The G-Lab: a Global BIM Architecture Studio

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Abstract

The value of Building Information Modelling (BIM) in Architecture, Engineering and Construction (AEC) and related disciplines is evident, with institutional clients and governments moving towards electronic procurement in BIM protocols in countries such as the UK, the USA and Singapore. After a decade of teaching courses and conducting BIM-related research in Australia and Singapore; and more recently in Italy, Switzerland and Hong-Kong, it is evident to the author that challenges arise with full BIM uptake in the tertiary and postgraduate higher-education sector. This paper reports on such experiences in delivering BIM-based architecture, construction and sustainability studios, with BIM embedded into the learning and teaching curricula.

The G-Lab is the unofficial name given to the author's BIM integrated practice studio in higher education. Enabling BIM in architecture and built-environment university degrees is still a challenge that is proving hard to address. On the one hand, industry demands BIM competencies from graduates which they do not yet possess. On the other hand, academics are still coming to terms with the importance of BIM as a core component of a university degree. The author asserts that higher-education institutions have a responsibility to increase BIM competencies in their graduates.

BIM requires professional discipline, managerial and leadership competencies that universities - in particular schools of architecture - should be integrating into the skill-set of design students, especially in final year, honours programs and at postgraduate levels. BIM has been shown to increase project efficiencies. In this paper, the author reflects on experiences and observations encountered in conducting BIM architecture and building studios in Europe, Australia and Asia. The paper provides insights and reflections on lessons learnt about BIM applications to architecture, sustainable design, construction and planning.

This paper distils over 10 years of teaching experiences across three continents. The research approach is that of the reflective practitioner in which experiences are mapped-out and discussed.

Various scenarios are described along with conclusions as to the opportunities and challenges they present for including BIM in higher education. Insights are provided on uptake scenarios as well as strategies for how the learning curve for students, and for non-BIM conversant academics, may be more easily scaled.

The paper is a qualitative reflection about bringing BIM into architecture, sustainability and construction planning and design. The paper is targeted at the need for embedding BIM in higher-education teaching curricula.

Keywords: Architecture; Building Information Modelling (BIM); Higher Education

1. A Brave New World

Australia is still a fast growing country with a stable economy. However; escalating building and construction costs, aligned with shortages in construction skills, have become problematic. Recently Aranda-Mena (2016) wrote about the building professions, and the people and systems that will eventually replace those professions as we know them today. We are experiencing a period of fundamental and irreversible change across built-environment professions. A call towards increasing productivity and quality, with more effective and cost efficient operations across the AEC sectors is currently taking place (BEIIC 2010, Teicholz 2013). Rifking (2014) in his volume, *The Zero Marginal Cost Society*, signals the decline of the capitalist era and the emergence of a new economic paradigm: *The Collaborative Commons* also know as peer production or commons-based production which is a term coined by Harvard Law School (Benkler, 2003). It describes a new socioeconomic production system in which large numbers of people work cooperatively on the Internet. Commons-based projects generally have less rigid hierarchical structures than those under traditional business models taking advantages of emerging collaborative Cloud-based possibilities. Free and open source hardware, software and digital product libraries. By sharing open source designs to be replicated with digital open-source manufacturing technologies peer production process eventuates contributing to a collaborative commons economy.

For Australia, it is paramount to reinvent the value chain in rapidly eroding mining and manufacturing industries. The need to increase the level of inventiveness and *innovation* in order to attain greater competitiveness was an issue of much international debate are clear reminders that the world is in a state of flux with uncertain economic repercussions. The AEC professions, as we know them today, are not immune to such technological, economic or policy changes. In many cases traditional jobs and services will simply disappear or morph into something new (Susskind and Susskind 2015). Hughes (2007) flagged similar issues in relation to built-environment professionals in Australia and the UK. In Southeast Asia, countries such as Singapore, South Korea and Japan have continued re-shaping the service and knowledge-based nature of their industries, including architecture, property and construction, and have perhaps become more aligned with what has been presented as *the fourth industrial revolution* by the World Economic Forum (WEF 2016):

