Making it real - engaging students in building performance research at the Mac

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Introduction

In the context of the Glasgow School of Art, the subject of architecture is unusual in one particular respect. Most other disciplines work with their artifacts. This is not the case for architectural students, who only work with representations of their designs. For most, the construction of a building is an abstract process that will take place some years away, and occupancy is an even more distant concept. In the vast majority of cases, the justification and explanation of a design – and subsequent judgment of its merits – is made for and by other architects rather than building users.

It can be argued that the inability to learn from the real building and its users is a weakness in educational processes. It is however representative of architectural practice, which rarely undertakes building performance analysis. Over the past 20 years changes in construction processes leading to roles such as project managers, and contractual relationships such as design and build, have distanced architects from completed buildings. As a result, opportunities to learn from the artifact and to close loops between the design and performance (of whatever element) of a building are rare both in practice and education.

This problem is thrown into sharp relief by the current context of climate change and energy supply [1] [2]. This has led to increasing demands on performance [3], which in turn is leading the use of new materials, technologies and systems. In effect every new building is an experiment, but we rarely look at the results and more importantly, the reasons for these results. In almost every other design or engineering discipline it would be unthinkable to design and make something but then not test it or learn from it.

Learning from performance has become a critical issue. There is clear evidence of performance gaps between design expectations and building operation [4] [5] [6], not just in terms of energy performance, but also issues such as comfort, indoor air quality and satisfaction [7] [8]. At the same time there are also examples of excellent practice [9]. The need for architects, and therefore students, to understand and learn what the effects of design decisions are, and use this knowledge to improve design intelligence is crucial. Failure to do so undermines the value of design.

An opportunity to address this problem in a unique way presented itself at the Mac in 2012. The Mackintosh Environmental Architecture Research Unit (MEARU) is formed of staff at the school who teach Architectural Technology and is engaged in a range of research projects. The unit had been engaged by the Glasgow Housing Association (GHA) to provide design advice on 'The Glasgow House'. This was a prototype for low energy, flexible, affordable housing that would be a solution for both social and private rented sectors, and housing for sale. It included a range of low energy strategies including: sun-spaces, mechanical ventilation with heat recovery (MVHR), a clay block construction system to provide a highly insulated envelope with thermal mass, solar thermal systems and a highly insulated roof cassettes.

Fig. 1. The Glasgow House

As some of these technologies represented a departure from conventional forms of construction, GHA took the unusual but very progressive step of constructing a prototype house using their industry partner City Building, the construction arm of the organisation. Two versions were built on the site of the City Building Skills Academy in Glasgow by apprentices, one using the clay block system, and the other using an offsite timber frame. They are 3-storey semi-detached houses with 4 bedrooms. Although the original intention was to trial the construction systems and provide training for apprentices in new technologies and materials, the houses also presented a unique opportunity to evaluate and monitor their performance.

Fig. 2. Pilot study participants

MEARU were commissioned by GHA to undertake a study to examine the performance of the dwellings. The houses were not occupied and whilst physical testing could be undertaken, this would ignore a crucial aspect, that of the user experience and effects due to occupancy.

MEARU proposed an evaluation that used test occupants recruited from students at the MSA, who would occupy both houses identically using occupancy 'scripts'. This would provide a high degree of control of behavior, allowing the evaluation to focus on the relative performance of the buildings, which would be closely monitored during these periods. A pilot study was undertaken in 2011, and the main project undertaken in 2012-13, funded through the Technology Strategy Board Building Performance Evaluation programme for a Phase 1 study. Quantitative Phase 1 tasks included: Airtightness Testing; Co-heating test; U-value testing; Thermography; and MVHR testing. Qualitative testing was undertaken during each of the occupancy scenarios, including surveys, interviews and comfort polling.

Project Development

With many live projects, matching up the timescale and expectations of the curriculum and the project can be challenging, but in this instance students were simply changing their accommodation. The project was subject to the GSA ethical policy as it used human subjects. An important element of this was to be clear that the study was testing the buildings and not the occupants, nevertheless, issues of informed consent and safety had to be satisfied. Volunteers were sought across the MSA. There was a high degree of interest and groups were formed for the scenarios through a mixture of self-selection and availability across all years. There needed to be matching occupancy in both houses, so students were divided between the houses to match year groups, sex and room occupancy.

