Integrating Technology Subjects with Design Studio Teaching: Comparing Curriculum of Architecture Education in Australia and Iran

Mahmoud Reza Saghafi
Architecture, Isfahan University of Art, Esfahan, Iran and
School of Design, Queensland University of Technology, Brisbane, Australia

Philip Crowther
Queensland University of Technology, Brisbane, Australia

Abstract

Purpose
Design studio and technology subjects are two dominant parts of the architecture curriculum. How to integrate these different parts of the curriculum is one of the important challenges in architecture education around the world. With increasing internationalisation of both the profession and higher education, an understanding of similarities and differences across the globe are important. This paper illustrates two different approaches to such integration in two very different contexts; case studies at the Queensland University of Technology in Australia and the University of Tehran in Iran.

Approach
The study implemented a case study approach, based on document analysis methods. This paper explores the integrated role of technology subjects in architecture education, followed by a critique of the teaching of technology within the design studio. The analysis is conducted across four significant features of the curriculum.

Findings
Overall, in both programs, the aim is for students to develop architectural knowledge and skills; although the Iranian program has a stronger focus on knowledge, while the Australian program has a stronger focus on the application of knowledge and skills, particularly within the design studio projects.

Originality
Comparative analysis of architectural education in these two different contexts offers an insight into alternative approaches to teaching technology. Such an insight may offer guidance in curriculum development to support the exploration of new hybrid approaches, as well as supporting international student mobility.

Keywords: architecture education, technology, design, studio, curriculum, pedagogy

Introduction

Architecture education is a combination of art and science, so its curriculum contains both theoretical and practical subjects. Two dominant parts of the curriculum are the design studios, as the core of architecture education, and the technology (building construction) subjects which offer a practical foundation for the design process. Integrating these different parts of the curriculum is one of the important challenges in architecture education around the world (Heath, 2010; Salama, 2008). Different countries benefit from different curricula that respond to their education needs, aims, and outcome. However, the rapid internationalisation of higher education is making the need for better understanding of different approaches more critical in the twenty first century (Watt and Mandhar, 2008; Zapp and Ramirez, 2019). In the case of Australia, the number of international architecture students who return to their home nations after study is increasing and diversifying (Maroya *et al*., 2019); this suggests an increased need to understand different international contexts. This paper focuses on comparing the architecture education curricula of two selected universities in Australia and Iran to analyse how technology and design studio subjects are integrated through these curricula. International architecture students from Iran are an increasing proportion of the student population in Australia (Maroya *et al*., 2019). Though they represent a much smaller proportion than China or Malaysia, they do present a significantly different curriculum and as such a comparative analysis of the two gives opportunity to understand and learn from each other, and also to facilitate better outcomes for international students.

The aim of this study is to expose alternative approaches to the integration of technology and design in the curriculum of architecture education. In particular to understand the differences in curriculum that international students may experience; with a view to bridging any divide and improving student outcomes. The research question is how can technology subjects be integrated with architectural design studios in the curricula. While there are numerous studies of architecture curriculum models (Ostwald and Williams, 2008; Harriss and Froud, 2015; Salama, 2016), there is little direct comparative analysis of international differences, particularly in developing areas of collaboration and mobility, such as Australia and Iran. It is also worth noting the historic development of Australian architecture curriculum, which was based on the RIBA model (Ostwald and Williams, 2008), and Iranian curriculum, which was originally based on the École des Beaux-Arts model (Saghafi & Sanders, 2020), but which after the cultural revolution of the early 1980's evolved to reflect the approach of the USA curriculum (Mahmoudi, 2014). These alignments with wide spread international curriculum models suggests a wider application of these research findings in similar contexts. The comparative case study methodology implemented a document analysis method in which documents are interpreted by the researcher to provide meaning around an assessment topic (Bowen, 2009; Fox-Wolfgramm, 1997; Zitzler and Thiele, 1999).

Background

"Architecture is a unique human activity that blends artistic creation with scientific knowledge and technology innovation" (Taleghani *et al*., 2011). The significant aim of architecture education is to develop the ability to "integrate divergent field of knowledge" including art, society, culture, history, business, and technology (AACA 2019). How this integration is achieved varies across the globe in different cultural contexts. Such differences, and similarities, need to be understood in order to facilitate internationalisation of education and the professions itself.

