Theory meets 'reality': an Energy-effective House Design course

Deborah White

School of Architecture, Landscape Architecture and Urban Design, The University of Adelaide, Australia

ABSTRACT: This paper describes a studio design course involving design of a house for a 'real' volunteer client. Students collaborate in small groups for the brief and site analysis, but produce individual house designs. The course involves lectures / tutorials, studio sessions, and class presentations / critiques. Lecture material, technical information, digital evaluation instruments etc. are available on the course web-site, which is also the context for student collaboration. The project demonstrates the trade-offs, compromises and conflicts between the theory of 'low-energy' building design and the real world of client expectations, attitudes, sites and budgets, highlighting the importance of building-inhabitant interactions. Students' proto-professional communication skills benefit from dealing with clients; a building-industry-sponsored poster competition challenges their capacity to communicate to the public the rationale of their projects. Group work simulates (if imperfectly) the teamwork of architectural practice, while seeing others produce different responses to the 'same' brief, combined with exposure to *client* assumptions and attitudes, encourages students to interrogate their own. However the project raises issues about the adequacy of specifically *architectural* approaches to ESD. The clients tend to be 'environmentally-aware', but many sites are in 'bush' areas: how ecologically valid are individual houses, however environmentally responsible, which involve alienation of natural environments and require extensive car travel for access?

Keywords: education, energy-effective design, houses, theory/reality nexus, users

1. INTRODUCTION

From the vantage point of the end of a career of practice and teaching in architecture, engaged both in issues of environmental sustainability, and in the socio-cultural significance of design, this paper describes a studio-and-web-based course in energy-efficient house design, and discusses some issues and questions raised — questions about the complex relationship between design and technical education, about 'energy-efficient' building design, and about environmentally sustainable design in general.

2. THE COURSE AND ITS CONTENT

2.1 Course context

Over more than a decade I have run the 'Energy-efficient House Design' project in Architecture Studio IB (ASIB), a compulsory part of the professional degree of Bachelor of Architecture (B.Arch.).

During the pre-professional course students begin to develop a theoretical capacity in planning and design, and arrive in the professional course as reasonably competent architectural communicators, whether verbally or in manual or digital graphics. They have studied the principles of building science — thermal performance, lighting, acoustics, structures (theoretical) and construction (practical/technical). They have also had some practice in manipulating — in a digital universe — form, materials and structures: in a compulsory second year course in domestic scale construction, students construct digitally a number of small buildings, initially from digital 'kits' of materials, then with an open-ended program.

In the two-year professional course, students are required to apply their knowledge and skills to the real, physical world of 'place, people, and stuff'.

2.2 The project, its aims and objectives

Architecture Studio IB is the second project undertaken in the first year of the B.Arch.. Students are required to design a house on a real site for a 'real' client, provide explanation and quantified evidence of its environmental performance (its water use, thermal comfort, energy use, and energy 'star rating' as required by the *Building Code of Australia*, the BCA), prepare a User Manual for the client, and produce a set of working drawings and an outline specification.

The course web-site sets out the educational aims and objectives of the course as follows:

The aim of this project is to span the pre-design, design and documentation stages of a project with a realistic scenario. You are to design within your developing knowledge of: architectural language and precedent; planning, structural principles and constructional practice in a small-scale residential construction (generally timber stud and roof framing, and brickwork/masonry, but including if required alternatives such as mud-brick and stabilised earth); the behaviour of materials; aspects of thermal performance; and natural and artificial lighting.

The project also confronts you with the difficulties of reconciling the demands of a particular client and *site with the requirements of energy-efficient and environmentally responsible design and construction.*

You also have the task of communicating with your clients — about their visions, wishes and constraints, and about your proposals, responses to both their wishes and to the demands of energy efficiency. (This should not be taken to mean that your design should be mundane and merely utilitarian, but that you should take seriously the necessity for your design to be buildable.)

