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# XRGREEN.CON

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# Development and piloting of VR simulations for learners

*The analysis is based on pre-pilot and post-pilot survey data, as well as the project list of VR scenario topics.*

## 1. Objective of the activity and developed result

The project originally planned to develop 20 VR simulations to supplement learners' learning process with practical and visually engaging digital content. In fact, 22 VR simulations were developed, meaning that the achieved result exceeded the originally planned output by two simulations.

All project partners participated in developing the VR scenarios, dividing the topics among themselves. The scenarios were based on real vocational education and construction situations. Content was filmed and photographed in real environments – in production facilities and laboratories, as well as at various construction sites. This made it possible for the simulations to use not only theoretical descriptions, but also real work processes, materials, working environments and construction situations.

Learners from Latvia and Croatia participated in the pilot. The pilot methodology included two survey stages: before working with the VR simulations, learners answered questions about their previous experience and expected benefits; after trying the simulations, they answered questions again about ease of use, comprehensibility, realism, attention retention, knowledge gained and their willingness to use VR in the future.


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# 2. Content of the developed VR simulations

The project developed 20 VR topics/scenarios, which resulted in a total of 22 VR simulations. Some topics included several sub-scenarios based on different real working environments. For example, VR Scenario 10, "Reinforcement installation at different construction sites", includes three sub-scenarios: reinforcement installation at a wind turbine construction site, at an apartment building construction site, and at a production facility. Thus, although the number of main topics/scenarios is 20, the total number of developed VR simulations is 22.

They cover several interconnected topic groups: reuse of concrete and asphalt, precast concrete production, dismantling and selective demolition, construction waste sorting, sustainable material selection, construction site safety and resource use.

| Simulation | Topic |
|---|---|
| VR1 | Preparation of concrete components using recycled ingredients |
| VR2 | Concrete mixing |
| VR3 | Porous concrete technologies – construction site preparation |
| VR4 | Installation of porous concrete |
| VR5 | Asphalt life cycle – separation, selection and mixing of components |
| VR6 | Asphalt paving |
| VR7 | Asphalt use and maintenance |
| VR8 | Overview of the precast concrete production process |
| VR9 | Reinforcement selection |
| VR10 | Reinforcement installation at different construction sites |
| VR11 | Concrete placement, compaction and vibration |
| VR12 | Concrete curing |
| VR13 | Use of a concrete readiness/strength sensor for optimisation |
| VR14 | Bathroom dismantling |
| VR15 | Dismantling of a residential room |
| VR16 | Construction waste sorting |
| VR17 | Optimisation of earthworks logistics |
| VR18 | Sustainable material selection and the urban heat island issue |

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| | |
|---|---|
| VR19 | Identification of potential safety measures |
| VR20 | Determining the safety measures required for a specific construction site |

The topic list shows that the VR content is not focused on only one stage of the construction process. It includes material preparation and use, production, assembly, dismantling, waste management, sustainable material selection and occupational safety. Therefore, the simulations can be used both for learning specific vocational processes and for explaining green skills and circular economy principles.

# 3. Pilot methodology

The pre-pilot survey received 50 responses. The post-pilot survey also received 50 responses. The survey data do not contain a separate field that would allow respondents to be accurately divided by country; therefore, this analysis does not draw conclusions about differences between learners from Latvia and Croatia.

The pilot sequence was practical: learners first provided an initial assessment, then tried the VR simulation and completed the tasks included in it, and finally completed the post-pilot survey. This approach made it possible to assess not only technical usability, but also whether the simulation helped learners better understand the construction process and green skills content.

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# 4. Pre-pilot survey results

## 4.1. Previous VR experience

Of the 50 respondents, 26 (52%) indicated that they had previously used VR technologies, while 24 (48%) had not.

| Response | Number | % |
|---|---|---|
| Yes | 26 | 52% |
| No | 24 | 48% |

## 4.2. Comfort with digital technologies

Comfort with using digital technologies for learning was assessed on a scale from 1 to 5. The average rating was 3.82. Eighteen learners selected 5, 14 selected 4, 12 selected 3, and only 6 respondents selected 1 or 2. This means that most pilot participants already felt relatively comfortable working with digital technologies before trying VR.

| Rating | Number | % |
|---|---|---|
| 1 | 3 | 6% |
| 2 | 3 | 6% |
| 3 | 12 | 24% |
| 4 | 14 | 28% |
| 5 | 18 | 36% |

## 4.3. Expected benefits

In the open-ended question, learners most often mentioned a desire to gain new experience and knowledge. Responses also repeatedly expressed a desire to better understand construction processes, see real-life situations, try a different way of learning, improve practical understanding, and use VR as a more interesting alternative to traditional learning methods. Some respondents indicated that they did not yet know what to expect, which is understandable given that some learners had no previous VR experience.


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# 5. Post-pilot results

After trying the simulations, the overall assessment was positive. Particularly high ratings were given to understanding the tasks, confidence in completing the tasks, the interest of the simulation narrative, and the extent to which the simulation helped learners better understand a construction task or process.

| Indicator | Result | % / scale |
|---|---|---|
| All XR tasks were completed | 47 / 50 | 94% |
| Task comprehensibility – average rating | 4.16 / 5 | |
| Ease of using the VR environment and controls | 3.94 / 5 | |
| Helped better understand the construction process | 4.08 / 5 | |
| Simulation realism | 3.82 / 5 | |
| Narrative interest | 4.14 / 5 | |
| Attention retention compared with traditional materials | 3.84 / 5 | |
| Confidence when completing tasks | 4.20 / 5 | |

### 5.1. Task completion and comprehensibility

94% of learners indicated that they were able to complete all simulation tasks, while 6% completed them partially. Task comprehensibility received an average rating of 4.16 out of 5: 22 respondents selected 4, 19 selected 5, 8 selected 3, and only one selected 1.

