

CSETIR – Construction Safety with Education and Training using Immersive Reality

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Abstract: Construction sites are dynamic and complex environments, making them difficult to control and monitor. Construction safety prevents people from dying or becoming incapacitated. It is a socially relevant issue that persists despite several initiatives. To cope with the pressure of avoiding accidents development, safety can no longer rely on traditional accident preventions measures. The project (CSETIR – Construction Safety with Education and Training using Immersive Reality, co-funded by the Erasmus+ Programme of the European Union - <http://csetir.civil.auth.gr/>) arises from the synergy between higher education institutions and construction company provider to implement the use of smart technologies in proper training. The digital tools allow the creation of instruments that simulate construction scenarios allowing the identification and prevention of risks for teachers, technicians, and engineers. This approved project aims at enhancing knowledge exchange between representatives of three sectors to innovate the accident prevention approaches through effective collaboration between researchers in the virtual reality field and construction companies. The project will develop innovative and interactive VR/AR (Virtual and Augmented Reality) solutions based on BIM modelling capacities to prevent accidents and train workers. The project intends to create usable tools for teachers, technicians, and engineers that will be used in any construction project. Project also aims at offering training sessions online on an online platform (project website, wiki) to grant learners and trainees access to interactive material and resources. These tools will range from applications to be used on smartphones to virtual reality contexts depending on the needs of training.

Keywords: Construction Accidents, Prevention, Augmented Reality, BIM, Virtual Reality.

1 Preamble

Most of the accidents that happen on-site are due to human failure. Manual monitoring and supervision are prone to error due to blind spots, workers loss of focus, awareness, and fatigue. As a result, serious injuries and fatalities are occurring. The human error theories discuss that human error is the factor to be blamed for the accidents, with specific work, and under the environmental circumstances.

According to the Occupational Safety and Health Administration (EU-OSHA) in 2015, about 21% of workers with a fatal work accident were from the construction industry. In Portugal, there are about 0,5 million employees involved in the construction sector and has around 60 fatal injuries per year. Another relevant fact is that a new worker's first months on the job have more than three times the risk for injury than workers who have been at their job for more than a year. Since new workers are unfamiliar with the site conditions, they are generating danger for themselves and other workers, by unrealizing or underestimating risks.

This will affect the ongoing construction work-flow, other workers moral, lower performance and schedule delay. This decreases also productivity and increases costs like direct costs (equipment damage, workers compensation, insurance, medical expenses, rehabilitation, etc.) and indirect costs (well-being, productivity, morale of workers, etc.). This is a major setback in terms of economic and financial perspectives, the implementation of the project and the image of the company.

Although all workers receive training and orientation meetings, they are not receiving on-the-job, hard-knocks-type training that simulates the site conditions. Nowadays, engineering and health and safety students finish their education and training without the due preparation to handle the prevention of accidents in construction sites. Every construction site is unique with different activities, schedules, execution approaches, diversity of workers attitudes and languages and that makes difficult the standardization of procedures for accident prevention. Therefore it is crucial the administration of training programs that are effective and can raise the level of preparation of all involved in terms of

safety awareness and competences. Yet the traditional methods and approaches do not reach everyone involved to prepare their prevention capacities in accordance with their tasks and responsibilities in the construction site. .

HEIs educational programs, like civil engineering and occupational health and safety (H&S), lack adequate training on construction safety. This is probably due to the gap between the industry needs and the HEIs and VET schools. The educational and training programs need to be adapted to the needs of the industry, to give future technicians more competences, experience and preparation in construction safety. The need to bridge the gap between the construction industrial sector and the educational and training sectors is crucial for both entities.

2 Needs Analysis

Based on several systematic and literature reviews done by researchers, on involvement in several international conferences, in H&S meetings, in H&S organizations, in construction sector contributions, several conclusions and guidelines became clear. First, the research on integrating technologies, such as VR/AR (Virtual Reality/Augmented reality) and machine learning, may bring possibilities to address the needs in terms of training in accident prevention. After holding several meetings with safety professionals, contractors and consultants from several countries it seemed that construction companies would prefer to cooperate with academia. Lacking the knowledge about the possible advancements of technologies and tools that might assist workers in terms of accident prevention companies considered the option to cooperate with researchers and trainers to profit from the technologies. These issues were an indication to start involving new technologies in the construction industry. After BIM/VR/AR showed a lot of potential in the research field and is a promising tool for education and training, CSETIR was created [1]. This project will offer innovative and different education and training techniques. VR/AR have been available mostly for specific applications for a while and a lot of research is being done involving these tools and it was considered adequate to place these tools into the construction companies spectrum and especially in terms of H&S [2].

