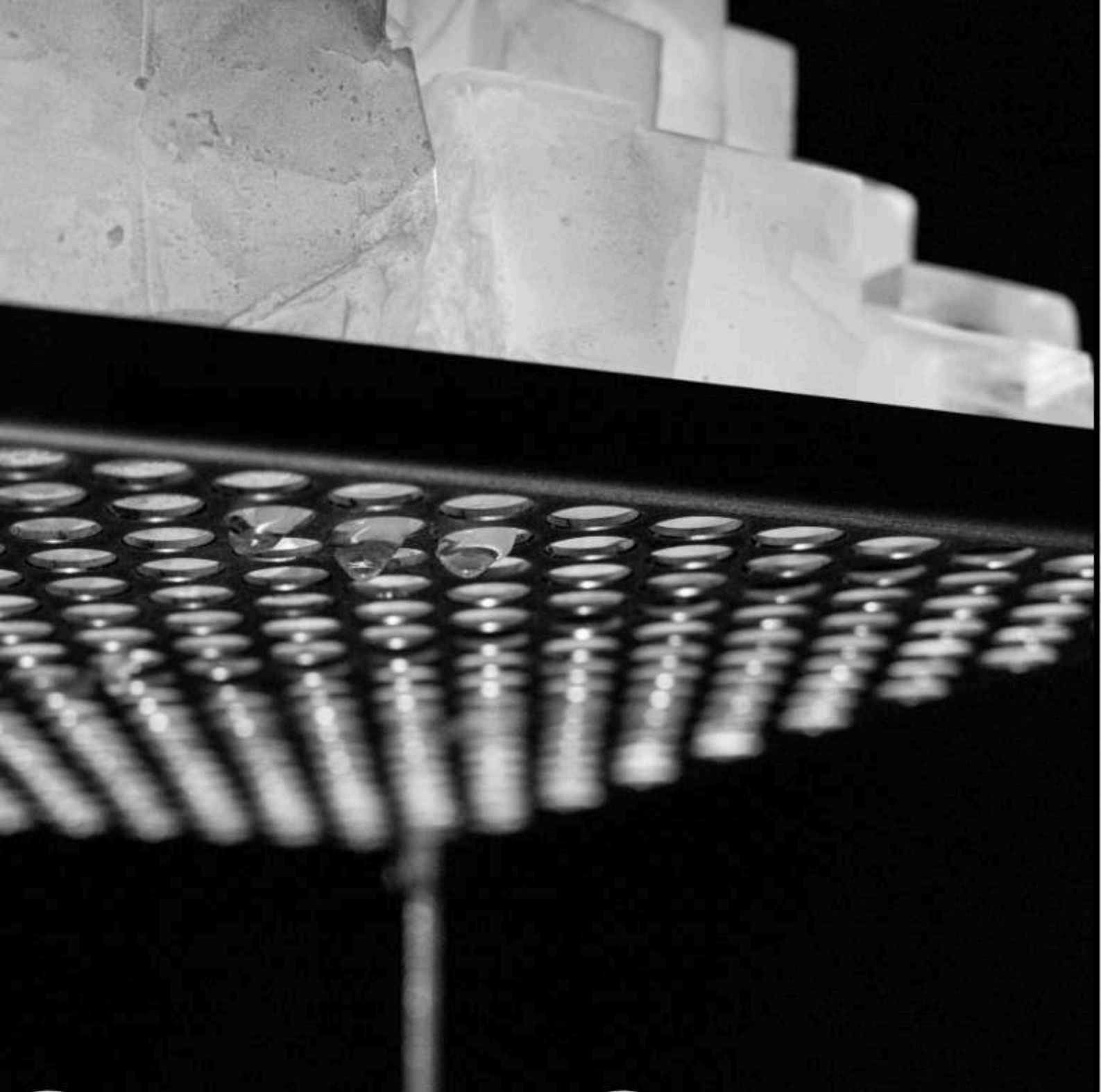


STATE OF CHANGE

Benjamin Barbaro
Isa Hovmand
Vasilis Ballas
Vlad Hațegan

(1ZM250),
Innovation space project: innovation through art & design
Q1 Winter 2025/2026,

Coaches,
Elke den Ouden
Isolde Hallensleben
Giorgio Gasco
Eline Westerbeek

Project,
Shaping flow
Mark IJzerman

Figure 0: Close-up of the ice structure melting (Team Final Demonstration).

WHAT



The theme of our challenge is water and its never-still nature. Throughout our journey, we strive to study how water moves and flows, how this is understood through human nature, and how art and nature can meet to create emergent meaning and beauty.

In collaboration with Mark IJserman, we decided to explore the physicality and natural qualities of water, not only as an engineering element, but also as an artistic opportunity. Enchanted by the seemingly magical state transitions of water, we decided to use this form of state change as a metaphor for the ever-changing nature of life. We are interested in amplifying the smallest quantums of change (water drops) and bringing awareness to their existence - for the big visible change can only exist because of small incremental changes.

Our team comes from various educational and cultural backgrounds, which has shaped our process from the beginning. Each of us provides different skills and perspectives, allowing us to approach water from different scientific, artistic, and human angles.

Figure 1: Droplet remains on the metallic sheet (Team Final Demonstration).

WHO

Ben Barbaro

Ben is a Mechanical Engineering Masters student at TU/e, coming from Northwestern University just outside Chicago. With a concentration in robotics, he combines solid design principles and a history of CAD design with math and programming skills. A bartender and avid home cook in his personal life, his attention to detail in food and drink transfer effectively into his design and prototyping work. He's been working with 3D printers for almost a decade and has worked with virtually every CAD software.

In this project, Ben would like to improve some key skills, focusing on PCB design and hand sketching. He would like to use his technical experience to create a project closer to the art realm than his usual work.

Isa Hovmand

Isa studies Design and Innovation at the Technical University of Denmark, DTU; her education is based on engineering with design and user approaches for innovative and functional solutions.

She has experience in CAD modeling with Creo and Fusion, prototyping, and 3D printing. Isa is also familiar with Arduino and various design tools. Isa's skill set also includes critical thinking and an understanding of human interactions within design processes.

