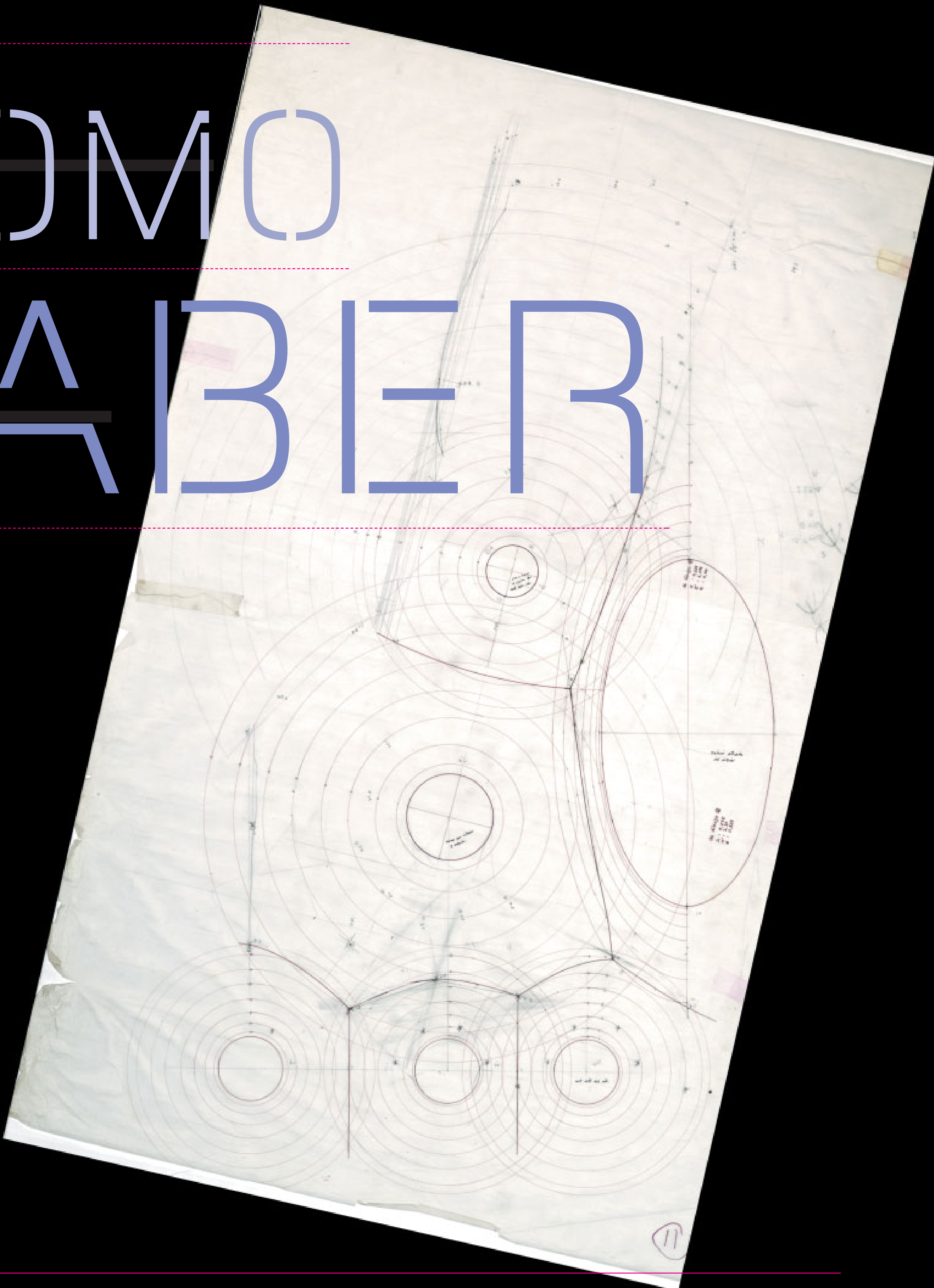
HOMO FABER



During his final 12 years, Gaudí proposed that the surfaces of the Sagrada Família Church all be defined geometrically – he rejected freeform in his experiment in updating the Gothic for the postindustrial age. His plastic experimentation is revealed in his final models for the project, but it is a notoriously slow process. Using cartographic principles, his geometry requires mapping by his successors for the project. This 1980 drawing shows the component geometry for the nave screen-wall composed of a series of different-sized openings formed by intersecting hyperboloids. The task is to find the curves of intersection between adjacent geometry and, more particularly, the 3-D coordinates of the triple points – points in space where three curves of intersections intersect. This work is the intermediary phase between Gaudí's 1:10 plaster of Paris studies, and the construction of the screen itself.