The long history of architecture has evolved around the design studio as the signature pedagogical mode of architecture education (Crowther, 2013; Shulman, 2005). Design studios universally apply the semi-structured learning strategy of experiential leaning; in particular the project which includes some aspects of the learning strategy of problem-based learning (Delahaye, 2004, pp. 324-326). In practice this mode of delivery seeks to create a learning environment in which students work on design projects while tutors offer formative feedback in the form of individual reviews given casually at weekly classes/tutorials. Much of the learning takes place through dialogue which 'elicits those activities that shape, elaborate, and deepen understanding' (Biggs, 1999; Schön, 1984). So central to architecture education is this mode of learning, that 'architectural education is based primarily around the design studio as a pivot and gathering point of all knowledge and skill accreted throughout the curriculum' (Mostafa and Mostafa, 2010).

This pivotal, gathering point, the studio, is supported by allied leaning activities in subjects related to history and theory, technology and construction, and professional practice. How these subjects then come together is a matter of curriculum structure, which is guided by individual institutional philosophy. It is precisely this difference in curriculum structure and institutional approach to pedagogy that this paper explores.

The role of Technology subjects in Architecture Education

"In order to ensure the feasibility of art creation, architects should be fully equipped with basic theoretical knowledge on structures. The objective of architecture structural subject is to help students to build and use the accurate structural concepts" (Tan *et al*., 2013). There are numerous ways in which technology and construction knowledge can be integrated into the curriculum (Allen, 1997; Aziz *et al*., 2007; Saghafi 2020; El Hanandeh *et al*., 2013; Salama 2016). While each has its merits they must all deal with the broader context of the profession and its changing knowledge pool. Each must also engage with new technological developments in areas such as sustainability and environmental consciousness, and develop appropriate pedagogical ways to deal with such new knowledge (de Gaulmyn and Dupre, 2019).

Technology subjects seek to develop an architectural understanding of building construction and structures as opposed to an engineering understanding (Lonnman, 2000), and the learning objectives of these subjects reflect that difference of perspective. As already noted above, the traditional or discipline-based approach (Toohey, 1999) to curriculum development has seen the division of architectural knowledge into four main types of subjects, (design studios, history and humanities, technology, and professional practice). This dis-integration of knowledge within architectural education has been widely noted and criticised (Kucker, 1997; Ridgway, 2003; El Hanandeh et al., 2013).

Therefore, it is recommended that the studio assignments are cross-referenced throughout the other technology classes to improve students' perception of a holistic design especially in early stages of the design process. This approach links structure with architectural design elements and students are able to provide appropriate proposals for the building construction system (Aziz *et al*., 2007). The relation between architecture and technology suggest that design is an act of interpretation the principles of environmental forces provides opportunities, not specific solutions for design (Smith, 1987).

Architecture students need to be familiar with the possibilities and limitations of building structure and how to select the appropriate system. Graduate students should be able to demonstrate understanding of architectural technology and its influence on design outcomes (AACA, 2019). Criticisms on integrating technology as an applied science in design studio may refer to different problems in pedagogy, curriculum, and institutional organization which vary from one university to another and can be presented as follows:

- Isolation of technology subjects from design studios as the core of architecture education (Heath and Jones 2010; Salama, 2008)
- Teaching technology as a pure science or for construction engineering, not as an applied science which should be translated into architectural design (El Hanandeh *et al.*, 2013)
- Focusing on aesthetic aspects of final product in design studio instead of focusing on the process of design and how to apply different part of curriculum including technology in a problem solving approach (Salama, 2016)
- Lack of technical support in design studios which may resulted from time shortage, limitation of tutors' expertise/knowledge, or lower priority for structural knowledge in the program (Maroya *et al.*, 2019)

Curriculum in Practice

The following section compares architectural education in Iran as a developing country in Asia, with Australia as a developed country in Oceania. As already noted, an understanding of these two curricula is important due to increasing student mobility (Maroya *et al.*, 2019). The research has utilised an illustrative form of research to expose alternative approaches to curriculum structuring. Document analysis has been used to compare and contrast the two cases; commonalities and differences are uncovered and discussed. While the two cases set the limitations of the study, they also illustrate possibilities for curriculum structuring that may be applicable outside of these cases, in similar contexts.

Education in Iran

Architecture education in Iran suffers from unrelated parts of knowledge, design, and skills in the curriculum, as well as weak relationships with the construction industry, building codes, and context (Vafamehr and Sanayeayan, 2007). Architecture students can benefit from building engineering collaboration in design projects at schools of Built Environment (Vafamehr and Sanayeayan, 2007). Architecture courses in Iran were firstly defined based on [the aesthetic aspects of] "Design", and then re-oriented to be focused on Architecture Engineering, reinforced by the study of technologies in building engineering and construction. However, teaching structure subjects as they have been taught at Engineering faculties, is not responsive (Golabchi *et al.*, 2004).

