



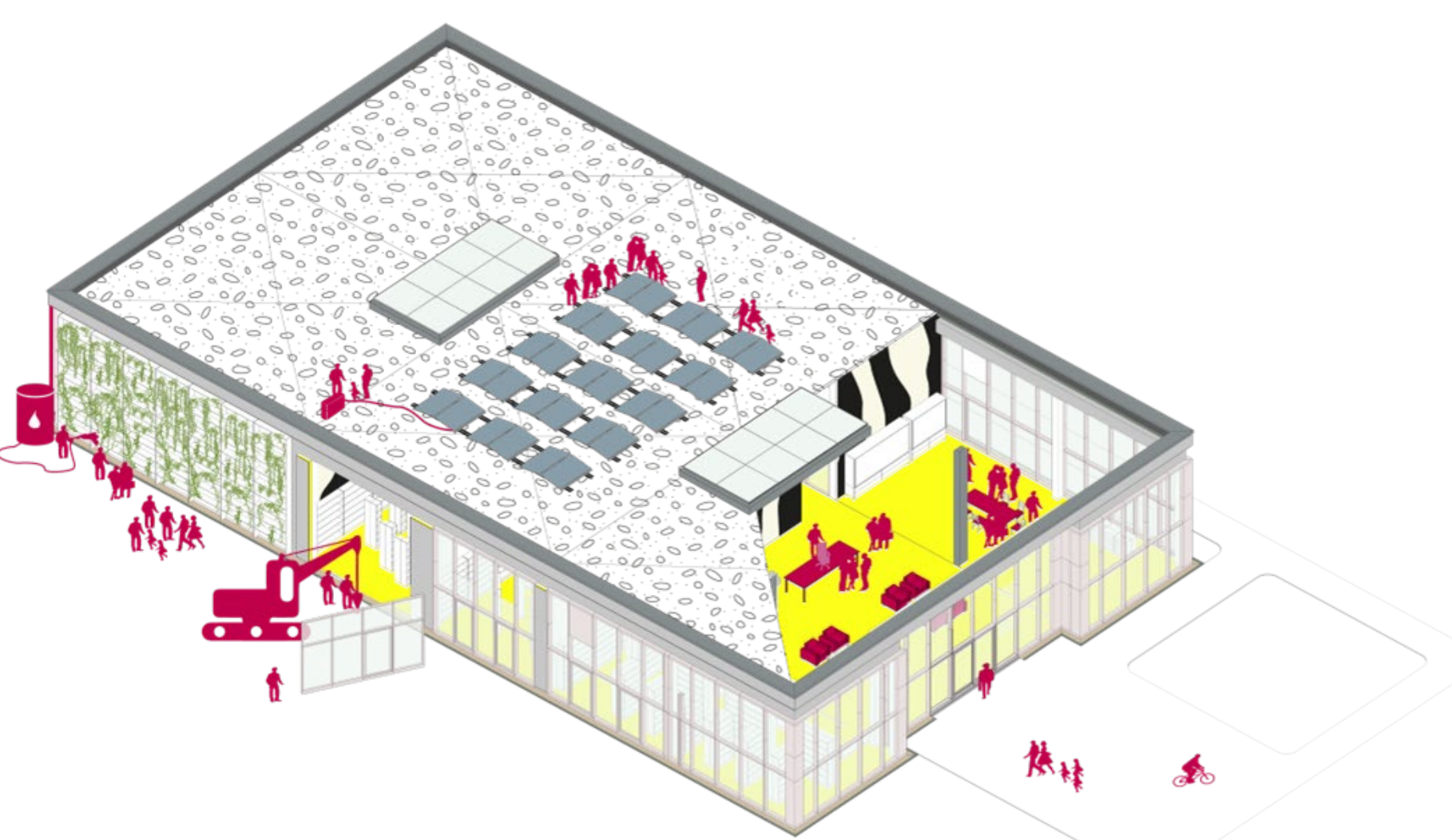
SDGs addressed

Context & research question

Context. Climate education often remains abstract and classroom-bound, even though SDG 4.7 frames education as a lever for sustainable development [1]. The Transformer starts from a different hypothesis: climate literacy grows when learners enter a real place where materials, infrastructures and social practices can be reworked. By activating a vacant building as a co-creation space, the project makes circular economy, energy literacy and urban mining visible, touchable and negotiable - and turns the university into an accessible 'third mission' infrastructure that learns with, not just teaches, its publics [2][3].