Currently, Isa's learning goals are to improve her time management and presentation skills, increase her decision-making through design research methods, as well as strengthening her capability to visualize and communicate ideas effectively within team projects.

Vasilis Ballas

Vasilis is studying Human-Technology Interaction at Eindhoven University of Technology, where his work combines elements of design, psychology, and engineering to understand how people interact with technology.

He has experience in usability analysis, 3D modeling, and design development, and enjoys finding practical and creative ways to solve problems. In group projects, Vasilis often helps organize the workflow and support brainstorming sessions, bringing a friendly and positive attitude that helps the team work smoothly together.

At this point in his studies, he is focusing on improving collaboration with people from different backgrounds, becoming more flexible and adaptable in changing project situations, and exploring how art and technology can complement each other. He is also working on his punctuality and time management to improve his overall effectiveness in team settings.

Vlad Hațegan

Vlad studies Embedded Systems at TU/e, doing the Cyber-Physical Systems track, and a minor in Industrial Design. His studies focus on programming small devices, managing limited resources, and making sure that short reaction times are met. This combines nicely with his skills in electronics and 3D modelling, forming a solid basis for high-definition prototyping.

Vlad is interested in understanding how his skills can be developed further and combined with his passion for understanding and developing Human-
Device Interaction experiences. He centers an appreciation of the possibilities enabled by high-tech connected small-scale systems, novel manufacturing methods, and intelligent algorithms.

ANALYSIS

Water is a multimodal element that exists almost everywhere on Earth (Oki & Kanae, 2006). It is in constant motion, shifting between its three states–solid, liquid, and gas – as it responds to its surrounding conditions (Oki & Kanae, 2006). Water creates and destroys; it sustains life but also erodes, floods, and transforms (Wolman & Miller, 1960). It was here long before us and will remain long after. This duality positions water as both a tool and an independent force of creation. While humans often attempt to control or exploit it through technology and infrastructure (Oki & Kanae, 2006), water maintains its autonomy, responding to gravity, temperature, and form in ways that often escape prediction (Milly et al., 2008).
Our exploration began with open discussions about what water means to each of us. A visit to the Rijksmuseum Twenthe (Gratis Rondleiding “Ik, de Ander & de Aarde,” 2025)deepened these reflections by showing how art can give form to invisible natural processes. This experience inspired our guiding question:

How can water’s transformation tell a story about change?

From this perspective, our project explores the coexistence between human intention and water's self-determined behavior. Rather than portraying water as an individual artist, we perceive it as a co-creator, a medium that interacts with its environment in ways that are both unpredictable and meaningful. Each interaction becomes a dialogue between control and surrender, between what we can measure and what we can only experience.

This relationship between control and autonomy extends to the broader context of our world. Water’s transformation in response to temperature or pressure mirrors how modern cities and ecosystems are increasingly shaped by forces outside their control - both human and natural. Just as melting ice signifies environmental imbalance, urban structures also "melt" metaphorically under the pressure of overdevelopment, decay, and human impact. Cities are reshaped by rising seas, abandoned and reclaimed by nature, or gradually eroded by time itself (Hallegatte et al., 2013; Hobbs et al., 2009; Notz & Stroeve, 2016).

Examples such as Pripyat in Ukraine, overtaken by vegetation after human withdrawal, or Jakarta, slowly sinking as groundwater levels decline, illustrate this tension between human control and natural reclaiming (Bulkeley, 2021; Chang, 2023).

We explore how melting ice can be experienced through sound, seeking to make the process of transformation something people can both hear and sense. Our project captures this tension through the metaphor of a melting city - a landscape in motion where transformation becomes audible. The amplification of each droplet intensifies the sense of urgency, echoing not only the melting of ice but also the fragility of our current way of living. Through headphones, the listener can hear what happens inside the ice - a quiet and intimate experience of the gradual melting. The melting reflects both the vulnerability of cities and the larger environmental changes of our time, creating an audible landscape that captures transformation and loss. Instead of giving clear answers, we keep the experience open to interpretation, inviting the listener to feel and understand change in their own way.

Our guiding question thus became:

How can we make the sensory transformation of water perceptible, using technology not to control it, but to reveal it?

This question continues to guide our iterative process. Each experiment - from our first melting tests to the development of the live sound setup - has helped us explore how natural unpredictability can meet technical precision. The goal is for the sounds to be experienced live, allowing the melting process to unfold in real time. However, we plan to record these sounds as part of our evaluation, to understand whether they communicate the story and emotions we wish to convey. Through these explorations, water emerges not just as material but as a storyteller - revealing time, fragility, and transformation through sound.
As the Rijksmuseum Twenthe exhibition Me, the Other & the Earth reminds us (Gratis Rondleiding “Ik, de Ander & de Aarde,” 2025):

“Our world is always changing, but in the early 21st century it seems as if we’re moving into a new era… And our human presence on Earth is now so dominant that it is forcing nature out of its equilibrium.”

This captures the essence of our challenge: recognizing the fragility of balance between human creation and natural processes.

PERSPECTIVE SHIFT

A significant conceptual shift emerged during our conversation with Matijs Bosman. His questions pushed us to look beyond the technicalities of amplification and focus instead on the intention behind our choices. He reminded us that "an artist cannot be their own spectator", prompting us to reconsider what kind of experience we are offering the audience. Our aim is not to demonstrate that "water makes music," but to create a space where change, fragility, and rhythm can be sensed rather than shown. His perspective helped us clarify the kind of perception and presence we want the work to evoke.
He introduced us to works such as the I Ching, which understands change as a continuous condition rather than a momentary event. Through this, the melting structure becomes less a symbol of decay and more an unfolding process: **each drop is both an ending and a beginning.** The negative structure gains new meaning - it carries the story of what once existed while being reshaped by the very water that dissolves it.

In this way, the installation tells its story not through explanation, but through its form and behavior.

A final parallel came through Kurt Lewin's freeze-unfreeze model. Our ice block literally freezes the structure into a temporary state of stability, only to release it again as it melts. This echoed our own reflections:

Structures that appear solid are always in motion, always vulnerable to slow and cumulative change.

