

LEARNING TO THINK AND DETAIL FROM FIRST (LEANER) PRINCIPLES

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ABSTRACT

Why are buildings detailed like they are? Why do we seem to come to the same kinds of solutions every time? Are we satisfied with this? In an age of increased environmental awareness the answer to the third question has to be no. We need to encourage an innovative approach to detailed design thinking and decision-making, starting with education and through into practice. This paper provides an overview of an innovative Level 3 undergraduate module that was designed with the aim of encouraging students to approach architectural detailing from first principles and within an environmentally responsible framework. A simple nine-cell matrix was used to help students to develop their detailed design work and more importantly encourage them to think beyond the familiar (inappropriate?) solutions taught in construction technology modules. Ease of maintenance and disassembly strategies was investigated as part of a whole life approach to architectural detailing. By focusing on the detail, the joint solution, students were able to re-appraise their approach to detailing, generate new ideas and develop their transferable skills. Analysis of the module delivery and student feedback helps to highlight the need for extending the constructability framework, while also illustrating opportunities for considering and realising a leaner approach to design and construction.

KEYWORDS

Constructability, Design quality, Detailed design, Disassembly, Education, Innovation, Productivity, Sustainability.

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INTRODUCTION

There has been a rapid growth in the provision of Architectural Technology undergraduate degree programmes over the past decade. Since 1992 the number of institutions offering these programmes has grown from one to 31, with 26 courses in the UK, three in the Republic of Ireland and two in Hong Kong (BIAT, 2003). Accredited by the British Institute of Architectural Technologists (BIAT) these programmes address three core areas, namely design, management and technology, as set out in the benchmarking document for the subject (QAA, 2000). In many respects these new undergraduate programmes have developed in response to market need. It has been recognised that with the shift of architectural education in the direction of conceptual design at the expense of technology and management (e.g. Cole and Cooper, 1988; Carpenter 1997) there was a gap in the market. It is the detail design phase that has received least attention in the literature and within educational programmes, despite its fundamental importance to the quality and functionality of a building. Employers have expressed a desire for graduates with design, technology and management skills and thus the architectural technology graduates are well positioned to fill this role (Emmitt 2001). Anecdotal evidence from employers confirms that recently graduated architectural technologists are securing employment much easier than architects, primarily because of their technical and managerial capabilities. As such, the architectural technology degrees represent an innovation in built environment education and have the potential of addressing the creative link between design and production. With focus on the building, through its details and the realisation of the details, there is a possibility of approaching the integration of design and production with a fresh outlook.

At Leeds Metropolitan University in the UK students on built environment programmes (a modular scheme) are taught rather traditional construction technology during year one and year two of their studies. There is no construction technology teaching in the third and final year of the undergraduate programme, which is a common pattern of delivery in other universities in the UK. Thus the scope for synthesis and creative thought within this important area was lacking. This was recognised by the course team and had been raised as an issue by external examiners for the architectural technology programme and also the building surveying programme (that shared the majority of modules with architectural technology). This provided the stimulus to design and implement a new module for both sets of students. Called 'detail design' the module aimed to integrate construction technology with design and construction management. This paper provides an overview of the development of the module and a brief analysis of student feedback.

RATIONALE

Construction technology books show typical details as they are constructed, they do not show how the details are constructed nor do they offer much advice on alternative approaches. This is also true of details provided in product specific technical literature. While this information is useful, the danger is that students simply apply standard solutions to their detailing problems and do not provide adequate thought as to why the detail is

constructed as it is, or indeed, the consequences of their decisions: a habit that is taken into industry and one that is arguably inappropriate given a desire for a built environment that is more responsive to its host. Bearing this in mind the course team set out to design a module that aimed to:

- Encourage students to learn to detail from first principles within an ecologically responsible framework
- Integrate architectural technology and management processes
- Improve the integration of staff research with undergraduate teaching

Development and formal approval of the module took place between the spring of 2000 and the summer of 2001. At the time of implementation and at the time of writing this paper this is the only module dedicated entirely to detail design across the entire range of undergraduate programmes in architectural technology (confirmed by mapping the content of all architectural technology undergraduate degree programmes). Due to financial restraints on resources the team were unable to develop the module to include physical building as advocated by Carpenter (1997), instead students were encouraged to make physical models and develop solutions using virtual modelling packages.