2.3 Other elements of the course

With the objective of bridging the gap between the academic and theoretical aspects of a student's experience and the practical world of the building industry, the students also participate in two field trips. One is a visit to a local factory which produces steel roofing and related products, the other a day spent visiting factories producing timber products for the building industry. (Plantation-produced softwood is widely used in Australian domestic-scale construction; its low embodied energy can be a significant factor in life-cycle energy use.) Students are also trained in use of the *FirstRate* computer program used in South Australia to evaluate the energy 'star-rating' of their houses.

A number of complementary parts of the course address the need for an architect to explain a project to a variety of audiences. As well as sketch designs, and the User Manual explaining the building's operation to the client, the students participate in a competition, sponsored by a local building materials manufacturer, for a poster explaining the environmental rationale of their design to the general public.

Given the generally accepted pedagogical reality that assessment drives student learning, students are required to submit for assessment an archive of their interactions with their clients, reports on the field trips, a sketch book, and a journal recounting their term's experience. These are submitted with their final design, the user manual, the working drawings and the outline specification, and the environmental evaluations (see Table 1).

2.4 The clients

Four or five students design for each client, but each student's house design is individual. Clients are chosen from respondents to an invitation published in the University newspaper. The choice of clients for selection is conditioned by the requirement that the projects provide similar levels of design/construction challenge and difficulty. After a telephone interview aimed at distinguishing *bona fide* applicants from those whose real interest is in a free set of drawings, the prospective clients are asked to respond to a questionnaire, and submit it with a preliminary brief, site information and photographs. Enthusiastic prospective clients often produce elaborate and persuasive extra documentation, and are very disappointed if not chosen.

The client submissions are exhibited in the studio, where the students select their preferred client and thus indirectly their preferred group, in a complex multi-factorial act of choice which they carry out without difficulty and with seeming nonchalance. They then collaborate in a collective client interview, after which they visit the site, produce a developed brief agreed by both the student group and the client (attested by signature), carry out site and micro-climatic analysis, and arrange the protocols for future client meetings over the course of the design process.

The agreement with the clients is that, in exchange for the time spent with the students, they receive a copy of the design drawings (but not the working drawings) for each of the houses designed for them. A number of unsuccessful applicants have asked to be considered the following year, while some clients with long-term dreams for their house, having participated and found the process interesting and valuable in the development of their ideas, have requested a repeat. One has participated three times. If clients intend to proceed with a student design, they are required to come to an agreement with the School for an appropriate fee to be paid to the designer.

3. COURSE ORGANISATION / DELIVERY

3.1 Time limitations

Due to the almost Byzantine politics of course development and timetabling, the course must attempt to compress what should be at least a full semester's work (12 weeks) into 6 weeks of classes, plus 3 weeks 'purloined' from non-class time, with the students' agreement. Much preliminary work is carried out during the mid-semester break; the first presentation of work-in-progress, the brief and site analysis, takes place on the first day of the course. After the end of semester the students complete the working drawings, with tutor consultations by appointment.

Student responses to the annual Student Course Evaluation questionnaire, a long-term part of the teaching programme in the School, have been positive — a consistent average vote of 6 out of a possible 7, a result very seldom achieved. It is agreed among students that the course is the most demanding of time and effort in the B.Arch. programme; however the general consensus is that 'it was worth it', and 'we learnt a lot'.

3.2 Project-based learning and specialisation

The Adelaide School is committed in its professional degree teaching to PBL, *Project*-Based (rather than *problem*-based) Learning. So the course centres on the design studio, with 'over-the-drawing-board' tutoring and assessment by appointment, regular class presentations, and peer/class critiques of work-in-progress. Each tutor has responsibility for 10-12 students. The time-table gives students time between studio sessions to develop responses to tutor and peer critiques and group discussions.