> *"We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before. We do not yet know just how it will unfold, but one thing is clear: the response to it must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academia and civil society."*
>
> Schwab 2016

The revolution Schwab refers to is the one that happens in a world in which the Internet, sensors, wearable computers, vehicles, cameras, smart-phones, refrigerators and all kinds of everyday objects and spaces co-exist and interact with us. The first industrial revolution was an extension of the human arm, with steam and water powered machinery introduced to manufacturing. The second was a revolution that industrialised production even further with electricity. The third technological revolution has used IT to automate processes and this fourth revolution is now about cyber-physical spaces characterized by the fusion of physical, digital and biological spheres, thus forming a richer ecosystem (Schwab 2016).

2. A BIM New World

The impact of technology in building design and architectural practice has been evolutionary and possibly revolutionary (Burry et.al 2013). Design methods and processes are continuing to change at a rapid pace. The question is no longer about hand drawing versus CAD (dominant in the 1980s-90s), or CAD versus BIM (dominant from 1990's to 2000). The question today revolves around Cloud platforms to deliver integrated projects (IPD) and with this, emerging project, procurement, financing and business models arise (Aranda-Mena 2016b). The practice of architecture as we know it today will be drastically different, and the recurring question is: how can architectural education better prepare future architects?

Even traditional models of architectural training will have to engage with the emerging tools and technologies available for designers. Applications for tablets and iPads are becoming increasingly used in the construction sector, and with a wider audience base. BIM is yet to reach its peak in architecture, and needs a serious response from architecture's professional bodies. It is already popular across engineering and construction, but full BIM uptake and implementation across architecture and property is still to take place.

In consequence of the development of BIM, tertiary education programs have had to be responsive in the disciplines of urban planning, property, architecture, quantity surveying and even construction, and will continue to be challenged by digital and mobile technologies (BAF 2013). In countries neighbouring Australia – namely Singapore and Hong Kong – both places where the author teaches - a rapid BIM uptake has been observed. In Singapore, the uptake is the direct consequence of strong government mandates for public sector projects (BCA 2016). In Hong Kong however, the uptake appears to be driven more by commercial private sector forces seeking to increase the capacity to produce and deliver integrated building systems such as kitchen modules and toilet pods, with anticipated commercial benefits flowing to both the local and export markets (Wong et.al 2010).

The global economic climate and modes of practice have changed dramatically since 2008. The Global Financial Crisis pushed architects to think about business strategy mechanisms (Heintz and Aranda-Mena 2012). In order to survive, architects and other building professionals not only need to learn more on business strategies and marketing but also acquire internal business competencies in order to efficiently deliver projects to stakeholders such as engineering consultants and contractors, and eventually satisfy clients' and end-user demands across their space and technology needs and requirements (Chevez et.al 2014).

Heintz and Aranda-Mena (2016) argued that architecture, architects and the architectural profession has to increase its competitive advantage from simply differentiating by design output to more tangible differentiation such as practice technical, managerial and business capabilities. Architects clearly need to acquire skills in business strategy and practice management; to deepen their domain knowledge and to sharpen their technological competence:

> *"If small practices are to succeed in attracting a loyal client-base, they not only need to nurture customer relations but to increase internal competencies in technical, managerial and business practice to effectively communicate and deliver projects in such a way that reputation is not only built upon design aesthetic but also on business merits. In this way architects could regain control of their projects and industry leadership"*
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> (Heintz and Aranda-Mena 2016).

Models for business internship in tertiary higher-education programs must tap into the changing dynamics of the workplace (Robson et.al 2015; Sher 2012) with programs like *'Work Integrated Learning'* wherein core practical competencies are honed at first hand during work placements. Traditional degrees like architecture are expected to change dramatically (Schwab 2016), driven by an emerging *services client-focused* economy and are expected to flourish during a 4th revolution – that will witness the advent of new economic arrangements akin to the "*collaborative social commons*" predicted by Rifkin (2014).

