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Reto climático: proyectar para la subida del nivel del mar

Climate challenge: designing for sea level rise

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Abstract

This paper describes a teaching improvement experience in third and fourth year design studio within a combined engineering and architectural design MEng degree at the Bartlett School of Architecture, London. The proposal was developed over the first four weeks of the academic year as an "ice breaker" exercise. The aim of the exercise was to meet three objectives: a critical and rational approximation to climate change in a context of uncertainty around possible future scenarios, involving the students in their own learning, and leaning on the materiality of their projects by asking them to build a scale prototype that floated or negotiated rising sea levels in any other way. The results of this exercise were highly satisfactory for both faculty and students. The latter got very involved in the process, and were able to build a highly convincing discourse supported by very interesting physical prototypes.

***Keywords:** climate change, flooding, uncertainty, physical modelling, adaptation.*

***Thematic areas:** research led teaching, active methodologies, challenge based learning, design / build, environmental technologies.*

Resumen

En esta comunicación se describe una experiencia de mejora docente en tercer y cuarto curso proyectos en un triple máster en arquitectura e ingeniería en la Bartlett School of Architecture, Londres. Esta propuesta se desarrolló durante las cuatro primeras semanas de curso, a modo de ejercicio para "romper el hielo." La intención era incidir en tres objetivos: una aproximación al problema del cambio climático de una manera crítica y racional ante la incertidumbre de los posibles escenarios futuros, implicar a los estudiantes en su propio aprendizaje, y profundizar en la materialidad real de los proyectos haciéndoles construir un prototipo a escala que flotase o se defendiera de la subida del nivel del mar por cualquier otro medio. Los resultados de este ejercicio fueron altamente satisfactorios para el profesorado y el estudiantado. Estos últimos se involucraron totalmente, construyendo un discurso totalmente convincente apoyado en prototipos muy interesantes.

***Palabras clave:** cambio climático, inundaciones, incertidumbres, modelo físico construido, adaptación.*

***Bloques temáticos:** investigación educativa, metodologías activas, aprendizaje basado en retos, diseño/construcción, tecnología medioambiental.*

Resumen datos académicos

Titulación: MEng Engineering and Architectural Design

Nivel/curso dentro de la titulación: Tercero y Cuarto curso

Denominación oficial asignatura, experiencia docente, acción: Design Practice

Departamento/s o área/s de conocimiento: Arquitectura e Ingeniería

Número profesorado: 5

Número estudiantes: 14

Número de cursos impartidos: 2

Página web o red social:

https://summer2024.bartlettarchucl.com/room/meng-unit4-flooding

Publicaciones derivadas: *no*

1. Introduction

The Engineering & Architectural Design MEng (EAD) at University College London (UCL) is an integrated master degree taught over four years. The course has been designed in close collaboration with industry leaders to combine the three major disciplines in the built environment, architecture, civil engineering, and environmental engineering, and it prepares graduates to be future industry leaders.

The course is led by three departments within UCL: The Bartlett School of Architecture, the Institute of Environmental Design and Engineering, and the department of Civil, Environmental and Geomatic Engineering. This integrated master supports students in developing robust interdisciplinary knowledge and experience. The programme is built with the design studio at the centre of engineering and architectural education, and 50% of credits are taught in a design studio environment by staff from all three departments.

The structure of this MEng is shown in table 1. In the first three years all the modules are compulsory. In the fourth year, they have two compulsory modules: Dissertation and Design Practice 3 (90 credits) and 30 credits of optional modules. As table 1 shows, the Design Practice modules account for half of the workload in years 2, 3 and 4.

Design studio modules in year one are shorter modules, focused on 1:1 design and construction in which students work in teams building pavilions. In Design Practice 1, students undertake design projects in response to a brief that is set across the whole cohort, through weekly tutorials and regular workshops. Design Practice 2 and 3 are taught within a unit system, common in British architectural education[1]. Each unit is staffed with design tutors from the three disciplines / departments, who set a unique design brief for the year. Circa 10-15 students join each unit and develop a design project, which is handed in as an interdisciplinary portfolio of architecture and engineering work at the end of the academic year.

Throughout the year, students use engineering tools to improve their design proposals, working with advanced fabrication facilities. Students develop their ability to critically consider and identify relevant questions and challenges in the built environment, develop creative proposals, and contextualise and advocate for their work as it progresses according to their level.