In spite of the centrality of the studio and the emphasis on student autonomy, given the strong focus in this project on the interaction of design with architectural science and technical / contextual realities, the course also involves lectures/tutorials, with content broadly categorised, for both comprehension and administrative / regulatory reasons, into Science (Sc), Construction (C), and Structures (St):

Table 1: Energy-efficient House Design • Schedule

W		**Lecture / tutorial** **Presentations**	Submit
7			
T	**St**	Introduction to ASIB Choose client groups **Presentations** #D1	
W		**Presentations** continued #D1	
	St	Structures	
Th	**Sc**	Recapitulation of assumed knowledge. Quiz. Objectives of environmentally responsive design. Passive / active systems. 'Thermal form' (thermal implications of building form).	#D1
		Studio - make appointments before noon	
8			
M	***D***	*Designers talk about their work. Optional* *(joint session with Domestic Scale Construction II)*	
T	**D**	Design strategies. Client / user / designer.	
		Studio - make appointments before noon	
W	**Sc** **C**	Insulation and mass; zoning, ventilation. Sunlight, sunshine and shade.	
	St	Structures	
Th	**C** **Sc**	Windows. *Windows and Energy.* Energy and the building regulations.	
		Studio + Assessment over d/b. Studio consultation by appointment	#Sc1 #C1
9			
M	***D***	*Designers talk about their work. Optional* *(joint session with Domestic Scale Construction II)*	
T	**Sc**	Passive/active systems. Introduce field trips.	
		Studio Assessment over d/b by appointment Studio consultation by appointment	#Sc1 #C1
W	**St**	Structures	
	C	Factory visit: Fielders Steel Roofing	
Th	**Sc**	The 'Green House'/ The 'autonomous house': materials • energy/power • water • landscape. Permaculture.	
		Studio - make appointments before noon	
F		Timber Field Day: bus tour all day: (Timber Development Association)	
10			
T	**Sc**	Introduction to *Enerwin.*	
		Studio: make appointments before noon	
W	**St**	Structures	
	Sc **C**	Using the program *FirstRate* for BCA evaluation for permit approval.	
Th	**C**	Revision: Brick cavity & brick veneer Footings and slabs / floor systems. Timber construction / cladding.	#D2
		Presentations #D2	#D2
F	**D**	Studio consultation *by appointment*	
11			
T	**C/Sc**	Other mass construction systems. Life-cycle costs/trade-offs. Materials & energy.	
		Studio Assessment over d/b *by appointment*	#C2
W	**C**	Joinery: windows / doors. Glazing.	
	St	Structures	
Th	**C**	Roofs (revision). Drainage / water storage.	
		Studio - make appointments before noon	
F		Studio consultation *by appointment*	
12			
T	**Sc** **D**	Heating/cooling systems. User / building interface. 'User manual'.	
	D	Studio consultation *by appointment*	
W	**St**	Structures. Tutorial Assignment.	
Th	**C**	Presentation and communication Working Drawings & Specifications. Details. Trade specialisation. Site organisation.	#Sc2 #D3
	D	**Presentations** (in tutor groups) #D3 / #Sc2	#Sc2/#D3
F		#Sc3 consultations *by appointment (no studio)*	
13			
T	**D** **C**	Debriefing and questions. Recapitulation: Working Drawings and Specifications.	
Th		Competition Exhibition #D4/#Sc4 + #Sc3	#D4/#Sc4 #Sc3
		Working Drawings consultations *by app'tment*	
F		Working Drawings consultations *by app'tment*	
14			
F		Submission: Folio of term's work, Working Drawings, journal.	#D5 #C3/#C4

distinct areas: Design (D), and technical areas see (partial) Schedule (Table 1). (In a long-standing agreement with the University's Engineering Faculty, the Structures course is taught separately by a civil engineer, in co-operation with the architecture staff.)

Such categorisation is of course problematic, given the interrelationships of factors in any complex architectural project, but the emphasis on working and collaborating with peers in the design studio (students often are tempted to work alone at home) promotes the integration of the material. In the group context in particular, students learn not only from their tutors but from each other.

4. PEDAGOGICAL ISSUES

4.1 Choice of project in design education

Why choose a self-contained house as the focus for energy-efficient design? In any specific cultural context, the programme for a house may appear more or less a given, but with the focus on thermal performance and client satisfaction, a house provides an ideal design 'site' in which the diversity of internal and external spaces, involving complex uses and meanings and the interaction of building and context, can exceed in complexity those of a larger building.