As the structure melts, its sharp architectural forms gradually soften, collapsing into a rounded, hilly landscape. This transformation "bastardizes" the structure, turning it into something organic, almost geological. This shift reinforces our metaphor: human-made systems eventually return to natural forms. What begins as a rigid, rational structure becomes part of a fluid, unpredictable landscape. In this way, the melting process documents a transition from order to organism, from design to erosion, revealing the long temporal relationship between human construction and natural reclaiming.

VIEW

Our individual perspectives on the story that our installation conveys:

Ben Barbaro

Our exhibit displays the cyclical nature of change through the melting of our ice structure. There are several climate change analogies to be drawn: as the environment changes, old systems are broken down and reformed. The sounds displayed in our exhibit show contrasting viewpoints of the change in the ice; the loud droplets that greet you show each little bit of damage in melting, and the headphones give a deeper understanding of the ice, a quiet world in conflict. I think it has a somber, yet hopeful message. Collecting the droplets in the pristine mold shows the opportunity for rebirth. The old system is crumbling, and a more liquid, flexible system is taking its place.

Isa Hovmand

When thinking about the project and what it represents, I see it as a form of change expressed through structure - a shape that holds many meanings. I see the structure as a reflection of the world and society I live in. Everything has its own systems and ways of functioning, yet these must evolve to move toward a better future. This gives me a feeling of circularity, of how one structure transforms into yet another when it is pushed out of its current state.

Vasilis Ballas

Change is everywhere; it can be small or quick, but it still has an impact. Even when we don't notice, change is there. There is so much power in change that even a slight change in certain situations can affect people's views or even lives. In my line of work, we care about how people interact with their environment (both physical and digital). Knowing how to make the correct changes to make people's lives better is a very valuable skill and holds great responsibility. I think telling the story of how much impact change has is important and there are many ways to show this impact. The way we chose to narrate the story is through an ice structure melting and deforming slowly but loudly. This is a multimodal representation of our story, with the edgy structure becoming softer and smoother, the droplets being loud and repetitive, and the water slowly rising in the collector.

Vlad Hațegan

I see change as something highly abstract, as existence in itself is something that always morphs into something else entirely. In my eyes, the state change of water is distanced from the real-world implications of the process, becoming a metaphor of something non-material and non-quantifiable. I would prefer not to over-emphasise the specifics of the subject of change. Each observer is free to choose their own fundamental object, as, in my view, it is the concept of change that is metaphorized by the state change of water, rather than by some sort of materiality. A metaphysical synecdoche of sorts.



PROCESS

While the idea was narrowed down, building it was yet another challenge we had to face. We had a few concerns about the nature of ice melting, so we created some experiments at home. There was quite a bit of an issue regarding the speed at which ice liquifies, as constructing an art piece comes with the issue of having something durable, yet something that shows the transformation in real time. Furthermore, we want the melted water to drip from multiple points along the surface of the ice to add variation to the aesthetics of the project.

Our preliminary experiments involved freezing a large chunk or multiple smaller chunks of ice, then recording or observing the behavior of the ice as it melted. Most of these experiments involved placing our ice on a metal rack that allowed the water to drip through without letting the ice fall.
We observed that the ice melted slowly, and there were a variety of locations where the water pooled before dripping.



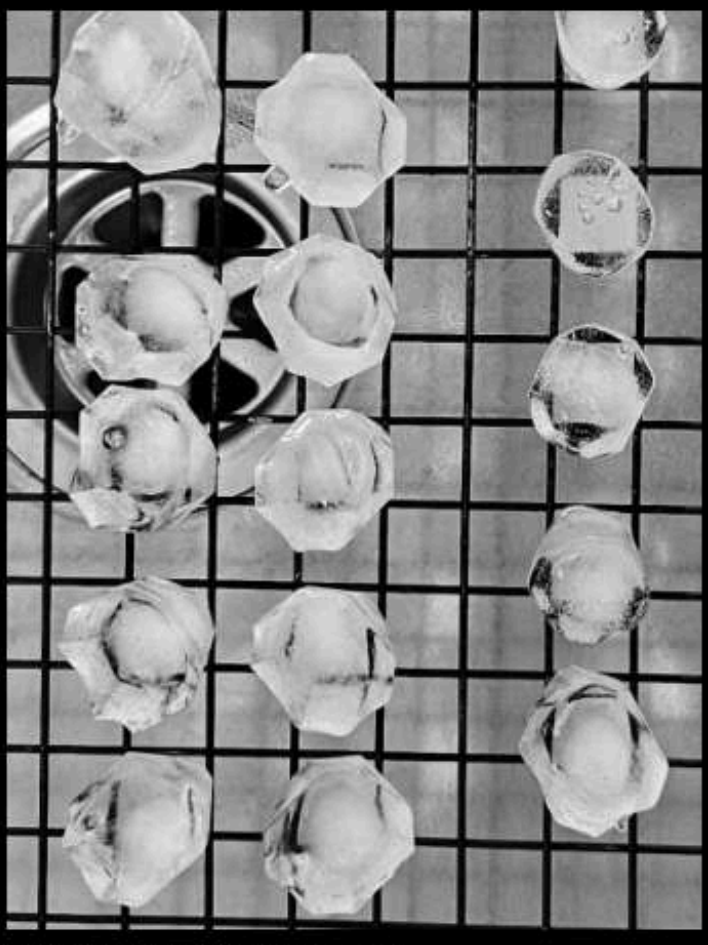
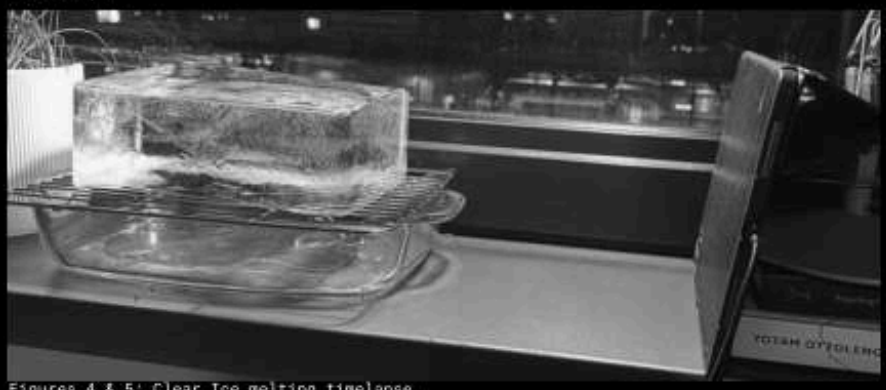


Figure 2 (left): Big block of ice melting.
Figure 3 (right): Smaller ice cubes melting (Team experiments).