MODULE DELIVERY

The first delivery of the module took place in 2001/2002. Three members of staff contributed to the module, with keynote lectures from each; detailing to prevent thermal bridging, functionality in design, and design management, forming the main research input. These were supported by other lectures, studio work and tutorials. Students were also directed to a decision-making matrix (see below), which was introduced during one of the lectures. Assessment was via coursework (60%) and examination (40%).

The teacher group associated with the module had seen a high standard of work and the majority of students had clearly demonstrated some creative and original thinking with regard to detailing. However, informal discussions with students revealed a general unease with the module due to a limited number of tools from which detailing could be helped from the concept through to the finished work. Analysis of students' work found that only a few students had used the matrix (there was no evidence of any other tools being used) and although work was of a high standard some of the fundamental principles had not been developed. Informal feedback from the students confirmed that they needed more guidance on detailing from first principles and would have liked more practical advice. Based on this feedback the module was redesigned to include more tutorial sessions aimed at developing details from first principles.

During the summer of 2002 the module was revised to reflect the experience gained by the teacher group during the first delivery of the module. The coursework was deliberately designed to try and 'force' students to use new methods of detailing and construction. Students were set the task of designing a small retreat for a writer, but with thermal performance standards (U values) more stringent than that stipulated in the UK Building Regulations, Approved Document L, (which had been increased in April 2002). Thus

standard details from the UK could not be applied (copied) and students were encouraged to start from first principles bearing in mind ecological considerations. (It was made explicit in the module guide that the student would fail the module if standard details were used). The brief also asked the students to consider disassembly strategies as part of their design solution. To do this, however, required some form of guidance.

A DECISION MAKING MATRIX

In recent years a number of models have been put forward in an attempt to help designers find their way through the challenges of designing within a sustainable framework. From the teaching group's perspective none of the models reviewed provided a simple approach that was suitable for students. The models varied in complexity, but all assumed a certain base knowledge that was grounded in tried and tested solutions. In the first year of the module delivery some students had tried to use some of these models, but had stopped quite quickly because the models were too complicated to use or because the models were inappropriate to their needs. Since the intention was to try and develop the students' transferable skills from first, ecologically grounded principles a model that helped to address fundamental design requirements was required; a simple model that could be referred to throughout the design process and that was applicable to all those involved in building design, regardless of circumstances or skill level. It was decided to introduce a decision-making matrix that had been used successfully elsewhere. Professor Peter Schmid had developed a matrix at Eindhoven Technical University and refined it based on user feedback (Schmid, 1986; Schmid and Pa'l-Schmid, 1999). The interesting point about this model is that it does not solve the problem; rather it serves to generate ideas and information from which the joint solutions can then be developed.

The model (Figure 1) aims to fulfil various functions:

- By focusing on the detail, the joint solution, it helps to provide an anatomy of the building through the integration of design, technology and management
- As a design aid it helps to identify important factors, which are conditional for the design and execution of the detail
- As an aid to design development it provides a simple framework for design iteration.

The basic model incorporates nine cells as illustrated in Figure 1. The central axis is the material axis (B1 & B2) and is concerned with matter and energy, building materials, components and structure and parts of the assembly. The central vertical axis is concerned with non-material factors (B3 & B4) namely shape and form, production processes and the time factor. The top corners address goals, function, building use (B5) and indoor climate, health and use factors (B6). The bottom corners address nature and environment, ecological factors (B7) and human factors (B8). The central cell is concerned with integration through the connections, details, joints, the nucleus (B9).