Research question. This contribution asks a practical but urgent question: Which didactic success factors and challenges emerge when climate change and sustainability are taught in informal learning environments? The study addresses this question through 26 workshop observations conducted in the TU Wien Transformer, a university-based co-creation space for extracurricular STEM and climate education. Across workshops ranging from upcycling and CO₂ experiments to ecological building, the project examines how hands-on, technology-supported maker formats can help turn abstract climate knowledge into meaningful learning experiences. It also explores how a university setting can function as a bridge between science and society, enabling climate education that is participatory, tangible, and action-oriented rather than purely theoretical.

A vacancy becomes a learning infrastructure



Vacancy as didactic actor: the 'as-found' environment invites experimentation and lowers barriers [4].

Visible transformation (reuse, repair, reconfiguration) makes experimentation socially legitimate and supports iterative learning in space [4]. Co-creation becomes visible in shared decision moments: themes, artefacts and routines are shaped with youth, students and partners [6].

As a university interface, the Transformer opens research to public encounter and collaboration. It also creates tangible boundary objects through which research can connect with neighbourhood practice [3].

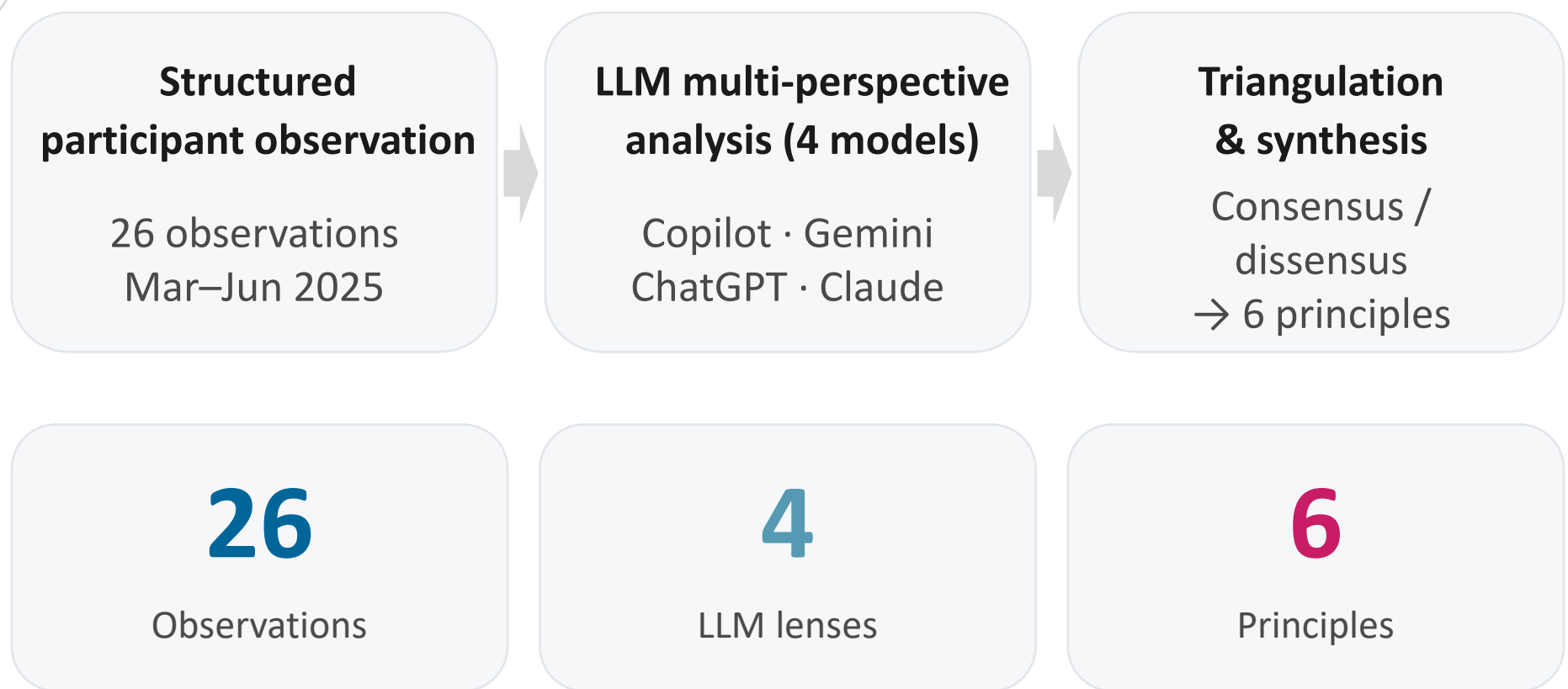


Transformer logic: three linked modules



The Transformer's programme consists of interconnected stages within one circular learning environment. Starting from the activation of a vacant building and the idea of space recycling, the project turns the site itself into a real-world laboratory for climate education. In the **Materialmine**, children and young people investigate everyday objects, materials, and building components by collecting, dismantling, sorting, and analysing them in terms of resource use and life cycles. In the **Kreationküche**, these findings are translated into new artefacts, spatial interventions, repair formats, and educational prototypes. In the **Zukunftsportal**, the resulting ideas and creations are further developed with a view to climate-neutral and climate-adaptive futures. What makes this model innovative is its circular logic: outputs can later be dismantled, reflected upon, and reintroduced into the process.

Methods



- This study combined structured participant observation with a contrastive multi-perspective analysis. Between March and June 2025, 11 students documented 26 workshop formats in the TU Wien Transformer using a standardized observation guide.