At the start of each project students were given a briefing at the Skills Academy, where they were asked to complete consent forms and also given copies of the occupant guides, which included the diaries and other relevant information such as contact numbers. External visits to the houses were minimized during the scenarios, exceptions being the need to maintain monitoring equipment, which included sensors for temperature, CO_2 and relative humidity.

Fig. 2. Real life

Scenario testing

The occupants were given an occupancy script, which determined their general activity and use of the house. Under these conditions we were also able to collect more detailed information about their everyday activities, such as cooking, window opening, frequency of shower use, etc.

The original intention was to undertake 6 occupancy scenarios. Some scenarios planned for the summer period to examine overheating were not possible due to poor weather conditions; however, alternative issues were examined including a scenario to measure the effects of thermal mass. A summary of the scenarios applied during the study were: -

SC1: A standard occupancy based on SAP assumptions – intended to provide a base case and comparison with SAP assumptions about occupancy.

SC2: Standard occupancy, with variation in the use of the MVHR system - testing the effects of disabling the MVHR system in a reasonably airtight house.

SC3: Continuous daytime occupancy – simulating the effects of an extended occupancy period, for example older people or unemployed.

SC4: Originally summer, revised to unoccupied testing looking at sunspace and thermal mass – scenario identifying the benefits in terms of heating and temperature stability.

SC5: Examination of continuous vs intermittent heating regime – comparing the relative performance of a continual low level heating regime verses a standard intermittent 2 period regime.

SC6: Comparison of natural vs mechanical ventilation regimes – comparing one week with MVHR only with a second week using natural ventilation only.

The results of the study in terms of building performance have been reported elsewhere [10]. Having occupants living in the houses provided a crucial level of information. For example, in SC5 comfort polling was used to determine relative levels of comfort between the houses. Important findings emerged from this, including qualitative aspects for example improved comfort in the thermally heavy house. In SC6 assessments of indoor air quality and ventilation, comparing window opening with the MVHR system found that with window opening, perceptions were better but actual conditions were far worse, especially in bedrooms. It also revealed interesting dimensions to assessments of comfort, which have affected on-going methodology. For example, it was clear that in assessing thermal comfort students were referencing their normal living conditions – those coming from draughty tenements rating the dwellings more highly.

Outcomes

The project had three major benefits. Firstly, BPE in domestic properties can be very challenging, both in terms of gaining access to peoples personal environments, but also because of variations in households and patterns of occupancy. In this project, controlling occupancy allowed a side-by-side comparison of the performance of the different dwellings, whilst gathering information about effects by - and on - occupancy.

Fig. 3. Construction systems

Secondly, the project exposed students to on-going research. This included the work of MEARU in general, and the context of research into the design and performance of low energy buildings, and related issues such as health and well-being. It also demonstrated the research methodologies being used, including both physical testing, environmental and energy monitoring, but also qualitative approaches such as comfort polling and interviews. It also gave the students an insight into the perspective of subjects of this type of research and these type of buildings. This was an important perception shift, to see themselves as the user and the subject, and helped to identify the ethical responsibility that architects have toward occupants.

Thirdly, and from the perspective of this paper perhaps most importantly, it gave a range of students an opportunity to experience living in a low energy building and to reflect on their experience through the BPE processes. Students had access to the drawings and specification and the adjacent houses are partially completed so students were able to see first hand the materials and construction, and the tests gave students an understanding into the issues of performance in buildings, in terms of technical requirements, comfort, air quality and usability.

Fig. 3. Real details – typical roof/wall junction.

The types of construction and low energy systems were no longer abstract issues, but tangible problems that students were able to apply in later studio projects, with a degree of knowledge and actual experience.

The feedback from students was entirely positive, and led to further student engagements with the research, including acting as temporary RAs and several students used the project as the basis for their own research projects in Stage 4 and for one student the engagement in research has led to PhD study.

Conclusions

The scope of contemporary construction is such that the conceptual distance between early designs stages and eventual occupancy appears to have increased. In addition, the greater complexity of construction processes means that there are larger numbers of specialisms and participants, through briefing, design, procurement, construction and sub-construction, commissioning and handover. One of the common findings from Building Performance Evaluation is that no-one has taken an overview of the project from beginning to end. If this is not the remit of the architect, then whose is it?

Participation in live projects is an important way of getting students to take their work seriously – to consider that what they design has real effects on the users of their buildings, to whom they bear a responsibility, and helps to close conceptual gaps between design and real life.

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