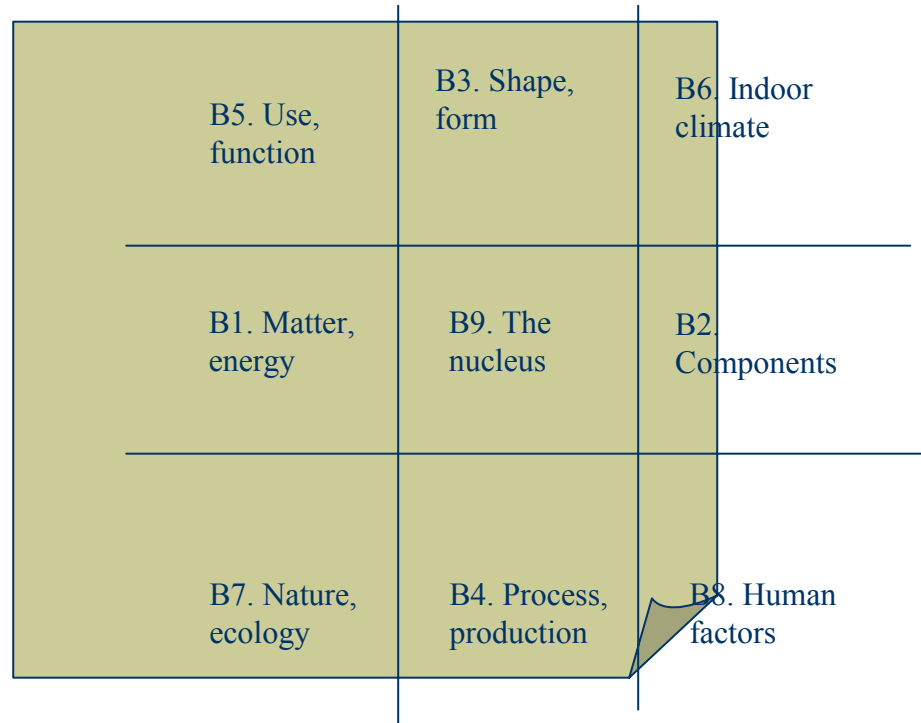


Figure 1: The basic model of the architectural detail

The model has been designed to be simple to use. For each project the designer (student) addresses each cell, ideally as early as possible in the design process. The order in which the cells are addressed is a personal issue and tends to vary from designer to designer, rather it is important that all cells are addressed in turn and then returned to as part of the design iterations, focusing in on the detail and refining ideas and information from which the details can be generated. The model is used to assist in the generation of creative design solutions to specific problems and unique projects, as such there can be no ‘correct answer’ (a point made on several occasions to the students by the teaching group).

Students used the matrix to generate ideas about their design proposal and concurrently for their joint solutions and detailing. Their developmental work was recorded in their design diaries, which were kept for the duration of the module, and analysis of these clearly shown that the students had tried to address the problem through the use of the matrix. In some cases this simply amounted to a few notes related to each cell, in other cases notes were interwoven with sketch details, which in many cases had been reworked several times on the same page. Although the teaching team had stressed the importance of all cells, it was clear in the analysis that different students had focused more on certain cells, reflecting in part their particular approach to the design project they were tackling and also their personal areas of interest. Combined, the diaries helped to show that the matrix had been used as a creative tool.

REFLECTIONS BASED ON STUDENT PERFORMANCE

The work produced during the second year, which focused on the decision making tool, was more considered and robust than that from the previous year. This may simply be that the

cohort was academically stronger than the previous year, although student feedback confirmed that the matrix did help them. A selection of comments being:

‘It made me think about my design from a different angle and ‘think outside the box’. I found this to be a very useful tool in the development of ideas, concepts and processes.’

‘It helped me to understand why I was detailing, rather than just doing it.’

ANALYSIS OF THE COURSEWORK

Across the cohort the following positive traits were demonstrated in the coursework in relation to a leaner and greener approach to construction and building use:

- Joints. Particular attention was given to minimising the number of joints in the design proposals and also minimising the variety of joints. This was done to try and improve constructability and reduce waste.
- Reclaimed and recycled materials were specified extensively. The majority of these were new to the market (and new to the teaching team)
- ‘New’ construction methods were explored, e.g. straw bale construction, earth sheltered construction
- Foundations. Traditional detailing was questioned and rejected by students, more environmentally friendly solutions were proposed (e.g. gabions that could be removed and re-used) and solutions where the building sat on, rather than in, the ground were proposed with the intention of reducing the amount of time in the ground and hence saving material and process waste
- Process management issues were addressed by the majority of students, which influenced the manner in which the building was to be produced and subsequently disassembled. Simplification of sequences and work packages was a popular theme. Sequencing of assembly and disassembly, to avoid material and process waste was also addressed by the majority of students.

Across the cohort the following negative traits were found in relation to a leaner and greener approach to construction and building use:

- Windows and doors. Only three of the fifty-three students attempted new window solutions (based on triple glazed units). The remainder specified a standard double glazed window. All of the students specified typical doors (which had neither insulation nor draft-proofing). These were inappropriate given the stringent thermal requirements for the entire fabric.
- Issues concerning health and indoor air quality were not addressed adequately across the cohort.

This ‘standard’ approach to detailing appears to be deep rooted and difficult to shift. When asked about this the students simply replied that they did not have enough time to deal with

all of the issues and so resorted to solutions they knew to work. This was consistent with the part-time and full time students.

