Experiential Learning for Seismic Protection Using Living Lab Approach in Romania

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Abstract. The purpose of the research: The paper is going to present the role of seismic areas as living labs/natural laboratories for studying the behavior of buildings and of people and establishing a relationship between a research, a training-education and a knowledge dissemination. The results materialized by experiential actions to reduce negative impacts of disasters are highlighted. Methodology: Engineering learning from earthquakes, based on a long-term seismic culture, became a continuous activity based on field observation, since more than a century. On the other hand, creating earthquake disaster prevention awareness and disaster preparedness can be achieved nowadays by education and active learning addressed to all levels of population, from elder generations to the younger ones, and from usual people to the representatives of authorities. The link between these two approaches is becoming more and more necessary in the context of high local seismicity: investigating the behavior of people, while using emerging technologies (computer-generated imagery, immersive virtual reality etc.), to obtain an active individual attitude. The general concept of awareness and preparedness trends evolved. To deal with earthquake-related situations, people are taught to take measures to prevent severe earthquakes effects, but we must take a step forward to get closer to the system that includes: research knowledge, innovation, GIS and specialized software, and more importantly, the access to all of these, through public and private involvement. Conclusions: The Vrancea seismic zone of Romania, as a natural laboratory, involves us with knowledge and individual perception and attitudes and we have time for improved engineering codes, exploring and experiencing some new learning modalities, refining new policies and regulations from this field, new scenarios for implementation of disaster measures.

1. Introduction
Effects of disasters are a matter of concern to engineering community and not only that. There are lots of dynamic concepts, multidisciplinary programs, methodologies and resources used to diminish them. The disaster resilience which implies many decisions and financial costs in the last instance is a national objective. In accordance with all definitions, the disaster resilience is determined by the degree of which
individuals, public communities and authorities are capable of organizing themselves to learn from past disasters, to develop a capacity to cope with and reduce their risks to future severe events [1], [2]. Within the idea of a seismic disaster resilience education, for better prevention, mitigation, preparedness and recovery after a severe event, the role of the seismic areas as living labs (natural laboratories) is well defined in order to study the behavior of buildings and of people and establishing a relationship between a research and a training-education, a knowledge dissemination and highlighting of results, materialized by experiential actions. Education is of great importance also for authorities, makers of policies and planning disaster response, post-disaster intervention and performing risk and vulnerability assessments, mass-media [1], [2].

2. Methodology: designing for learning through experience

Engineering learning from earthquakes, based on a long-term seismic culture, became a continuous activity based on field observation, since more than a century. On the other hand, creating earthquake disaster prevention awareness and disaster preparedness can be achieved nowadays by education and active learning addressed to all levels of population, from elder generations to the younger ones, and from usual people to the representatives of authorities. The general concept of awareness and preparedness tends to be evolved. Implementation of wireless sensor networks in earthquake prone areas, inside/outside of buildings, is used to communicate, generate, disseminate, store and perform information with role in disaster management and also offers possibilities which are used in order to move the observer in the middle of the action (the observer is brought into the laboratory to look at all the flow of information) for a better understanding and greater involvement, taking some necessary prevention measures. Sometimes the researcher moves to the user to help him understand and solve.

Having in mind the context in which William Mitchell [3] founded the living lab concept and the general principles of David Kolb's model (involving concrete experience, reflective observation, abstract conceptualization and active experimentation) [4-6], but in this field with specific types of observations and learning styles, with advantages and disadvantages implied of experiential learning, and also integrating the modern means, the process of awareness and disaster preparedness could gain a progressive form of expression, with a greater impact than classical actions.

The link between the specific issues related to “living lab” concept is becoming more and more necessary in the context of high local seismicity, the behavior of people, within investigating methods, and emerging new technologies, to obtain an active individual attitude. Also, this link could become another dimension in a theoretical background for living lab methodology, based on the innovation process and new technologies. There are dedicated programs and theoretical and practical knowledge transfer seminars on preparing to deal with earthquake-related situations, people are taught to take measures to prevent severe earthquakes effects, but we must take a step forward to get closer to a system that includes research knowledge, innovation, GIS and specialized software, and more important, the access at all of these. The transition from a theoretical presentation of most of the real disciplines on a more practical/experimental level is a made step and there are many examples. Application of theoretical knowledge in through more practical, intuitive and attractive activities, modeling and simulating some situations, represents an important stage in a living lab.

