Environmental Design Analysis Models in Technology and Environment Teaching in Architecture Schools

Reflections on the Past and Speculation on the Future

Gillian Treacy
Tutor in Technology and Environment
University of Edinburgh

Ola Uduku
Reader in Architecture
University of Edinburgh

Teaching Technology and Environment at undergraduate level in Architecture schools can be challenging. Aside from wider issues related to the restructure of the entire undergraduate architecture programme in the specific School where we teach, environment teaching has undergone a significant change in the past five years. This change is described and explored prior to the paper's key focus on new learning tools for UG teaching in environmental design. The latter part of the commentary attempts a critical evaluation of the success of the environmental teaching tools that have been in use, and in closing discusses how the utilization of digital teaching tools might affect future trends in environmental design teaching within Architectural Education.

Since the Rio Protocol, UNFCCC, (1992) and the sustainability targets that were globally agreed in its wake, sustainability in Architectural Design has moved from being an "esoteric", non mainstream topic to becoming a core element of the Architecture curriculum. Its teaching and implementation within the teaching and learning structure of Architecture courses has however remained an area that has been locally defined within Architectural Schools. Some key pedagogic issues categorise the different teaching approaches taken.

The 'studio-based' vs. 'lecture-based' teaching or knowledge delivery strategy is the most clear. Architecture schools generally take one of the approaches; studio-based delivery within the format of a design project, or lecture-based delivery, with studio integration only in the later years of the undergraduate course. The 'scaffolding' or support teaching available for environmental design teaching also varies, from Oxbridge style small group tutorials to more dispersed group tasks with more 'light touch' tutorial support. Uduku (2009)

Probably the least used teaching methods for 'environmental design teaching today are the involvement of students in actual environmental measurements and analysis. Few wind tunnels or artificial sky/heliodomes remain in commission, as they require substantial 'commercial investment' or 'industrial collaboration' to remain viable. In our research we are aware

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of such lighting research facilities only being available at the Architecture and Environmental Science Research Departments at UCL, University of Wales, Cardiff, and acoustics research facilities at the University of Liverpool.

Furthermore most analogue equipment such as wet and dry bulb thermometers and 'sound' meters, have been relegated to physics departments, as such measurements within a building context are rarely asked of today's architecture students. The reasoning for the move away from these forms of measurement tools is both pragmatic and understandable, digital technology makes the use of analogue measurements and analytical calculations obsolete. Students now entering into architectural education are generally computer savvy; most are able to deal with routine computer software and expect to use current digital technology relevant for their course.

Nowadays also, for the undergraduate curriculum in Architecture all that is required in environmental design teaching is "an awareness" of the current jargon and codes; such as the issues surrounding carbon neutral buildings, BREAAM and basic building environmental performance/ energy use assessments. This is in acknowledgement of the higher specialisation levels of environmental service engineers, who deal with environmental analysis and evaluation in practice. Consequently there is therefore a need for less detailed knowledge of this area of environmental analysis at undergraduate architecture level. (ARB, 2011, RIBA 2011)

ENVIRONMENTAL ANALYSIS USING COMPUTER MODELLING PROGRAMS

With the demise of 'real' modelling and analyses, in wind tunnels and heliodomes however, has emerged the relatively new analytical approach predicated on the use of environmental algorithms modelled with real time data to predict building performance – from user-generated Computer Aided Design, (CAD) building models. This is otherwise known as environmental modelling and analysis.

This science creates more 'accurate' data than former laboratory generated research but requires a higher level of computer engagement at design level, as the algorithms and conditions used require coding skills to alter. Also, unlike wind tunnels for example, which were developed as a collaboration between building scientists and architects, (working with physical small scale models) computer modelling is more a collaboration between the computer coders and environmental scientists, with building design taking on a background role as the analytical object, and the conditions being in the foreground.

The effect of this has been that current computer modelling programs available commercially and in education are more focused on environmental analysis of existing conditions rather than geared towards experimentation within design contexts, discouraging the iterative design process that is expected of students exploring designs within their discipline.

Furthermore, the interface of the modelling program for the architectural student or designer has generally been difficult for those with only a basic knowledge of environmental design, and somewhat opaque as the physical connection with the model is lost.

