EXEP3D

TALLINNA TEHNIKAKÕRGKOOL
TTK UNIVERSITY OF APPLIED SCIENCES

TECHNISCHE UNIVERSITÄT DRESDEN

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

DELIVERABLE REPORT

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Student competition results

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1 Summary

This document presents the results and an assessment of a student competition organized within the "Innovation Excellence in Construction Engineering: Novel 3D Concrete Printing Technologies and Sustainable Mixtures" (EXEP3D) project. Funded by the European Union's Horizon Europe research and innovation programme under grant agreement N°101158492, the EXEP3D project aims to advance 3D concrete printing technologies and foster sustainable mixture designs. A key objective is to widen the scientific and technological capacity of TTK University of Applied Sciences (TTK) through strategic collaborations with leading European academic institutions, including Technische Universiteit Eindhoven (TU/e) and Technische Universität Dresden (TUD), with the goal of positioning TTK as a prominent competence centre in construction engineering.

As a core component of its knowledge-sharing and capacity-building initiatives, the EXEP3D project spearheaded Estonia's inaugural national student competition in 3D concrete printing, named "Concrete Print 2025."

2 Event Details and Structure

The competition was hosted at TTK's main campus (Pärnu mnt 62, Tallinn) and its specialized 3D Concrete Printing Laboratory (Siidisaba 8, Tallinn), running from August 25–29, 2025. It brought together multidisciplinary student teams, each comprising 4-5 individuals, from five Estonian universities: TTK University of Applied Sciences, Tallinn University of Technology, Estonian University of Life Sciences, Estonian Academy of Arts, and the University of Tartu. Participants represented diverse academic backgrounds, including engineering, architecture, material science, and design.

The event was designed to stimulate creative thinking, promote teamwork, and facilitate the practical application of extrusion-based 3D concrete printing techniques. Its structure included thematic workshops, a hackathon-style idea development phase, and a live printing session, all supported by industry experts and academic mentors. Presentations from the first day can be found on the following link: Presentation. Student assignment requirements are present on the following link: Requirements.

3 Participation and Engagement

The competition was promoted through a series of open lectures conducted at the participating universities, successfully engaging a total of 129 students and academics.

Open lectures and meetings were held as follows:

TTK University of Applied Sciences on May 6th, with 28 participants

TTK University of Applied Sciences on May 13th, with 10 participants

Estonian University of Life Sciences on May 21st with 17 participants

University of Tartu on May 27th with 15 participants

University of Technology on 28th of May meeting with team leader Mattias Põldaru

Estonian Academy of Arts on 29th of May with 7 participants

TTK University of Applied Sciences on June 9th, with 15 participants

In addition, a lecture at TTK University of Applied Sciences on August 27th for first year students. The lecture was held in parallel with the student competition, and interested students had the opportunity to visit the competition printing session. 36 students participated. Participation in all lectures was verified by signing forms.

Teams from four universities participated in the competition. Participants included:

- Tallinn University of Technology, team members Jürgen Tammepärg, Raimond Lilles, and Kaarel Volk.

- Estonian University of Life Sciences, team members Loretta Pohlasalu, Kerstyn Pärn, Kaarel-Hannes Kalivere, and Karmen Viikmaa.
- Estonian Academy of Arts, team members Kaur Laasi, Renete-Ly Greim, and Heli Salmela.
- TTK University of Applied Sciences, team members Erkki Koitla, Rober Šommet, and Daniel Eerik Sillamets.

Participation was verified by signing forms.

4 Competition outcomes

4.1 Strategic Alignment and Outcomes

The competition directly aligned with the EXEP3D project's strategic goals: promoting excellence in digital construction, fostering practical student engagement, and strengthening collaboration across academia, industry, and research institutions. It also functioned as a pilot for potential future international competitions, underscoring Estonia's growing competence in 3D concrete printing. Notable outcomes included the establishment of collaborative ties between TTK and the Estonian Academy of Arts (EKA), and a request from the University of Life Sciences (EMU) for EXEP3D personnel to supervise a graduation thesis focused on "Impact resistance and collapse analysis of 3D-printed concrete structures. The jury included Martti Lukki from Kiili Betoon OÜ, Kaarel Oberschneider from Mapri Ehitus OÜ, Kalev Ramjalg from the Estonian Concrete Association, as well as team members Lauri Hass, Karsten Nefs, Gustav Gerretz, and Aivars Alt also participating in the jury. In addition to the jury work, companies were also involved as financial sponsors of the competition. The supporting companies were Mapri Ehitus OÜ, Bildgren Ehitus OÜ, Savekate OÜ, and the Estonian Association of Construction Engineers. The companies involved provided a good opportunity to increase the project's visibility among construction companies.