Fien and Winfree (2012) argue that the higher-education sector across the building professions has been slow in tailoring technological uptake in their curricula, even when demands from employers are clear. The integration of practice and educational curricula is often a challenging one, Work Integrated Learning (WIL) programs in Australia are a response, but fall short in supporting integration implementation in Construction Management (Aranda-Mena et.al 2013) and Property (Robson et.al 2015) degrees. To alleviate the situation, the tertiary sector must deliver the skills and competencies demanded by industry. Information and Communication Technologies (ICT) including BIM can change and drive things rapidly; encouraging the industry to become more efficient and increase effective communication (Senescu et.al 2013) and competitiveness (Patrick et.al 2008). Educational books dealing with topics such as *"What an architecture student should know"* (e.g. Krupinska, 2014) will include chapters such as “BIM for architects”. Today, they rarely do.

3. *BIMplementation* in Architecture Education

According to the latest McGraw Hill BIM report major rationales for implementing BIM include the need to improve project efficiency, the attainment of high quality project outcomes and the containment of project costs (anon. 2015). Project success is beyond *‘good design’*, it should be integral to building performance and managerial success. In many instances, BIM take-up has been a direct and reactive *ad-hoc* response to alleviating various endemic challenges particularly in terms of project documentation and the management of information. Current skills shortages, poor productivity, lapses in the maintenance of safety standards, high construction costs, unhappy customers, poor quality outcomes are *all* relevant issues.

Teaching with some level of BIM usage compels teams to think beyond their professional/academic disciplines. Since BIM presents itself as a digital or virtual equivalent of real-world building activity, a different type of thinking framework is required if buildings are to be better designed and constructed (Frutcher 1999; Breit et.al 2006).

This section discusses the pedagogic approach adopted by the author in classes, laboratories and studios. The teaching and learning experience goes well beyond the mere presentation of, and exposure to, BIM software tools and applications. Rather, the participants are immersed in a multi-disciplinary training environment where the boundaries among disciplines such as engineering, architecture and construction are deliberately blurred and students are compelled to broaden their focus of deliberation beyond what they may have hitherto felt were the limits of their disciplinary training. These learning sessions also include assessment and panels or juries formed by professional experts across the disciplines to facilitate the learning process with appropriate comment and criticism.

Project, rather than subject based curricula can be one way to initiate curriculum change. Core and elective courses that begin with a project in mind (which is typical of studios) are experienced more like 'problem-based-learning'. This is an important consideration. Multi-disciplinary teams interact to resolve problems which are by nature multi-dimensional from a discipline perspective (Aranda-Mena et.al 2007 & 2009), acknowledging that, while *‘solo-work’* is fundamental in design and innovation, however, it is put to the test with more frequent iterative solo-team-solo cycles.

BIM is a technology platform that makes use of 3D modelling software, along with analytical building performance tools, to simulate the design, construction and operational behaviour of a design proposal. In so doing BIM enables postgraduate studio participants to integrate their practices more effectively, thus generating information that can be used to make decisions and improve the process of delivering the facility.

BIM methods and technologies are increasingly being adopted by industry practitioners, which suggests they are well informed of the advantages associated with their use in project decision-making. Other clear commercial drivers such as automatic generation of shop-drawings with built-in quality assurance have provided enough business incentives to adopt BIM (Aranda-Mena & Wakefield 2006; Aranda-Mena et.al 2009).

The need to implement BIM in the teaching curricula is paramount. Architectural practices have started to demand BIM-competent graduates who are not just conversant, but also competent in a true sense; and not just via modelling tools (such as Revit®) but also with increasing Cloud-based applications: graduates who are ready to work collaboratively. Academic disciplines as architecture must ensure that BIM is well embedded and integrated in the program offerings they oversee (BEIIC 2010; Fien and Winfree, 2012). This is certainly the case in Australia. Embedding BIM in education is more challenging than doing so in industry. Since most BIM software applications are available to academic institutions at negligible cost, the poor up-take by academic instructors has more to do with their *“cultural resistance”* to new methods of managing and designing projects which some may find daunting and threatening, or simply discard as not necessary for architects to learn.