The University of Tehran (UT) is a large size university ranked as a 1st in architecture in Iran (University-of-Tehran, 2019). The College of Arts, as the primitive core of the Faculty of Fine Arts, was closely modelled on the French École des Beaux-Arts as a model of architecture education (Saghafi and Sanders, 2020). The course design has been partially changed in 1968 and changed overall in 1982, after the Cultural Revolution in Iran (Saed Samiee, 2004). As the first major change in course design, the course was re-oriented toward Iranian Architecture and covered more technical subjects; in doing so forming the Architectural Engineering degree.

The next major shift in course design occurred nationally when the Continuous Master Degree of Architecture changed to the Bachelor and discontinuous Master Degree in Architecture in 1999 (Hojat and Sedaghati, 2018). The continuous 6-7 years Master program was divided into a 4 years Bachelor and a 2 years Master degree to provide more flexibility, offering various fields for Masters, including Architecture design, Architectural studies, etc. But the Bachelor Degree of Architecture remained with no other alternatives. Furthermore, there was an opportunity for students in a few Iranian universities to continue their study in Architecture construction at Master level which focuses on technology subjects.

The revised curriculum (2014) in Iran has defined a Bachelor degree for four years which is between the conventional duration for Bachelor of architecture in the USA (5 years) and Europe (3 years). From 2017, universities which have their own 'Board of Trustees' were authorised to offer their own curriculum, and if it would be approved by 'Council of Educational Planning', it can be used by other universities. There are also two other accredited curricula for the Bachelor of Architecture produced by the Ferdowsi University of Mashhad and the Master of Architecture produced by University of Beheshti. However, most of the universities in Iran follow the accredited curriculum of UT for their architecture education (Saghafi and Sanders, 2020).

Most of the universities do not play a role in programming architecture courses. There is not a logical interrelationship between the lecturers of different subjects (Golabchi *et al.*, 2004). Architecture education does not generally benefit from a comprehensive relationship with other related schools. Also, the content of the subjects are not up-to-date and appropriate and they are not properly linked to the other subjects (Golabchi *et al.*, 2004). Architecture students have difficulty in integrating technology into their design due to three basic problems including the curriculum, the teaching pedagogy, and the instructional tools; which are borrowed from engineering courses and do not respond to students' needs (Aziz *et al.*, 2007). What is needed is an effective architectural structure curriculum which may lead to a better integration of architectural concepts with structural solutions, without major changes to the curriculum and without increasing students learning hours (Aziz *et al.*, 2007).

One of the problems is isolation of technology subjects and the assignments of the architecture design studios. The design studio does not utilise the knowledge gained through the structure class to assist students visualising their design in relation to structural applications (Aziz *et al.*, 2007). Most of the students are not creative in their structural solutions due to a lack of understanding of the application of this knowledge. There is a need of understanding structural application rather than structural calculations. Similar to studio teaching, the structures subject should be taught by learning, doing and critical thinking instead of listening to and calculating, to engage the interest, innovation and creativity of the students (Aziz *et al.*, 2007).

Education in Australia

Given the need to comply with the capabilities in the Standard of Competency (AACA, 2019), most architecture courses in Australia have strong similarities in their content and learning outcomes; they do however vary in how knowledge and skills are developed and applied. Architecture courses across Australia can be seen to be structured from several fields of knowledge/content type. These fields have been developed from the Royal Institute of British Architects (RIBA) model of architecture curriculum and as such are fairly universal across Australia (Ostwald and Williams, 2008; Maroya *et al*., 2019).

Queensland University of Technology (QUT) is a large size university ranked within the top 10 in Australia. Architecture is one of the design courses at The School of Design, which moved from the Faculty of Build Environment and Engineering to the Faculty of Creative industries in 2012. This school has professional accreditation for its latest version of Architecture Course in 2016. The architecture program at QUT is typical of other Australian programs, with one structural difference. It is arranged as a four year undergraduate degree (Bachelor of Design) followed by a one year postgraduate degree (master of Architecture), while currently all other programs (of the 18 accredited in Australia) have a three year undergraduate degree followed by a two year postgraduate degree. This structural difference makes effectively no difference to the curriculum, course content, or delivery modes, which in all universities must meet the requirements of professional accreditation (AACA, 2019). That being said there are some minor differences in the approaches to the integration of technology and design studio.