The project confronts students with the inter-section of theory and practice and with the trade-offs, compromises, even conflicts, between the apparent theoretical simplicity of 'low-energy' building design and the greater simplification of 'rules-of-thumb', and the real world of client intentions, expectations and attitudes, with the constraints of specific sites, micro-climates and budgets. This highlights the importance of building-inhabitant interactions, and helps students develop a more sophisticated understanding of the thermal performance of buildings *in use*. They learn that human comfort is a socio-cultural matter which extends beyond the merely physical and technical.

4.2 'Realism'?

Providing a realistic experience of working with actual clients in a real context is a constant challenge in architectural education. The 'real world' is difficult to simulate; and the catchment of clients interested in and capable of working with students is restricted. However the need to transform their ideas into working drawings and specification provides students with a persuasive 'reality check'. They are eager to create innovative, unusual designs, but producing technical drawings challenges their knowledge of building techniques and their capacity to provide evidence of buildability. (The submission requirements for the Working Drawings state that 'Information on the drawings should be TRUE, NECESSARY, USEFUL & POSSIBLE'.) Former students also report that they have found very valuable the course's introduction to the real world of building and the building industry.

4.3 Design checklist

The one-on-one teaching situation of the design studio is one of the most expensive in a university. A mentoring level similar to a master class is beyond the resources of the School. Six hours per week for 11-12 students per tutor are clearly insufficient to provide the level of continuous monitoring and tutor assistance desirable. So a form of 'dummy' tutor (Table 2) is provided on the course web-site. It asks in a colloquial manner the sort of detailed and searching but constructive questions a tutor might ask over the drawing board, and provides a series of columns for responses + , o , - (not shown) over time. A completed checklist must accompany each design submission.

The checklist is in two parts, one dealing with design (use, function, aesthetics, thermal performance and other measures of environmental effectiveness); the other with graphics, presentation and communication. The Design questions make clear that 'passive' design of energy-efficient buildings must also address the people-building nexus, the aspects of design which have to do with human occupancy and use — culture, personal preference, delight and psychic comfort — as well as technical measures of thermal comfort, heat flows, insulation, mass, fenestration, zoning, shading and ventilation.

