A reflection: Transformative aspects of teaching building science to architecture students

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Building science is not generally the favourite area of interest to undergraduates studying architecture. However it is an essential ingredient in assisting future architects to produce low energy buildings. Successful teaching and learning involves the engagement of students in their own learning and transformation. This paper discusses the links between transmissive learning, a standard approach in the teaching of building science, and a transformative approach, which can have a fundamental impact on the approach of architecture students to building science.

One way of encouraging the engagement of students in their transformation is to provide experiential learning through such activities as site visits and hands-on assignments and experiments that demonstrate the impact of building science on design. This paper focuses on a number of aspects of one building science unit that teaches the basics of heat transfer in buildings. It examines how the learning experience is related to transmissive and transformative teaching approaches. The paper concludes that there are some missing threads in the learning experience which results in transmitted knowledge not leading to higher levels of understanding.

Keywords: architectural education, building science

INTRODUCTION

Student feedback in a science related unit in the architecture course at Curtin University (CU) frequently refers to a missing link between the content of this unit, the science of heat transfer in buildings, and the applicability of the unit to designers. Interestingly the feedback also shows that in this unit students believe they are well informed about heat transfer before they start the unit. This paper reflects on how teaching and learning within this science unit can evolve from an essentially transmissive form of teaching to a more transformative approach. Both Maslow’s Hierarchy of Needs (Maslow 1943), extended to apply to education, and an adaptation of Bloom’s Taxonomy of Educational Objectives (Krathwohl 2002) are used to develop an educational framework related to transmissive and transformative learning that can be applied to sciences in an architecture course.

The paper uses two sources of student survey responses to identify issues in the teaching of the unit. Conclusions drawn from these surveys are placed within a proposed educational framework to identify possible directions for more effective teaching.

1. METHODOLOGY

Building sciences are compulsory units for all second and third year students studying architecture at CU. This paper provides a framework for examining the components of the teaching and reflects on which aspects of the teaching of a second year unit that looks at the basics of heat transfer in buildings is most successful and how the teaching and learning outcomes could be improved.

1.1. Understanding the framework of teaching

This paper suggests that Maslow’s hierarchy of needs may provide a way to better understand the shift between needs and wants within the sciences. In his paper “A Theory of Human Motivation” Maslow describes the hierarchy of basic human needs (Maslow 1943). The most basic of these needs, the physiological, are identified as the most prepotent – those that are likely to provide major motivation for those who “are missing everything in life in an extreme fashion” (Maslow 1943, p373). When these most basic of needs, such as food, homeostasis, breathing and sleep, are met other, higher needs emerge as behavioural motivators. The need for safety starts to dominate, followed by the need for love, affection and belonging. Other needs follow, such as a desire for self respect and the esteem of others, and finally, at the top of Maslow’s pyramid, self actualization – the desire for self fulfilment (Maslow 1943). In the example related to teaching of building science in architecture, the desire of students to satisfy their basic needs (enough information to pass assignments, exams, etc) could be considered as equivalent to the basic physiological needs, while the desire to develop a way of integrating science into design thinking is intrinsic to the higher order need for esteem / self actualisation.
The concept of cognitive demand has been used to develop a hierarchy of levels of thinking, adapted from Bloom’s Taxonomy of Educational Objectives (Krathwohl 2002). This is considered in a similar way to Maslow’s hierarchy of needs, in that “mastery of each simpler category was prerequisite to mastery of the next more complex one” (Krathwohl 2002, p212). Mastery of the lower levels of thinking, such as remembering, comprehending, applying, are required prior to the mastery of the higher levels of thinking - analysing, evaluating, creating. This approach is used by CU’s Office of Teaching and Learning to assist in the development of units, by using Levels of Thinking to frame and structure the unit learning outcomes and assessment tasks (CUT OTL handbook).

In order to apply this approach to the teaching of building science in architecture, Maslow’s Hierarchy of Needs and Krathwohl’s Levels of Thinking, have been aligned and adapted to focus on the anticipated learning needs of the student. It is suggested that when the learning needs of the students are met at the higher levels of thinking as shown in Table 1 below students will recognize the importance of using science to inform architectural design.

<table>
<thead>
<tr>
<th>Maslow Hierarchy of Needs</th>
<th>Krathwohl Levels of Thinking</th>
<th>Learning Needs of Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiological</td>
<td>★ Remembering</td>
<td>Information</td>
</tr>
<tr>
<td></td>
<td>★★ Comprehending</td>
<td>Knowledge</td>
</tr>
<tr>
<td>Safety</td>
<td>★★★ Applying</td>
<td>Skills</td>
</tr>
<tr>
<td>Love / Belonging</td>
<td>★★★★ Analysing</td>
<td>Relevancy</td>
</tr>
<tr>
<td>Esteem</td>
<td>★★★★★ Evaluating</td>
<td>Judgement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Values</td>
</tr>
<tr>
<td>Self Actualisation</td>
<td>★★★★★★ Creating</td>
<td>Application</td>
</tr>
</tbody>
</table>

Although Maslow (1943) acknowledges that there is some overlap across the hierarchical levels and that the lower order needs may not be 100% gratified in order for the higher order needs to emerge as motivators, this structure for thinking about learning may provide some insight into student feedback about a variety of teaching tools used in building science.