The winner of the concrete printing competition, the team from the Estonian Academy of Arts, made a presentation at the Concrete Technology Day on October 28. The students introduced the winning project, the BENK concept, and the possibilities for material use. The students' knowledgeable approach to the technological details stemming from the specifics of concrete printing was very positive. Looking back, the winning project has brought greater recognition to the concrete printing team. The work was displayed during Design Night from September 29 to October 5. After Design Night, the project moved to the front of the EKA main building, where it is visible and usable in public space.

The national broadcaster ERR made a very good summary of the student competition, which can be found at the following link: https://jupiterpluss.err.ee/1609775606/kofe?t=1111 (Relevant clip starts on minute 19). Video and photo material taken from competition can be found on the following link: Media

5 Descriptions of the competition works

5.1.1 Winner: Estonian Academy of Arts

Benk Design Summary

The BENK design project emphasizes comfort for both clients and end users, utilizing modular elements that allow for over a hundred different compositions to adapt to various environments and needs. It addresses complex urban space challenges, including limited seating, disorganized visuals, and insufficient bicycle parking, making the elements suitable for both public and domestic settings.

Inspired by urban landscapes in Tallinn, the design focuses on modularity, minimalism, and geometric simplicity to create a system where each component—benches, notice boards, flowerpots, and more—fulfill a specific role while forming a cohesive visual and structural whole. The trapezoidal core module is the foundation of this modular approach, offering adaptability in function.

The production process involves 3D modeling and unique concrete-printing technology, with modules printed upside down to ensure structural integrity and a smooth finish. Modules weighing between 100-500 kg require careful logistics for handling and transportation. They can be maneuvered with a forklift and other equipment, and design strategies are employed to facilitate lifting heavier elements.

Overall, the BENK project merges aesthetics and functionality through experimental design, aiming to enhance urban spaces with versatile, practical solutions that remain visually coherent.

Link to materials: Materials

5.1.2 Estonian University of Life Sciences

Summary of the Multimodule Product

The Multimodule is an innovative modular concrete element designed for versatile use in urban spaces. It can be configured to serve various functions, including noise barriers, landscaping components, seating areas and partitions, while emphasizing aesthetics, functionality, and sustainability.

Leveraging the advantages of 3D concrete printing, Multimodule features a unique design that enhances public spaces. Its lightweight structure (approximately 200 kg per module) simplifies transportation and installation. The product aims to replace traditional, characterless noise barriers with visually appealing options that contribute to greenery and ambiance to urban environments.

Key features include sound-blocking capabilities due to material density, weather resistance, and durability over time. The module's cavities can accommodate plants, enhance aesthetics, and promote biodiversity. It offers diverse applications, including noise barriers along roads, traffic restrictions, slope reinforcements, and urban furniture.

With a streamlined form that harmonizes its surroundings, the Multimodule is adaptable to various design needs and can incorporate LED lighting and seasonal decorations. Future prospects include variations with different acoustic effects and refined designs as technology advances.

This product not only balances utility with urban character but also introduces environmental benefits, supporting local ecology and creating inviting public spaces.

Link to materials: Materials

5.1.3 Tallinn University of Technology

Summary of the PISAR Concept

The PISAR concept proposes a modular bench system designed for public and private spaces such as parks, playgrounds, and barbecue areas. The benches can be combined in various configurations and come in four standard layouts: a bench with a flower planter, a U-shaped gathering corner with a central table, an S-shaped elongated bench, and a single bench.

These benches feature adjustable seating surfaces with openings for greenery or trash bins, offering advantages over traditional benches by being more resistant to weather and vandalism. If benches are no longer needed in a location, they can be repurposed elsewhere, minimizing waste. Their hollow structure allows them to be filled with sand to serve as temporary road barriers during events, which are visually more appealing than conventional blocks.