Table 2: Design checklist

Assess your work as you develop it
Design
How well does the design accommodate the requirements of the client's **brief** - and perhaps extend the possibilities beyond the imagination of the client?
How does the design of the building and site layout & treatment express/develop the ideas in the ***parti***?
How well does the house 'address' the **street**, and/or declare its identity to the public realm? (For country houses, a welcoming aspect / legibility for visitors.)
How well does the overall scheme relate the building to its **site** and **context** including access (car and pedestrian), privacy for family activities, micro-climate and orientation (eg for sun & cross-ventilation etc.), views, landscape, planting etc.?
How well integrated are the **ESD** aspects of the design with the typological / aesthetic / social / **cultural** qualities of the scheme? (eg water retention / recycling, landscape / planting, rainwater tanks / retention, solar hot water service at appropriate orientation and inclination, photovoltaics, composting, recycling, cycle storage .)
How appropriate to your client is the level of **user – building interaction** required to run the building for energy and comfort effectiveness?
How successfully does the design **relate interior & exterior spaces** (both access & visual connection)?. Do 'habitable' rooms have pleasant views? Will plants grow in internal courtyard – eg sun, access?
How successfully does the design (interior and exterior) provide the level of **privacy** required by the client? (Consider privacy both between inhabitants of the house, and for inhabitants from the outside world.)
How successfully is <u>**people**</u> **entry** / access provided for? (Consider access for inhabitants, friends, visitors, tradespeople; pedestrians, cyclists, car drivers, taxi passengers. Consider shelter & light at entrance; storage for umbrellas, boots, coats etc.)
How successfully is <u>**service**</u> **entry** / access provided for? (Consider mail, meters, garbage, recycling, composting, clothes drying, etc..)
How well does the scheme provide for the **car**(s)? (Consider access, shelter, disguise, space to alight, access and space for visitors cars' if necessary, workshop, tools storage etc..)
How successfully is functional **circulation** dealt with in the dwelling? (eg small proportion of space used for circulation alone, minimal interference in the use / occupation of spaces by access / circulation.)
How well are **circulation** spaces designed – are they wasteful of space? Do they have architectural / experiential value in themselves(rather than being mere utilitarian 'corridors'?
How adequate is **storage** provided both inside and outside the house (garden, carport, garage)? Consider location, size, arrangement and the ergonomics of storage in kitchen (pantry and crockery etc.) & laundry (clothes, brooms etc.).
How successfully is **light** provided to internal spaces for ***utilitarian*** purposes (task and general lighting). How appropriate is the quality / direction of light to uses of different spaces? Does the design avoid unpleasant glare?
How successfully is **light** provided to internal spaces for ***aesthetic*** purposes (revelation of architectural form, atmosphere, drama). Consider different times of day/year.
Do all habitable rooms receive adequate and appropriate natural **light and ventilation**? (. *Openable* skylights / clerestories which can be considered 'window equivalents' may be acceptable.)
Is there adequate **light and ventilation** to kitchen, laundry and bathroom(s) ? (Standard ventilating skylights are legal, but problematic [winter heat loss, summer solar gain].) How are eg highlight windows opened / cleaned?
How successful is the design in utilising **orientation**? (eg the difference between east and west (morning and afternoon sun), north (potentially sunny) and south (cool)). How sunny and warm would the building be in Winter? Would north-facing windows actually receive winter sun?
How successful is the design in utilising **orientation**? How flexible is the climatic response for the changeable weather of Autumn and Spring? Does the building make the most of the experiential possibilities of solar entry in temperate seasons?
How successful is the design in utilising **orientation**? Is each interior space oriented appropriately? How cool and shady would the building be in Summer? Do layout and fenestration optimise cross-ventilation from cooling night breezes eg in bedrooms?
How appropriate and realistic is the **shading** regime? (Consider hot, cold and in-between periods — adequacy, appropriateness to orientation, adjustability , maintenance, operability, contribution to the overall design of the building.)
How successfully does the design reconcile the need for **cross-ventilation** with eg interior privacy, acoustic privacy and protection from traffic and other noise?
How well does the design explore the **aesthetic** and psychic value of 'solar'/ **climatic design** - eg rays / 'pools' of sunlight, contrast, articulation / modelling of architectural forms, shadows, dappled shade etc..
How appropriate is the choice / location of **heating and / or cooling equipment**? With slow combustion stoves — space for firewood; does the flue fit well in the space? In 2-storey buildings, is heat loss up the stairs addressed?
How well integrated is the design with the choice of **materials and** construction types and systems? In particular consider the use of mass and light-weight insulated elements in relation to summer and winter.
Does the design successfully accommodate **activities / uses** of spaces - and how clearly do the drawings represent the 'inhabitation' of spaces?

How does the design provide for the patterns of the clients' **way of life**: eg guests, sociable cooking, distinction between formal and informal areas, quiet in the study, sound-proofing for TV/music rooms, space for piano, separation of children from adults?
Buildability? — structural and constructional considerations (including details); economics.
Total floor area in sq.m.: include wall thicknesses; count stairwells on each floor. Give *separate* figures for a) dwelling area; b) area of balconies, verandahs, pergolas, carports; **Estimated total cost** [= (a +b/2) x $2000] (not including site works and landscaping.)

4.4 Working in groups

Group work simulates in some ways the teamwork characteristic of architectural practice. Responding to their clients' assumptions and attitudes, and seeing other students produce very different responses to the same brief and context, encourages students to consider the relationships of energy consumption to both quality and way of life, and to interrogate their own assumptions about the 'normal' and the familiar (students rarely have much experience of difference).