1.2. Structure of learning experience

Using the principles of Maslow’s Hierarchy of Needs and Krathwohl’s Levels of Thinking, a framework of learning experience has been developed (Karol & Mackintosh (forthcoming)). This framework is used to examine the structure of the learning experiences in the science unit and to assist with the development of transformative teaching and learning experiences. It has also been used to analyse the results from student feedback.

Table 2 below provides a summary of the format of the unit within the framework of learning experiences. This has been structured to illustrate relationships between format and the educational taxonomy. The unit is run during a 12 week semester. It is a 12.5 credit unit, a half-unit which has the equivalent of 1 hr lecture and 1 hr tutorial per week. Each lecture covers a discrete topic. For example one lecture examines solar geometry whilst another looks at heat transfer though glass and a third considers heat transfer through ventilation. The weekly tutorial generally consisted of a series of questions (with answers provided) about the topic of the lecture. One tutorial involved a hands-on experiment to examine solar penetration. Another tutorial was a site visit that enabled students to experience thermal conditions in one of two buildings that had been designed to maximise the thermal benefits of the local climate. The assignment required that each student measure the thermal conditions in his/her bedroom with a thermal data logger, tabulate the results and, over the course of the semester, discuss/analyse the thermal performance of the room in terms of outdoor conditions and heat transfer through the building envelope.

Table 1: Hierarchy of Needs and Levels of Thinking aligned

Table 2: Format of Unit within the Framework of Learning Experiences
Table 2: Unit structure related to educational taxonomy

<table>
<thead>
<tr>
<th>Structure</th>
<th>Maslow – Hierarchy of Needs</th>
<th>Bloom/ Krathwohl Levels of thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physiological (information)</td>
<td>Safety (skills)</td>
</tr>
<tr>
<td>Lecture 1 hour / week</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tutorial 1 hour / week</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hands-on experiment</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Site visit</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Assignment</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

1.3. Assessment of learning experience

Two general types of student surveys were carried out. One type was an on-line survey that was conducted by CU for every unit. The other type was an in-class survey, issued specifically for this unit.

The eVALUate CU online survey is conducted at the end of each semester and while it is not compulsory, students are encouraged to respond, and incentives are offered by CU. Depending on the size of the class, a minimum response rate is considered indicative of the whole student group (Curtin University of Technology 2010). 120 students were enrolled in the unit in 2010. As 40% of the class responded the results were considered to provide a valid source of indication of specific issues.

The eVALUate survey is structured with two types of questions. One type is quantitative with a five-step scales of agreement ranging from strongly disagree to strongly agree. This type applies to questions regarding the structure of the unit and use of the learning experience. The other type is qualitative and seeks subjective comments on the content and structure of the learning experience.

In-class surveys were conducted twice, first in the early part of the semester and then close to the end of the semester. The first survey sought to try to understand how students were engaging with the unit and to assess if particular aspects of the unit could be improved to assist in engaging students. The second survey was seeking to identify if students recognized the transformative possibilities of experiential learning such as the hands-on experiment, the site visit and the assignment. Both surveys were written to try to assess the levels of interest in and understanding of the unit as well as to gauge the most successful parts of the teaching of the unit. Responses rates for in-class surveys were similar to the eVALUate CU online survey with a 49% response rate in the first survey and a 41% response rate in the second survey. Two types of in-class survey questions were asked. One type was quantitative with a five-step scale of agreement ranging from strongly disagree to strongly agree. The other type was qualitative and sought subjective comments in particular areas related to the teaching and learning of the unit.

2. RESULTS

Only those questions from both surveys that relate to the taxonomy of learning are shown below. The results from the on-line survey and the in-class surveys are shown separately.

2.1. eVALUate on-line survey

From the quantitative part of the eVALUate survey this paper focuses on the following two questions, related to the students motivation to achieve and how they make best use of the learning experiences. These two questions provide indicators of general satisfaction with content and learning experience. Student perception of motivation, Q8, is used to explain the perceived relevancy of the content. The ability of students to identify how they might use their learning experience in this unit, Q9, is considered an indication of the perceived relevancy of the unit to the other units within the course.

Q8  I am motivated to achieve the learning outcomes in this unit  64% agreement

Q9  I make the best use of the learning experiences in this unit  77% agreement

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Within the qualitative part of the survey, the subjective comments received have been assessed to gain a broad understanding. The survey requests comments regarding the most helpful aspects of unit, and how the unit might be improved but respondents were not directed as to which area of the unit to comment on. To assess the focus of the comments in relation to the types of activities and learning experiences within the unit, the responses have been grouped in relation to the structure of the unit, namely which elements of the structure were most helpful in transmitting information and/or raising understanding.