Furthermore, such resistance means that faculty may remain ignorant about the benefits of applying these techniques so that even though they may feel they are operating in the best interest of students, the latter are left ill-equipped for industry. When proponents of BIM are faced with the challenge of convincing resistant academics of BIM's virtues, they should be aware that their mind-set may be tied down by *cultural rules* or *cultural imprints* (AQC, 2002). Under such circumstances an empathetic evolutionary exposure to BIM will promise a greater appreciation of its merits than a radical disruptive one. In other cases, new emerging architecture Schools and Faculties of Architecture will start operating with the new practice paradigm right from the outset. However, a completely uniform adoption of BIM in AEC education is not entirely realistic, and it might even prove more challenging than in practice, where much of the uptake has been driven by business competition and commercial demand (Succar et.al, 2007) and universities are less exposed to such market pressures. Whilst the author acknowledges that BIM adoption in practice is well documented, education will face a stronger disruptive process as strong cultural and technical barriers exist, the scope of the present paper is to elaborate upon the evolutionary/empathetic approach to BIM instruction alluded to earlier, and the above phenomena could be explained by innovation diffusion theory (Roggers 1995). It should be noted that software developers and suppliers have readily addressed the technical issues of making BIM applications readily available to cohorts of students in universities.

4. The G-Lab

The "G-LAB" is the unofficial name given to the author's BIM integrated practice studio. In some, attendance is optional, others work as an integral part of the course or elective. Undergraduate and postgraduate students work on their semester project assignment, which is often a response to a call for Expressions of Interest (EOI) (or competition entry) aligned with a government call for tender or competition entry (which can be international in scope). Industry experts are often invited to join the studio – not necessarily to train but to engage with the students. The author employs introductory lecture material and demonstrations *to develop student interest, curiosity* and *creative capability* as generic skills but leveraging on what BIM has to offer, not just for architecture but also for property, construction and project management (in which the author typically lectures). The groups range in size from 10 to 200 but the strategy appears to work best when the targeted groups are less than 30 – which is the case of offshore undergraduate courses in Singapore and Hong-Kong or Masters classes in Melbourne or Milano. Notwithstanding this last observation, the G-lab provides an engaging learning environment in which to master BIM tools and applications irrespective of the country in which the exposure is offered, the size of the student cohort and whether or not it is an undergraduate or postgraduate offering.

The following sub-sections will describe some of the studios, lectures or electives. The paper is not intended as a prescriptive *'know-how'* recipe or formula but as an idea-generator for those educators looking to integrate BIM to their teaching practices. Note that the majority of the courses have been delivered with the collaborative participation of other teaching staff.

UNESCO Master of Architecture: The Unesco Chair in Mantova, Italy includes a number of architecture and design research studios (Aranda-Mena 2016a) to which the author has been contributing since 2013. These include three architecture studios and three Master Theses projects conducted in Milano and Mantova. Projects have included the St Kilda Triangle site in Melbourne, an art gallery of Aboriginal culture for the National Gallery of Victoria, a bus-stop system for Karosta, Latvia; and three thesis projects including an urban regeneration project in Milano Lambrate and the repurposing of the abandoned Lambreta factory. A book is currently under preparation and expected to be published as part of the PoliMI SpringerBriefs in 2017 (Springer, 2016).

The PPP CLUB: Melbourne, Singapore and Hong Kong. In Melbourne this started as part of a former one-semester subject in which various infrastructure procurement methods and techniques are put into practice, including Public-Private Partnerships. Subsequently, The PPP CLUB evolved into the equivalent of a large-scale studio which considers the strategic, tactical and technical aspects of a specific infrastructure project including economic, social, well-being and environmental perspectives. Technical lectures on project finance, legal and operational issues for a project consortium form the theoretical base. Aspects of value creation and stakeholder management form a practical base before moving onto a given real project. Each semester, studio enrolees are expected to prepare and submit an Expression of Interest (EOI) report and presentation in response to a government call for infrastructure projects such as train stations, airports, hospitals, convention centres or museums. In 2016 the project is an EOI for a Melbourne Metro station. “Revit” with “Navisworks” have been used, as well as other visual tools such as Autodesk Formit, for early planning and stakeholder engagement.