The practical integration of technology and construction knowledge is considered to be one of the most challenging and problematic areas of the curriculum, with both the profession and students calling for it to be given greater attention within the programs (AACA, 2019). Within QUT's curriculum development philosophy, these technology subjects are intended to promote an authentic learning experience for the students, one aligned with real world experiences and practice. The aim has been to identify terminal behaviours, standards, and conditions (Delahaye and Smith, 1998), that are more authentic and relevant, while covering the technical content, mapped down from the program level competency standards. While the technical background knowledge is important, these subjects also seek to develop the ability to apply such knowledge in a design environment, thereby treating the subjects' content as both declarative knowledge and as functioning knowledge (Biggs, 2011).

In practice an architect would never be expected to conduct the structural calculations but being able to understand what an engineer is talking about is a vital capability in practice, as is using and applying an understanding of structures in the design process. 'Selection and configuration are the most important phases of technical design activity, yet they are precisely the phases that are taught least in [architecture] school' (Allen, 1997, p. 92). Therefor in the QUT technology subjects 'the goal is to develop a conceptual thinking process that identifies structured relations of technology and construction that simultaneously work to broaden and enhance formal, mechanical, experiential, and aesthetic possibilities' (Kucker, 1997, p. 110).

The integration of technology subjects in the curriculum at QUT is managed through a range of approaches, with particular focus on the cognitive approach (Toohey, 1999). What is needed are learning activities in which students can actively engage with processing and questioning, and practice thinking skills (Toohey, 1999); the kind of thinking that leads to learning (Sale, 2001). The aim is that students will interpret sensory input to actively construct their understanding based on prior knowledge and experiences (Toohey, 1999).

The teaching and learning of building construction, structural systems, and technical documentation (drawing), traditionally uses a process of externalisation through metaphors and models, such that tacit knowledge becomes explicit (Nonaka and Takeuchi, 2007). In the curriculum developed here, these conceptual models are supplemented with physical models and experiments as a learning strategy that adds a process of internalisation in which explicit knowledge becomes tacit (implicit and internalised), through 'learning by doing' (Nonaka and Takeuchi, 2007). Such physical experiments create a learning environment that has a dynamic relationship between the three aspects of learning: knowledge, thinking, and doing (Sale, 2001). Physical experiments run as tutorials are active in recognition of the fact that thinking is an active process, and as such requires a pedagogy that is both collaborative and interactive (Sale, 2001).

Comparison

The comparative case study has implemented a method of document analysis in which a range of documents are assessed by the researcher to provide meaning (Bowen, 2009; Fox-Wolfgramm, 1997; Zitzler and Thiele, 1999). Document analysis is a systematic procedure for the interrogation of documents as empirical data and is well suited for case study research (Bowen, 2009) and as such is well suited to this comparative analysis. Document analysis is also suited to a grounded theory methodology, as applied in this study, in which theory is developed from analysis of the data.

UT and QUT represent Iranian and Australian Universities in "Architecture Engineering" and "Architecture Design". Therefore, this analysis is also a comparison of curricula with different points of focus or priorities in their educational program. Educational curriculum can be compared through different documented criteria. In addition, there is often a gap between the aims of the curriculum and the teaching outcomes or achievements. However, comparative analysis of technology and design studio subjects has been provided in this section through the following features:

- Analysing the quantity of technology subjects and their teaching time at each curriculum as well as some qualifications of their learning environments (Table I)
- Comparing the outlines of technology subjects at UT and QUT based on their specifications (Table II)
- Analysis of the structure subjects of UT and QUT based on the components of their outlines (Table III)
- Analysing the relationship of Technology subjects to design studio projects through their outlines (Table IV)

Compare the quantitative aspects of Technology subjects based on their curriculum

There are four technology subjects at QUT (excluding those that relate directly to environmental technologies and sciences) with 156 teaching hour compare to 11 technology subjects at UT with 464 teaching hours (Table I). This indicates that if the overall curriculum content of both schools are assumed as equal, at QUT the curriculum is compressed and students may feel under time pressure. This means that at QUT students must study and learn to a large extent on their own; self-directed. Moreover, comparing theoretical teaching time reveals huge difference between UT and QUT (304 and 52 hours respectively) that can be explained though the focus of architecture and architecture engineering curricula. The practical teaching hours for technology subjects at QUT (104) is less than UT (160) which results in less opportunity for the application of knowledge. However, the four technology subjects at QUT benefit from tutorial sessions for problem based learning and practicing to apply the knowledge. At UT, most of the technology subjects are delivered as lectures and theoretical content (excluding Building Technical Design and Project Management) without any opportunity to apply them in architecture design projects, which means that students cannot explore how to apply this knowledge.