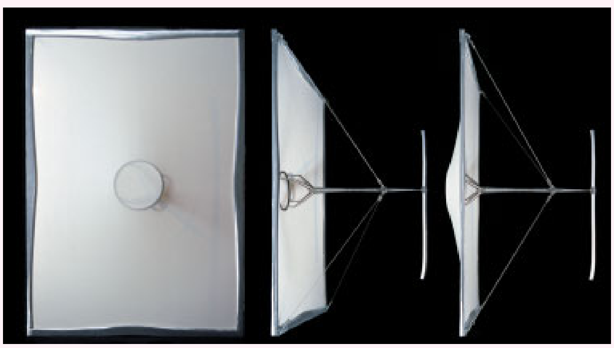
Professor Mark Burry's extraordinary and devoted work is nothing short of a measure by which standards for architectural research are set. Known for his investigative use of computational techniques to unravel the mysteries of Gaudí's Sagrada Família Church, he here takes a moment to reflect on where computational technologies in architecture are taking us. His experience suggests that before we abandon old tools for new, this is a good moment to put the brakes on. Hybrid activity, he remarks, demonstrates unequivocal benefits to the design process, and slow design has proven to be indispensable for success.

1995 student project for an art space
Half-size prototype for a section of the proposed building using a constrained set of timber sizes. The assignment included an investigation into the normally undisclosed potential of constituent materials. Intriguingly, in this example the project's author has used timber in tension to add strength and value to its contribution to the assembly. It is a predigital haptic experiment testing such potential through direct hands-on experience, and it is not certain that these tentative propositions would emerge in digital experimentation alone. (Credit: Colette Mullin)

Visitors to Jean Nouvel's Torre Agbar building in Barcelona during its construction phase will have noticed a large 1:1 3-D prototype constructed in the precinct of the actual building site. The project itself is radical in as many ways as possible – his use of colour and the building's second skin, plan and programme, profile, and its proximity to Gaudí's Sagrada Família Church less than a kilometre distant, apparently in some gesture of homage, though it might be regarded as in competition. In an age where airliners are digitally prototyped, built, then tested entirely from a digital design process, it may seem curious that crude, full-size 3-D prototypes are required during the construction phase of this innovative building, rather than as an essential precursor.

For me, it was one of the more heartening experiences of recent years, where, firmly seated within the context of ubiquitous computing and pervasive digital design, *homo faber* – 'man the maker' – is required to experiment with the actual stuff of his or her endeavours, at full scale and regardless of all the automated design and building aids increasingly at our affordable disposal. Possibly this circumstance is evidence of a maturity in practice, where each tool and each modus operandi is evaluated independently for merit, and retained or adopted accordingly. Successful slow design married to the quicker pace that capitalism ordinarily ordains.

Full-size prototype of a modular fabric screen, predigital in all respects other than the frame, which is shaped in response to calculated bending stresses. The prototype is made from the proposed materials for the final product, including turned stainless-steel fittings, cast aluminium and canvas. (Credit: Chris Norman)



The debate surrounding the appropriateness of the computer in design has shifted away from direct and often unfavourable comparison with *Handwerkskunst* to a number of more intractable and problematic issues – the role of computation in design, apparent enfranchisement of the amateur, the 'art of the accident' elevated to legitimate design enquiry, and the formation of entirely new multidisciplinary creative teams mediated by the computer. New paradigms for practice through the previously impossible virtual collocation of designers and manufacturers, and the real effect of rapid prototyping, has yet to reach proportions that actually threaten time-honoured craft based firmly and exclusively within the discipline of architecture. When the affordability and ubiquity of rapid prototyping facilities attain levels similar to the desktop computer and associated 3-D modelling software, however, will we see the end of the studio as we have known it since *homo faber* first experimented with the plastic formation of ideas? There are already indicators that we will have a similar period of the less thoughtful and zealous overproduction that comes with the ease of automation, typified by the increased use of paper precipitated by the arrival of the inkjet plotter.