4.5 Implications for design

The character of the course appears to offer other advantages. It is often assumed that energy efficiency imperatives constrain design creativity. In our experience the realistic context, and the necessary attention to the responses of the people directly affected by design decisions, and to the relationships of spaces to function and use, to solar orientation and light, to volume and materials, often lead to innovative and creative designs.

5. THE USE OF THE INTERNET

The University supports the 'MyUni' platform for individual web-sites for all courses. In ASIB all lecture material, technical and practical information, digital building evaluation instruments, assessment criteria, grades etc. are available on the site, which also provides a context for student collaboration and peer mentoring, and a store for digital work.

5.1 Basic information delivery

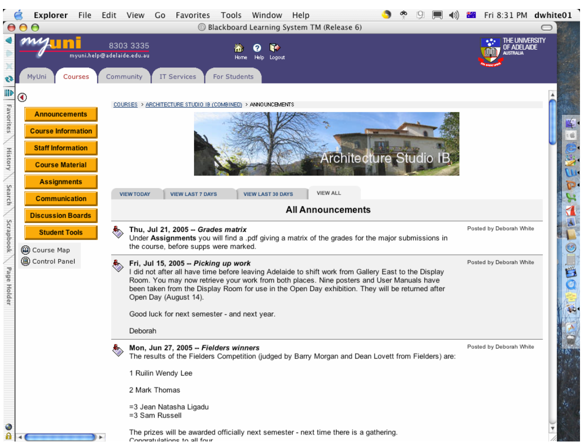

Figure 1: Course home page

From the home page — *Announcements* — the students can access *Course Information* (aims and objective, schedules, assessment etc.), *Staff Information*, *Assignments*, and *Course Material* (lecture notes, technical and practical information, the Design Checklist, digital tools for energy evaluation, and access to the University library catalogues and bibliographies tailored to the course).

Under *Course Material* students find for example the following:

D/C/Sc Lecture Notes

This folder contains lecture notes and other related material in the form of .pdf files, .ppt files, and links to websites.

Useful information

Students who find useful URLs and/or other information … should let me know and I will post it here.

Working Drawings

This folder contains .pdf files of Working Drawings for houses. They provide exemplars of the relationship between construction & design.

Link to BSL resources [University Library]

Project-based learning challenges you to develop a self-motivated and creative approach to finding out information. Remember: no architect ever 'knows' everything — but knowing where to look, how to formulate effective questions, whom to ask, and how to evaluate the information found, is a very important part of the competent architect's 'tools of trade'.

The Student Association library is a useful source of printed trade literature, manuals etc. on paper not yet superseded by the internet. Although there are no text books for this subject, you will find that you also need to use the Barr Smith Library (BSL) for:

- *journals and other texts to give you inspiration, ideas and precedents for your designs,*
- *technical information (on structures, building construction, architectural science, costs etc..),*
- *trade literature, much of which is on the web,*
- *Codes and Standards: up-to-date versions are available only electronically: the BSL has a licence which covers all enrolled students.*

5.2 Communication tools

The web-site also provides *Communication* links (email) and *Discussion Boards* (one for generic discussion, one for each client group), where students collaborate in group work, organise activities, and share information and images, comments and mutual critiques. The discussion boards also provide a site for discussing issues arising during the course which would be impossible to fit into the tight schedule.

The ease and effectiveness of communication offered by the internet has revolutionised the organisation of project-based courses. It not only allows for a much greater complexity of organisation, and a more rapid and sociable level of communication between staff and students, and between the students themselves, but increases the potential for student autonomy in learning. Both staff and students post information about such matters as availability of building materials, the sizing of rainwater tanks, or municipal building and planning regulations for the various projects (which in spite of the existence of the BCA may vary considerably in different jurisdictions).

5.3 Assumed knowledge and revision

This project clearly requires an adequate level of scientific and technical knowledge. Students have different modes of learning and proceed at different rates. The School has a diverse student population: it includes overseas students with varied educational backgrounds, and a number of Australian students who enter the professional course after a preliminary degree elsewhere, or even in another discipline, after a bridging course. Thus a background in architectural science of appropriate scope and at an acceptable level cannot be guaranteed. The teaching must walk the tightrope between boring knowledgeable students and leaving unprepared students behind. Given this project's short duration, the web-site is particularly crucial in providing technical / theoretical background.

