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SIMULATION IN EDUCATION: APPLICATION IN ARCHITECTURAL TECHNOLGY DESIGN PROJECTS

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ABSTRACT

This paper reports on the development of the building performance simulation delivery within an undergraduate programme in Architectural Technology at Plymouth University, UK. It reviews the lessons learnt from delivering two faculty driven, student developed live design projects over the past years, but also reflects the student voice as captured through focus group sessions. The paper then proceeds to discuss how simulation is currently being embedded in a significant restructuring of this Architectural Technology undergraduate programme, which provides various opportunities for improved delivery.

This paper provides insight into the challenges faced at undergraduate level while using simulation in the context of teaching design. This research suggests ways of introducing simulation through negotiated understanding that balances qualitative under-standings with more experiential and conceptual design.

INTRODUCTION

Increased emphasis on promoting resource efficiency and improved occupant well-being in buildings is leading to a need for design practitioners to be trained in the use of building performance simulation. This is recognised by Higher Education, where building simulation is now regularly taught on numerous programmes in Architecture and Construction.

Building simulation is widely used in postgraduate programmes. Programmes in areas like high performance buildings, sustainable design, and building information management are using building simulation, computational modeling and simulation for optimizing design and operation of buildings in terms of energy use and indoor environmental quality.

In the United Kingdom, amongst 33 architectural technology study programmes accredited by the Charted Institute of Architectural Technologists (CIAT 2015), most of the programmes put a strong emphasis on building information modeling as the most recent CIAT QAA benchmark statement requires these programmes to achieve threshold standard awareness of building information modeling (QAA 2014). However, building information modeling is not equal to building performance simulation. In these 33 study programmes, the coverage of building simulation depends on the specific alignment of the architectural technology programme; for instance, architectural technology and management programmes have greater emphasis on BIM whereas architectural technology and environment or design programmes have greater thrust on performance of the building. For those programmes that include simulation as part of their curriculum, different software tools are used; which ones is highly dependent on the available resources (staff expertise) and software licence cost. Some of the typical software used includes Ecotech, EnergyPlus, SketchUp Daylight Analysis, Sefaira and IES VE.

This paper focuses on the education of Architectural Technology (ATE) students at Plymouth University, UK. Currently building simulation is taught by means of a series of building blocks at different stages and modules in Plymouth University. Architectural Technology students are provided with theoretical underpinning of building physics and HVAC systems in the Building Science and Services module in the first year (ENBS117). Students are then introduced to series of simulation software in the Technology module (TECN201) in the second year, where students learn to operate the software and later are required to use these as a design tool in the Design Studio module (ATE202). In the final year, students are encouraged to develop further proficiency and use simulation software to test and validate their design in other modules, especially their capstone project (ATE301). However, this structure is being changed due to a university-wide curriculum restructuring, which includes a move from terms to semesters. This opportunity has been used for an in-depth reflection on the delivery so far, the student experience, and prospects within the context of the new structure.

METHODOLOGY

This paper first reviews student work resulting from the current set-up (ENBS117, TECN201 and ATE301) as described before.

This is followed by the outcomes of a student focus group, undertaken with a small group of students representing second and third years, providing insights from those at the receiving end.

From there, the paper reflects on lessons learnt, and presents the new structure moving forward.

Throughout, the paper reflects on fostering qualitative understandings within the student cohorts, and how to best integrate simulation in the curriculum through experiential teaching and use in (conceptual) design context. This supports a continuous review cycle by the module staff.

EXAMPLES OF RECENT STUDENT WORK

Students are provided with a solid basis for building science in their first year at University in the ENBS117 Module. Subjects covered include heat and mass transfer, lighting, noise and acoustics, and indoor environmental quality (McMullan 2012). Students are trained to manually carry out simple calculations of key terms such as U-values, transmission and ventilation losses, and basic boiler sizing, as well as daylight factors and reverberation times.