The Swiss BIM Studio: In 2013 the author undertook a research placement at the Fachhochschule Nordwestschweiz (FHNW Unversity) in Switzerland in collaboration with OOS Architects in Zurich. During the research the author was also invited to co-lecture in the delivery of a BIM Architecture studio at Berner University, with a particular focus on sustainable design and energy simulation assessment. Students presented green strategies and interventions to improve energy performance assessment of their own faculty building (which was due for a major retrofit). Four project proposals were fully developed and shared on-the-Cloud. The final project was presented to a professional architecture and engineering panel on building repurposing, retrofit and energy consumption. Forecast assessments included life-cycle energy simulation in “Ecotec” and “Vasari” applications.

Home-in-a-Box: Fiji Studio: This studio eventually developed into the construction of a 200-home-village in Lautoka, Fiji. Undertaken in a community originally devastated by a cyclone, this project has mainly been a voluntary program with financial support from the Rotary Club International and the Engineers Without Borders organisation. The G-Lab proposed that the initiative should use BIM, not only to develop and document the design work but also to run building performance assessments. 3D models as construction guides were handed out to the volunteer workforce. Since it was built, the village has survived two cyclones, the most recent being “Cyclone Winston”, with hardly any damage compared to the ruinous aftermath experienced in more traditional settlements. The construction guide was very useful for securely fixing and reinforcing the homes. The G-Lab is currently creating a proposal for a community facility, playground and sports centre for the same site. “Archicad”, “Sketchup” and “IES Virtual Environment” were the applications used for this studio. The future community building will be designed and documented using DELMIA - Dassault Systèmes experience for academia on the Cloud (http://academy.3ds.com/cloud/).

Hoi An Architecture Studios: This UNESCO World Heritage town in Vietnam is confronting a host of challenges including rapid urbanisation and volatile climatic conditions that result in regular flooding and storm damage. The author participated in two architecture studios with Architects Without Frontiers and RMIT University, and practicing architects were also invited to assist at facilitating the design workshops. The first studio aimed at developing a primary school building project for Children with learning difficulties, which eventuated into a real physical facility which also performs as a community centre. A second project intervention looked at an urban proposal to protect the UNESCO heritage-listed old part of Hoi An, as other valuable infrastructure assets are often badly affected by flooding. The resulting project proposal was an eco-city strategy which was presented to the local planning and tourism authorities and to UN-HABITAT. “Archicad”, “Sketchup” and “StrateGIS.NL” were the applications used for this studio.

Living-Façades: This studio is part of RMIT's Master’s degree program in energy efficient and sustainable building (MEESB). The studio first started in 2016 and aims at designing innovative building envelop and façade solutions utilising passive energy and innovative commercially available building materials. The resulting designs are presented to an expert panel of architects and façade designers and engineers. Student proposals might take an existing or new building project to re-think and evaluate the benefits of smart design. The first of the studios re-assessed six finalist proposals for the Flinders Street Station in Melbourne, thus improving the winning proposals from an energy sustainability standpoint. The second of these studios will develop a strategy to integrating photo-voltaic panels in an

RMIT heritage building without causing adverse visual or architectural impacts while maximising the cost-benefit of the intervention. “Revit” and “Sefaira” BIM applications are used for this studio.

BELL SHAPE: The Built-Environment Learning Laboratory is the first of RMIT's SHAPE electives initiative in which students and academics directly engage with planning and architectural interventions in Melbourne's Central Business District. Studio partners include the City of Melbourne, Melbourne Metro Rail Authority and private sector sponsors. The studio is truly collaborative across built-environment disciplines including planning, architecture, landscape architecture, construction management and civil engineering. The studio engages with social and economic infrastructure projects, such as planning and designing a new station for Melbourne Metro CBD North. The studio integrates tools, technologies and Cloud-based BIM services. Any BIM tools and applications are allowed in the studio as long as they interface with the teaching staff via “ACONEX” which is the Australian most popular cloud service for project and document management.

