Collaborative building design education using Building Information Modelling

Abstract

Current building design education practice in Australia rarely involves collaboration between students training in the architecture, engineering and construction (AEC) professions. The construction industry worldwide is moving towards collaborative design practices for the majority of projects, but the AEC education sector is falling behind in this respect. The use of Building Information Modelling (BIM) is widely recognised as having the potential to change the way building projects are run by facilitating collaborative working practices that engage all design team members at an earlier stage in the design process, aided by BIM tools. Graduates with collaborative design skills and BIM expertise will be in high demand and will also have a profound effect on the AEC sector, leading industry change by developing innovative and collaborative working practices using BIM. This project aims to address the need for such graduates through the development of a transferrable curriculum that can be used by all Australian universities that offer architecture, engineering or construction degrees.

Project summary and purpose

The construction industry worldwide is moving towards collaborative design practices as a means of improving project quality and certainty. This move is being supported by the use of Building Information Modelling (BIM) technologies and processes. BIM requires practitioners to rethink the ways in which they develop designs and manage construction projects and is leading to changes in traditional design team job descriptions. However, the current shortage of graduates trained in collaborative design (and in BIM as a technology to facilitate collaboration), remains a barrier to progress in this area. Architecture, Engineering and Construction students continue to be educated in separate schools, with little or no integration or collaboration between the disciplines. Often the first time that students of these disciplines are exposed to working with design team members from other disciplines is in the workplace after graduation. It is important for graduates to have an understanding of the roles played by other design professionals in the construction process and the impact that their individual design decisions can have on projects overall. However, the isolated manner in which they are currently educated does not provide this understanding.

This project has the development of collaboration and understanding between AEC graduates as its primary goal. It aims to achieve this by developing a flexible and transferrable curriculum to assist the teaching and learning of collaborative skills, utilising BIM technologies as a tool. The proposed curriculum will include recommendations about learning objectives, course content, pedagogy, learning environment, assessment and evaluation. It will be designed to span across a range of course types, year levels and delivery modes (e.g. flexible, online or intensive training). The project addresses Priority Two: Curriculum Renewal of the ALTC Priority Projects Program, since its focus is on the re-shaping of current discipline-based courses and programs in AEC. This will be achieved through the development of contemporary curricula that meet AEC industry needs, by using inter-disciplinary pedagogies and cutting-edge BIM tools. The curriculum developed will be suitable for adoption by all Australian universities offering architecture, engineering or construction related programs.
Project rationale and need

The need for collaboration in the AEC professions

The construction industry is vital to the economies of most developed countries. The industry represents approximately 6 per cent of both Australia’s and the UK’s gross domestic product (ABS 2010 and ONS 2010). Despite the importance of the construction industry to the developed world, some studies suggest that productivity has declined over the past 30 years and that the industry is extremely inefficient compared with others. The construction industry has also been described as extremely fragmented and lacking integration (e.g. Egan, 1998 and NIST, 2004). Other reports show that the quality of project documentation has declined over the past 20 years and that poor documentation is contributing an additional 10 to 15% to project costs (QCIF, 2005).

In the light of such studies major changes have been recommended by organisations such as the US National Academy of Sciences (2009). Two of the five key activities identified by the Academy for improving the industry were:

1. Widespread deployment and use of interoperable technology applications, also called Building Information Modeling (BIM);
2. Improved job-site efficiency through more effective interfacing of people, processes, materials, equipment, and information;

These activities in particular can be addressed by the education innovations being proposed in this project. Collaborative working practices, where all design team members are engaged at an earlier stage in the design process, aided by BIM tools, are estimated to save up to 10% of the cost associated with traditional design-build projects. This is because necessary changes can be picked up earlier in 3D BIM models and changes are much cheaper to effect on a computer screen than on the building site. Other factors such as globalisation, increasing project complexity, and technological improvements are also encouraging the move towards collaborative working, facilitated by BIM.

What is BIM and how can it be used to improve collaboration in building design?

Building Information Modelling (BIM) can be defined as “a modeling technology and associated set of processes to produce, communicate and analyse building models” (Eastman et al. 2008: p13). These models consist of:

- **Building components** – digital components that have intelligence (i.e. they have programmable attributes and parametric rules)
- **Components that include data describing how they behave** (this allows them to be used for analysis, specifications, and quantity take-offs, for example)
- **Coordinated data** – all views of the model are represented in an integrated environment that facilitates and supports coordination and hence all changes made to the model in one view are automatically reflected in other views

Changing from 2D CAD (computer aided design) drawings to 3D BIM requires a shift not only in the technology used, but also in the way design and construction teams work together. The current shortage of building design professionals trained in BIM remains a barrier to the adoption of collaborative working practices in the industry. This was recently noted by the Built Environment Industry Innovation Council (BEIIC) - established in 2009 by the Australian Government. BEIIC wrote to all of the Deans of Australian Architecture and Engineering
Schools in March 2010 to ask about the current implementation of BIM and how integrated
digital technologies and integrated practice in university coursework could be effectively
promoted.