Insert Table I. here

The ratio of the practice-based teaching hours to the whole teaching hours of technology subjects at UT is 34% while the relevant number at QUT is 67%. So QUT students have twice the opportunity to apply knowledge gained from theoretical subjects in practical situations (such as Problem Based Learning).

Although there are three subjects in building structure and eleven overall in technology at UT (University-of-Tehran, 2014a, 2014b) compared to one in structure and four overall in technology in QUT, students at UT usually do not apply their knowledge in studio design projects. QUT students have been asked to apply structure and materiality before their first technology subject at semester three. This approach may encourage them to engage with why and how they need to use technology as necessary knowledge in the architecture studio. After the first subject in technology, students have to provide a structural design based on their previous architecture studio (Dwelling; semester 3).

Compare outlines of Technology subjects at UT and QUT

Comparing the outlines of technology subjects at each university highlights similarities in their content. Combining them into four (at QUT) in comparison to 11 (at UT) provides more opportunity to link between the different areas of content. In other words, teachers would be able to link different areas through teaching activities such as research, analysis, exercise, and practice and students have more opportunities to understand, ask question, and synthesize the relationship of these areas. On the other word, 11 different classes (mostly theoretical) during 8 semesters with different teachers and following various theoretical subjects provides less chances to discover the relationship and application of the content.

Usually a subject outline provides a brief explanation for the topic, subject specifications, rationale, aims, learning outcomes, content, assessment, resource materials, approaches to teaching and learning, academic integrity, and risk assessment (the last three are not included at UT subject's outline). The main difference between two major curricula for Bachelor degree in Iran is more in depth explanation of aims, learning outcomes, and approaches to teaching and learning. Although the latest one, which is a newer version of the previous one (University-of-Tehran, 2014a), does not present how different teaching and learning approaches can be applied with the same time-table and learning environment.

Insert Table II. here

Table II presents technology subjects and their specifications at both universities. From this Table it can be seen that most of the subjects (9 out of 11) at UT are delivered as theory while at QUT all of them include 1 hour lecture following by 2 hour practice on problem solving and application in tutorial environments. Also at QUT, design studios from the second year onwards are supported with technology subjects that develop the students' abilities to marry design ideas with technical understanding and an appreciation of buildability (AACA, 2019). Moreover, assessment at UT mainly relies on exams with the emphasis on delivering theoretical knowledge, while at QUT the maximum allowable assessment load for exams is 50% and the main focus of assessment is on drafting plans, workbooks, reports, and portfolio.

A comparison of the 'Aims' in outlines shows that at QUT application of knowledge is part of primary importance while at UT 'Aims' stop at the level of 'introducing a knowledge'. Finally, the review of Learning Outcome indicates that at QUT students are expected to apply the knowledge of technology, such as selecting appropriate structures for a design project, but at UT the learning outcomes in many subjects remain at the level of cognitive knowledge, which does not enhance students' skills and experience of how to apply this knowledge.

In Iranian curricula, the aim of the theoretical subjects is usually for students to become familiar with technical knowledge, not the application of it. For instance, in the outline of building mechanical services, the content headlines and reference list for this subject have been borrowed from the resources for mechanical engineers. Even the reformed outline (Mashhad, 2017) states "being familiar to Mechanical services of the building and the effect of the mechanical services in building architectural design", which remains at the level of introduction to the knowledge. This means that some information has been selected from the mechanical engineer field to present to architecture students, while the effective approach would be to translate the knowledge to architecture design language and teach students how to apply it when designing a building. Although at the stated 'Approaches to teaching and learning' in this outline recommend that students will benefit from question and answer, problem solving, and analysis of case studies in class, there is not enough time for problem solving and analysis during 2 hours of lecture time (practically 1.5 hours). Moreover, learning outcomes of this subject expect "gaining knowledge and ability of combining mechanical services with appropriate design in buildings to provide environmental comfort while decreasing fuel consumption" which is well beyond students' ability after 32 hours (practically 24 hours) of lecturing.