In year two, students are instructed in the use of a commercial building simulation tool, IES-VE (IES 2015), and then employ this software to study the performance of their design project in the design studio module, revising and optimising the design in order to achieve good performance in terms of thermal comfort, energy efficiency, and solar access.

The first project discussed here is a series of simulations conducted in this second year undergraduate programme (TECN201) (Figure 1 and 6). The module changes the specific design brief every year, but maintains the same set-up in terms of instruction in IES-VE.

The TECN201 module is designed to develop students understanding of issues in building construction and in designing the internal environment (building physics) (TECN201DMR 2014). Students are asked to work with computer software to analyse and test a particular space of the student's own design developed in ATE202 module. The Module consists of staff/guest presentations, related workshops/exercises and tutorials. The main submission for the module is a Technology Report, where students are asked to simulate the buidling desgined of their desgin project in ATE202 module (TECN201 2014). Students consistently demonstrate their techinical understanding and now they are pushed to be more analytical and reflective than mere descriptive in their assignement.

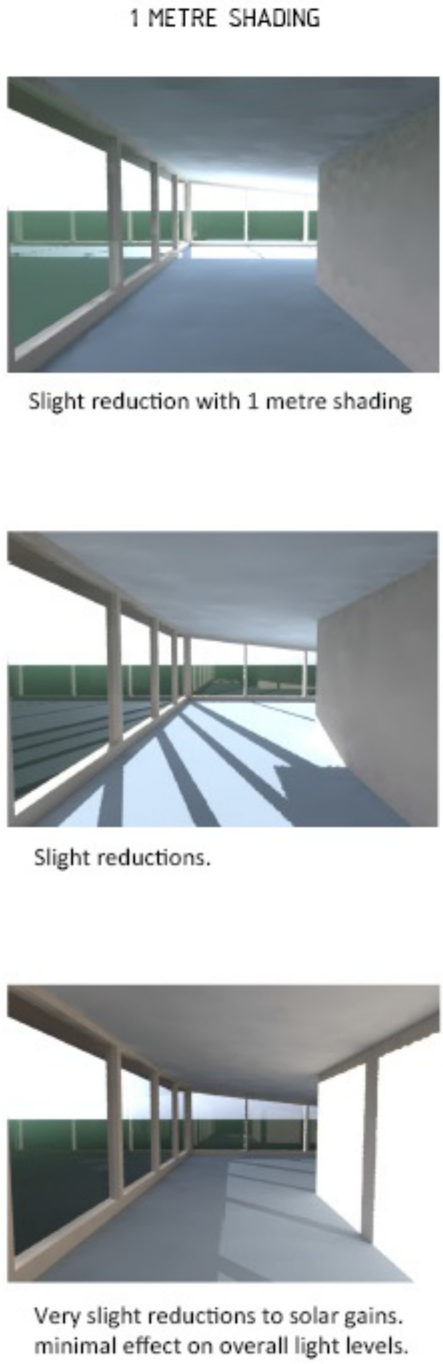

Figure1: Solar access study by student Kai Edwards, TECN201, May 2013.