Confidence in completing the tasks was even higher – an average of 4.20 out of 5. Twenty-three respondents gave a rating of 5 and 16 gave 4. This indicates that most learners felt confident in their ability to complete the tasks included in the simulation after becoming familiar with it.

### 5.2. Learning benefit

For understanding a construction task or process, the average rating was 4.08 out of 5. This is a significant result because the main purpose of VR simulations is not merely to provide a technologically interesting experience, but to use the virtual environment to improve understanding of learning content.

Thirty-nine of the 50 respondents (78%) indicated that they had gained new knowledge or a better understanding of green skills. Six (12%) answered “No”, while 5 (10%) selected “Other”.

The willingness to use VR simulations in the future is high: 36 learners (72%) answered “Yes”, 9 (18%) answered “Maybe”, and 5 (10%) answered “No”.

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### 5.3. Realism, interest and attention retention

The realism of the simulation was rated at an average of 3.82 out of 5. This is slightly lower than the other main ratings and indicates an area where further improvements are possible. At the same time, 43 of the 50 respondents (86%) indicated that the VR environment was realistic and engaging.

Narrative interest received 4.14 out of 5, while attention retention compared with traditional learning materials received 3.84 out of 5. Overall, learners therefore perceived the VR approach as an interesting and sufficiently engaging form of learning.

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# 6. Technical usability and problems

Forty of the 50 respondents (80%) indicated that they had not experienced technical difficulties, while 10 (20%) reported that they had. At the same time, 41 learners (82%) considered the VR simulation easy to navigate and use.

| Indicator | Yes | No |
|---|---|---|
| Experienced technical difficulties | 10 (20%) | 40 (80%) |
| The VR simulation was easy to navigate and use | 41 (82%) | 9 (18%) |
| Experienced discomfort (dizziness, eye fatigue, nausea, etc.) | 11 (22%) | 39 (78%) |
| The VR environment seemed realistic and engaging | 43 (86%) | 7 (14%) |

Descriptions of technical problems were relatively rare in the open-ended responses. Slower downloads, internet connection issues, optimisation problems, movement, and difficulties using the simulation on a phone were mentioned. This is consistent with the recommendations to improve navigation and control elements.

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# 7. What was most useful to learners?

The open-ended responses show that learners were particularly interested in the practical and visual parts of the simulation. Material mixing, the steps for producing green concrete, the sequence of work processes, videos and explanations, questions/quizzes, the 360° environment, and the opportunity to explore a construction site virtually were frequently mentioned.

In several responses, learners emphasised that the real environment helped them better understand things that can be difficult to imagine in a classroom. They also valued the opportunity to explore the environment themselves, learn at their own pace, and repeat information.

| Most frequently observed themes in open-ended responses | Examples |
|---|---|
| Practical processes | mixing, materials, steps for producing green concrete |
| Process sequence | ordering of work steps, mixing sequence |
| Visual content | videos, 3D representation, 360° environment |
| Real working environment | construction site exploration, real-life situations |
| Interactivity | questions, quizzes, opportunity to interact |
| Learning support | explanations, practical examples, opportunity to learn at one's own pace |

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# 8. Recommendations for improving the simulations

Most learners answered that they would not change anything when asked about improvements. However, several specific areas emerged from the remaining responses:

- improve movement and navigation options, especially for use on a phone;
- make control elements more intuitive and simpler;
- increase the number of interactive tasks and choices;
- allow interaction with more objects;
- add more examples from different construction sites;
- extend the simulation and include more real-life situations;
- add clearer instructions and feedback after tasks;
- improve image resolution and the overall sense of realism;
- where possible, use VR headsets rather than only a phone-based environment.

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# 9. Overall evaluation of pre- and post-pilot results

Before the pilot, learners' initial comfort with digital technologies was relatively high – an average of 3.82 out of 5. After working with the simulation, confidence in completing the tasks was 4.20 out of 5. These two indicators are not identical and therefore cannot be used as a strict pre/post measurement of the same construct. However, together with the other post-pilot results, they show that the VR environment was generally not a barrier to task completion for learners.

The most important result is that 94% of learners completed all tasks, understanding of the construction process was rated 4.08 out of 5, 78% of respondents confirmed gains in understanding green skills, and 72% indicated that they would like to use VR simulations in the future as well. This indicates that the simulations are well suited to the learning process while also providing clear directions for further technical and methodological improvement.

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# 10. Conclusions

1. Instead of the planned 20 VR simulations, 22 simulations were developed within the project, exceeding the originally planned output.

2. All partners participated in scenario development, dividing the topics among themselves.

3. The VR content is based on real working environments – production facilities, laboratories and various construction sites – thereby ensuring a closer link with professional practice.

4. Learners from Latvia and Croatia participated in the pilot using a pre- and post-survey approach.

5. 94% of respondents were able to complete all simulation tasks.

6. Task comprehensibility (4.16/5), confidence in completing the tasks (4.20/5), narrative interest (4.14/5), and help in understanding the construction process (4.08/5) received high ratings.

7. 78% of respondents indicated that they had gained new knowledge or a better understanding of green skills.

8. 72% of learners would like to use VR simulations in the future as well.

9. The main areas for improvement are navigation, movement, increased interactivity, more practical tasks and examples, and technical performance on mobile devices.

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