The seed for CAD (computer-aided drafting to some, computer-aided design to others) was first sown within the education sectors of graphic representation and professional practice, thus beginning its life in relatively innocuous circumstances with regard to the status quo. CAD, after all, would be a significant labour-saver at the level of drafting, providing the designer with extra time to contemplate and reflect – increased time to hatch ideas rather than hatch drawings. The shock wave caused by the rapid and unplanned infiltration of CAD to wider architecture programmes worldwide during the 1990s, most notably design, has exacerbated the traditional generational gap that has always spiced up architectural educational programmes.

Formerly, during at least 150 years of institutionally based architectural education, programmes benefited from the frisson of the antler-locking between experienced world-weary senior practitioners and the young Turks not yet burdened with mortgages and family responsibilities and atypically willing to provide free labour in support of the project. A further predominant source of creative friction came from the competing agendas of theory and practice, further complicated by the debate between architectural historians (architects first, historians second) and their counterparts, historians of architecture who have never made a single building, still less designed one.
In this context, during five years of study, contrasting often with contiguous part-time work in offices or the interregnum of a gap year, young architects could set their sails according to their own predilections formed from a clear and reasonable set of both contrasting and complementary priorities.

With the insurgency of new digital design tools to the design studio, new pressures and often irreconcilable differences have produced, in many cases, an unbridgeable gulf between the fuddy-duddies, whose currency is the sagacity born from experience, and a generation of digitally adept school-leavers, who not only have to attempt to assimilate the priorities associated with a traditional way of practising that increasingly becomes irrelevant, but are also in the key position to point towards new ways of operating without the benefit of any meaningful apprenticeship in as yet untried modes of practice. Of course, in the world of exploring ideas this situation provides wonderful opportunities for truly innovative design enquiry, not least in the world of virtual space, and the spatial representation of information that is everything about intellectual engagement but may have nothing to do with a more tangible world of bricks and mortar.

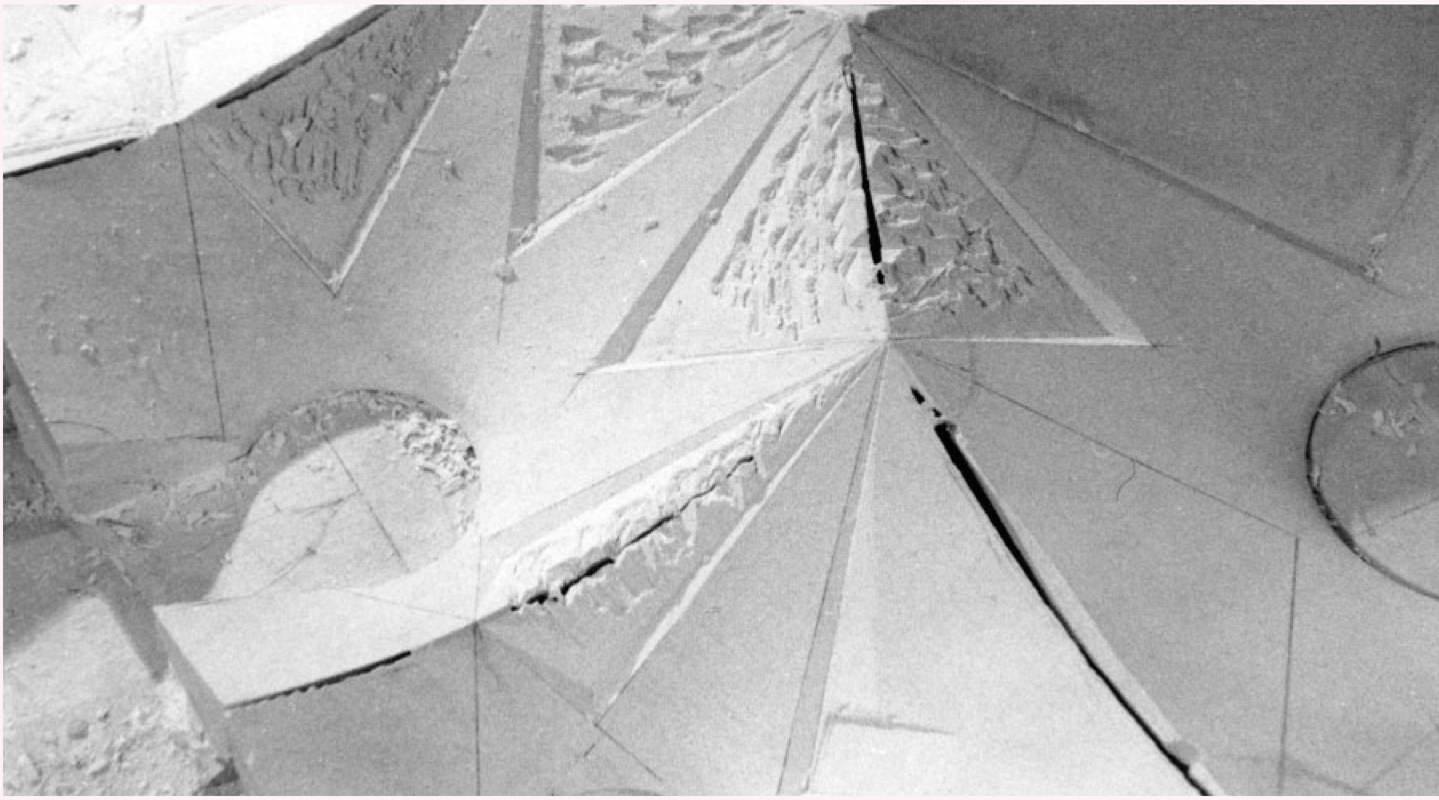
Sagrada Família Church
Gaudí's quest for form is plastic in its expression yet rational in its description. It emerges from a haptic process using setting plaster of Paris. In the 20 minutes it takes for the plaster to set, the rotating hyperbola profile shapes half a hyperboloid of revolution that acts in turn as the master form to provide any number of negative reproductions.