The computer modelling analysis is focused on physical conditions with experimentation of building form often being more difficult to effect, and requiring more skill within a computer modelled environment to the analogous situation in a wind tunnel or artificial sky, where the cardboard model is physically altered, and the revised model is then simply reinserted into the test environment for the next reading.

In this paper we review our experience with a commercially available environmental analysis model, IES-VE™ (IES), that we have used as a teaching tool for 2nd and 3rd year students, in both studio based and lecture based tutorial contexts, over the last four years. We highlight the successes and the failures of using models as a teaching and design analysis tool, at undergraduate (UG) Architecture level. The paper concludes by recording our future views on how these programs might be developed and better integrated into future environmental design teaching at UG level.

There are many challenges in environmental design teaching in architecture. Some of the key areas are the following:

EDUCATIONAL PEDAGOGY

Key or core concepts in environmental design teaching are grounded in environmental physics comprising disciplines such as acoustics, thermal heat transfer, and lighting studies. These are “threshold” concepts in pedagogic theory, which can be areas of “troublesome learning” for some students. (Cousin, 2006, Meyer and Land, 2003) These basic mathematical theories in lighting, etc are sometimes difficult to grasp for students without A-level maths backgrounds. Furthermore there is a need to emphasise the connections or “application” that these theories have in relation to building design.

DELIVERY

The delivery of environmental design teaching can be problematic. In a classroom based teaching program mode, these applications can be difficult to conceptualise. Often a mixed mode of delivery with classroom teaching, case study visits, and the use of environmental analysis computer models was most successful in allowing students find what modes of delivery best suited their learning styles. Using computer modelling, within the environmental design program for analysis, we were able to allow students to work simultaneously on their individual or group projects.

Physical testing in labratories often requires students to "wait their turn", due to staff-to-student ratios required or minimal quantities of apparatus. Students do seem to enjoy viewing others projects being tested and watching for those that "fail" or those that "work". In a lab or 'real life' environment students are more inclined to watch others experimenting and see the results.

This is in contrast to computer modelling and testing within environmental analyses programs, where students work at laptops or fixed workstations, and their concentration is fixed on the task ahead, meaning that interaction between students has been viewed to be significantly less.

FORMS OF ASSESSMENT

The assessment of students' understanding or comprehension of the environmental analysis building theories can also be difficult. Examinations have been proven not to be the best determiners of learning, whilst group learning tasks have collaboration issues. As with teaching delivery, we have found that, the more mixed the modes used for assessment, the more likely it is that assessment methods will be able to cover the range of learning styles and competencies found in class cohorts.

INTRODUCTION AND USE OF ENVIRONMENTAL ANALYSIS TOOLS

Using an environmental analysis model to help deliver environmental design teaching is no panacea to these issues, however its use can work successfully as a learning tool, and organising device within the typical teaching course.

In our teaching practice we first used a basic model program, LT™, (LT) developed by Nick Baker et al at the University of Cambridge in the 1980s. (CAR, 2012) Its main strength was in the straightforward way in which it was possible to calculate expected daylighting levels in basic (rectangular) shaped design models. Students had to "create" a new 3D model within the program by typing in specific dimensions and co-ordinates. No real understanding of 3D CAD drawing was required to achieve a basic model. With the insertion of climatic data it could also be used to compare energy levels required for heating or cooling, and optimal glazing areas, in different country locations.

LT also provided an excellent "flow chart" to follow through, requesting inputting of basic information at each stage and creating a clear distinction between selecting design information and analysing modes. Students could select basic heating/cooling/natural ventilation modes and lighting systems to form graphical outputs with generalised results but informative guidance nonetheless.

We then graduated to using IES-VE™, (IES) a commercially available, environmental engineering focused Environmental analysis model. This had been developed from pioneering energy research analysis at the ESRU, by J. Clark, et al. at the University of Strathclyde, since the 1970s which had many features including a range of analytical tools for lighting, thermal analysis and climatic analysis. (ESRU, 2012)

With this system, it was recommended that 3D CAD models were built within the IES environment prior to analysing as it contained its own Modelit™ 3D drawing program within the software. However, models could also be imported from the popular Sketch Up™ program (an industry standard program, often taught to UG architecture students as part of their course) or Revit, ™ most suitable for structural engineering drawing compatibility.