2. The teaching experience

The EAD's first cohort graduated in the Summer 2021, amid the COVID-19 pandemic, and the effects of remote instruction have been a challenge for such a young programme, forced into three years of online or hybrid instruction at the very beginning of its life.

The teaching improvement experience described in this communication corresponds to Unit 4 in modules Design Practice 2 and 3. The third and fourth year students involved in this teaching experience began their studies in September 2020 and September 2021 respectively. Following College policy at that time, they began their design training remotely, which means that they tend to default of digital tools when starting a design exercise in Design Practice.

This innovative experience started in the 2022-23 academic year, the first year of uninterrupted face-to-face teaching after the COVID-19 pandemic lockdowns. That year, a short four to five

[1] The 'unit system' was first introduced at the Architectural Association in 1936, at a time the school moved away from a Beaux Arts model of education to a course structure and curriculum based on modernist principles. This system, that groups circa 15 students under the tutelage of one or two tutors was brought to UCL's Bartlett School of Architecture in the 1990s under Prof. Peter Cook's directorship (Bottoms, 2010).

week design exercise was introduced as part of the module structure, and the Unit 4 tutors decided to frame this as a making exercise. The reason for this decision was an attempt to balance the weight of analog and digital forms of working among two cohorts of students that had the beginning of their design education significantly shaped by distance learning and tended to default to digital tools as a result. The experiment was refined in the academic year 2023-24 by closely relating the exercise to the topic of the brief (flooding) and introducing an element of empirical testing at the end of the four weeks.

Table 1. Engineering and Architectural Design MEng Prospectus

Cr.	Year 1	Year 2	Year 3	Year 4
15	Mathematical Modelling and Analysis	Advanced Mathematical Modelling and Analysis	Making Buildings	Engineering and Architecture Dissertation
15	Building Physics and Energy	Urban Physics		
15	History and Theory of Engineering and Architecture		Professional Practice and Management	Elective Module
15	Building Physics and Environment	Environmentally Responsible Building Systems	Sense, Sensing and Controls	Elective Module
15	Materials Mechanics and Making	Structures and Foundation Analysis	Mechanics of Buildings	
15				
15	Design Make Information	Design Practice 1	Design Practice 2	Design Practice 3
15	Design make Live			
15				
15				

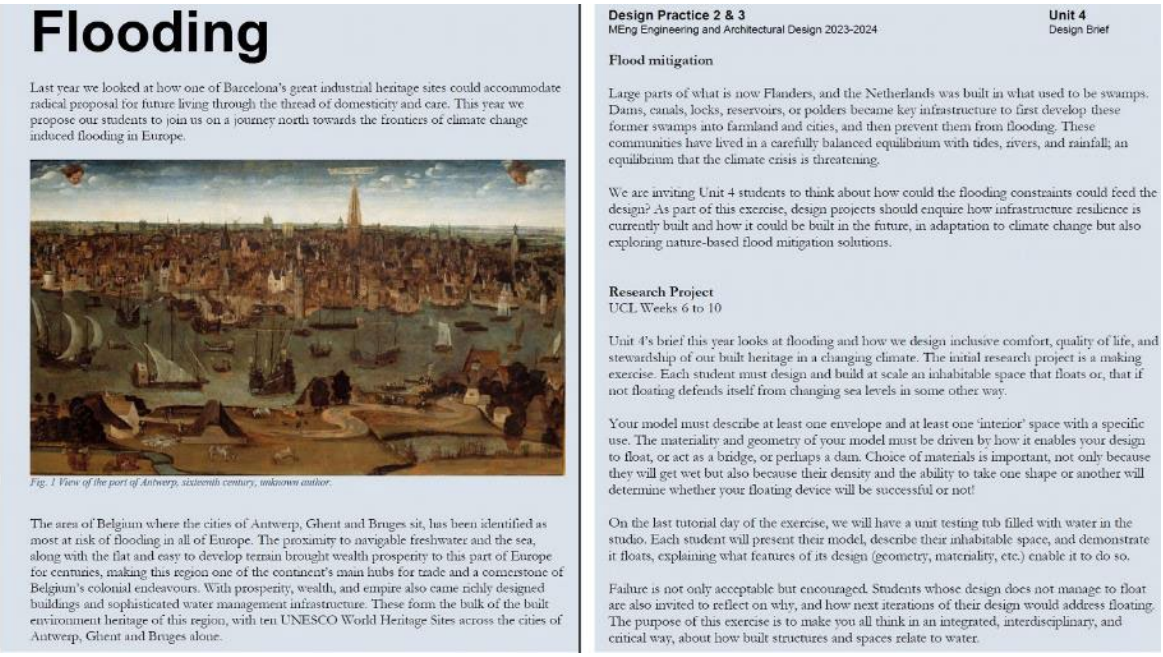
	Institute for Environmental Design and Engineering
	Bartlett School of Architecture
	Department of Civil Environmental and Geomatic Engineering
	Shared across all three departments