Under *Assignments* a series of Quizzes provides a revision course (or for some students an introductory course) in the physics of energy and the thermal performance of buildings, in effect defining the assumed knowledge required for the course. Students complete these quizzes in their own time early in the course (answers supplied after three attempts). They are then given an assessed test, Quiz 6 (Table 3), with contextualised questions based on the knowledge contained in the Quizzes.

Table 3: ASIB Quiz 6 2005

Circle your answers.

1. You have poured yourself a cup of hot tea, but before you put in the cold milk the telephone rings. To keep the tea as hot as possible (no lid): do you pour the milk before answering the phone, or wait until you return? Before / after.
2. You are an office worker with a desk at which you are overheated by sun from the window to your left on summer afternoons. You ask the building supervisor to lower the a/c thermostat temperature in your area. Will this suffice to provide thermal comfort? Yes / No.
3. "Double glazing is useful in reducing solar input through a window." True or false?
4. It is possible / impossible to design a *fixed* device to shade an equator-facing window (ie north in southern hemisphere) to maximises winter solar gain and minimise summer gain?
5. In which place(s) would an underground dwelling be climatically appropriate?
   Adelaide plains Adelaide Hills Kalgoorlie Alice Springs Sydney Canberra Brisbane
6. "Fans would be useful to cool a room full of computers and other equipment, but uninhabited by people." True or False?
7. "Appropriate climatic design for winter in temperate climates conflicts with good design for summer, and vice versa." True or False?
8. "Carpet makes a significant / insignificant difference to the effectiveness of the floor slab as thermal mass in a 'passive solar' building in a temperate climate." True or False?
9. A solar hot water service is more efficient, with the same collector area, with a large/small tank?
10. "The sun is always towards the north in the Southern Hemisphere." True or false?
11. The colour of a dwelling's *internal* walls can make a difference to the energy required to live in it comfortably.
    Which reason is most important?
    1. Light coloured materials insulate better.
    2. Dark colours absorb heat so require more heating.
    3. Dark colours absorb more light, leading to high electricity consumption for lighting.
12. "For a given area a circular plan has the least external wall area (assuming vertical walls) for heat gain / loss, so a cylinder is the most efficient thermal shape for a building."
    True or False? Why?
13. Which factors are the most important in buildings (one or more in each category)
    In hot arid climates?
    shading mass insulation orientation fenestration ventilation
    In tropical climates?
    shading mass insulation orientation fenestration ventilation
14. The following statements are commonly made. Are they true or false?
    "Mud brick is a good insulator." True or false?
    "The air space in a pitched roof with a flat ceiling is a good insulator." True or false?
    "Westerly windows should always be avoided." True or false?
15. Which of the following is better for curtains to provide insulation for windows?:
    heavy weight material lined externally (ie towards the glass) with metallic material, or
    pale colour open-weave material in full drapes.
16. A continuously air-conditioned building is best constructed with high / low thermal mass (internal admittance to the internal surfaces), and high / low levels of insulation.

6. A WIDER ISSUE

Beyond the theoretical, practical and pedagogical experience of the course, the project raises issues about the wider built environment. The client 'catchment' in the University tends to produce a particular type of client: middle-class, well educated, already interested in environmental issues. However, given the demographics and geography of Adelaide, many intend to build a house in the hills flanking the city, or along the nearby coast; so questions arise about the ecological validity of individual detached houses, however environmentally responsible, which involve the alienation of natural environments and imply extensive car travel, emphasising the necessity of a holistic approach to Ecologically Sustainable Design.

ACKNOWLEDGEMENTS

I acknowledge the staff and students of the School of Architecture, Landscape Architecture and Urban Design of The University of Adelaide, in which it has been my good fortune to have worked over many years, and to have been able to develop this course.