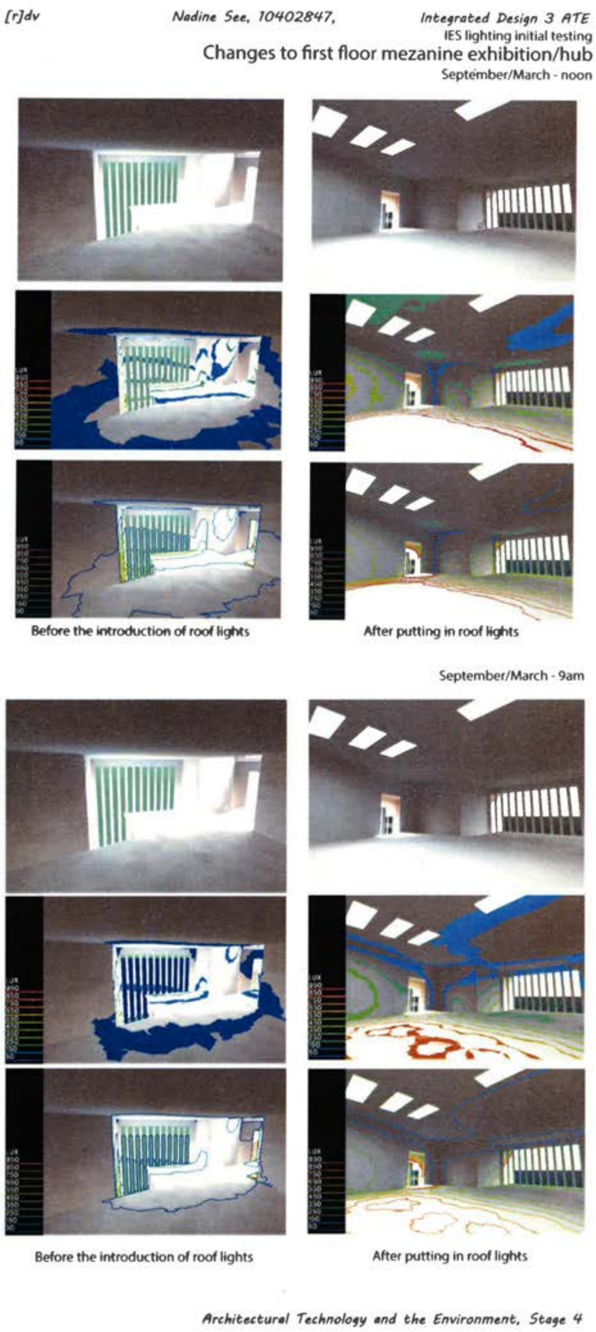

Figure 2: Daylight and comfort analysis models by student Nadine See, ATE301, Feb 2015.

The second simulation project takes place during the final year of the course, in the ATE301 module. Here, students triangulate their learning through an investigation of the similarities or differences between three approaches to the analysis of a building: personal experience of the quality of spaces; a qualitative assessment of the spaces by means of post occupancy evaluation (POE), and a modelled assessment using the IES-VE software (Figure 2, 3 and 5).

The ATE301 module allows the student to identify a specific building and set of technical issues related to its sustainability; to carry out research to evaluate the building's predicted and analyse actual performance in use; and to present a coherent argument for its suitability as an example of good practice (ATE301DMR 2014).

The Module consists of Staff Lectures/Presentations and Workshops/Seminars. This technical dissertation is a major piece of research and critical written work which will gives students an opportunity to investigate and understand a particular building typology and technology in detail, and to understand some of the key technical implications of building design decisions in relation to building sustainability (ATE301 2014).

Introduction of new environmental related software (like SAP, IES, THERM) has changed students' perception of technology from most dissatisfied module to one of the key strengths of the ATE programme (SPQ 2014). Though the students works (figure 1-3 and 5-6) demonstrates their understanding and ability to use building simulation software, not all students could grapple with the deep learning and not many could use the simulation as part of their design process.

THE STUDENT VOICE

To complement the hands-on experience of the academic staff with insights on the student side, a focus group session was held in April 2015. Two students from second year and three students from the third year took place in a discussion about the specific subject of simulation within the Architectural Technology curriculum. Discussion was prompted by investigative questions by the academic staffs, which were then discussed by stage two students and was followed by stage three students; this order was imposed to prevent contamination between the years.

Theoretical underpinning and basic understanding of software is addressed in different modules and different stages of the ATE programme. Focus Group Students' feedback clearly suggests that, theory (ENBS117) and practice (TECN201/ATE301) seem reasonably aligned. Students' feedback also further confirms the significance of teaching solid underlying theory, which enables students to adapt to any new software interface and toolbars. Students acknowledged the integration and constructive alignment of different modules (Biggs 1996, Cottrell 2013), for instance, the theoretical understanding is well understood in the simulation labs, which are tested and validated in a design project. Follow-up site visits and analysis of user behavior help the students to triangulate their understanding and students acknowledge the benefits of site visits.