Source: The authors based on University College London's Engineering & Architectural Design Meng information

2.1. Description of the proposal

The proposal was scheduled during the first weeks of the year, in order to provide an ice breaker exercise that would set the students into a hands-on mode of working from the beginning by doing something different, fast, fun and ground-breaking relative to the teaching received thus far. The unit brief, which described the exercise in detail (see *Fig. 1*) asked students to design and build a scale model of an inhabitable space that could float or defend itself from changing sea levels by any other means.

The group was given a timeframe of four weeks to develop their proposals. The first session consisted of a longer introduction to the brief by the unit tutors, and a short lecture on model-making with both historical and theoretical reflections and practical examples. This was followed by a weekly day-long session of individual tutorials held in a round table format, culminating in a year-wide review with all units in which students had to demonstrate their prototypes' ability to float in a water tank provided.



Flooding

Last year we looked at how one of Barcelona's great industrial heritage sites could accommodate radical proposal for future living through the thread of domesticity and care. This year we propose our students to join us on a journey north towards the frontiers of climate change induced flooding in Europe.

Fig. 1 View of the port of Antwerp, sixteenth century, unknown author.

The area of Belgium where the cities of Antwerp, Ghent and Bruges sit, has been identified as most at risk of flooding in all of Europe. The proximity to navigable freshwater and the sea, along with the flat and easy to develop terrain brought wealth prosperity to this part of Europe for centuries, making this region one of the continent's main hubs for trade and a cornerstone of Belgium's colonial endeavours. With prosperity, wealth, and empire also came richly designed buildings and sophisticated water management infrastructure. These form the bulk of the built environment heritage of this region, with ten UNESCO World Heritage Sites across the cities of Antwerp, Ghent and Bruges alone.

Design Practice 2 & 3 **Unit 4**
MEng Engineering and Architectural Design 2023-2024 Design Brief

Flood mitigation

Large parts of what is now Flanders, and the Netherlands was built in what used to be swamps. Dams, canals, locks, reservoirs, or polders became key infrastructure to first develop these former swamps into farmland and cities, and then prevent them from flooding. These communities have lived in a carefully balanced equilibrium with tides, rivers, and rainfall; an equilibrium that the climate crisis is threatening.

We are inviting Unit 4 students to think about how could the flooding constraints could feed the design? As part of this exercise, design projects should enquire how infrastructure resilience is currently built and how it could be built in the future, in adaptation to climate change but also exploring nature-based flood mitigation solutions.

Research Project
UCL Weeks 6 to 10

Unit 4's brief this year looks at flooding and how we design inclusive comfort, quality of life, and stewardship of our built heritage in a changing climate. The initial research project is a making exercise. Each student must design and build at scale an inhabitable space that floats or, that if not floating defends itself from changing sea levels in some other way.

Your model must describe at least one envelope and at least one 'interior' space with a specific use. The materiality and geometry of your model must be driven by how it enables your design to float, or act as a bridge, or perhaps a dam. Choice of materials is important, not only because they will get wet but also because their density and the ability to take one shape or another will determine whether your floating device will be successful or not!

On the last tutorial day of the exercise, we will have a unit testing tub filled with water in the studio. Each student will present their model, describe their inhabitable space, and demonstrate it floats, explaining what features of its design (geometry, materiality, etc.) enable it to do so.

Failure is not only acceptable but encouraged. Students whose design does not manage to float are also invited to reflect on why, and how next iterations of their design would address floating. The purpose of this exercise is to make you all think in an integrated, interdisciplinary, and critical way, about how built structures and spaces relate to water.