Further experiments were done to obtain clear ice because it is aesthetically pleasing. By utilizing a special method called directional freezing, we get a nice clear block of ice attached to a section with the impurities of the block. We can cut away these impurities to achieve a crystal-clear block. One negative aspect of this process is the lack of impurities in the final product, which means that the droplets do not conduct electricity effectively (Wu, Berezansky, & Sun, 1995).





Figures 4 & 5: Clear Ice melting timelapse,

An initial plan was to use the conductivity of the ice to join various wires below the block of ice, but we have moved away from this idea with time. This plan would have a grid of sensors to detect the falling drops and play a sound whenever an electrical connection is made. The conclusion of the water conductivity for clear ice and other avenues of exploration has pushed us towards building a prototype that amplifies the sound of the physical impact on a surface below our ice instead. We built the presentation prototype without expecting a certain result, and although the impact noises were quieter than expected, their natural beauty was the star of the show.



Figure 6: Sound-recording the Dommel with Mark.

Our exploration also took us experimenting with microphones to listen to the sound of water. We investigated the interior sound of ice using a frozen hydrophone and listened to the flow of water in the Dommel. We have also experimented with amplifying the sounds of drops falling on a metal sheet, with our first prototype consisting of a pot lid with a piezo setup taped on.



In the end, our idea was to include a hydrophone to display the internal noise of the ice and a piezo element at the bottom of the plate onto which drops fall to amplify their impact sounds. This is a very direct way of making the physical act of drops falling to produce sound, allowing us to avoid digitalizing the sound at any step, providing an effect of transformation that is purely analogue and natural.

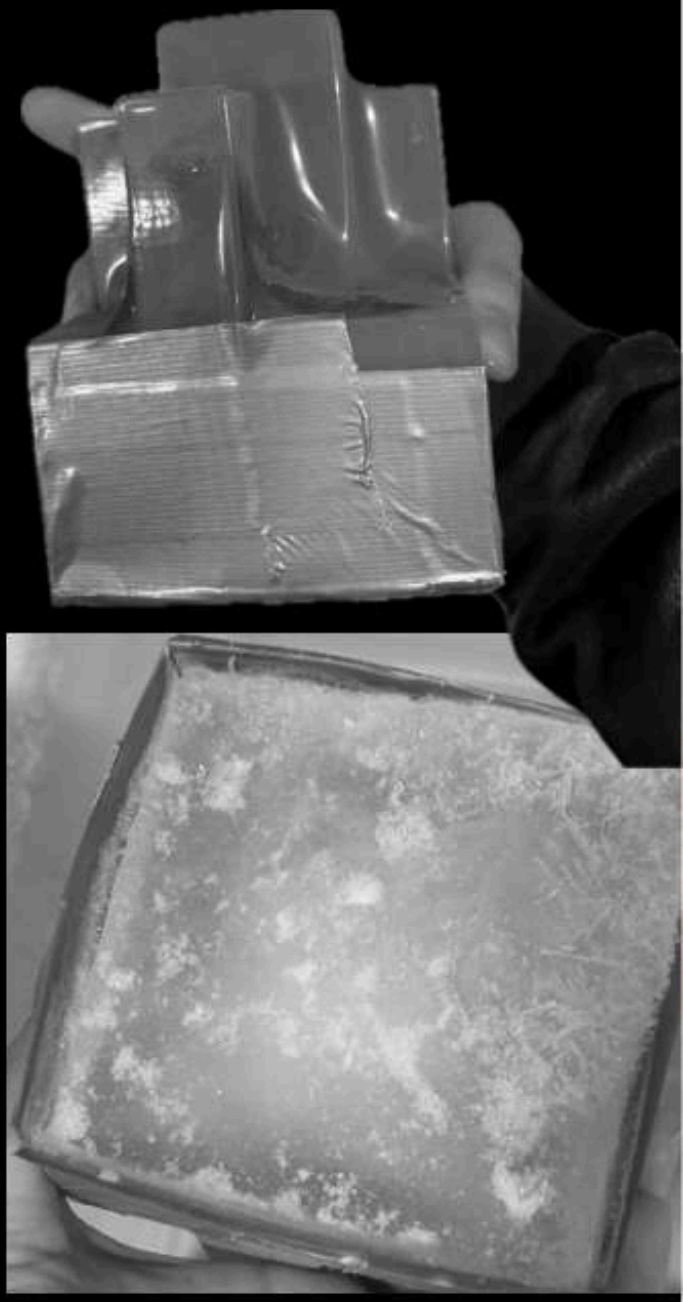
A hanging pair of headphones allow the user to enter a private conversation with the ice, by listening to the small cracks caused by the internal stresses within the material that does not manage to keep its structure. The sound is captured by a field recorder, which in turn powers the headphones. We iterated multiple times using the DIY hydrophones, in different blocks of ice, obtaining positive results.