Collaborative working using BIM requires not only the learning of new
technologies/software, but also the learning of a new way of working. This means moving
from a culture of litigation and fragmentation to one of information sharing, collaboration
and integrated project delivery. BIM requires practitioners to re-think the ways in which
they develop designs and manage construction projects. There is a great opportunity for
educators to train undergraduates in the concepts of collaborative design with the aid of
BIM, before they learn about the “old” litigious, pugilistic ways of working in the industry
that are not conducive to the sharing of information. These new graduates will have the
potential to spearhead the adoption of collaborative approaches to working practices that
will positively transform the industry.

**How can collaborative design with BIM facilitate curriculum renewal in AEC education?**

In order to develop a collaborative building design curriculum using BIM tools, a change to
existing education practice will be required. At present, architects, engineers, quantity
surveyors and construction managers are educated separately, occasionally in the same
School or sharing a few courses, but frequently in different schools, in different programs
and sometimes at different campuses or universities. The current barriers to collaboration
between AEC disciplines can be cultural, economic, geographic and logistic. All of these will
need to be overcome for curriculum renewal around collaborative design to be successful.
BIM provides a tool that can potentially overcome all of these barriers, but in order to utilise
it to its maximum potential, it will also be necessary to overcome resistance to the teaching
of computer technologies within AEC disciplines.

Since the introduction of 2D CAD systems, there has been resistance among many educators
in the building design professions to teaching CAD technologies to students. This refusal has
often been made on the grounds that there is little difference between producing 2D
drawings by hand and producing them on the computer screen. In Engineering there is
similar resistance to the teaching of many computer analysis and design programs on the
grounds that university courses should teach theory and that computer applications are
something that students can learn later in the workplace. These arguments miss the point
that BIM is not merely a new CAD tool or computer application: it is a new paradigm and its
benefits are far greater than mere visualisation. BIM provides a vehicle for collaborative
design and performance testing since every building design and construction phase can be
modelled within it. Many AEC educators are unfamiliar with these technologies and hence if
BIM is used at all within courses, educators currently expect students to learn it by
themselves, as they do many other software applications (Williams et al 2009). This default
approach to learning BIM means students will not develop an understanding of how BIM
tools enable them to work effectively with others in a collaborative environment. Hence
training of staff will also be an essential element of this project if collaborative building
design curriculum is to be successfully implemented.

Some Australian universities (for example Newcastle and UNSW) are beginning to teach
aspects of collaborative design utilising BIM, but so far none of these courses have involved
input from the engineering faculties. Architecture students, instead, are required to assume
the roles of the other inter-disciplinary team members. Inter-disciplinary design can be
more creative, innovative and efficient, and is the model that students will be expected to follow when they go in to practice, but universities are still locked in an outmoded teaching model that ignores the potential of inter-disciplinary projects facilitated by BIM. This project plans to address these issues by developing curricula that will allow truly inter-disciplinary building design courses to be implemented through the use of BIM technologies.

The most visible outcome of the proposed curriculum renewal in this project is likely to be the development of a flexible, inter-disciplinary course(s) that will involve architecture, engineering and construction students working together on collaborative design projects facilitated by BIM technologies. Although such courses alone will require a paradigm shift from the isolated approaches to education currently used in the AEC disciplines, the bolting on of a single inter-disciplinary course at the end of a program does not constitute curriculum renewal. Such “capstone” collaborative courses need to be underpinned by curriculum interventions and modifications necessary to provide both students and teaching staff with the prior knowledge needed for the projects to succeed. If such changes are supported by educators and industry practitioners alike, then curriculum renewal is much more likely to be achieved. This is the ultimate aim of the proposed project.

Links with other ALTC projects

Discipline-based projects to chart future directions have been carried out through ALTC grants in each of the Architecture, Engineering and Construction discipline areas. The proposed project clearly links with the findings of each of these. *Addressing the supply and quality of Engineering graduates for the new century* (King, 2008), which was initiated by the Australian Council of Engineering Deans (ACED), included many references to the importance of collaboration between both engineering disciplines and other discipline areas as well as with industry. In particular it stressed the importance of engineers working with architects and construction managers (p. 12). It noted that there was currently a “lost opportunity” to prepare graduates with the skills required in this industry (p. 80). The King report also stressed the desirability of the development of curricula that could be shared across universities, through projects such as those sponsored by ALTC.