Compare structure subjects at UT and QUT

In Table III, the structure subjects of UT (including 3 subjects of Steel Structures, Concrete Structures, and Buildings Structures) and QUT (Integrated Technologies 2) have been compared based on their outlines. Comparing aims at these two groups of subjects reveals that curriculum at UT remains at the level of introducing theoretical knowledge in generic terms and rarely mentions the application of that knowledge, while at QUT it refers to utilizing specific knowledge (such as structural and construction systems) in a specific field (such as design development of low-rise buildings). Therefore, it seems logical that learning outcome at UT remains at “being familiar with structure design” while at QUT “selecting appropriate structural and construction systems” would be expected from the students.

Insert Table III. here

Content comparison reveals a considerable difference between the two regarding the variety and quantity of topics which have been covered at each university. Teaching time comparison also reveals the same result; 112 hours at UT for 3 subjects and 39 hours at QUT for one.

According to Table III, the approaches to teaching and learning at UT is based on lectures and potential discussion in the lecture room, while QUT benefit from project-based learning which is delivered in a studio setting through group activities and desk critiques of students’ work.

Assessment at UT is mostly reliant on theoretical examination (100% for four subjects and 80% for Building Structural subject) while at QUT the relevant figure is 40% for mid-semester examination and 60% for professional plans and workbooks. This shows emphasis being given to the application of knowledge at QUT. The outline of the newer version in Iran, for the subject of Building Construction 2, has been considered 25% of assessment based on the final project. Also, it was recommended that students practice their knowledge through designing the details of Architecture Design 6 (next semester; semester 6). Moreover, a large volume of content for this subject which runs 2 hours per week, does not allow students to draw details during their class time (as is recommended as a teaching-learning approach). Many of the resource materials introduced at UT include specialized text books (some in the second language for Iranian students) from other courses such as civil engineering which are not reviewed by students.

Linking architectural design to technology subjects

This section compares the relationship of technology (structure) subjects with architecture design in QUT and UT. Table IV presents the architectural design subjects/studios which are linked to technology subjects. The table shows four architectural projects at both universities linking to technology subjects with different rates of distribution between different semesters. The main differences are the mode of Theory/Practice, teaching hours (which in UT is about three times larger than QUT), and assessment (which focuses on the final product at UT while it focuses more on design process at QUT).

The aims of the architecture studios at QUT is mainly to focus on design development with various points of specialisation while at UT the aim is very wide and considers different aspects of architecture which is often beyond the students’ abilities. Regarding the connection to technology, the outlines at QUT refer to keywords such as application, integration, and addressing, while at UT, they refer to keywords such as paying attention, studying, and discussing the technology topics.

Insert Table IV. here

Discussion

An academic program must do more than providing a sequence of subjects and matching university schedules, “a curriculum should be a well-designed package of integral components each of which serve in the capacity of the others” (Smith, 1987). Design studio subjects need to provide effective ways for students to apply knowledge that has been gained from technology subjects. Ultimately these fields of knowledge must be integrated, if not within the curriculum, then by the student themselves. Ideally, the appropriate model supports the application of technology knowledge in the design studio in the same semester (Golabchi, 2004). It should also provide workshops for teaching structure, using different learning styles, collaborative learning, practical assignments, periodical assessment, team working, and multimedia resources (Golabchi, 2004).

Although UT provides more subjects, content, and triple teaching time, there is less integration of that knowledge. This is because of a large amount of information delivered through lectures without relevant linking between the fields of knowledge and enough time for students to learn how to apply them. While at QUT less content has been organized for a smaller but more efficient outcome. Although the number of technology subjects, as well as teaching hour, at UT is about three times bigger than QUT, the opportunity to apply the technology knowledge is less. In Iran the focus of design development in architectural studios is on responding to spatial aspects of the project. While in Australia application of technology in structural design as well as detail design is at the same level of importance and technical issues are not ignored by focusing solely on creativity and form. Moreover, the budget for each project is often one of the factors in Australia, while in Iran this factor is out of the project scope (Saghafi and Grutter, 2013).

Conclusion

This paper has used an illustrative study to demonstrate two possibilities for the integration of technology subjects with the design studios in architectural education. It has also, through this, highlighted possible issues for the internationalisation of curriculum and the mobility of international students. While this study has shown there to be significant differences between the structures, curriculum, and content of the programs in Australia and Iran, there are also significant differences in the social and political contexts and the associated pedagogical philosophies in higher education. It is not therefore reasonable to say that one approach is better or worse than the other as each has been developed in response to its context and as such offers significant benefits over the other in that context. It is however possible to make some observations about how the academic practice in one program might be implemented in the other program to its betterments. And how, with increased international student mobility, it is increasingly important for architecture schools to be cognisant of international trends and curriculum developments.