The concept includes complementary elements like smaller benches for children, tables with 3D-printed legs, and matching flowerpots and trash bins. The design allows for a distinctive surface texture, double print width for stability, and internal support for added robustness.

Transporting the benches is efficient, as they are printable in two parts—seating base (approx. 500 kg) and backrest (approx. 120 kg)—allowing larger quantities to be moved. The planned dimensions accommodate two people, and the seating surfaces can be customized with wooden slats or other materials.

With a strong focus on usability, the PISAR benches are designed to be stable without anchoring, use elastic material for additional support on hard surfaces, and require careful handling during transport to prevent damage. Pricing for the benches is set at €550 for the seating base, €150 for the backrest, and an additional €50 for wooden coverings and maintenance products.

Overall, the PISAR concept combines functionality, aesthetic appeal, and sustainability, aiming to enhance urban spaces while allowing flexibility in design and use.

Link to materials: Materials

5.1.4 TTK University of Applied Sciences

Summary of PARA-RAMP Concept

PARA-RAMP is an innovative parametric 3D-printed concrete ramp designed to enhance accessibility in urban environments. By utilizing advanced technology, the ramps are tailored to specific stair configurations, thereby reducing CO_2 emissions through an optimized hollow lattice structure.

The ramps serve both temporary and permanent applications in various public spaces, including cultural institutions, shops, office buildings, and parks. They also cater to protected environments where alterations may be restricted. The design process is user-friendly: clients can input stair data via a website or scan stairs to create a point cloud, resulting in an immediate visual representation of the ramp.

Constructed from a specialized concrete mix, the PARA-RAMP features a lightweight hollow structure that promotes slip resistance in wet conditions, while integrated steel components provide shear resistance and moisture insulation. Production can occur either in a factory or on-site, with modules easily transported on Euro-pallets.

PARA-RAMP aims to improve accessibility for individuals with mobility challenges, such as wheelchair users and parents with strollers. Each ramp is uniquely designed based on user input parameters, allowing for quick installation with reduced material use and lower labor requirements. The project emphasizes quality control through stable printing and curing conditions, achieving up to a 40% reduction in concrete use, significantly decreasing the overall CO_2 footprint.

Targeting partnerships with concrete companies, PARA-RAMP modernizes accessibility solutions, creating inclusive urban spaces for all. Ultimately, it transforms physical barriers into opportunities for enhanced mobility and openness in the community.

Link to materials: Materials

6 Competition Feedback

6.1 Student Feedback Summary

Student feedback was overwhelmingly positive, with key highlights including:

- **Overall Satisfaction**: 100% of respondents rated the event's organization, execution, and the support and availability of organizers as "excellent" (score 5 out of 5). All participants confirmed that the event met their expectations (57.1% scored 5, 42.9% scored 4).
- **Material and Guidance Quality**: 85.7% rated the materials and guidance as "excellent" (score 5), with the remainder rating as "good" (score 4).
- **Specific Aspects**: Information availability and clarity of tasks received very positive ratings. The competition significantly increased interest in concrete printing and new technologies for most participants.
- **Most Valuable Parts**: Participants highly valued gaining new knowledge in concrete printing, practical laboratory experience, insightful lectures, and the opportunity for creative expression.

- **Future Participation**: A significant 85.7% expressed a desire to participate in future iterations, contingent on the event maintaining high organizational standards, offering opportunities for knowledge expansion, and being executed efficiently.
- **Evaluation Transparency**: While positive overall, this area showed room for improvement, with 57.1% rating it as excellent, but 14.3% rating it 4, 3, and 2.