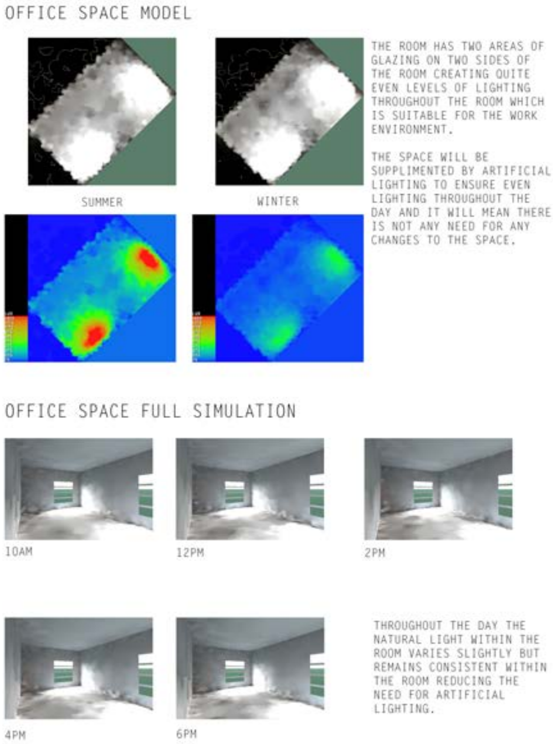

Figure 3: Daylight and comfort analysis models by student Ross Nunn, ATE301, Feb 2015.

At the same time, it was obvious that students - in spite of dedicated lectures on both subjects - easily confuse building information modeling and building simulation; at the receiving end the vast array of tools like SketchUp, IES-VE and Photoshop all merge into a host of programmes that need to be mastered within a limited time, and which all are required to enable their design activities. This lack of differentiation might be due to the fact that this is the first time they would have been exposed to a chain of activities that require analysis, visualisation, editing, and reporting activities.

The choice of the simulation software used in class is based on robustness of the tool, with the academic staff opting for a leading package: IES-VE. Interestingly, in the research community IES-VE is seen as a safe modeling environment, often used in teaching, which hides many of the complexities and need for computer literacy that is evident in other tools such as TRNSYS, EnergyPlus and Modelica. Students on the contrary felt the IES-VE software was complex software, and not really user friendly. Those in the final year, which already had been through job interviews, reported that prospective employers saw this software as expensive; most potential employers said they were not using it in practice.

One of the key interests with this review of delivery of simulation teaching was to find tangible evidence of application of building simulation in practice and as a tool in the design development: At the undergraduate level, developing understanding of the simulation and using it as a design skills is a greater challenge. Second year modules suggest a positive result; however, students have some reservations and this is mostly due to lack of awareness, as summed up by one student during the focus group discussion, '*software has definitely helped in design; but we should be careful not to let the software limit our design journey in a way. At times, because you don't know how to use software fully, you won't let your design to develop fully… Use the software to your best benefit, not to let it overrun you*'. Further limited understanding of tools (software) has negative impact as this is seen to prolong the design process and to slow down the progress; students see the simulation effort as non-reversible. For instance, a model exported from sketch up edited in IES-VE cannot easily be imported back to SketchUp and if any changes required, one has to start all over again. Another important factor is timing; getting a grip of knowing the right time to employ simulation tools in the design process. Students report to face challenges to develop the understanding of what they trying to resolve at which stage of their design process.

Another key dimension is client expectation; students strongly feel that clients and the general public at large still have to develop an understanding that simulation software can be used to make better buildings, which in turn will push the industry to integrate the simulation as a design tool. However, they are skeptical about the speed of this process, stating that it has been years before BIM was generally accepted, and that a similar trajectory for building simulation still has to follow.

