a way that conventional alarms cannot, by communicating the location of exits using broadband noise" (p.24). Following the hearing cues, which vary in tone and intensity, the students may evacuate the building quickly.

At first level the students were individually practiced in recognizing the indoor and outdoor sounds in their school. They were encouraged to listen different sounds, distinguish and classify them. Some sounds' sources may become very helpful in providing information, but in parallel, it was recorded that other sounds may impede the students with visual impairments and become tiring and confusing. Two different alarms (battery charged) with directional sound were installed in the two school exits. The sounds chosen were distinguishable. Additionally, the sounds were neutral and/or indifferent and easily identified, avoiding the correlation with other familiar sounds in the school. Therefore the misunderstanding and confusion were limited. The tone and volume were adjustable appropriately, in order to be clearly perceived in case of emergency. The students were individually exercised to follow the sound from different spots in the school in order to find the way out. This stage was included mainly for mdvi students, since the previous stages weren't completely comprehensive. Moreover, the students were guided by their educators individually. They detected the sound sources and promoted their orientation in the school, in order to create an auditory map. By the time the individualized interventional program was completed, all students succeeded in sound- detection and were able to move towards the sound source and find the school exit, from different areas in the school. Additionally the students were exercised to detect, distinguish and alert when hearing the emergency alarm.

4.4 Fourth Stage: The process of olfactory stimulation

The students were individually exercised in using olfactory cues as means of orientation. Under the prism of olfactory awareness, the students were practicing in distinguish different smells. More specifically, different herbs were used such as oregano, mint and basil (see fig. 4).

Figure 4. A pot with mint outside of a classroom.

These herbs have distinguishable odors and were used as orientation hints, The herbs could provide spatial information to the students and function as an olfactory map. Students have learned where the plants were placed and were encouraged to find the spot where every odor was emitted. It is noticed that the herbs couldn't constantly emit their sense of smell, but only when a student was touching the plant's leaves. Therefore, the plant's odor couldn't be used as an olfactory cue. It was proposed that the sound sources should be connected with an odor source. As in the previous stage two different and distinguishable odors were chosen (cinnamon and orange) and two odor sources were placed in the two school exits. A deodorizing device (see fig.5) was activated with movement and ensured that odors were emitted every time a student was approaching the exit, giving a clear sensory cue and providing spatial information. Individually, each student was exercised to detect the odor, move to the spot where the odor is emitted and evacuate the building through the school exits.

Figure 5. A Deodorizing device.

Then, the process was applied to all students. It is noticed that, all students were helped to know where they were, based on the odors. The use of olfactory cues, was rather effective for the students of the nursery school and the mdvi, deafblind students, who succeeded in detecting the smelling source and finding their way out.

4.5 The final stage

The implementation of the pilot study with the targeted group was well planned and well applied. Since there weren't reported any particular difficulties, gradually all students will participate in the school evacuation program relied on multisensory cues.. The multisensory approach reinforced and supplemented the students' orientation and mobility. It was designed for all the students, since it supported the students regardless their sensory potential and their additional difficulties. The sensory cues were rather complemented, than competitive and overlapping. Therefore the individualized practice was followed by the team practice. All students from each class were now exercised in detecting, distinguish and follow the sensory cues in order to perceive spatial information and orientate themselves in the school. The students, as a class group now, were asked to identify and follow the simultaneously emitted multisensory cues in order to locate the school way out. The practice mentioned above was repeated regularly several times. By the end of the project the students were expected to become motivated when hearing the relevant alarm cue and following the accessible multisensory path find the way out, evacuate with safety the school and be gathered at the safety point.

5. CONCLUSION

The combination of sensory information and knowledge of the environment encourage the blind, visual impaired, mdvi and deafblind students to orientate themselves and move independent in their environment. Students usually need to correlate several sensory cues to learn about new environments or to maintain orientation in familiar areas. They become receptive to sensory cues of all types (visual, hearing, tactile, olfactory), identify them, interpret their meanings and use them to move purposefully.

It is important for the case of emergency, earthquake, the students to become able to perceive all the necessary sensory information to locate destinations, find the usable circulation path, and maintain orientation to the area of refuge. Sensory integration and orientation are usually motivated effectively when actual experience is combined with immediate feedback.

More specifically it was resulted from the pilot study showed that the visual cues were rather helpful for students with remaining vision. The spatial information perceived from the tactile map, encouraged the advanced students to orientate themselves and move with safety in the school areas and evacuate the building, but it was challenging for mdvi and deafblind students. They couldn't use them to extract information and find the school way out. On the other hand the hearing and olfactory cues were rather helpful for mdvi and deafblind students.

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