It is likely that the differences in approach to the development of knowledge, skills, and application between Iran and Australia, also reflects differences in the profession of architecture in those two contexts; differences in how architects practice, how they collaborate with each other, with engineers and contractors, and what their professional and legal responsibilities are. With a rapid increase in the number of Iranian students studying architecture in Australia, it is important to understand how the education system of one country might transpose into the professional practice context of the other. Similarly, with increased professional mobility, it is important to understand the differences in curricula and possible career consequences.

For a modern team-based practice environment of professional collaboration, as is typical in contemporary Australian practice, there are distinct advantages in all team members having a more generalist understanding of the impacts of technology on design development. Technological decisions are not the sole responsibility of one designer or engineer, but a collaborative team effort. As such there are advantages in architects understanding the application of technological knowledge and skills; understanding the impacts on design.

In a more traditional and hierarchical practice environment there may be advantages in greater depth of knowledge that can be input to the design process under the guidance or supervision of a senior architect or designer. In such a hierarchy there are advantages in different architects having specialist knowledge.

This being said it is also reasonable to critique the programs against each other and suggest that the depth and breadth of knowledge in the Iranian program highlights that the Australian program may not be covering the full content field, and that as such may be leaving graduates with an ability to apply an understanding of technology, but only from a limited knowledge base. Conversely the Iranian program does not offer students much opportunity to apply their knowledge through project-based learning, and as such leaves graduates well informed about technology, but unable to fully use technology to guide design decisions. The two cases explored here can be seen as two examples on a spectrum of approaches to the integration of knowledge and skills in an architecture program. Neither is perfect or perhaps even optimal, though both offer ideas that might be applied in similar contexts. While this paper offers just two examples of curriculum, it highlights the need for all architecture programs to be aware of how they deal with certain knowledge fields in a growingly globalised context. Australian and Iranian architecture curricula are based on wide spread international models; as such there are wider applications for the insights this research offers, in similar contexts across the globe.

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Mahmoud Reza Saghafi is an Associate Professor in Architecture with research interests in Architecture Education and Sustainable Design. He has been a full-time academic member at the faculty of Architecture and Urbanism, Art University of Isfahan since 1997. He is a Registered Architect and has more than 50 publications. He obtained MArch degree (Architectural Engineering) from University of Tehran (1997), Iran, and his PhD from Queensland University of Technology, Australia (2012). Recently, he has worked as a visiting Academic at QUT while he undertakes a research on ‘Knowledge and its Application in Design Studio’.

Philip is the postgraduate architecture program coordinator at the Queensland University of Technology, Australia. He has qualifications in architecture and in film, a Masters in education, and a PhD in architecture. Philip has twenty years of academic experience and has taught in all years of the program, with specialist experience in first year transition to university. Philip is a multiple teaching award winner and recipient of a National ALTC citation. He has published over twenty papers on aspects of studio-based education and curriculum development in the design fields.

Table I. Technology subjects' specifications in architecture education curriculum at UT and QUT, has been extracted from; (QUT, 2016; University-of-Tehran, 2014a, 2014b)

Factors	UT	QUT
NO. of Technology subjects	11 (10 in B., 1 in M.)	4 (3 in B., 1 in M.)
NO. of Credit Points	24	48
Theoretical teaching hour	304	52
Practical teaching hour	160	104
Sum up of teaching hour	464	156
Ratio of practical hours to whole technology subjects	34%	67%
Ratio of Technology hours to whole subjects	11%	11%
Class size	40-80	180 in Lecture room and up to 20 in tutorial session
Knowledge application	Exercise	Problem Based Learning
Learning Environment	Lecture room/Studio	Lecture room/Tutorial/ Studio/Workshop

Table II. Comparing Technology subjects at UT and QUT according to their outlines, has been extracted from; (QUT, 2016; University-of-Tehran, 2014a, 2014b)