Taking "hands-on" experiences and the digital platforms like BIM and VR/AR simulations will be an innovative way of transmitting to the diverse group roles of the construction site tools that should be easy to use, affordable and effective. These tools may also supporting schools and training centers to teach and train learners in creative and interactive mindset about accident prevention [3].

CSETIR is based on a network of innovative cooperation activities, through the creation of active links between researchers, educational and training institutions and construction companies. As a complement to these initiatives, the digital tools look for a more practical approach of teaching and training H&S in various environments based on applied work based learning as a competence acquisition tool. CSETIR aims to apply a methodology for collaborative and hands-on work, integrating a broad vision concerning the simulation of realistic scenarios that occur in construction sites for each site. The tools to support enhanced simulation are defined as well as the training sessions to convey the competences (knowledge, skills and attitudes) to work like if these learners were in a real environment in the construction site. Students, technicians, engineers and workers will experience a more practical and innovative learning and training approach in an environment, mimicking future construction scenarios.

The transnational nature of the project can simulate the work reality of international teams, a practice that is becoming more useful given the globalization of construction. This integrated and innovative methodology may allow the development of an autonomous learning attitude (learning by doing) and the exchange of knowledge and skills between the participants. Additionally, the activities will enable the interaction between participants from different countries and from complementary fields [4].

3 Methods and Results

The relation between the reality of the construction world and the active involvement in solving problems that affect the uniqueness of the construction sites present aspects that require further engagement by HE courses and research. Given that, HEIs play a decisive role in the training of professionals and efforts will also be formulated to raise the learner' awareness about their future technical role in preventing accidents. Nevertheless, employability, qualification and relevance of accident prevention are becoming important subjects in society's. Research that is being done in terms of H&S in construction is not a strong activity and this project may effectively contribute to prepare students, workers, engineers and technicians to act in construction sites with an emphasis in adopting proactive strategies and tools.

In this context, CSETIR's design was based on joint analysis and on partners' know-how and experience, to propose viable solutions. The specific aims for the projected are:

- ✓ Developing, implementing, validating and tuning of interactive VR/AR approaches to promote multidiscipline creativity, innovative thinking, and practical skills in the digital era;
- ✓ Ensuring education and research are mutually reinforcing, and strengthening the role of institutions in their local and regional environments;
- ✓ Explore synergies and stimulate greater dialogue between HE, enterprises and VET schools, in the scope of community and outreach activities;
- ✓ Supporting the civic and social responsibility of students, workers, engineers and technicians.

To elaborate on the previously mentioned aims and objectives CSETIR includes:

- ✓ Contribute indirectly to encourage VET and HEI students and staff to get involved in construction safety;
- ✓ CSETIR intends to promote best practice exchanges, supporting the development of more varied teaching methods and personalized training, in accordance with the 2012 "Bucharest Communication" (Ministerial Conference-EHEA) recommendation of promoting 'student-centred learning' characterised by innovative methods of teaching;
- ✓ CSETIR pedagogic development together with its activities is expected to mobilise institutions, teachers, engineers, workers and technicians. CSETIR interactive learning tools development and maintenance of an open, collaborative repository, tutorials and operational guides that support the performance of specific tasks;
- ✓ Contribute towards the development and application of tools and practical guides for architects and engineers involved in construction design.

By taking into consideration the listed aims CSETIR will be achieving and focusing on the collaboration and knowledge exchange between the HEI/VET organizations and construction companies. In addition, the advancement and innovation in an HR/VET education and training may benefit the construction companies and helping the development of an entrepreneurial mindset and foster future cooperation. Nevertheless, allowing the collaboration between HE and enterprises CSETIR may develop the creation of an educational and training strategy that may boost the H&S competences and investment in construction industries.