The production of negative hyperboloids of revolution, which are the actual components sought for interaction with neighbouring forms.

In terms of being able to influence practice, the profession has now suffered for some while from an impasse that curiously affects architecture in ways other industries have been able to deal with quite successfully; most notably the aeronautical, nautical and car design industries, along with manufacturing. Rapid prototyping and the efficiency gains obtained thereby are regularly proselytised as the necessary technological advance required to lift the profession of architecture into the 21st century. My experience in both teaching and practice to date suggests that this is a good moment to apply the brakes to headlong adoption of all the new tools prior to figuring out how we will at least retain the skill base of traditional methods of design exploration and representation, especially in 3-D. It strikes me that an amalgam of both handcraft techniques that are currently threatened, and the digital tools that will increasingly proliferate at affordable price points, ought to be actively sustained for at least as long as we need to understand fully what we lose through a degree of abrogation of

Several of the individually produced forms are intersected by hand to provide the underlying rationality for the nave screen-window. The surfaces are all characterised by the fact that they are 'ruled' with an infinite array of 'non-coplanar' straight lines that intersect obliquely with the surfaces. This property aids construction and provides the clues for the decorative treatment.

Decorative overlay in detail for the nave screen-wall. The star-shaped decoration is set up by the straight lines that run obliquely along the surface. Any point on the surface has two such lines running either side of the opening 'collar'. Adjacent surfaces intersect usually as 3-D curves. These intersections themselves intersect, providing key points in space known as 'triple points'. In selecting these key points as the basis for the sculptural surface treatment, Gaudí introduced a decorative logic to the composition. This process involves excision from some of the surface areas, and addition of material to other areas, a handcraft process not easily emulated digitally.



The interior and exterior of the Sagrada Família Church clerestory windows, as proposed by Gaudí at a scale of 1:10.

To make the mould-masters for the full-size components, Gaudí's process is simply scaled up using the same process that he used for his 1:25 and 1:10 scaled prototypes, and uses the same materials.

Full-scale mould-master for part of the central nave ceiling vaults (inverted for convenient fabrication at ground level). This plaster of Paris mould-master is for the production of fibreglass production moulds for building components.

workload to the machine, while not necessarily being blind to what we stand to gain.