Students' performance, students' feedback during the module evaluation, feedback from architecture tutors in the final year, as well as the focus group discussion demonstrate that there clearly is interested in a deeper approach on how to use simulation in design. Interestingly students have both an awareness of their limitations (knowing that the software can do more than they have done) as well as at the same time stating that they are confident in doing the tasks they have been trained on.

Further examination of students' aspirations to utilise the software clarifies that they are keen to develop proficiency in using the simulation software. However they also acknowledge their own limitations and see their own knowledge as a basis for communications with other experts such as building services engineers who could be deeper specialised in building simulation.

LESSONS LEARNT

One of the challenges of introducing simulation in education in an Architecture Technology curriculum delivered by different staff across consists of integrating the learning outcomes of the building simulation in different modules.

The transition between building science theory and simulation ENBS117 to TECHN201) seems to work well but in fact has not been put in place consciously. Being a first year module taught across the school, ENBS117 just builds up general knowledge for various students in architecture and construction. The jump to simulation within TECHN201 seems the correct time to make that jump, however it would benefit the students if further guidance is given on this step. From both student work and student experience as voiced in the focus group, emphasis ought to be put on the 'why' of using simulation, rather than the 'how'.

The structure of the TECN201 module was recently (2014) reworked to introduce building simulation software, which enabled students to assess the energy consumption and carbon emission of their own project designed in another course (ATE201). Earlier, students were studying these two models without much interaction. Now, students are asked to revisit their design in ATE202 based on their learning outcomes of the TECN201 module. As an example, after learning new software for thermal simulation, students are asked to examine their design to reduce carbon emissions. Students work and out come of the group work clearly demonstrates that students successfully adopted software like THERM effectively at the second year level. However, they demonstrated analytical ability and used IES VE software as a design tool only in the final year.

The above experiment is underpinned by the research-based learning in higher education and scaffolded by the Learning Development emphasis on students to be familiar with methods of collecting and analysing data and also provides them with an understanding of the nature of research within the context of the ATE (Hagyard and Walting 2011). The nature of research is driven by the staff research interest and employability, which has been critical in the emphasis on the sustainable built environment and inspires students through research informed teaching (Jenkins and Healey 2005, Lee 2004). The Charted Institute of Architectural Technologist (CIAT), in their recent Accreditation Panel visit have identified ATE programme structure as an exemplar of good practice and commended the ATE Programme for using technology (simulation) as a design tool.

The ATE tutors and colleagues positively acknowledged introducing new software and setting an open-ended assessment. However, as elaborated in the students' work, students' output - a technical report – did not reflect their understanding of the software and their learning outcomes. Furthermore, not many students demonstrated the impact of their technological understanding in their Design Studio.

The reasons for the gap in expectations and students' performance can be attributed to the timing, prior knowledge and the tutor's expectations.

CURRICULUM DEVELOPMENT

Plymouth University has initiated a university wide initiative, the Curriculum Enrichment Project which, in marketing speech, seeks to achieve a first class learning experience to ensure all students have the opportunity to succeed as graduates of choice with second-to-none employability skills (CEP 2015). This opportunity is used to reflect on the ATE tutors and students feedback, and using CEP as a vehicle of change the ATE programme has been restructured, with a clear focus on performance of the building, which is enabled by a series of modules with emphasis on building simulation (Figure 4).

A new module is created in the first year to specifically address CAD software and building information modeling and more theoretical underpinning of building simulation will be incorporated in a new BLDG401 module (first year). Both first and second year, second semester design modules are now multidisciplinary and provide an opportunity for students to collaborate with other disciplines like architecture, Building Surveying and Construction Management. An additional design module is created in the final year to provide more opportunity for students to use building simulation in their design projects. The Technology module in the second year and the technical dissertation module in the final year are now more research-informed and extensively supported for simulation. Finally the strength of the programme, use of building simulation, is used to integrate other programmes; BA Architecture and BSc building programmes. This whole process is used as a platform for the proposed MSc programme in High Performance Buildings, where building simulation is used extensively and acts as a natural progression for ATE students.