Fig. 1 Year 2023-24 Unit 4 brief. Source: the authors

2.2. Aims of the proposal

Most design briefs in architecture schools around the globe present students with a site, a more or less open-ended research topic or both. As a result, students embark on a journey of deductive thinking through research in said topic and/or analysis of the site, from the more open and generic to the more specific, from the larger scale to the detail. The exercise presented in this experience was framed to short-circuit this linear mode of thinking. Instead, the tutors proposed to start the year with a very specific exercise to be resolved at a scale quite close to that of the user. This is a scale that many studios tend to postpone, if at all deal with. Such a framing of the design brief aims to engage with Edward De Bono's ideas of lateral thinking, and specifically with the emphasis he draws towards the selection of the entry point into a creative process as crucial to the setting of priorities and the attraction of the designer's attention. (de Bono, 1990)

Following the ideas of Atxu Amann and Gonzalo Pardo in their 'Specul-actions Preparatory Workshop' (Amann, 2014), the proposals did not need to be useful or practical. The intention was to initiate a design research stream connected to the uncertain future of our climate in order to generate a desire for transformation and innovation.

This research exercise was focused on three main objectives:

(i) To reflect on the climate emergency;
(ii) To involve students in their own learning; and
(iii) To deepen the real materiality of the projects by having them build a scale prototype of their proposal.

One of the main objectives of this experience was to encourage students to approach the problem of the climate emergency in a critical and rational way, in the face of the uncertainty of possible future scenarios. While this exercise is not comparable in scale or ambition with the well-known Solar Decathlon competition, both share the objective of educating the next generation of architects and engineers on the challenges of the climate emergency and the need for efficient use of limited resources, and to inspire the public (Kalpkirmaz, 2023). With this aim, the students

were asked to individually design the above-mentioned inhabitable space that would float or defend against the rising sea levels, proposing and describing, at least, an envelope and an interior use. The materiality and geometry of the prototype had to be conditioned by the requirement to empirically demonstrate that their design was able to float, or act as a bridge or dam.

This issue links to the second point of the proposal: within a research-based teaching model, students are responsible for their own learning.[2] According to Mª Isabel Alba (Alba, 2019)

> *'Unlike other subjects in which the students adopt a passive attitude towards a learning process controlled by the teaching staff, the teaching of the architectural project requires a change of attitude from the very beginning. Students must become critical subjects who actively participate in their own training process, while the teaching staff must act as facilitators in this teaching-learning process.'*

With this aim, the students are encouraged and expected to develop and set their own design brief, clearly stating the challenge to be pursued, and their approach to address it. As a result, another aim of this exercise was to invite students to reflect in an integrated, interdisciplinary, and critical way on how the built environment can relate to water.

Bearing in mind that the possible behaviour of the designed artefact depended to a large extent on the choice of materials and shapes adopted, it was proposed that the only deliverable would be a physical prototype, to scale, made with the materials with which the real object would be built, or with materials that could be assimilated to them.

This leads us to the third point of interest of the teaching improvement: the resulting scale prototype was subjected to the conditions defined a priori by each student: an artefact that floats, an artefact on pilotis that the new sea level does not reach, an artefact that works below the water level, etc. To this effect, learning by doing was at the core of this exercise, to balance the weight of analog and digital resources and skills, and to return to the physical prototypes that were made in the last century in schools and architecture studios, and which have in many cases been replaced by digital ones.

According to Tuğlu Karslı and Özker (Tuğlu, 2014), architectural education combines the acquisition of technical knowledge with less tangible or conceptual abilities such as, imagination, intuition, flexibility, and creativity. It is therefore beneficial for architecture students to become accustomed to learning abstract concepts that are self-taught through their own design experience rather than delivered in a lecture setting.

With this purpose, the students were encouraged to research the materials available in the market, their properties, conditions of application, advantages, carbon footprint, etc. and to apply them to their proposal. All the while bearing in mind that the scale of the prototype often required a translation of materials to match the performance in the water tank test, a process that involved many of the above abilities: intuition, flexibility, and imagination; as well as technical knowledge.