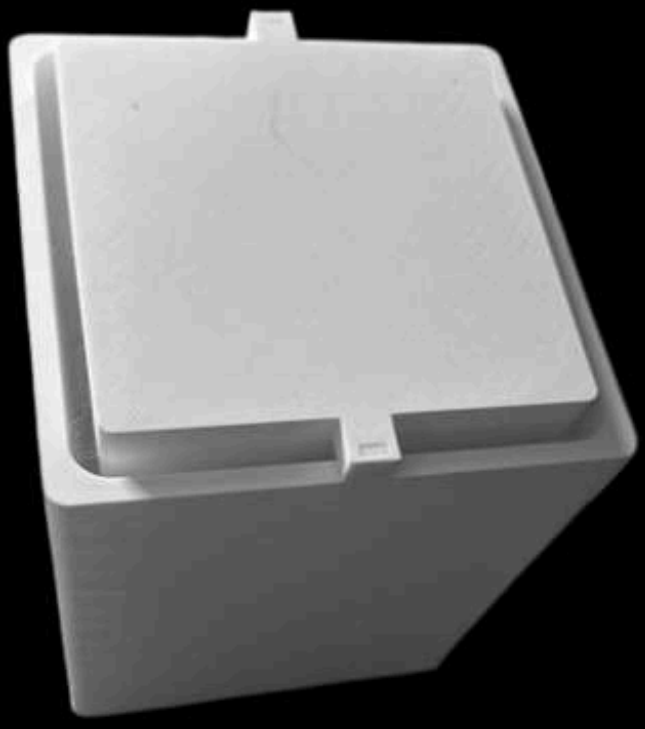




Figure 7: Piezo on a metallic pot lid (Team experiment).
Figure 8: Field recorder with the hydrophone and headphones connected
Figure 9: Headphones presented to visitors in the installation

We needed a mold to create the shape of the ice and a negative structure to fall into. We started thinking about vacuum molding because it was a quick and easy way to create a complex convex structure. After some testing, we saw that it was challenging to remove the mold without some serious design choices, and the vacuum molder in the prototyping studio had a maximum size of 23x43x14. The biggest limitation there was the height as we wanted the structure to seem citylike, which we thought required tall buildings. We also found that it would be challenging to create a transparent structure like we wanted, limited by materials. If transparent we would need to use thin plexiglass – which frozen turns brittle and unclear. We sealed the edges of our vacuum mold using gaffer tape and attempted to freeze a structure in there and another structure using a purely 3D printed mold, neither of which was very successful. We moved away from vacuum molding and tried prototyping a miniature version of the structure to make a silicone mold. We 3D printed both halves with 5mm spacing between them and added features to two sides to align the parts.



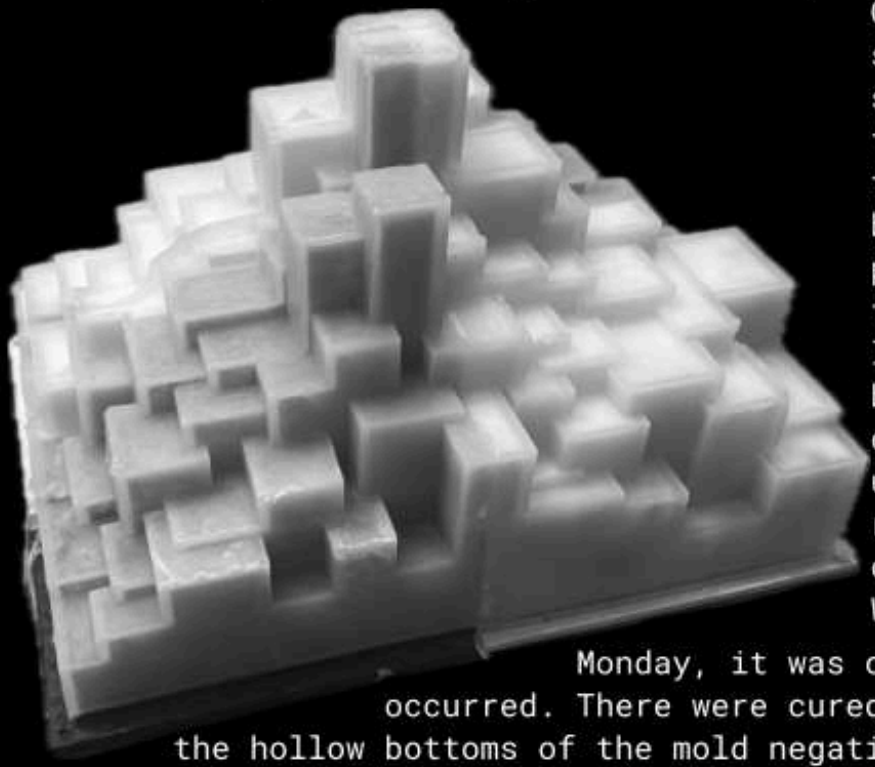


The mold was successful, but the buoyancy of the liquid silicone led to some issues with the process, and we had to find a heavy weight to keep the positive of the structure seated while the mold was curing. It was also very challenging to remove the positive after the mold had cured, so we ended up ripping it apart to expose the mold. We needed the negative of the structure to prevent the mold from sagging as it froze, which we carried onto the final version.

Figures 10, 11 & 12: Versions of ice structure molds (10 & 11: vacuum mold, 12: silicon mold).