Currently, the relative expense of the rapid prototyping machinery and materials combined with the relative slowness of their operation ('rapid', sadly, is a relative term in this debate as a single 3-D print can tie a machine up for more than a day) limit use of such equipment to tasks of relative importance, so this seems a perfect time to ponder the best possible relationship between *homo faber* and the agency offered through the automated procedure. The three projects that follow variously span the 10 years that separate the pre- and postdigital eras, in the first case predating ubiquitous computing, and deliberately make use of the best aspects of both manual and machine-aided making. Together they provide some pointers on how hybrid activity demonstrates unequivocal benefits to the design process, where slow design has proven to be indispensable for the success of the project, despite the successful quest for the relative rapidity provided through adoption of the computer across all sectors of architectural design activity.

1 Student projects: 1:1 – predigital

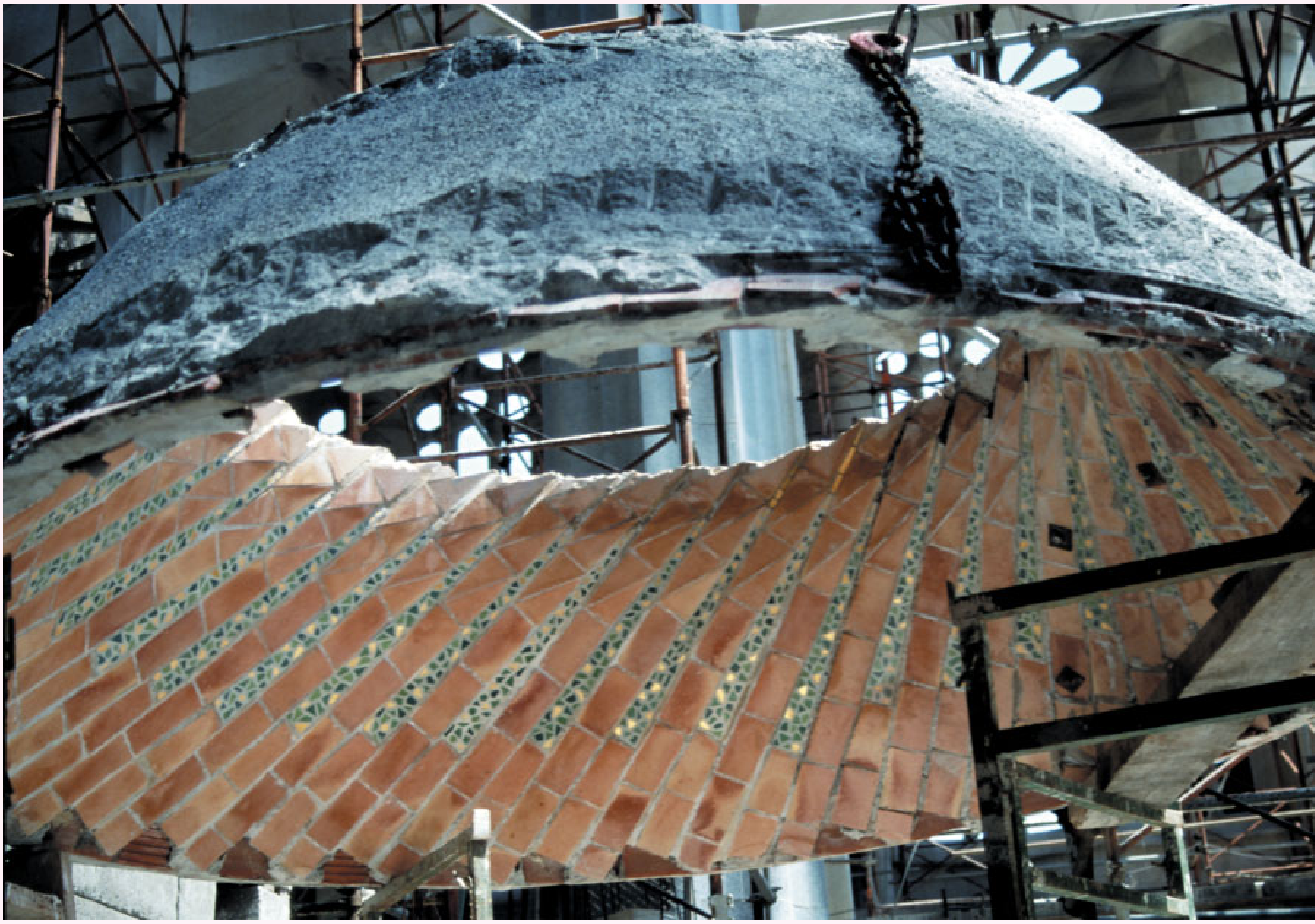
In consolidating the association between idea and artefact, I have been running courses in 1:1 ideation-fabrication for senior students of architecture since 1990. At that time, the construction of buildings was much less interesting to the students than architectural theory, especially theory more inclined towards philosophical preoccupations. Buildings, it seemed, somehow managed to be built from loose sketches. Other people would effect this essential translation – 'they' would find a way with a minimum of prompting. This attitude is apparently still with us, as engineers, among others, regard part of their role as 'problem solvers', where the architect is seen as part of the problem.