In Table 1 are shown some specific issues which generally underlie any living lab approach.
Table 1. Principles and components of a “living lab”

| Specific issues                                                                 | Based on                                                                 | Needs                                                                 |
|--------------------------------------------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------|
| learning and monitoring the reaction involving experimentation of a technology in a “living lab”, innovation | - follow-up activities, drills, testing the disaster potential of the natural events  
- dedicated programs  
- theoretical and practical knowledge transfer seminars  
- pilot studies, interdisciplinary projects  
- monitor people’s responses/behaviors/attitudes | o infrastructure, materials, digital information, open knowledge environment  
o didactical modeling and testing  
o seismic network as tool for education, training and communication on earthquake simulators, models, simulations at multiple scales  
o real-time and archival observational data, to be analyzed and linked to the simulations |
| involving users in the development process                                     | - teams of researchers; public/administrative authorities; institutions, companies; students, population | o information and communication technology  
o specialized software  
o computer-generated imagery  
o immersive virtual reality |
| organized and structured multi-disciplinary networks fostering interaction and collaboration | - from individual to group  
- through industry-academic collaborations  
- from national program/network to international one  
- from urban to rural areas | greater interdisciplinarity collaborative strategy |
| organizations facilitating/maintaining developing activities for living lab     | common results and interests                                             | promotion and financial support |

The conceptual and logic scheme of a Romanian living laboratory with all its components is shown in figure 1 (based also on table 1). The establishment of the methodological framework of the education process through awareness, assumption and experimentation, in a living lab concept, is not enough and each component requires another mechanism in turn of tight integration. In addition, the accumulation of theoretical knowledge, sometimes even practical, does not guarantee the involvement in taking concrete actions to change a future unfavorable situation (see also the cognitive-emotional-social relationship, the observations related to non-learning/learning defense/learning resistance, etc.). On the other hand, the characteristics of a living lab in our case are different related to those from other domains (business and management), because, in some situations a living lab user could create/be involved in finding solutions in the innovation process while in the field of earthquake engineering this is not always possible, as a result awaiting a pro-active attitude of the user in taking measures to prevent and reduce the potential for disaster.
Figure 1. The specific components of a Romanian living lab

3. Living lab research, a concept with tradition within NIRD URBAN-INCERC

In the framework of some Romanian national programs, under the aegis of the relevant ministers, since 1990, many theoretical and practical studies have been made on two main directions, general education programs for the population (urban and rural communities) and specific education programs for socio-professional and age-related categories of the population. Several materials (posters, brochures, leaflets, videotapes, etc.) were developed after 1990 in present, with emphasis on rules of earthquake behavior and the application of legislative provisions related to the reduction of seismic risk of constructions through the state-subsidized consolidations in the case of dwellings. They were intended for residents in buildings, students, teachers and school administrators, health care staff, buildings and public areas with large crowds.

A new 2005 initiative aimed at re-launching the actions in the education system, with the development of brochures on several categories of school age. Between 2002 and 2008, the Japanese and Romanian experts supported numerous seminars for citizens, authorities, engineers, teachers and pupils using attractive means and devices from Japan.

There were also important initiatives developed as possible constitutive issues for a living lab, in the last years, and in accordance to most of the its definitions. The challenge is to assemble all these initiatives into an integrated, unitary and coherent system, functional over a long period and with the potential to continual improvement of its resources in order to achieving the goals (active involvement by taking protective measures against the negative effects).

Thus, the following Romanian initiatives are presented:
a. Demonstrative Centre and Training Platform for Public Education, Training and Communication on Earthquake (2009-2011) - a prenormative research, with the following objectives [7]:

- education, training and antiseismic protection for pupils, citizens and authorities, as well as in the mass media network;
- information and training with computerized means and seismic simulators, to ensure the informational capacity and preventive education;
- recommendations on seismic protection in public institutions, as part of the communication with citizens and in the media;
- elaboration of materials and e-learning questionnaires to be used in seismic education, referring to building consolidation and behavior during the earthquake and after the earthquake.

b. Educational (Figure 2) Seismic Network of Romania (ROEDUSEIS-NET), SeismoLab III (2012-2016), with specific objectives as [8], [9], [10]:

- developing, implementing and validating methodologies for instructing teachers and students for practical activities in the field of Earth Sciences;
- installation and management of an Educational Seismic Network to be managed and used by the teachers involved; data archiving and distribution through web tools; installing a network of seismometers in schools and using them and data recorded for didactic and educational purposes;
- the use of advanced scientific instruments in high schools, which are usually only available in research laboratories;
- using seismic records in order to learn more about the dynamics and evolution of Earth and especially an awareness of risk and seismic hazard;
- experimenting with new methods of planning and implementation of didactic activities;
- development of modules within the curriculum and proposal for their implementation in the compulsory curriculum;
- better practical training of students and masters in the importance of earthquakes for environmental studies;
- creation of a database of seismic records from the equipment installed in schools, to be integrated into the national and international seismic archive;
- the opportunity to set up a network of seismometers that can be integrated into the National Seismic Network;
- use of network data for the development of integrated risk management.

Figure 2. Images from the project presentations (E. S. Georgescu, NIRD URBAN-INCERC; Jean-Luc Berenguer, Centre International de Valbonne) [8]
Some of the teaching materials developed by NIRD URBAN-INCERC team are developed on the fundamental aspects of the building oscillations, their response and damage, aiming especially the behavior of the slender tall buildings in order to be able to understand the role of bracings and the structural walls [11-14]. The new proactive approach is that students are the makers of models and simulators, using them to understand the concept and make real observations. Frame models are made of cardboard and infilling walls of polystyrene and may show the fundamental aspects of the building’s oscillations when shaken.

c. European Centre for Rehabilitation of Buildings ECBR within NIRD URBAN-INCERC (2003-present), is a specialized center within the EUR-OPA Major Hazards Agreement [15].

Since 2003, ECBR is aimed to the dissemination of knowledge on disaster prevention in support of the enforcement of the strategic Programs for building rehabilitation coordinated by the Romanian Government and concerned ministries. Because the number of the high-rise rehabilitated buildings is still reduced and people’s lives are at risk, especially in Bucharest, the ECBR task is also to educate and provide training to citizens as they shall cooperate in buildings rehabilitation and earthquake safety. In this respect, the ECBR activities are directed towards promoting risk culture among the population (children, adults and groups with special vulnerability), according to the Fourth Priority for Action of the Sendai Framework “Enhancing disaster preparedness”:

- fostering silence by investing in the preparedness of citizens, school students and neighborhood volunteers for personal, family and group protection, at the community level, involving the most vulnerable groups of population from disasters;
- creating earthquake education, awareness raising and public participation guidelines;
- raising awareness and provide citizens and senior population with knowledge about the risks and inherent self-protection behavior;
- promoting the advocacy of a risk culture within the population, to create stakeholders for earthquake preparedness by training volunteers to be trainers for other people;
- inviting schools to participate in activities to explain the protective measures to students; to transfer knowledge to communities;
- communication sessions for public institutions, citizens and the media, will include recommendations and anti-seismic protective measures for public institutions and their staff;
- practice training of students in the civil engineering field etc.;
- benefiting of the facilities of existing laboratories in the INCERC Bucharest Branch and cooperating with universities, the Centre promotes partnership with specialized institutions, agencies and authorities related to building design and building rehabilitation from Romania, UE and worldwide.

The ECBR Project for 2018-2019 has the topic as “Seismic risk preparedness and disaster risk reduction – DRR training for vulnerable groups of populations, school students and volunteers in neighborhoods in Romania” [15]. The target is people living in old and vulnerable buildings, such as low-rise and high-rise (apartment) buildings. Specific objectives in 2018 were:

- knowledge transfer by training seminars for citizens/volunteers/students using courses, printed materials and didactic seismic simulators;
- development of specific knowledge transfer/training materials for neighborhoods with traditional, old and vulnerable low-rise buildings, for citizens and volunteers - in the Romanian language; organization of short time free-field seminars directly with citizens in two neighborhoods - traditional, old and vulnerable low-rise buildings.

Topics of presentations and training during ECBR Seminars were:
- a framework of EUR-OPA Major Hazards Agreement and ECBR; role and place of NIRD URBAN-INCERC;
- earthquakes at the global scale and in Romania; hazard, vulnerability, risk; impact on buildings;
- historical evolution of earthquake resistant constructions;
- types and vulnerability of structures;
- destructive earthquakes in the history of Romania;
- situation of buildings on the seismic risk classes;
- earthquake preparedness of buildings, equipment and furniture;
- demonstrations with seismic mini-simulators from Japan;
- a vulnerability of occupants and human behavior during earthquakes, means of protection;
- preparedness for earthquake impact: what to do during an earthquake?;
- preparedness for the situation after the earthquake;
- session for questions and answers etc.