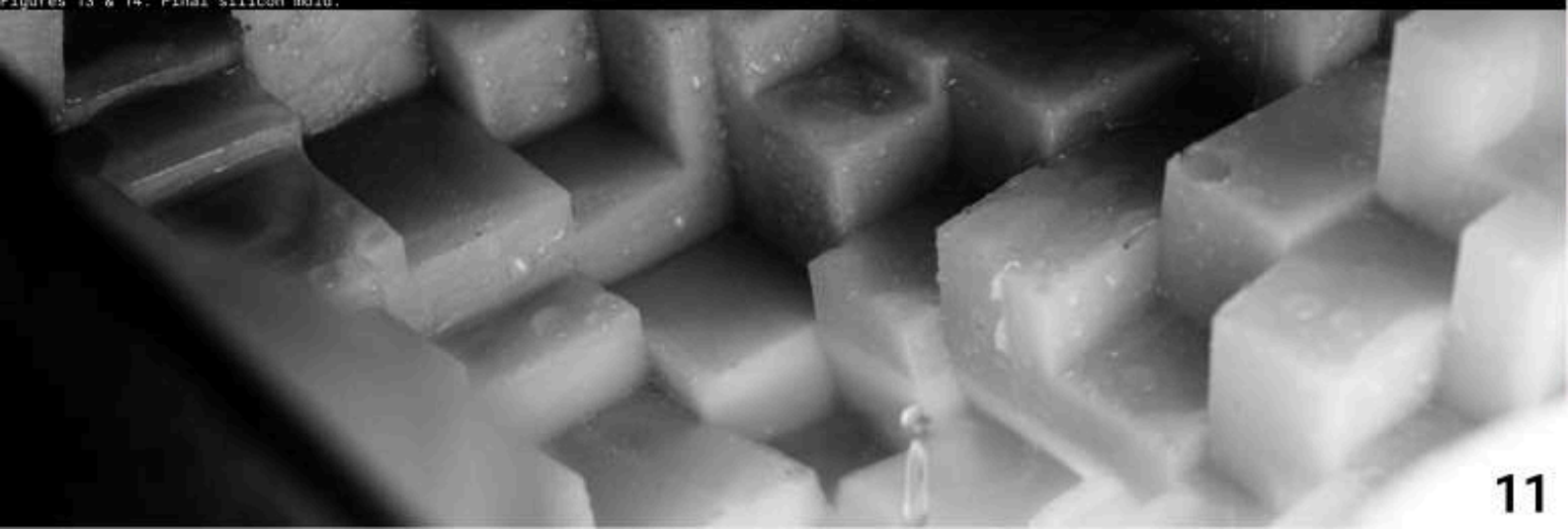
For the final product, we have defined the size to be as big as the freezer available allowed us, and implemented some intelligent mitigations of previous issues. We sanded down some of the rough layer lines using the sandblaster then spent some time with sandpaper to reduce friction when removing the mold. We split the external parts of the mold into 4 separate pieces, aligned with pins hoping that it would make the mold release easier. Right before the molding, we smeared Vaseline on every surface on each half of the mold, trying to form an even layer. Our digital measurements had shown that we needed around 2L of silicone to fill the mold, so we bought 4L to be safe.

On the day that we poured the mold, we glued all 4 pieces of the mold positive together and sealed the seams with superglue. We clamped the mold's negative direction with two clamps, hoping that the force would prevent leakage between the parts.

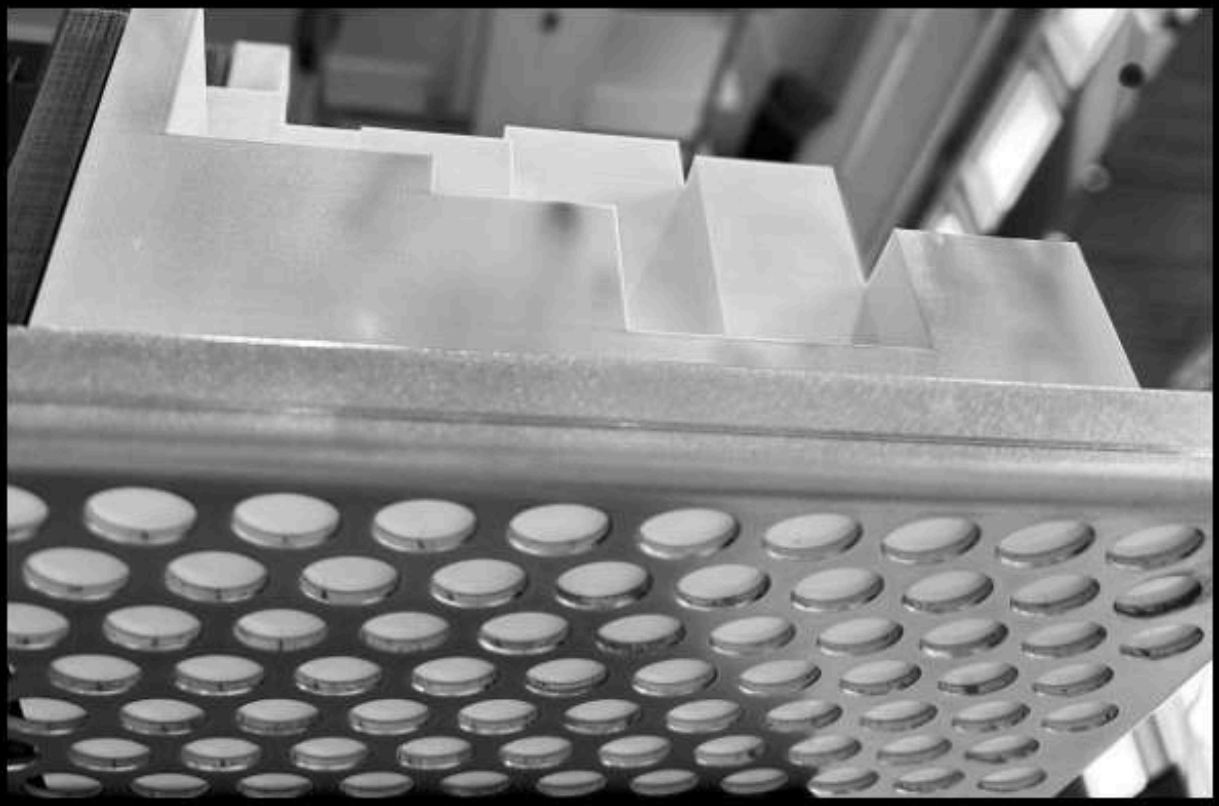


Once we started pouring the silicone, it was clear that some were leaking. We tried to duct tape the sides where the liquid seemed to be coming out and kept pouring until the mold seemed full. As we poured, it seemed like more material would leak because the fill line kept dipping. We kept pouring, using at least 3L of resin. With nothing left to do, we let the silicone cure. When we checked on the mold Monday, it was clear that lots of leakage had occurred. There were cured pucks of silicone in each of the hollow bottoms of the mold negative. Most of the mold had been filled, but the top few centimeters were not full of liquid. After pondering and researching, we decided that we would re-pour the mold and hope the two parts bonded together. We used the remainder of our molding silicone and left the mold to cure. The operation was successful, and we had our completed mold.

Figures 13 & 14: Final silicon mold.