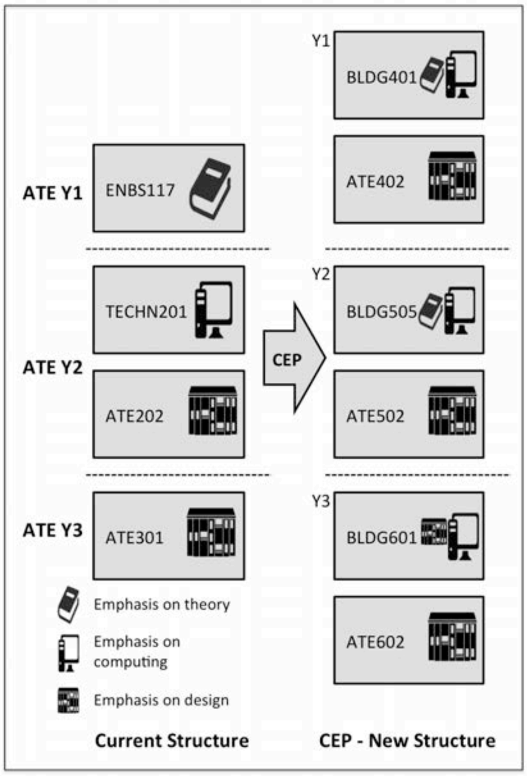

Figure 4: CEP – Restructured ATE Programme: emphasis on building simulation

CONCLUSIONS AND REMARKS

This paper, using a review of recent student simulation work, critically reflects the achievements and challenges faced while applying simulation in the design projects. Further, this paper has highlighted the challenges faced at the undergraduate level while using simulation in the context of teaching design.

The particular points are as follows:

- Theoretical understanding and the prior knowledge underpin students' performance in using simulation as a design tool. The need to understand basic knowledge of the subject to enable students to understand the potentials of simulation software can be identified as 'threshold concept' (Satish 2014). This also confirms the need for educating solid underlying theory, as the basic principles are always the same.
- At the same time, students identify a need to learn more about the use of simulation in a design context – the why rather than the how. This will be part of future teaching efforts.
- Overall, this paper provides an overview of the role of the Architectural Technologists and where students tend to believe to have developed shallow knowledge of a wide range of subjects and consider the understanding of the building simulation as an expert of a building engineer.
- This paper also demonstrates that students have both awareness of their limitations (knowing that the software can do much more than they have done) as well as at the same time being confident in doing the bits they have been trained on.

Finally, this paper highlights the need for greater industry interaction; encourage end users from industry doing guest lectures on building simulation and need for the design tutors to acknowledge the significance of the simulation in the design studios and further link this with site visits for the successful teaching of building simulation for Architectural Technology students.

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REFERENCES

ATE301 (2014) ATE301: Honours Project - Module Handbook. in *ATE Programme*: Plymouth University.

ATE301DMR (2014) ATE301: Honours Project - Definitive Module Record. in *ATE Programme*: Plymouth University.

Biggs, J. (1996) 'Enhancing teaching through constructive alignment'. *Higher Education, 32*. 347-364.

CEP (2015) The Curriculum Enrichment Project. in https://www.plymouth.ac.uk/your-university/teaching-and-learning/curriculum-enrichment-project, Plymouth: Plymouth University.

CIAT (2015) *Chartered Institute of Architectural Technologist: Educational Establishments* - http://www.ciat.org.uk/en/careers/educational-establishments/index.cfm, Available: [Accessed 02 Feb 2015].

Cottrell, S. (2013) 'Revolution by stealth: the impact of learning development on democratising intelligence through constructive approaches to student support'. *Journal of Learning Development in Higher Education, 6 - Nov 13*.

Hagyard, A., Walting, S. (2011) 'The Student as Producer: Learning by doing Research'. in *Learning Development in Higher Education: Universities into the 21st century*, Hartley, P., Hilsdon, J., Keenan, C., Sinfield, S. and Verity, M., (eds.) Hampshire: Palgrave Macmillan.