2.3. Results

After the four weeks of this exercise, all students had around 10 minutes to present their proposals, explaining their reaction to the brief, their interests and how they had technically and conceptually developed these into a prototype. Many shared calculations or models

[2] Research-based education is one of the foundational and guiding principles of the University College London, and the University is currently second in the UK in 'research power' after Oxford University.

demonstrating whether their artefact was supposed to float (or not), but they all had to empirically demonstrate these findings by placing their prototype in a water tank (see *Fig. 3*).

Fig. 2 Presentation of the proposals. Authors: a) Ako de Siran b) Cameron Alexander c) Shakthi Manoharan d) Lama Ahmed e) Claudia Navarro f) Juliette Loubens

The diversity and richness of the results impressed both the unit tutors and guests from other units alike. The range included prototypes that analysed the damaging effects of rising sea levels on London's Victorian housing stock (*Fig. 2a*), to artefacts designed to coexist with varying sea levels in a dynamic way (*Fig. 2b*), and including proposals that focused on the politics of the climate emergency from, the climate denial propaganda to the inaction of the political class. Within this range, the proposal for an uncomfortable space (*Fig. 3b*), designed for local politicians deserves highlighting. Within this space, lawmakers experience in their own flesh the undeniable

effects climate change induced raising sea levels. The proposal would expose decision makers to feelings of vulnerability in the face of the combined effect of the wind, the rain and the sea, in an attempt to bias their decision making, not without a dose of vindictiveness.

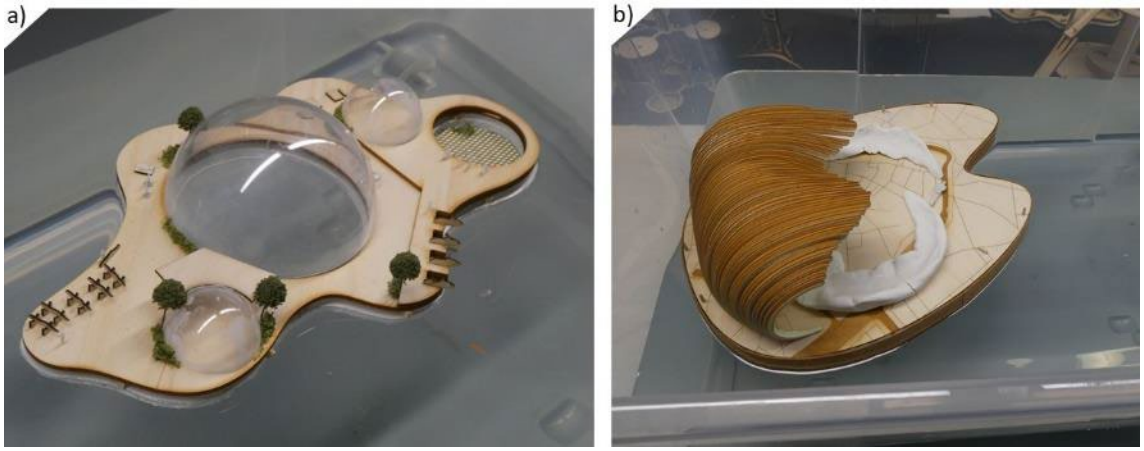


Fig. 3 Floating artefacts. a) Author: Noey Satheinsoontorn b) Author: Marjoleine Mooijiman

2.4. Student feedback

In order to evaluate the results of the exercise beyond the qualitative assessment carried out on the day of its conclusion, a survey was handed out to the students at the end of the academic year, asking them to reflect back on a year of design studio and comment on the role that this first exercise had in the overall development. The surveys were handed over during the last day of tutorials in paper form to be filled in by the students and hand over by the end of the day.

The questions in the survey were as follows:

1. Did you like being responsible of coming up with your own brief for your research project?
2. Do you think that including current affairs such as climate change and sea level rise in the project brief has helped you improve your understanding of those issues?
3. Do you think that including current affairs such as climate change and sea level rises in the project brief has helped you improve your skills?
4. Do you think that being constrained to a physical model for this exercise adds richness to your learning?
5. Do you think that the research for selecting materials in your model has help you develop new skills?
6. Do you think four weeks is enough time to develop this research project?
7. Do you think the water tank experiment added richness to your learning through this project?
8. Did you find planning for the water tank test challenging?
9. Are you happy with the result of your research project?