- The observations focused not only on workshop content, but on the situated dynamics of informal climate learning: how children and adolescents interacted with space, tools, materials, instructions, peers, parents, and facilitators, and how moments of confusion, experimentation, frustration, and adaptation shaped the learning process.
- In a second analytical step, the reports were independently read by four different large language models in order to generate contrasting interpretations rather than automated evidence. Convergences and divergences across these readings were then triangulated and checked through peer debriefings, selective manual coding, and negative-case analysis, allowing robust patterns to be distinguished from model-specific artefacts.

LLM-assisted synthesis: robust themes, different emphases

Different models foregrounded different aspects, but convergence mattered more than style: the same workshop ecology repeatedly surfaced as hands-on, inclusive, scaffolded and relational.

- Recurring themes across all four models:**
- Hands-on making turns climate into something tangible
 - Mixed-age facilitation needs differentiated entry points
 - Autonomy works best with light structure ("scaffolded freedom")
 - Digital tools motivate, but tool access and waiting time must be designed
 - Parents and peers can enable participation - or reproduce inequalities
 - Language-sensitive, non-verbal and material communication matter

M365 Copilot Strong on practical structure and recommendations; weaker on conceptual depth.	Gemini 2.5 Pro Best balance of theory, observation and synthesis.
ChatGPT-5 Richest synthesis; tendency to add structure beyond the data.	Claude Opus 4.1 Sharpest condensation; strongest for practice-facing wording.

Triangulation increased confidence in recurring patterns. The value of LLMs lay in contrastive reading - not in replacing interpretation.

Why the TU Transformer matters for...

- ...scientists**
 For scientists, the Transformer is more than an outreach venue: it is a real-world interface where research can be translated, tested, and discussed in public. By working in a co-creative setting, researchers do not simply communicate finished results; they encounter how climate- and sustainability-related topics are understood, questioned, and reinterpreted by children, families, students, and community partners. This creates a feedback loop between research and society and turns science communication into a source of insight rather than a one-way transfer exercise. In this sense, the Transformer strengthens the university's third mission by linking disciplinary expertise with public engagement, participatory formats, and socially grounded experimentation.
- We also welcome interdisciplinary collaboration and knowledge exchange across institutional boundaries, as former and current collaborations with KPH Wien, MUK, acib, WasserCluster Lunz, the University of Vienna and others show.