We had an idea to use resin to form the negative of the city for the water to fall into. This way, we could have a transparent box that showed the progression of our structure as it melted. After doing some digital calculations, we found that we would need about 20L of resin to create the shape that we desired, which was more than our budget or time allowed. We instead created a polycarbonate box to which we could hang the final silicone mold upside down, creating a partially transparent structure that showed the change that we wanted.



To support the structure, we originally considered having a grid of clear plastic that would allow the exhibit to be viewed from all angles. After our CAD was completed for the structure, our measurements showed that the ice would weigh around 20 kg. This seemed like a tall ask for the plastic grid, so we transitioned to a metal plate. We ran FEA simulations with various thicknesses of metal in the structure we wanted to validate that we could bear the weight of the structure without notable sag. We landed on a 2mm steel plate and created a .dxf file with an accompanying drawing sent to EPC for them to laser cut and bend. We considered using the waterjet but after consultation with EPC it was clear that the laser cutter would achieve a better and faster result. We also cut out the panel for the water droplets to fall onto the same material, accounting for the angle we wanted to sit flush below the other plate.

Figure 15: Close-up of the final metallic grid.



To hang the exhibit, we connected lashing straps diagonally between two of the structure beams, forming a cross in the middle. In this cross, the structure was secured and hung. The structure itself started out with threaded rods and bolts between our two panels, rigidly holding them together. We tested the sound of droplets hitting the base with our amplifiers and liked the results, but the presentation left something to be desired.

We purchased steel cables to try instead, hoping that they would be less noticeable in the exhibition to highlight the essential parts of the project. The steel cabling was attached to our parts with cable stops and clamps, and we immediately preferred the clean aesthetic. We trimmed the cables at the ground, securing the audio cables to the steel cables with electrical tape to minimize distraction.

Due to time and space constraints, we only had one opportunity to freeze a block of ice. When we went to check on the ice, we noticed a crack in the structure near the microphone and attempted to fill it with water in hopes that it would freeze together. When we removed the mold from the freezer, it was clear that the plastic segments had spread apart as the ice expanded during freezing. We attempted to be as gentle as possible as we removed each of the 4 segments holding the mold in place, but force was required to remove them. As we peeled the silicone, a few sections of the ice were broken off, and a large crack had formed roughly the center of the part. We made the best of it, putting pieces back where we could and leaving the crack separated.

Figure 16: Final installation set-up with steel wires.

REFLECTION



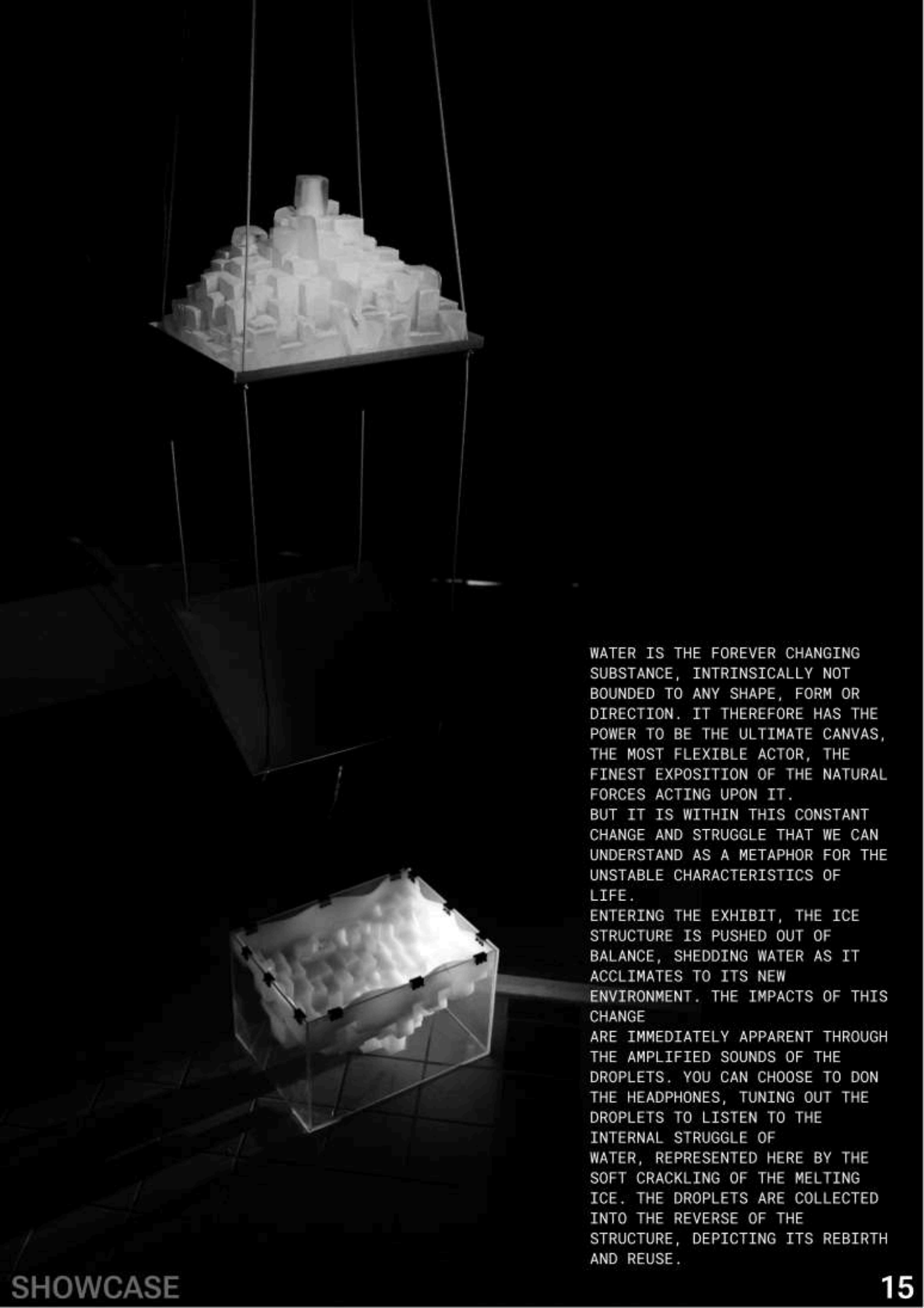
Figure 17: Water reflection on the Eindhoven canal (captured by the Team).