With the distribution of answers shown in *Fig. 4*, it can be observed that students overall felt quite positive towards the proposal. The more controversial issues were the lack of time to develop the exercise (question 6), and the responsibility for proposing their own approach to the exercise (question nº 1 with 30% disagreeing or totally disagreeing).

On the other hand, it can be seen that more than 70% of the students agree or totally agree that including climate change, developing a physical model, researching about materials, and demonstrating their designs' performance in the water tank added richness to their learning and improved their skills, with the 80% happy with the results of their research project.

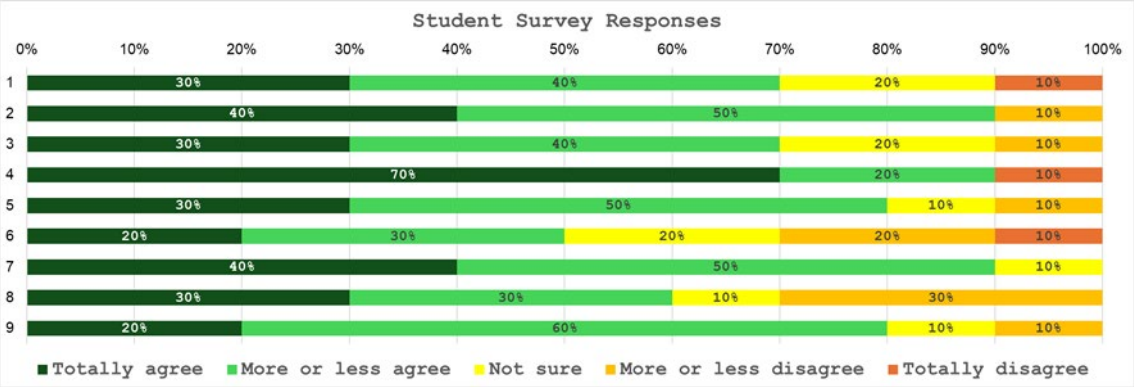


Fig. 4 Survey responses. Source: The authors

3. Discussion

The success of the exercise described is discussed from the point of view of student experience and from the more academic perspective of the tutors delivering the module.

3.1. Students point of view

The survey above was drafted and distributed among students to gather their feedback and add a student perspective to this paper. The responses show a very strong agreement around the premise of question number four, with students highly valuing the relative analog bias of the exercise within an academic context that is computer dominated. This was an expected outcome of the survey as the lecturers observed that this analog prompt was taken on by a majority of students who used hand sketching to develop their models and then carried on this design methodology for the rest of the year. Some of these sketches are shown in *Fig 5.* Additionally, handmade story-telling sketches have been presented to explain the uses of the spaces and their adaptation of the rising of the water level, as can be seen in *Fig 6.*

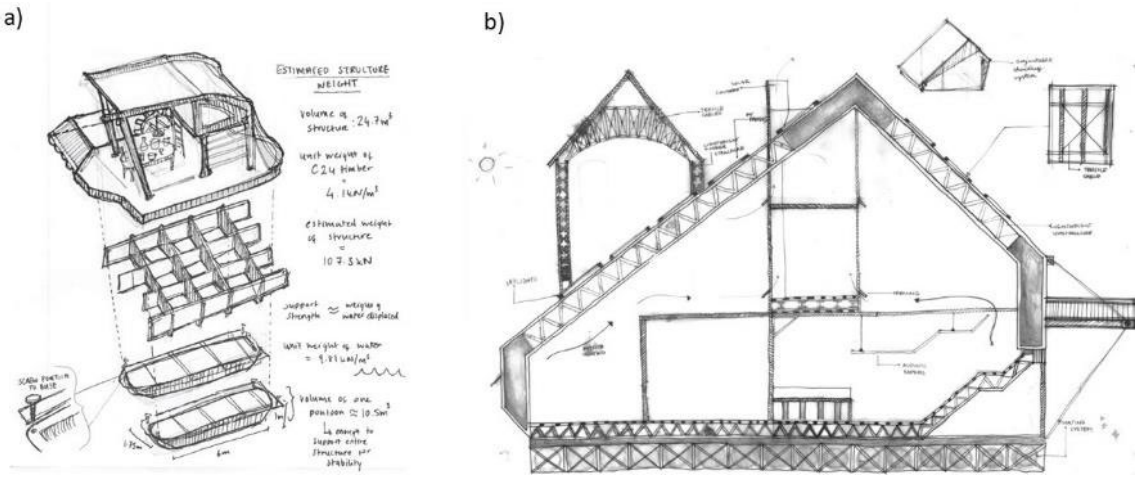


Fig. 5 Examples of hand sketching for the design and development of the four week exercise extracted from students' final portfolio submission. a) Author: Shakthi Manoharan b) Author: Aleksandra Lemieszka