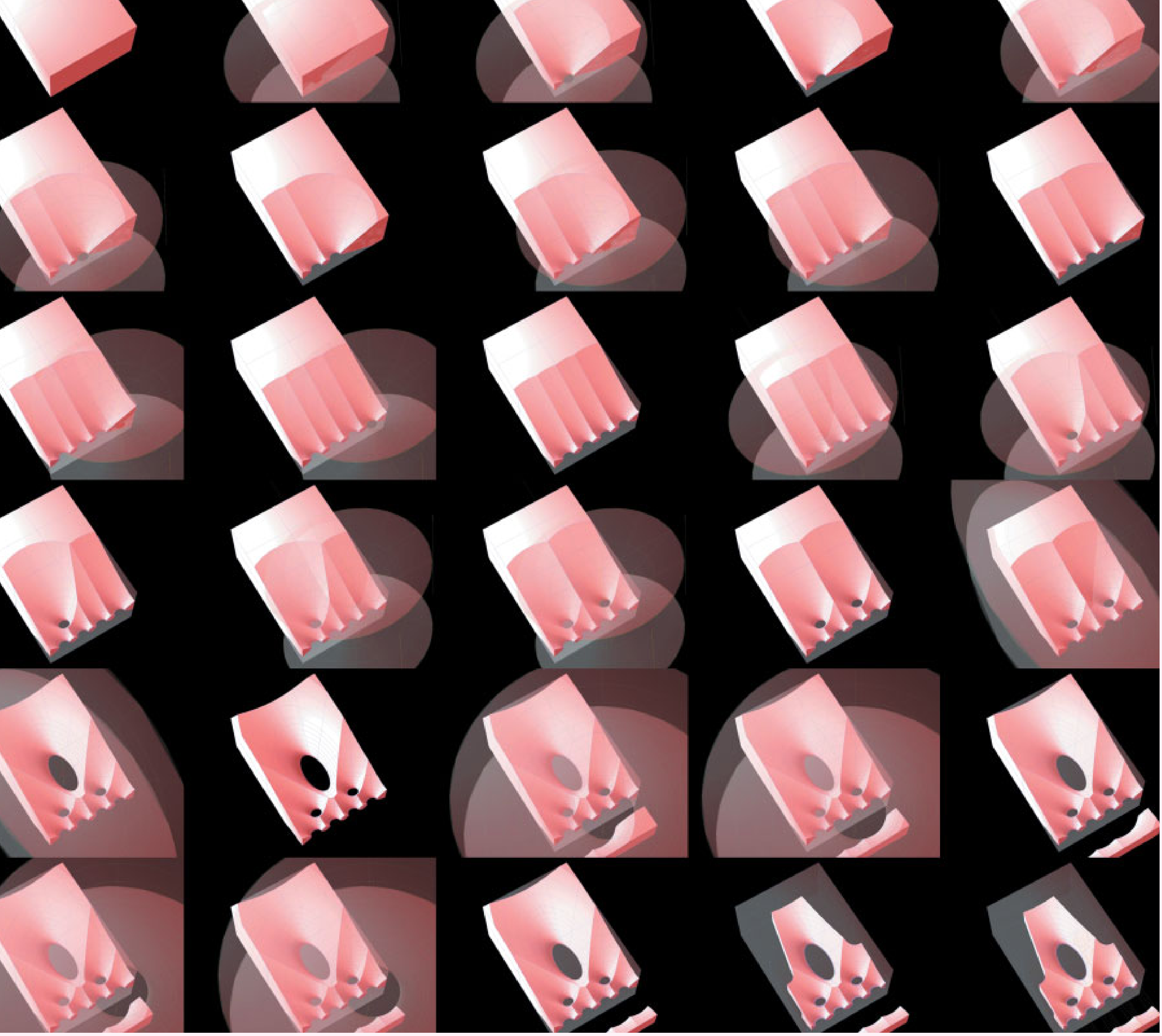
Since commencing with full-scale projects, I have found that in working this way students observe forcefully that, in fact, what they design might be influenced in reverse, that is to say, considering built architecture in its possible fulfilments may work backwards to influence the ideation at a point where the physical manifestation of an idea is still hardly defined. Working at 1:1 essentially means working with real materials where practicable, and simulation only when absolutely necessary. This activity may provide students with interesting insights regarding the messiness of foundry work, the dangers of welding and the propensity for timber to be wayward. More critical, in my view, is the connection with scale, particularly pertinent in an era of CRT/LCD renditions that have no scale at all and the confrontation with materiality and its intellectual extension way beyond fitness for purpose.