PROBLEMS WITH THE PROGRAMS

The problems concerning environmental modelling and analysis programs relate to their ease of installation and use, integration into critical pedagogy and design analysis, and finally the utilization and transfer of the learning acquired from using the programs to later design work.

Both programs, LT and IES, were problematic to use in the classroom. The concepts they supported were clear, lighting analysis, climatic analysis etc, but the translation of this to the practical evaluation of the thermal analysis of a building model remained difficult for both programs. The link between 3D modelling and thermal analysis remains particularly difficult; as 3D CAD drawing skills have to be well developed and very accurate (in the case of IES), or the building designs to be analysed had to be restricted to basic geometric “box”forms (in the case of LT).

When using IES, the students “imported” their current studio design models from Sketch Up. The importing of models became difficult for many students as their CAD drawing skills were not accurate enough to create appropriate models to test. The stringent requirements of IES model imports became very clear. It was often not just a matter of tweaking the models but rather re-drawing was necessary to create a suitable model for testing. The students frequently found they had to revise and re-run the drawing check feature several times, most requiring individual tutor help, some without any success at all without re-drawing from scratch.

We noted that this integration process was particularly problematic, as students had to create new models solely for environmental testing purposes, rendering previous CAD models redundant. This was in contrast to usual CAD drawing practice convention, that would have had the environmental analysis model created, simply become an overlay with another level of information, that would be kept within the CAD drawing library for the project.

The practical issues related to installation and program bugs have remained a well-known issue with both programs used. For architecture students particularly, this is also a major hindrance, as computers are used predominantly as design tools, with few students having the skills or patience to deal with hardware or software issues. The Mac/PC divide also affects usage, as both LT and IES programs used in teaching run natively within a PC environment. Thus despite IES now being able to run in a Parallels™ enhanced Mac environment, there are continuing teething problems, as bugs associated with its use in a Mac environment, have yet to be resolved. (Uduku et al, 2011)

Furthermore, whilst both LT and IES are able to produce relevant data in graphs and mapping related to building energy and environment use, the processes of analyses remain opaque to the user. The calculations producing the graphs go on behind the screens , and are more evaluative of an end product, than encouraging of further experimentation or change to the original design. This 'black box' analysis model also removes the students from understanding the analysis process that is undertaken behind the scenes whilst the user interface is often unclear and often bug-prone in usage.

WHAT WORKS…

The more positive aspects of using environmental modelling programs within the UG tutorial environment can also be discussed within themes of equipment and content, learning acquisition models, and critical pedagogy. In terms of equipment, clearly the most beneficial aspect of environmental modelling is the, agency it gives the student. Once familiarised with the program, a student or student team can load and run the program on a computer, and get 'results' which they should be able to understand, test against different parameters, (climate, materials, illumination, etc) and be able to apply this pragmatically to future design decisions they might make. In the case of IES its ability to import 3-d models from the open source Sketch Up ™ program, (with some acknowledged hitches) was an added bonus to its versatility.

Furthermore, by virtue of it being essentially a high-end PC software program, it can be installed on the average (windows) personal computer, as well as institutional computers, indeed IES does have a commercially available student version of its program, intended for personal use. This obviates the need to either insure or ration the use of expensive apparatus and equipment such as digital sound and light meters, for example.

From a critical 'pedagogic' perspective the ultimate benefit of using environmental analysis programs based on computer models is the flexibility it should give the designer to experiment with as many different parameters of his/her design that the model will allow. In theory this could present too much choice, but when well defined has produced interesting student work. Also it means group and individual learning can take place within a defined course plan.

CRITICAL ANALYSIS

Within our teaching practice the experience had with both LT and the IES-VE programs have been mixed. As teaching tools, they have been used successfully as a link from hand calculations and analysis to understanding how this process is manifestly speeded up and transformed within a computer program. At their best also both programs have enabled students to conduct detailed studies of their models' responses to different environmental conditions, in relation to daylight, sunlight and shading for example, and how that changed with different design adaptations to the original model(s). (Treacy and Uduku, 2012)

The need for a more experimental approach to such programs is fundamental to undergraduate tuition in Architecture, as this course in particular is often not studio based in delivery, the use of materials that allow students both view and experiment with different options becomes crucial to the learning process.