ANALYSIS OF EXAMINATION

Although the main focus of this paper is on detailing issues, a brief comment on the examination may be useful in terms of context. The examination addressed design management issues based on scenario type questions, all of which dealt with managing detailing and construction, for example changes to details on site and the implications of the decisions made. Analysis of the students' answers demonstrated a high level of understanding of design management issues and a willingness to address environmental issues in a management context. This was a significant improvement on the first cohorts' examination answers, which, even allowing for a stronger cohort, indicated that improvements had been made in the students' understanding of the role of professional design management.

STUDENT FEEDBACK

The University student feedback is rather elementary. A representative of the cohort is requested to fill in a questionnaire that asks for three factors the students thought went well, and three factors that could have been better. This questionnaire was used towards the end of the first delivery of the module. The comments received were positive, however there was not enough detail from which to gauge student perception and so, as noted above, the course team were reliant on informal feedback from the students. So a module specific questionnaire was designed with the aim of gathering more detailed feedback that could be used to refine the module content. The questionnaire was piloted and then issued to all students at the end of the module. A total of 53 students were enrolled on the module (25 ATs and 28 BSs). Fully completed questionnaires were returned by 42 students (22 ATs, 20 BSs), representing four fifths of the cohort. Students were asked to fill these questionnaires in at the time of submitting their coursework, this helped to get a good response, although some negative comments were anticipated because many of the students had been working late the night before in order to complete their coursework. In the event the entire cohort reported very positive scores and comments for the module.

The overall view was that the module had helped the students to address detailing from first principles and had helped in identifying environmental considerations in relation to specific detailing problems. They also noted that the module had been the most enjoyable they had undertaken while at the university (a point reflected in high coursework and examination marks across the whole cohort). Students were critical, however, of the amount of literature available to read with regard to architectural detailing. At present there is only one course specific text-book, *Architectural Technology*, (Emmitt 2002), which is also endorsed by BIAT, and clearly more are needed. Likewise, there are a limited number of papers and research reports that are applicable. The challenge for the teaching group is to find (or produce) more guidance and appropriate literature for the student in support of their studies. On a related theme, students were asked to what extent they were aware of the

lecturers' research work being incorporated into the module. Although students confirmed that they were aware of research integration, their comments suggested that the teaching group should make the link more explicit.

One unexpected result of introducing the detail design module was the students' realisation that the construction technology taught during the first two years of the undergraduate programme was largely inappropriate. The response recorded in the questionnaire was that the principles of architectural detailing should have been introduced much earlier in the course, possibly at year one but certainly at year two. The students also raised an interesting question about other programmes within the built environment modular programme. In particular some suggested that the construction project managers should undertake the module so that they were more aware of the affect of their decisions on detailing issues and hence may be more understanding of environmental issues.

CONCLUSIONS AND RECOMMENDATIONS

So far the module has been successful in encouraging the students to think about detailing and management issues from a different perspective. The module has been successful in integrating design, technology and management within an environmental framework. This is clearly demonstrated in the coursework and in the student feedback. There was also evidence of lean thinking, primarily based on simplification of process and product and the avoidance of waste. This came from a desire to improve the environmental credentials of the design proposals, which started to lead to process improvements. Interestingly, the students did not have any lectures on lean construction in this or any other modules; the lean approach seemed to be a 'natural' development of trying to improve design and construction.

The teaching team cannot be complacent. The module still needs to be strengthened, in particular the range and depth of the reading material provided to students needs to be improved as does the way in which staff introduce their research findings. The module will continue to evolve in response to student feedback, comments from external examiners, and the focus of staff research activity. With this in mind the following recommendations are made:

- The module should be available to all students within the built environment scheme, especially those undertaking architecture and construction project management.
- Construction technology modules at Level 1 and 2 need revising to introduce students to the concept of creative thinking within the detailing phase. In particular there needs to be better synergy between Levels 2 and 3.
- More attention needs to be paid to the joint and the joint solutions throughout the students education (not just at Level 3)
- More appropriate literature is required (books, papers etc) to help students better understand the principles and this could (should?) be better linked to staff research and research within the architectural technology field.

- The constructability model needs to be extended and revised to incorporate a whole life approach and introduced to students early in their education.

Some of these recommendations could be implemented with minor modifications to the module content. Other recommendations will take a fundamental shift in the way construction technology is taught during undergraduate education at the University. The third presentation of the module will take place in 2003/4 and will be monitored. To what extent the module serves as a catalyst of change can only be determined by monitoring the progress of students in industry and trying to observe the extent to which they detail from first principles in practice.

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