The two examples shown here are from a five-week project: a three-week conceptual design for an artist's workshop and gallery within the platform area of a busy railway terminus, followed by a two-week 1:1 3-D *esquisse* of a single meaningful element. Neither project is digital, although one is influenced in shape by numerical calculation of forces. I believe that both projects, and the majority of those of other students at the time, would have

Positioning the fibreglass moulds above the ambulatory around the apse.

Not all the ceiling vaults are made from in-situ artificial stone. The central nave vaults are made from three layers of flat tile using the time-honoured '*bovedas Catalana*' (Catalan vaulting) technique, recorded as being Gaudí's original intention. This image shows the first such use for this project in 1996, 70 years after his death: it has been made as a full-scale prototype, and in this image it is about to be lifted to its proposed location 45 metres above.





The introduction of the computer to the design office in 1989 was to further enhance an exceedingly slow process, whether by hand modelling or the subsequent analytical drawing. This image shows the series of subtractions required to produce the proposal for the nave clerestory.

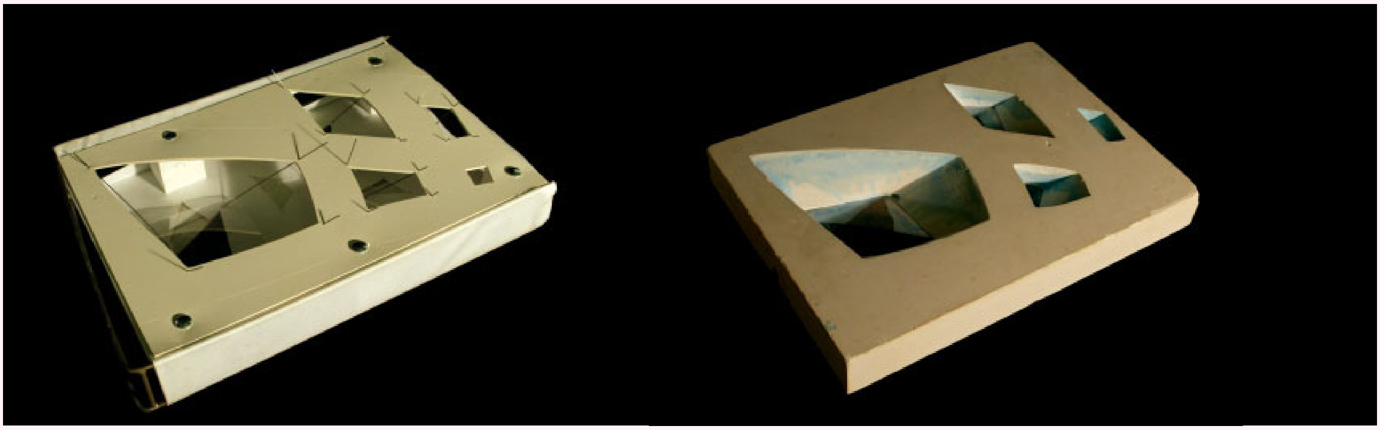
missed many of the potentials and ironies that could only be played out by hand.