Results: 6 design principles

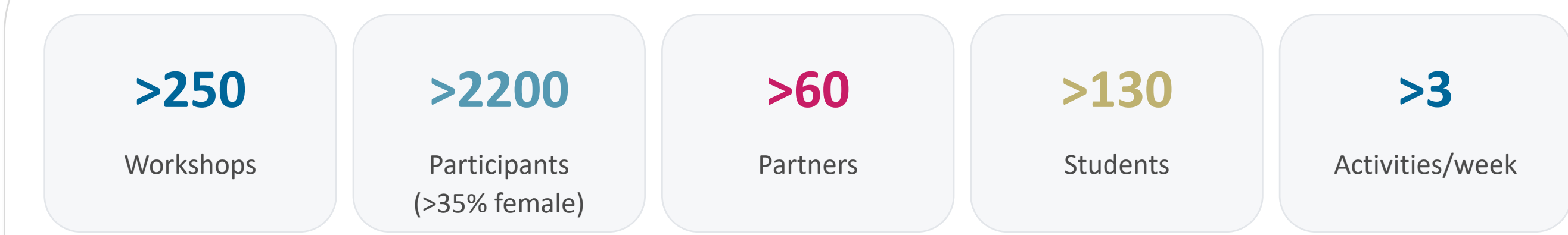
- 1 Material literacy**
 Material contact makes climate and circularity discussable because learners can see, touch, open and compare real artefacts [2,4].
- 2 Productive failure**
 Iterative design-make-test-revise cycles turn mistakes into learning moments and support higher-order thinking [5].
- 3 Scaffolded freedom**
 Open tasks become inclusive when freedom is combined with cues, examples, timing and facilitation [5,6].
- 4 Technology as bridge**
 Tools such as 3D printing or robotics attract attention, but their climate value emerges when energy, material use and waiting time are reflected upon [2,3].
- 5 Multi-level differentiation**
 Mixed-age groups benefit from layered tasks: sensory exploration, model-building and systems reflection can coexist [2,5].
- 6 Community learning**
 Peer exchange, mentoring and family contact can widen participation - but inclusion has to be actively governed [6].

Why this matters for climate practice

Climate agency does not arise from awareness alone. Research suggests that learners need opportunities to experiment, reflect, and experience themselves as capable of shaping change [2,4,7]. The Transformer addresses this gap by turning sustainability into a material and social practice: young people work with real materials, test ideas, and see that their actions can alter a place. In this way, learning becomes more than information uptake; it becomes participation in a modifiable environment [4,5,7].

The Transformer connects circular economy, repair, design, and energy literacy in one learning arc — from analysing what exists to reimagining what could exist next [2,5]. What emerges is not only understanding, but agency: the capacity to imagine alternatives, test possibilities, and experience oneself as able to contribute to transformation [2,4,7]. Its scalability lies less in copying one building than in transferring the logic: activate existing spaces, organise learning in circular modules, and train multipliers across schools, universities & partner organisations [6,3].

Facts about the TU Transformer & pathways for collaboration - let's build climate solutions and future skills together



Initiating team of the TU Transformer:

Faculty of Technical Chemistry:
 Faculty of Civil and Environmental Engineering:
 Faculty of Architecture and Planning:
 Faculty of Electrical Engineering & Information Technology:
 Faculty of Informatics:
 Faculty of Mechanical and Industrial Engineering:

Bettina Mihalyi-Schneider, Bianca Köck
 Azra Korjenic, Ines Kirchengast, Alexander Pichlhöfer
 Emanuela Semlitsch, Katharina Tielsch
 Lara Lammer, Georg Jäggle
 Andrea Hackl, Stefan Szeider
 Vasiliki Archodoulaki, Lisa Schardt

- Partnership pathways (examples):**
- Equipment & material donations (e.g., electronics kits, tools, robot kits, software)
 - Sponsoring workshop series or innovation prototypes
 - Funding proposal for collaborative research
 - Co-creation workshops (sector-specific challenges, competitions, holiday programmes)
 - Expertise & mentoring (guest experts, excursions, internships, long-term mentoring)
 - Research collaboration (living lab; co-innovation; joint publications & events)

Literature & Poster: <https://transformer.project.tuwien.ac.at/publikationen-poster/>

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