4 Discussion

The CSETIR project is following a collaborative and hands-on strategy to learning, integrating a broad vision concerning a project where the activities establish a very close and interconnected cooperation, where the exchange of co-creation of knowledge between HEIs and construction companies is a key factor. This methodology defines the responsibilities of the stakeholders during the project and within all its phases. Furthermore, the tools to support an enhanced cooperation are defined as well as the training sessions to convey the competences (knowledge, skills and attitudes) necessary to prevent accidents in construction.

Therefore, the project's activities will encompass different types of international activities will happen in the partner countries to fulfill the project vision requiring the development of equipment and of software resources (innovative use of integrated VR/AR tools), online content and digital platforms (supporting the dissemination of knowledge, the training and the validation of results), and collaborative processes (to facilitate group and exchange cooperation) [5]. This intends to portrait the work reality of collaborative teams needed to prevent accidents in construction sites. For CSETIR the development of realistic simulations based on existing developments and respective adaptations will provide to all those involved the possibility of experiencing a practical learning and training approach in a virtual environment like the one they may find in their future construction sites [6].

The tasks were developed according to the expertise of each partner. Besides project management, and quality assurance tasks, the project activities were divided into 4 main groups:

1. Preparation

- a) Identification of the state of art in the field strategies, solution, trainings, studies, technologies etc.
- b) Selection of an online platform for interaction with users and content developers.

This WP is crucial in setting the grounds for the Development and Implementation WP.

2. Development and Implementation

- a) Physical content: the interactive VR/AR tools.

b) Learning content: Development of interactive movies, VR/AR models and simulations, written materials/manuals, and other forms of pedagogical publications.

Both "Physical" and "Learning" content must be adequate for different kinds of interaction. These different types of contents are project outcomes, as described in the appropriate section of the proposal.

3. Validation and Tuning

a) Development of activities in laboratories, construction sites, workshops; and other facilities, including local and international events to implement validate and tune the solutions.

b) Testing of the learning tools amongst other HEIs so they can be improved, gauged and validated for Engineering Education and Training.

4. Exploitation and Dissemination events

a) Considering user participation and location, activities can be divided in three main groups: Lab centred events, site centred activities, Online activities.

b) Content developed in this project will be designed to allow use in different environments.

For each type of activities digital records, videos and manuals will be developed and made available online. This allows these activities to be adapted or simply replicated elsewhere. This section is where the data is interpreted and validated by stakeholders. The materials will include explanation of how the results may be similar or different from those which were obtained with the initial design allowing the interpretation and adaptation to future situations.

5 Final Comments

CSETIR is an international project comprising several types of HEI and methods of training and teaching prevention in construction. The participation of a construction company to involve stakeholders from construction sites will allow the interpretation and feedback from those that are most affected by the construction accidents. At the construction company level, each enterprise and official regulatory agencies have their own construction safety regulations and guidelines, different construction techniques, different construction culture and educational backgrounds of the academic and engineering staff. This diversity will be handled during the simulations while ensuring training that is independent from local characteristics allowing possibilities of adaptation to the actual scenarios.

The tools will be interactive relying on the particular diversity to provide the adequate answers. This will allow that the several HEI, construction companies and training entities to implement interactive strategies regardless of regional policies, construction habits and H&S guidelines. The repository of case studies obtained from the application of the tools will facilitate the adaptation for different scenarios and situations. The European cooperation may strengthen the collaboration and cooperation between the companies, the teaching and training organizations and the students, workers, engineers and technicians with shared case studies and examples. This cooperation may also be helpful to raise awareness about solutions to eliminate or decrease the risks in construction. One of the added values of these learning/teaching/training activities will be the possibility of different participants in different countries with different construction cultures to be in touch with each other and to experience sharing in a digital platform. Since all materials will be digital the access by all interested in the tools will be easy and cheap.

Different configurations for learning and training materials and methods will be tested, leading to a virtual information repository that can be accessed by any interested participant. This may allow materials, tools and techniques to be compared with different scenarios. The validation of the results will also be done with participation of international organizations in the area of training for construction safety (AECEF) and in the area of construction safety coordinators professionals (ISHCCO). It is expected that CSETIR project will provide efficient and effective tools to be used by the different stakeholders to reduce accidents in construction sites and to progress towards a Zero Vision transformed in reality.

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