2 Sagrada Família: pre- and postdigital design development

Gaudí introduced a rationality to his work at all times, despite appearances to the contrary. He dedicated his final years (1914–26) exclusively to the Sagrada Família Church, and combined the Gothic Revival basis of the design – from an earlier architect's involvement prior to his own commission in 1883 – with a growing sense of a need for a system. The system was to ensure that his design had a legacy, as he realised the implications of his own physical frailty.

The work today is as complicated as it has been for the century and a quarter it has been on site, made more complicated still today by the two million visitors who come to see the building as a construction: the project has to use high-end modelling software aimed for the vehicle and aircraft design and manufacturing sector. Gaudí insisted that innovation must be in the design, not in the making, arguing that traditional methods should be used in order to keep risk to a minimum. In his final years, however, he began to realise through experimentation that new materials and methods would need to be introduced to the project, which can be seen with the construction of the finials on top of the first four towers, with his inevitable uptake of concrete having avoided its use from the first.

The accompanying images show the comprehensiveness of Gaudí's design modelling, and its posthumous translation to full-scale building operations. Especially appealing is that, despite the need for the introduction of software beyond the architectural sector's demands, and despite being one of the first projects ever to involve rapid prototyping of design and CNC automated material preparation, the modelling studio remains intact, and its workforce vibrant, as any visitor can witness. It would seem that not only was the Sagrada Família Church one of the first projects anywhere to have adopted the most sophisticated digital tools, it is also one of the first to enter a postdigital era as a leader, in circumstances where the



Politics of Water design studio
1:10 scale model for the parametrically variable windows. The analogue parametric model shown to the left led to the 1:10 scale model on the right, cast in plaster of Paris. (2004 studio collaboration between architecture and industrial design students: Tatu Parssinen (concept), Sheree Danli Lai, Tony Josendal, Jakob Lange, Stephen Wallace (developed design), Mark Burry, Dominik Holzer, Malte Wagenfeld, Mark Taylor (studio directors)).

continued contribution of the craftsperson is judged as a crucial partner to the digital dialogue.

3 Student project: 10:1 postdigital

The final project shown here is part of a 2004 design studio where architecture and industrial design students worked together on a project based on water, working ultimately to a scale of 10:1. It is an extension to the 1:1 project referred to as predigital, but over a decade later this studio reflects a number of realities and opportunities. The enlarged academy, where student numbers have risen dramatically, means that it is now very difficult to offer them the material intimacy of one on one working at 1:1. We deal with this by asking them to work in groups. However, the use of the Internet not only provides incredible access to materials and construction information, but also allows students to work in different physical locations to each other if desired.

Further, the very nature of design authorship can now be questioned by asking a particular group to work on a project whose original author is not in their midst, he or she being located in a different group, also working on someone else's project. Encouragingly, the original authors have almost always been open enough to acknowledge that, in most cases, the design development has added considerable value to their original proposal. Equally, group members have not expressed any negative views about working as hard as they do on 'someone else's' design.

The final opportunity we are making the most of is the breakdown of discipline boundaries through the convergence of technology. Whereas going back to the guilds we see the emergence of protected materials and techniques, the digital era has brought in devices of common currency. Whether the students prefer to work using time-honoured manual techniques or not is hardly evidence of degree or lack of digitality, or a value judgement of either. That today's students are far more aware of other disciplines and their respective ways of working, combined with intimate association through sharing the same digital tools, points to a new era of design collaboration regardless of how 'digital' as individuals we are inclined to be. It is for this reason that I believe the academy should resist both any tendency for conservatism or a total rush into technology. Rather, it seems best that they seek to consolidate both traditional and digital design processes within teaching programmes lest we lose the skill to pass on skill – the malaise currently besetting some schools of fine art. AD

Working model of part of a swimming-pool facade 'parametrically' variable at a scale of 1:10. Although there are over 400 unique window openings for the swimming pool project, whose opening sizes respond to the required degrees of interior privacy, only five sizes of glass are proposed. The glass in this analogue parametric model swivels around the four pins fixed to the corners of the exterior surface (represented by the cardboard plane). These pins point to the interior surface. The glass panel is twisted until the interior opening (represented here by the rubber band) is deemed satisfactory. This overlaid image is indicative of two of an infinite range of possibilities.

Acknowledgements
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