IES (2015) *Integrated Environmental Solutions Limited,* http://www.iesve.com/, Available: [Accessed 02 Feb 2015].

Jenkins, A., Healey, M. (2005) *Institutional Strategies to link Teaching and Research,* York: The Higher Education Academy (HEA).

Lee, R. (2004) 'Research and teaching: making or breaking the links'. *Planet, 2*(2). 9-10.

McMullan, R. (2012) *Environmental science in building,* Basingstoke: Palgrave Macmillan, 7th edition.

QAA, S. (2014) Architectural Technology benchmark statement. in *Planet*: UK Quality Code for Higher Education.

Satish, B. K. (2014) The relation between the learning development theories and the Architectural Technology and the Environment programme. in *PGCAP, Learning Development* Plymouth University.

SPQ (2014) Student Perception Questionnaire and National Student Survey. in https://intranet.plymouth.ac.uk/nssspq/intranet.htm, Plymouth: Plymouth University.

TECN201 (2014) TECN201: TECHNOLOGY 2: Issues in Building Construction and Building Physics - Modulehand Book. in *ATE Programme*: Plymouth University.

TECN201DMR (2014) TECN201: TECHNOLOGY 2: Issues in Building Construction and Building Physics - Definitive Module Record. in *ATE Programme*: Plymouth University.

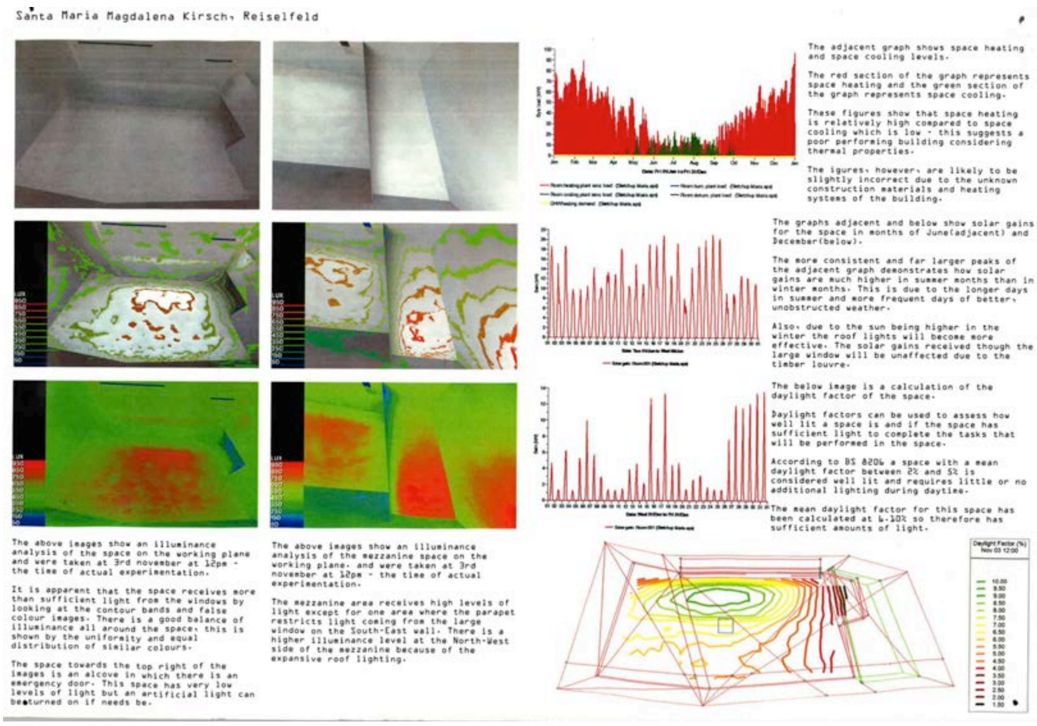

Figure 5: Daylight / thermal comfort models by student Jack Smith, ATE301, April 2015.