The project started with an open exploration of water and our individual relationship with water. Team discussions, a walk along the Dommel River, and a visit to the Rijksmuseum in Twente got us to think on how natural elements can express the relationship between humans and their environment. These shared experiences shaped our concept: using water's transformation as a way of telling a story about change and vulnerability. Throughout the process, we received valuable guidance from Mark Ijserman and Giorgio Gasco. Mark encouraged us to stay within our scope and define the main idea rather than expanding it in too many directions. Giorgio's feedback made us reflect more in depth on why we chose ice, how it connects to the structure, and how sound can communicate change. Together, their feedback helped us find a balance between our conceptual ideas and what was technically possible.

Our meeting with Matijs Bosman added an important layer to our reflection. He encouraged us to question the assumptions in our work and to consider how the audience might interpret the piece. His reminder that "the artist cannot be their own spectator" made us think on our choices, why a structure, why sound, why melting, and made it clear that it was our responsibility to shape an experience that guides rather than dictates meaning.

Technically, our focus was on the melting of ice - a process that can be measured but never fully controlled. We created a setup where the sound of melting was experienced live, making the invisible process audible. We also planned to record and analyse the sound, to understand whether it communicated the story we want to tell. Because of freezing time, it was not possible to record the sound.

Artistically, the project could continue to evolve through experimentation and exchange of ideas. We reframed our view of water - from artist to seeing it as a co-creator in a listening experience, one that invited reflection rather than provides explanation. This process taught us to work with unpredictability and to let natural change guide the outcome.



WATER IS THE FOREVER CHANGING SUBSTANCE, INTRINSICALLY NOT BOUNDED TO ANY SHAPE, FORM OR DIRECTION. IT THEREFORE HAS THE POWER TO BE THE ULTIMATE CANVAS, THE MOST FLEXIBLE ACTOR, THE FINEST EXPOSITION OF THE NATURAL FORCES ACTING UPON IT.
BUT IT IS WITHIN THIS CONSTANT CHANGE AND STRUGGLE THAT WE CAN UNDERSTAND AS A METAPHOR FOR THE UNSTABLE CHARACTERISTICS OF LIFE.
ENTERING THE EXHIBIT, THE ICE STRUCTURE IS PUSHED OUT OF BALANCE, SHEDDING WATER AS IT ACCLIMATES TO ITS NEW ENVIRONMENT. THE IMPACTS OF THIS CHANGE
ARE IMMEDIATELY APPARENT THROUGH THE AMPLIFIED SOUNDS OF THE DROPLETS. YOU CAN CHOOSE TO DON THE HEADPHONES, TUNING OUT THE DROPLETS TO LISTEN TO THE INTERNAL STRUGGLE OF
WATER, REPRESENTED HERE BY THE SOFT CRACKLING OF THE MELTING ICE. THE DROPLETS ARE COLLECTED INTO THE REVERSE OF THE STRUCTURE, DEPICTING ITS REBIRTH AND REUSE.

FINAL DEMONSTRATION

For our final presentation, we set up our installation in a dark square environment made of black curtains. The installation was highlighted by two spotlights; one placed in the top right corner of the entering curtain aiming at the ice structure and another one placed in the bottom right corner of the opposite side of the entrance aiming at the water-collecting box. Initially this box was going to have an inner led-based lighting but after some useful insight by Mark, we decided to go with the second spotlight.

Even though the ice structure came fractured off the mold, we managed to place it on the metallic grid and connect the hydrophone to a wired headset. From that point, the ice started slowly melting on the angled metallic sheet connected to the piezo, transferring its sound to a wired speaker near the second spotlight. We decided to place the speaker opposite the installation entrance so that viewers would be able to observe the melting act while listening to the drops from the same direction. We managed to have every part of the demonstration in-place about two hours ahead of the start of the exhibition.

During the demonstration, visitors responded positively to our installation, showing great appreciation to our narrative vision behind it, which prompted many to share their own interpretations and opinions. Some even attempted to gently interact physically with the piece, touching the structure and the metallic sheet. One point that both the team and the visitors noticed was that the inner-ice sound, coming from the headphones, was quite thin, less consistent, and at times barely noticeable due to the melting stage of the structure.
Another point that the team did not expect was that the temperature of the room would be quite higher than the rest of the exhibition building, accelerating the melting process. We believe that the cause for this was the complete insulation of the room with dark material in combination with the number of people actively inside that closed space. Other notes we took from the demonstration were about the spotlights creating flattering reflections on the ice and the box, enhancing its visual appeal but also the behavior of drops sometimes falling outside of the water-collecting box, creating a potential safety concern for the visitors. Finally, the fractured ice structure did not seem to worry about the visitors. While melting, some cracks merged while the main dividing one separated further adding an engaging dynamic to the installation. Overall, we considered the feedback received to be overwhelmingly positive, and essential for further improvement.

CONCLUSION

Our project embodies the meeting point of art, nature and technology, following the spirit of the Art and Tech course.
A foray into the unknown, an exploration of how the ephemeral and the transient can reveal profound truths about the never-ending character of transformation. We invited our audience to listen, to perceive the transience of time and the fragility of our reality.
What started as a mostly technical challenge evolved as a poetic dialogue with this amazing material. By learning to see water not as a limitation, but as a collaborator, we have understood the hidden stories that only this elixir of life can reveal. We found that the crack in the final model showed the nature of controlling and affecting our environment and just as our structure, nothing is ever perfect or unchangeable.
All indicate that change might not be visible at one glance, but looking through a greater frame of time, the impact is major. One droplet might not be noticeable, but everyone hears the rain, a melting structure of ice won't melt at once, but with enough time its state will completely change. And while the water slowly finding its way into a vessel does not seem very drastic, eventually the vessel will fill up. This is all proof that change has an impact, and if we, as humans, cannot notice it as happens, then we should think of our general view of change in our world.



Figure 18: The Team, from left to right: Isa, Mark, Ben, Vlad & Vasilis.

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APPENDIX

Collection of images from the project.