6.1.1 Key Areas for Improvement

Despite its success, the event identified several areas for refinement:

- **Schedule & Logistics:**
  - **Overcrowding:** Excessive activities were concentrated on Wednesday and Thursday.
  - **On-site Flexibility:** Insufficient time for substantial on-site adjustments.
  - **Timing:** Suggestions included an earlier hackathon start (e.g., Monday afternoon) and adjusting the event timing to avoid conflicts with other academic meetings and potentially integrating keynote speakers.
- **Event Content & Format:**
  - **Printing Session:** Ideas were proposed to make the final concrete printing session more engaging for competitors.
  - **Model Format:** Clarifying model formats and requirements to ease code generation.
  - **Architect Involvement:** Suggestion to include architects in teams or the mentor pool.
  - **Lectures:** Clarification needed on whether a broader public audience for lectures is desired and how to achieve it.
  - **Competition Focus:** Clarifying the balance between design and concrete printing focus.
  - **First Day Content:** Broadening the initial presentation to cover general digital manufacturing methods for concrete.
  - **Web Version:** Exploring a web-based version for future years.
  - **Language:** Decision needed on whether the event will be in English or Estonian.
- **Evaluation & Mentorship:**
  - **Work Evaluation:** Proposals included separate winners for different categories to reduce disappointment and dedicating more time to reviewing PDF submissions.
  - **Mentorship:** Improving coordination for mentor rotation to ensure consistent feedback and avoid conflicting advice.
- **Administration & Planning:**
  - **Team Recruitment:** Initiating team recruitment earlier in the academic year.
  - **Gifts & Certificates:** Addressing issues with the quality and timeliness of gifts and certificates.
  - **Internal Communication:** Resolving identified communication issues between organizers.
  - **Organizer for Next Year:** Deciding on the responsible entity for organizing future events.
  - **Resources & Assistance:** Suggestion for organizers to seek more assistance.

6.2 Organizing Team Feedback

Overall Assessment: The event was successful, with EXEP3D completing one project component. However, many ideas and proposals were generated for better organization next year.

Key Areas for Improvement and Discussion Points:

1. **Schedule & Logistics:**
    a. **Overcrowding:** Too many activities were concentrated on Wednesday and Thursday (scripting, decision-making, plastic print code).
    b. **On-site Flexibility:** There was insufficient time for substantial on-site changes or additions during the week.
    c. **Monday Start:** Consider starting the hackathon earlier on Monday afternoon.
    d. **Event Timing:** Late August is not ideal due to conflicts with the annual Twinning meeting. Suggestions include moving it to the end of the school year and potentially integrating keynote speakers from the twinning meeting.
2. **Event Content & Format:**
    a. **Printing Session:** The final concrete printing session on Friday could attract more public interest, but might be less engaging for competitors; ways to make it more exciting for participants need to be explored.
    b. **Model Format:** Simplify the model format to ease code generation for both plastic and concrete printers.
    c. **Architect Involvement:** Consider adding an architect to each team or to the mentor pool.
    d. **Lectures:** Lectures were open to all, but only competitors attended. A decision is needed on whether a larger public audience is desired and how to promote them effectively.
    e. **Competition Focus:** Feedback suggests the competition leans more towards design than concrete printing; the focus needs to be clarified for future events.
    f. **First Day Content:** The presentation on the first day could be broader, covering digital manufacturing methods for concrete in general.
    g. **Web Version:** Competitors inquired about a web-based version for next year, though one organizer (Aivars) was skeptical.
    h. **Language:** Decision needed on whether the event will be in English or Estonian (considering Karsten's participation).
3. **Evaluation & Mentorship:**
    a. **Work Evaluation:** Evaluation was challenging. Suggestions include having separate winners for each category to reduce disappointment and dedicating more time to review PDF submissions, while also being mindful of evaluators' time.
    b. **Mentorship:** Mentorship could be improved; the idea of rotating mentors didn't fully materialize. Better coordination is needed to ensure consistent feedback and avoid conflicting advice to teams.

4. **Administration & Planning:**
    a. **Team Recruitment:** Start recruiting teams much earlier (e.g., April 1st or beginning of the year), acknowledging difficulties in planning with students.
    b. **Gifts & Certificates:** Gifts and certificates should be prepared before event.
    c. **Organizer for Next Year:** A decision is needed on who will organize next year's event (e.g., institute, EXEP3D, or school).

7 Conclusion and Next Steps

The student competition proved to be a highly successful undertaking, significantly contributing to the EXEP3D project's goals of fostering innovation and capacity-building in 3D concrete printing. The positive feedback from students underscores its value and impact. The identified areas for improvement offer a clear roadmap for enhancing future iterations, ensuring the event continues to evolve and provide an exceptional learning and competitive experience. Currently the project team is involving companies for next year's competition. According to institute plans, the competition is scheduled for week 35, 2026.