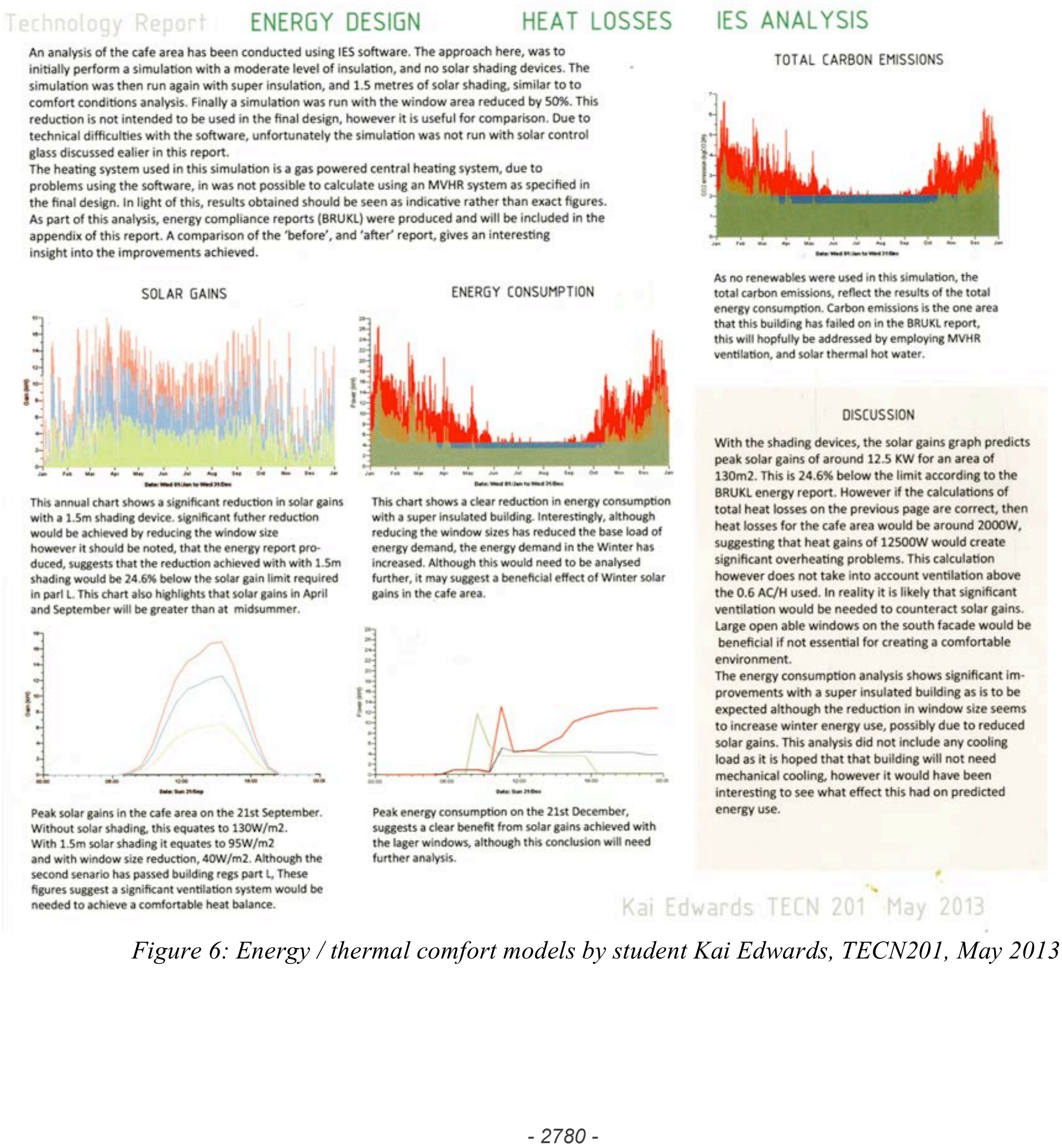

Figure 6: Energy / thermal comfort models by student Kai Edwards, TECN201, May 2013