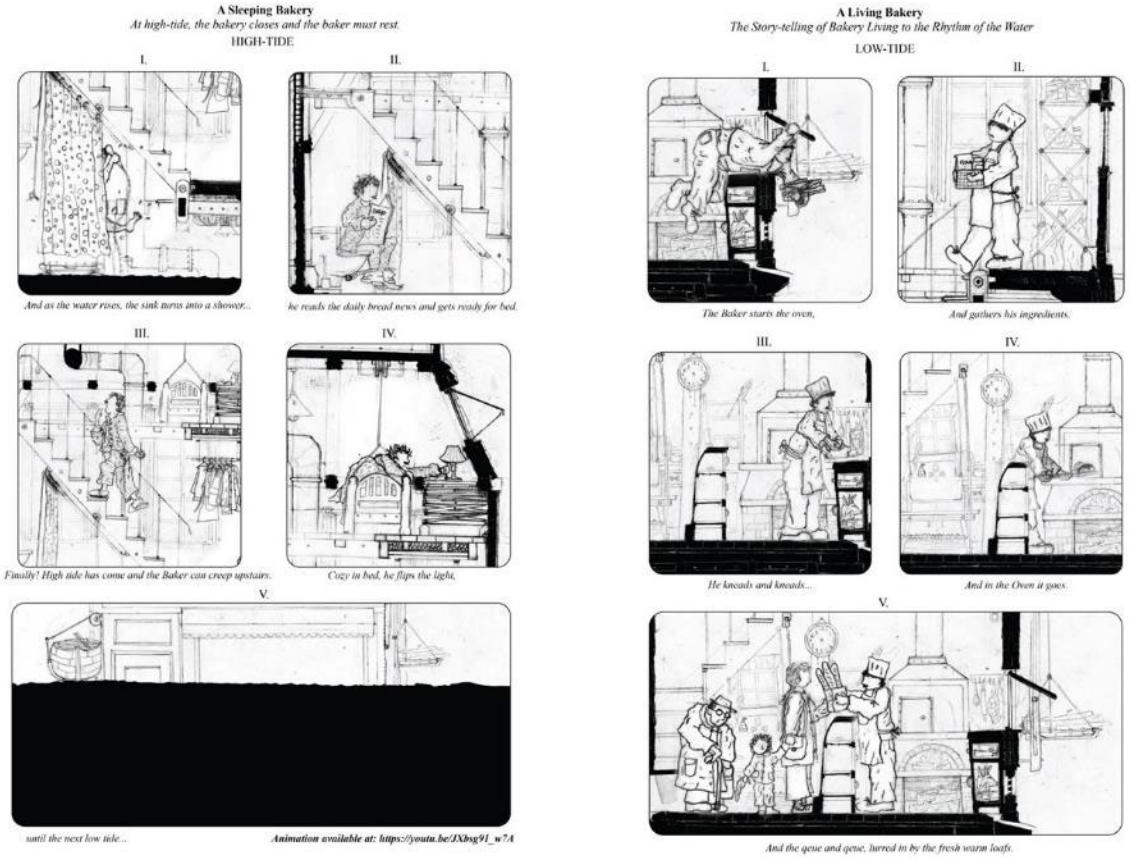


Fig. 6 Story-telling of Bakery living following the tide's rhythm. Author: Juliette Loubens

There was also a strong agreement around the premise that the exercise had excited students' curiosity to learn more about the climate emergency and its effects on the built environment. This was a less expected outcome from the exercise initially, but it was palpable in the projects that students developed over the rest of the academic year. These proects engaged with the high risk of climate emergency driven flooding across the sites in Flanders in creative and innovative ways. Examples of this approach included a flooding council chambers or a floating cattle farm.