Both programs, IES and LT have been used in group situations and have been generally successfully utilised for peer to peer and group learning situations. The more technical nature of both programs, has meant however that the most successful group work had been done by teams with one or more knowledgeable or computer savvy students within the team.

From a 'constructive alignment' teaching perspective, the environmental analysis programs integrated within an undergraduate environmental design teaching programme, brings a diversity of learning experience and material, which has helped contribute to the program. (Biggs, 1999) The flexibility in use; from small group, class taught and individual self-led, and the different possibilities of assignment parameters allows for the creation of an extremely wide range of teaching and assignment tasks.

The continuing small but problematic bugs with environmental program interfaces with non specialist students, however remains a hindrance in the wide adoption of programs similar to the two discussed in architectural schools. We are currently involved in a project in which we have worked with IES staff to produced a simplified, less bug ridden "IES-education" version of the IES program and are currently trialling this across schools of Architecture in Scotland. (Treacy and Uduku, 2012a)

Despite the main offices for IES remaining in Scotland, uptake amongst Architectural schools of the programme is patchy. Our initial research findings suggest this is due to the identified issues related to the complexity of the program, lack of intuitive commands for designers and glitches or bugs with the main program requiring good technical support from a local source. Its focus as an evaluation tool for buildings already predesigned and not as a tool to be used within the more experimental phases of design is also still disappointing. (Treacy and Uduku, 2012b)

THE FUTURE

We believe that environmental analysis , in the light of continuing global pressure on environment and more national concerns about getting buildings to carbon neutral status, is set to become more integrated into the design process. Building Information Modeling (BIM), is currently being adopted by many architectural and engineering practices in the UK. Already almost one third, of practices use some form of BIM in their projects. (NBS, 2012) In June 2011 the UK government published its BIM strategy, announced its intention to require collaborative 3D BIM, with all project and asset information, documentation and data being electronic on its projects by 2016. The government has made the statement; “accept “BIM” or be ‘Betamaxed out’ (Bd Online, 18th May, 2011).

For these reasons the introduction of computer aided environmental building modelling as part of the teaching curriculum in UG architecture is inevitable. The future programs however will be more accurate, intuitive, less ‘clunky’, ‘bug-prone’ and than today’s. In order for these environmental modelling programs to succeed commercially the designers will need to consider more fully easier model importing and exporting, with fewer specific design parameters to ensure a smooth transition between members of the design team covering each discipline.

An improved method of revising models during the design process, be it in a classroom environment of design students testing an idea to a commercial office with professional designers reviewing options for a building warrant application is key to encourage the iterative design process and subsequently enhanced, informed design solutions.

Technology itself is set to move on as we can now with the use of remote wireless sensors record and download real time data into programs such as the environmental analyses programs we work with. Current mobile phone technology provides in-built devices such as cameras, lights and thermometers, easily adapted for use as a personal “environmental measuring toolbox”. This information could automatically link into a BIM system and allow for analysis in real time. Also the rise and rise of “Apps”, accessible on different wifi or 3G devices, from smartphones to tablets, suggests that students are unlikely to be tied to even laptop computers for analysis in the near future. [1] An example of this is our introduction to the Windtunnel App™, (available from the Apple iStore™), by our PhD teaching assistants who ‘tutor’ on our Environmental design course. This ‘app’ is now used by undergraduate students, in the modelling of airflow across their building designs. Collaboration has already gone global as networks such as Skype™ and Google™ talk allow for ‘real time’ talk and collaboration with colleagues internationally.

We envisage therefore a future where these initial attempts at transforming building engineering tools to teaching tools in Education will have been fully realised and we will have architectural teaching and small practiced focused software, probably in App format, which is accessible for different teaching and assessment modes to student and CPD attenders at local and international level.

This ‘future’ is becoming an area of growing academic research interest for ourselves and others in this field. (Horne and Thompson, 2008, Uduku et al 2011, Treacy and Uduku, 2012)

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