Digital Creativity for Circular Construction

Sustainability in Focus

Abstract

*The **Digital Creativity for Circular Construction** course engages students in the challenge of designing and building with reclaimed construction materials. Working in interdisciplinary teams, they collaborate with external industry partners to identify reusable building components and create digital material inventories using technologies such as LiDAR scanning, photogrammetry and computer vision, and develop new design proposals based on the resources available. Rather than starting with a design idea and selecting materials afterwards, students learn to work in reverse by adapting their designs to existing materials and real-world constraints. Throughout the semester, students combine fieldwork, digital tools and hands-on construction to take a project from material assessment to a built prototype. In doing so, they develop practical skills in stakeholder engagement, project management and interdisciplinary collaboration while gaining a deeper understanding of circular economy principles. The course also encourages critical reflection on the role of emerging technologies, helping students evaluate when and how tools such as AI and XR can meaningfully support more sustainable and responsible decision-making.*

Learning objectives

After completing this course, students will be able to:

- ✓ *Analyze the opportunities and limitations of emerging digital technologies such as AI, XR, and reality-capture tools, for supporting circular and sustainable construction practices.*
- ✓ *Assess material reuse strategies considering environmental, technical, and stakeholder perspectives.*
- ✓ *Plan and implement sustainability projects in collaboration with interdisciplinary teams and external stakeholders.*
- ✓ *Develop feasible design solutions from reclaimed building materials by integrating circular economy principles and digital technologies into the design and construction process.*

Department	Department of Civil, Environmental and Geomatic Engineering (D-BAUG)
Degree program	Architecture Bachelor, Civil Engineering Master, Electrical Engineering and Information Technology Bachelor, Computer Science Bachelor, Integrated Building Systems Master
Educational level	Bachelor's, Master's
Size	ca. 30-50 students
Course format	Project-Based Education (PBE), Experiential learning

Quote

"Having students build towards a real objective, not just a theoretical or hypothetical exercise, is essential. When they know people will actually use the structure, there is no room for shortcuts: the de-sign has to hold. It also must be feasible to build the pavilion with their own hands within the course timeframe, as in real-world conditions. And with digital technologies emerging so rapidly; why not use them for good, to make the world more circular and more sustainable? "

~ Dr. Catherine De Wolf

Sustainability in Focus

Let's deep dive: Disassembling and rebuilding: Hands-on learning of circularity using digital technologies

The course follows a five-step workflow that takes students from a building scheduled for demolition to a newly built structure made from reclaimed materials. There are weekly modules typically structured into three parts: an introductory theory lecture, an interactive hands-on activity (e.g., image classification or scanning), and a guest lecture from an external expert. In the project-based learning part, inter-disciplinary groups of 5 to 6 students manage a project from "A to Z":

- ✓ *Detect: Students scan an existing building using LiDAR, photogrammetry, and AI-supported image analysis to identify, measure, and catalogue reusable components.*
- ✓ *Disassemble: Working on-site, students dismantle parts of the building, recover materials, and document their condition, learning first-hand why reuse is often more complex than demolition.*
- ✓ *Distribute: The recovered materials are sorted, inventoried, and matched to future uses. Components may be reused within the course project, donated to community initiatives, or redirected to rebuilding efforts.*
- ✓ *Design: Instead of starting with a design concept, students begin with the materials available, using tools such as generative AI and BIM to design a pavilion or installation.*
- ✓ *Deploy: Using XR and digital fabrication, they construct the designed structure for a real client using only reclaimed resources.*

This workflow teaches circularity by reversing the conventional design process. Rather than selecting materials for a predefined design, students must adapt their ideas to the resources they have recovered. In doing so, they learn to combine digital technologies, stakeholder requirements, and material constraints to deliver a real-world project from inventory to implementation.

Process

Before

- ✓ Aligning the academic semester with real-world demolition and construction schedules.
- ✓ Securing industry partners (clients and practitioners).
- ✓ Obtaining necessary digital equipment (e.g., scanners).
- ✓ Mandatory safety training and strict adherence to regulations before students begin physical work on-site.

During

- ✓ Field trips to deconstruction sites using AI and robotics for waste sorting.
- ✓ "Desk crits" (informal feedback sessions): instructors and students discuss and improve design solutions.
- ✓ Midterm presentations to a jury of experts (feedback on the feasibility and impact of designs).
- ✓ Intensive on-site construction days: semester culminates in the physical assembly of a full-scale structure.

After

- ✓ Final presentation and jury assessment, where students present their completed pavilion or project to an interdisciplinary panel for a grade or a pass-fail evaluation.