The last area of strong agreement among students, was on the value of the empirical testing of the prototypes at the end of the exercise. This response was not a surprise given the positive and enjoyable atmosphere of the day, which lead to the intuition that students had valued this part of the exercise in a positive manner.

Architectural education has historically utilised public presentations for reviewing design work and provide feedback to students, typically referred to as 'crits' (short for 'critique') in the British context. These forms of assessment and feedback have recently been under severe scrutiny from a student wellbeing and pedagogical standpoint, and many have criticised their pedagogic value and have highlighted how the format can often reproduce or even amplify existing biases within faculty and the wider profession. (Flynn, 2019) It was therefore refreshing that this particular review, given its performative and live empirical demonstration aspects, broke down the pattern of a typical design review and put the student project and presentation at the centre, with comments from guest 'critics' leaning towards understanding more about the students thought and design process than to critiquing it.

3.2. Lecturers point of view and grades

The exercise described in this paper is not assessed as a standalone piece of work, but rather its assessment forms part of the grade for Phase 1 (Registration) within the Design Practice module. Despite this, the performance of the student in this initial exercise was key to the discussion of their performance and marking their work for the module overall.

Unit 4 staff were in agreement on a strong correlation between the commitment to and success with the initial exercise, and the result of the overall portfolio. This correlation was particularly strong in terms of risk-taking in the student's approach to the brief. I.e. students who took more risks in the initial exercise, were able to build on this pedagogic experience and increase the ambition of their year-long project.

As a result, Unit 4 faculty concluded that the first exercise provides the students with a relatively safe space for taking risks almost consequence free, since its grade implications are very limited. This framing of the first exercise is complementary to the one set out at its inception as a self-contained 'warm-up'.

The subject of this project is far removed from professional practice, yet valuable to the training of future practitioners. This initiative focuses more on research and practice, without pursuing a professional utility. As Linazaroso states

> *"The School, like the University in general, is a field of teaching and research and not a place for the fictitious reproposal of professional relations which do not exist. It is, in any case, a paradigm of "external"* [and we would add future] *problems and a reflection on these problems."* (Linzasoro J.I. 1984)

On the matter of grades, it is worth noting that these are evenly spread across the first two phases of the module (30% each), with a small additional weight (40%) given to Phase 3 (Synthesis). Moreover, these grades are built up of assessments by tutors from the three disciplines, who look at different sets of learning outcomes but share the same assessment criteria, common to all design work at the Bartlett School of Architecture since the 1990s:

- Observant Analysis
- Intellectual Ambition
- Design Development and Synthesis
- Communication and Representation

The module follows a process of double marking, but does not carry out blind marking. I.e. first marks are given by unit tutors who have taught the student, and the work is second marked and moderated by the module coordinators, who have visibility of submissions and marks across all units, to ensure parity.

With the above in mind, the grade results of implementing this exercise are promising, with the caveat that many other factors have gone into influencing grades since its introduction, such as the return to face-to-face teaching, or the programme moving to a new building.

4. Conclusions

In conclusion, this experience of analog making and empirical testing to kick-start a year-long design module has been very positive. On the one hand, the thematic and methodological framing has helped students find a strong focus to their projects very early on, helping them balance their use of analog and digital tools, as well as providing new entry points into learning about the climate emergency. On the other hand, the grade results have shown a correlation between the positive engagement with this exercise and overall performance in the module as a whole.

This experience, its results and the feedback received from students validates the framework of starting the year long design module with a shorter exercise centred around analog making. The feedback also highlights the additional benefit of thematically linking the brief for this shorter exercise with the design brief of the yearlong project. As a result the tutors in the unit have committed to continue the strong thematic link between both exercises and use the short making task as a key driver in developing the year-long brief over the summer.

Finally, after the Barttlet Summer Show 2024, that showcase the architectural work of over 900 students displayed across the Bloomsbury home at 22 Gordon Street, London, design website Dezeen published a review about the exhibition, with one of the Unit 4 students prototypes as its cover image (see *Fig. 7*). This has certainly encouraged teaching staff to continue the lines of this innovative approach.

Fig. 7 One of the student prototypes published in Dezeen, design and architecture magazine (Dezeen, 2024). Author: Aleksandra Lemieszka

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