Bringing BIM into the academic curricula has not been a straightforward process and more often than not takes place *ad-hoc.* The G-Lab is a support mechanism for students to work on their assignments either as part of the lecture/studio process or as an extra-curricular activity. The G-Lab is also the space for Honours and Postgraduate thesis supervision, industry discussion, software demonstration and drop-in support.

5. Discussion

It can be concluded that BIM technical skills, beyond adding to design capabilities, are highly desired by employees. This paper is a call for architecture schools and departments to think seriously about making BIM an integral part of design studios, moving proactively rather than reactively. We have already seen transformational change in industry however, and professional bodies such as the Australian Institute of Architects need to support initiatives for integrating BIM into education. Without doubt, BIM and other digital information and communication competencies should be at the heart of professional accreditation, with direct repercussions to the delivery of tertiary education degrees. The question is not about change *per se*, but about timing.

In industry the push for BIM uptake is being accelerated by emerging, more sophisticated procurement modes in which real value outcomes are achieved through the project life-cycle (McCann et.al 2016). Change is about managing, skill creating, acquiring and creating knowledge and therefore a first step is to modify behaviour by changing attitudes and creating willingness to reflect upon new practice directions (Garvin 1993). Viewing BIM uptake through a *‘field-force’* lens might help to explain the tribulations of moving forward, including identification of drivers and impediments to successfully bringing BIM into built environment tertiary education (Baulcome 2003). Unfortunately BIM is still seen as a disruptive technology and not core to the learning outcomes in the training of architects.

The world is currently witnessing radical changes in business conditions, thuse business strategies. Radical emerging businesses such as AirBNB and Uber are just a reminder of a few well known examples sitting at the tip of the transformation iceberg; all off which *bypass* traditional business, practice or professional conventions and protections. Architects are not immune to changing practice, nor to changing technological and economic circumstances with global impact. This is an early call in what is effectively a game-changing professional scenario. To clearly establish a competitive advantage, develop capability and innovative processes are all aspects of this scenario. The call to effectively and efficiently deliver goods and customer-focused services will continue to grow. Increasingly, global markets will change economic drivers and project conditions, client requirements and emerging information ecologies in which the boundaries between real and virtual outcomes will continue to blur.

6. Conclusion

The G-Lab has been an empathetic way to introduce BIM into the teaching curriculum. Although the Australian BIM studios are still *ad-hoc* it makes sense to bring them into the core teaching curricula in architecture programs. Professional skills and competencies demanded by employers will continue increasing and aligning towards the BIM trajectory, as contract types will continue to request BIM-based design tenders. Architectural sensibilities, spatial awareness, artistic, cultural and design appreciation are still core and critical skills to be honed in architecture education. However a more aligned set of technological *know-hows* is fundamental for architects landing their first jobs and building their careers. Although BIM has achieved some momentum in practice and academia it is still seen as a specialist area when it should be an expected core skill in the profession. The major shift will take place when BIM develops from just a platform to document projects, into a Cloud-BIM. This is when a real change will take place, and have a ripple effect into industry.

BIM implementation can take place bottom-up or top-down. It really comes to individual lecturers and academics to discuss with their schools or departments and program directors on 'taking the plunge' in supportive, constructive and engaging ways.

Among architects there is usually skepticism on the value of BIM when the need is to think creatively. Lessons and experience show that the one is not exclusive of the other but that both can coexist in the design process. BIM can certainly facilitate processes, speeding up tedious processes, and technology uptake should not be a deterrent to architectural education and practice, nor should uptake be left to chance. BIM helps architects to explore and further investigate their conceptual hand-drawings and to explore the impacts of their ideas in more precise ways which could also justify design decisions to clients. While adopting BIM techniques and tools, architects can still do architecture. Combined industry and support practice groups have emerged such as MelBIM in Melbourne (www.melbim.com.au) in which some of its 1000+ members engage across professions, academic disciplines and student bodies. This model is expected to provide a supportive environment not just for architects but to AEC professionals and to students alike.

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