Figure 1: Responses to eVALUate on-line survey question

“Please comment on the most helpful aspects of Building Science 201”

2.2. In-class student surveys
From the quantitative part of this In-class survey this paper focuses on the question that relates to the students awareness of their own prior understanding of the content of the unit. This question was asked in both the first and second in-class survey. Results are shown in Figure 2.

Figure 2: Response to in-class survey question

“When I started this unit I understood why indoor temperatures were effected by sunlight and outdoor temperatures”
The response from the qualitative question in the survey, relating to the part of the unit structure that was perceived as most successful have been grouped similarly to those of the eVALUate questions. This can be seen in Figure 3.

A question posed only in the second in-class survey focused on the students perception of the relevancy of the unit with regard to other units studied at the time, in particular design studio. The result is shown in Figure 4 below.

3. DISCUSSION

Both survey tools show that students are generally focused on the transmissive qualities of the teaching although they place value on those parts of the unit that encourage higher levels of thinking. This is reflected in the high level of appreciation of tutorials and assignments.

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Figure 3: Response to in-class survey question

“What part of the teaching of this unit has been the most successful in improving your understanding of designing for thermal comfort in buildings?”

Figure 4: Response to second in-class survey question

“I was confident in using my understanding of sun movement to inform my Design 201 projects”
Tutorials were presented as a series of questions and answers, which related the content of the lectures to real-world scenarios and problems that relate to other areas of studies such as design. In both the first and second in-class survey 59% and 52% respectively identified tutorials as being the most successful part of teaching that improved students understanding. Evaluate comments relating to how the unit might be improved focused on how the facts, particularly how to use formulae to compute heat transfer, could be better transmitted when a large proportion of the students have little mathematical background.

The assignment was also seen as being a successful learning experience. Students were asked to measure performance of their own home and evaluate this in terms of the concepts and principles addressed in the lectures and tutorials. The student responses reflected the higher level of thinking for this learning experience.

With both the tutorials and the assignment, there was little difference between the responses of the surveys conducted at different times of semester. From Figure 3 it is clear that the site visit added a significant learning experience. In the first in-class survey three aspects of learning were highly rated. They were the tutorials, the lectures and assignment. However, in the second in-class survey in addition to the tutorials two other aspects of the learning experience were significant. They were the assignment and the site visit. This shift in response has been taken as a measure of the value placed of the site visit experience by the students.

In spite of the possibilities for a variety of levels of thinking through the different activities in the unit it seems that the learning experiences are generally transmissive. However one student’s comment in eVALUate that “information provided is fantastic and so is its accessibility, only the practical sense is lacking” supports results from the second in-class student survey that shows that 76% of students agreed or strongly agreed that the site visit was important in showing the relevance of the unit in the wider architectural realm.

The results from the eVALUate survey and both in-class surveys indicate that the majority of the teaching remains at a transmissive level. Through the use of a transformative learning matrix it has become evident that improving the level of self awareness, in other words enabling students to recognize their own growth in understanding the place of building science in the design profession is essential. This matrix uses Levels of Understanding to evaluate the transformative nature of the learning experience. These levels are the transmissive levels of thinking, the relevancy of the learning experience, the self awareness of the student’s learning and the development of a philosophical position.

By considering the various activities within the unit, as indicated in Table 2, and using the responses from the surveys to assess the transformative experience, a 3-dimensional diagram has been developed, as shown in Figure 5.

Figure 5: 3-dimensional diagram representing tasks in terms transmissive and transformative experiences

In the in-class surveys, when questioned about their awareness of prior understanding, the response indicated that while there was a low level of disagreement with the statement, there were also about a third of the respondents that were non-committal about their level of understanding (Figure 2). Between the first and second survey, this lack of shift in self awareness indicates that those learning experiences that offer a higher level of thinking, do not result in
higher levels of understanding. This is more clearly seen in the 2-dimensional diagram in Figure 6, which compares the levels of thinking (transmissive) with the levels of understanding (transformative).

In the second in-class survey there was an attempt to try and establish the students’ confidence and transferability of the knowledge learnt in this unit to design. The results of this can be seen in Figure 4. The responses to the question regarding the relevancy of understanding heat transfer to design indicated that nearly half (48%) of students could see the relevancy although one quarter were unsure and another quarter could not see the relevancy.

CONCLUSION

Ideally, educational experience requires achievements at both the higher levels of thinking and understanding. Analysis shows that the student learning of building science remains at a transmissive level. How do students move towards higher levels of understanding which enables them to integrate sciences and design? This occurs with transformative thinking starting with a level of student self awareness and development of the whole learning experience rather than discrete components within a unit.

In the current program there seem to be some missing ‘threads of change’ which could potentially transform some of the learning activities, particularly those activities that already show a higher level of thinking such as the site visit, assignment and hands-on testing. What are these ‘threads of change’? And can these ‘threads of change’ serve as this holistic tool?

Further research is required to examine these ‘threads of change’. They could include cross curriculum teaching to better integrate science and design or the use of exhibitions and peer review sessions of work which are not traditionally included in the teaching of science or additional modes of feedback that help students to see the implication of their work in building science.

REFERENCES


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