University	Subjects	hours	T/P	Sem.	Assessment	Aims	Learning Outcome
QUT	Architectural Technology 1	13 26	T P	4	40% mid-term Exam 60% plans & Workbook	Use building construction systems in domestic projects, introduce building code	Use building materials for small scale buildings
	Integrated Technologies 2	13 26	T P	5	40% mid-term Exam 60% plans & Workbook	familiarise you with the qualitative influences of structural and construction systems on the design ar.	select appropriate structural and construction systems
	Architectural Technology 2	13 26	T P	6	25% mid-term Exam 50% final group project 25% end-term exam	use technical skills and knowledge of building services to create safe, functional, and comfortable buildings	Understanding of the way in which building service systems work
	Project Management (in Master level)	13 26	T P	10	60% mid-term Report 40% Portfolio; individual and group	understanding of conducting project feasibility studies, professional writing, and project programming	How an architect manages an architectural project
UT	Statics	32	T	1	70% final exam 30% mid-term exam	Being familiar with statics and building's reaction against forces	Cognitive knowledge
	Building Materials	32	T	1	70% final exam 30% project	Being familiar with specifications of materials and their implication in building	Cognitive knowledge
	Strength of materials and Steel Structures	48	T	2	70% final exam 20% mid-term exam 10% during term	Materials' behaviour against forces and conclude building design codes & steel structures specifications & design	Cognitive knowledge
	Reinforced Concrete Building Design	32	T	3	70% final exam 30% mid-term exam	Being familiar with concrete, its qualifications, construction technology, computing & design concrete structures	Ability to design regular concrete buildings
	Building Structures	32	T	4	80% final exam 20% project	Introducing structure systems and their qualifications, behaviour, and implications	Cognitive knowledge
	Building Construction 1	32	T	5	Final exam	Understanding the role & function of materials and details in building	Cognitive knowledge
	Building Construction 2	32	T	6	Final exam	Building's details and their connections	Details drafting,
	Electrical_ Acoustics	32	T	6	Final exam	Get familiar with artificial lighting and acoustic principles	Cognitive knowledge

Building Mechanical Services	32	T	7	Final exam	being familiar to mechanical services of building and its effect on building design	Design ducts and mechanical room
Technical Design	96	P	7	40% final project 20% mid-term project 40% during term	How to build a building, relation between architecture, structure, and installations	Executive maps for an ar. Project of student
Construction Procedure	64	P	12	50% final project 50% during term	Use technical skills and knowledge of building construction to create safe, functional, and Environ. friendly buildings	Executive maps and technical issues and codes of Ar. project

Table III. Compare the outlines of Structure's subjects of UT and QUT, has been extracted from; (QUT, 2016; University-of-Tehran, 2014a)

Outline Elements	**UT**	**QUT**
Aims	Introducing structural systems, steel structures specifications and design concrete structures	Ability to utilize of structural and construction systems to advance the design development of low-rise buildings
Learning Outcomes	Being familiar with structure design of steel and concrete structures, how structural systems behave	select appropriate structural and construction systems in a manner that informs design decisions
Contents	steel structures specifications, construction technology and structures, different types of Structural systems	include both steel and concrete systems as well as structural possibilities and limitations
Approaches to teaching and learning	Lecture, discussion, presenting some building constructions through slides	Lecture and studio based activities such as project-based activities/experiments in group or individual
Assessment	Generally 70-80% final exam, 20-30% on mid-term exam (or projects for subject of Building structure)	60% on end of Semester; Plans & Workbook 40% on mid-Semester; Theory examination
Resource materials	Refer to several books (in Persian and English) and journals for each subject	There is not set text but 200 page 'Study guide' on online learning environment

Table IV. Design studio subjects which refers to Technology ones, has been extracted from (QUT, 2016; University-of-Tehran, 2014a, 2014b)

University	subject	Sem.	T/P	hours	assessment	aim	Connection/s to Technology
QUT Australia	Ar. Studio 3	3	T P	13 39	40% mid-term 60% late term	develop architectural designs with a focus on aspects of problem solving	Application of structure and materiality
	Ar. Studio 5	5	T P	13 39	40% mid-term 60% late term	Focus on modern technology, development of heritage and social sustainability	modern technology by aid of digital tools and methods
	Ar. Design 8	8	T P	13 78	35% early term 15% mid-term 50% end of term	detailed design development and construction documentation of a complex building	integration and assembly of the structural system
	Master Studio B	10	T P	- 78	40% mid-term 60% Late term	development of evidence-based design including tectonic development	Evidence based report and design addressing tectonic
UT Iran	Ar. design 4	7	P	160	80% final project 20% during term	Combining functional, structural, and installations systems in a project	Structure system, building services, technical design
	Final design project	9	P	192	90% final project 10% during term	Ability to develop a design project from schematic stage to executive maps	all theoretical and practical subjects
	Ar. Design 3 (Master)	11	P	64	50% final project 50% during term	Use technical skills and knowledge of building construction to create safe, functional, and environmental friendly buildings	Focus on technical, functional and executive aspects
	Master Thesis	12	P	192	100% final Project and Thesis	Research on design theme and context, designing a project as a professional work	Structure system and building services