The free-field seminars with citizens of Bucharest neighborhoods have been very close to the concept of a livinglab (Figure 3), in order to help potential users of laboratory information in their concrete situations, the residents have been advised how to avoid further damages and some behavior rules before, during and after earthquakes.

Figure 3. A free-filed seminar, with an owner of a small house, South-East of Bucharest. Discussion of Dr. Eng. Emil Sever Georgescu, Director ECBR, about earthquakes, house with cracks at socle and about the possibility to rehabilitate it and add one attic as living space, delivering an ECBR leaflet.
d. Real-time data transmission system within the National Seismic Network for Constructions as a tool in engineering education [15]

Its functions are aimed to support emergency situations and monitoring of the territory of Romania for seismic and other actions that can be hazardous for constructions/buildings and infrastructure, in order to get as much as possible strong-motion data in real time for advanced research and to understand why damages in buildings occurred. All its results could be used in the learning process and in supporting another initiative (Figure 4) [16].

Figure 4. NIRD URBAN-INCERC has currently 60 seismic stations of latest generation- free field and in buildings (left). Real-time data transmission system (right)

4. Results and discussions
Analyzing the structure of the all presented initiatives on disaster awareness and disaster preparedness developed over time in Romania, the following results related to the structure of a living lab could be determined:

- principally, the direction of research and development of projects, programs, developed/ongoing, is directed towards achieving a disaster prevention and protection culture, based on a pro-active attitude;
- there is a moderate correlation of the living lab issues with the most effective initiatives of mentioned projects, but due to lack of funding or continuation of projects some activities could be achieved in the future;
- in many cases, there isn’t the possibility of monitoring the reaction of projects users or of those implicated due to the lack of a feed-back (activities are short-lived);
- a more active role of users in a living lab activity represents an important but hardly achievable target, depending on the individual availability, the available time, the involved resources, etc.;
- highlighting the socio-economic impact of any project dedicated to seismic culture (as the proposed actions also provide a warning about the social and even economic impact);
- innovation, generation of ideas, or solutions, require long-term dedicated involvement, consistent financial support and national strategies to converse;
- in the experimental learning process, the generalization of the results is not effective, differing from objective to objective and depending on each individual; it is possible to implement a model / methodology, but the evaluation process of each stage is more important in the case of natural events
such as earthquakes-event (that puts the individual on the waiting line, but compels a continuous involvement of it);

- there are not organizations facilitating/maintaining/developing activities for a living lab on a long term and, in the presented research activity, one can observe the periods in which there were the state financing and the collaboration between several institutes in this respect;
- there are challenges related to the voluntariness of participation in this field;
- highlighting the need to establish some impact indicators at the living lab level (numbers of ideas; levels of users involvement; funding; number of involved researchers; innovation technology; number of laboratory tests/simulations; relationships with authorities, other public organizations, universities; response of public and emergency teams; new perceptions of earthquake risk; information dissemination; lessons learned; economic profit etc.).

5. Conclusions
At European and world level, seismic disaster mitigation programs prioritize seismic safety, increasing earthquake awareness, promoting training and reducing measures, encouraging disaster education, reducing risks, improving plans emergency response, improvement of antiseismic design norms, etc. More of these, attention focuses also on evaluations of proposed measures, emergency interventions and evacuation.

In Romania, Vrancea source offers the opportunity to study the data recorded over time, the explanation of the effects on the constructions/buildings and the environment (distributed on 50% of the territory), the modeling/simulation in labs at small or large scale of some technical concepts of construction, technological, or related on materials.

Some Romanian projects aim to identify/develop and implement best practices and methodologies in line with EU policies in the field, in the direction of an efficient urban/territorial management, but is not enough and only a stronger link between them, based on strong partnerships between the parts, with all actors from the disaster management, and with highly involved users, would lead to obvious results. Scenarios of possible disasters available to living lab users are of great importance, the involvement depending on them. A living lab would be also a pertinent mean of promoting to a large extent of the consolidation of old buildings, with historical and architectural value, and for the seismic/Ambiental vibration building instrumentation (temporary) or building monitoring (in permanent regime).

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