Time investment for students

Most of the work is done in-class as these are times dedicated for the interdisciplinary hands-on work. Students also spend about 5h per week outside of classroom hours to hand-in intermediate homework building up to the in-class design.

Illustrations



Figure 1: *Students dismantling and recovering materials for reuse. © Anna Buser*

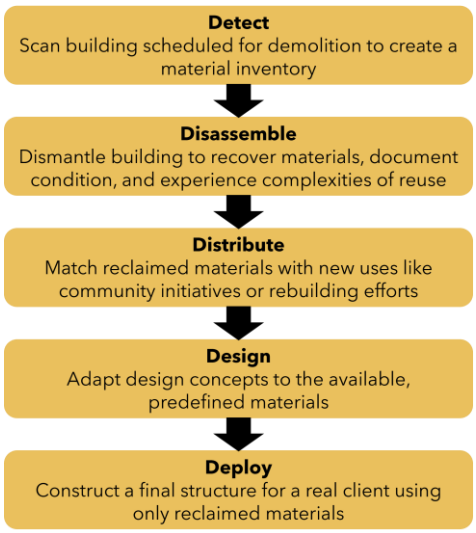

Figure 2: *Circular construction project workflow. Illustration created by Dean Nugent*

Competencies in the teaching activity

Subject-specific

- ☐ Concepts & Theories
- ☒ Techniques & Technologies

Method-specific

- ☐ Analytical competencies
- ☒ Decision-making
- ☐ Media & Digital Technologies
- ☐ Problem-solving
- ☒ Project Management

Social

- ☐ Communication
- ☒ Cooperation & Teamwork
- ☐ Customer Orientation
- ☐ Leadership & Responsibility
- ☐ Self-presentation & Social Influence
- ☐ Sensitivity to Diversity
- ☐ Negotiation

Personal

- ☐ Adaptability & Flexibility
- ☐ Creative Thinking
- ☒ Critical Thinking
- ☐ Integrity & Work Ethics
- ☐ Self-awareness & self-reflection
- ☐ Self-direction & self-management

Sustainability topics

Sustainability in Focus



Environment

- *Life-cycle assessment (LCA)*
- *Waste, pollution & hazardous substances*
- *Land use, urban & landscape planning*



Economy

- *Digital economy & IT sector*
- *Circular economy & circular business models*
- *Construction industry & built environment*



Social

- *Environmental & technology ethics*
- *Stakeholder engagement, participation & local communities*

Assessment

☒ Yes	☐ Graded	☐ Individual	☐ Output
☐ No	☒ Ungraded	☒ Group	☐ Process
		☐ Both	☐ Both

How it is assessed

Students are assessed through midterm and final presentations evaluated by an interdisciplinary jury of academic and industry experts. In addition, successful course completion requires active participation in all project phases and strict adherence to safety regulations during deconstruction and construction activities. Through this assessment format, the following competencies are fostered and assessed:

- ✓ *Techniques & Technologies: by applying and critically integrating emerging technologies such as LiDAR scanning, photogrammetry, generative AI, extended reality (XR), and digital fabrication throughout the circular construction process.*
- ✓ *Project Management and Decision-making: by planning, coordinating, and delivering a real-world project across the entire circular workflow, from material identification and recovery to design, construction, and deployment.*
- ✓ *Cooperation & Teamwork: by working in interdisciplinary teams and collaborating with external stakeholders, clients, and industry experts to develop and present viable solutions.*
- ✓ *Critical Thinking: by evaluating the environmental impact, technical feasibility, and practical value of different design decisions, including when digital technologies provide meaningful advantages over conventional approaches.*

Transfer tips

- *Collaborate with an external partner and engage students in solving an authentic problem with a tangible outcome, creating a strong sense of purpose and ownership.*
- *Involve industry experts, community partners, or professionals not only as guest speakers but also as mentors and reviewers who provide feedback on student work.*
- *Use digital technologies as tools, not goals: Encourage students to critically evaluate when and how digital technologies add value instead of assuming that digital solutions are always superior.*
- *Create meaningful outputs: Whenever possible, design projects with a lasting impact, such as solutions, prototypes, datasets, policy recommendations, or community-facing outcomes that extend beyond the classroom.*

Contact

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Credits

The teaching activity presented here is one example among many valuable approaches identified within the ENHANCE+ project Teaching Activities for Sustainability and Ethics. Its purpose is to support knowledge transfer and inspire colleagues across European technical universities. We classified our offer based on the ETH Competence Framework, a framework developed by ETH Zurich. For further information, visit **www.ethz.ch/comp-teachingstaff.**