The 2009 report *Construction education in Australia: a review of learning and teaching challenges and opportunities* (Williams et al, 2009) was led by Anthony Williams and Willy Sher from the University of Newcastle, who are also members of the project team for this application. This report noted the importance of teaching new technologies including BIM but noted that this was currently difficult due to the lack of academic staff with proficiency in this area. It also recommended an increase in the delivery of inter-disciplinary courses and the establishment of a web portal to disseminate curriculum resources. The 2008 Report on Architectural Education (Ostwald and Williams, 2008) identified that an issue with BIM adoption/implementation exists in Architecture Schools where "almost two thirds of survey respondents identified that they taught drawing, graphics and verbal presentation while one third taught CAD and BIM" thus showing the lack of readiness to deliver learning experiences in the technology.

The most recent relevant ALTC report is *Professional Education in Built Environment & Design* (Savage, David and Miller, 2010), which considered the challenges facing built environment and design education (incorporating architecture, construction management and civil engineering among others). The report noted that the move to integrated practice, the emergence of building information modelling systems and globalisation “have
inexorably altered these professions” (p. 8). A survey of industry professionals, academics and recent graduates conducted as part of the study reported that the greatest challenge facing the building design area was “the need to work across discipline boundaries” (p. 57).

The proposed project, therefore, clearly aligns with the findings of all of the aforementioned projects that stress the importance of developing inter-disciplinary and collaborative education in the AEC professions. This project will take advantage of the networks for communication and dissemination that have been established by the previous projects through involvement of previous project leaders as team or reference group members.

**Project aims**

Specifically, this project will aim to:

1. Determine the current level of collaborative building design education and the knowledge and use of BIM in AEC programs in Australian universities
2. Benchmark Australian practice in this area with rest of world practice
3. Evaluate the range of BIM tools available and assess their suitability for use in the development of collaborative building design education in Australia
4. Develop a flexible, platform-independent curriculum (including associated teaching and learning resources) for collaborative building design education course(s) utilising BIM, which can be used by AEC programs across Australia, informed by international practice.
5. Evaluate the curriculum developed by trialling in the partner universities
6. Disseminate the curriculum to staff in AEC education across Australia using appropriate forums, project website and established on-line networks.

**Project approach and methodology**

In order to achieve these aims a comprehensive research and development methodology is proposed. To develop curriculum for collaborative design education utilising BIM in AEC undergraduate programs, the following research questions need to be addressed:

- What is the current level of collaboration between AEC disciplines in Australian universities and how does this compare with international best practice?
- What are the most effective curriculum strategies that could be adopted to improve collaboration between students and staff in the various AEC disciplines and at what point in their programs should these commence?
- What pedagogies are most appropriate and effective for inter-disciplinary collaborative learning in AEC?
- Given that BIM technologies have already demonstrated that they improve collaboration in industry, how do we best integrate BIM into this curriculum development? How soon should/could BIM be introduced? What prior knowledge is needed in each discipline area for the introduction of BIM to be successful? Woo (2006) comments that “there is no accepted instruction strategy for teaching BIM in AEC-related curricula” so the development of such a strategy will be an important outcome of this project.

These questions will be addressed as part of the process of curriculum development within the project. The project will utilise a staged approach over two years, detailed below. It should be noted that several of the stages overlap or will be ongoing during the project, since it is proposed to adopt a model that will be flexible enough to allow continuing development for the life of the project and beyond. The project will build on a University of
South Australia (UniSA) funded pilot project, (nearing completion) by Mills, Chileshe, Smith and Fong in conjunction with Mitchell (BuildingSMART/UNSW), which has involved an initial literature review, face to face interviews with AEC academics at the partner institutions, and development of an initial project website.

**Stage 1: Project establishment (Months 0-6)**

In Stage 1 the project team will first agree on the size, terms of reference and membership of the Reference group. It is expected that the Reference group will include a leading educator from each of architecture, engineering and construction management, as well as representatives from relevant industry partners (the participation of King and Savage from the related ALTC discipline projects will be sought, or their recommended alternatives). Once the Reference Group has been established, they will meet with the project team in the first face-to-face meeting to:

- establish the project collaboration
- develop and document a shared understanding of the project aims and processes
- agree on details of the administrative and financial management of the project
- appoint the independent evaluator as required by ALTC
- establish the communication strategy for the project, which will involve:
  - Initiate communication with key AEC education and industry bodies, using the dissemination strategy discussed below
  - Broadcast the existence of the project through existing networks of AEC educators and building design industry professionals using tools such as email lists of AAEE and AUBEA and the databases of the previous related ALTC projects mentioned earlier, and invite participation for Stages 3, 4 and 5
  - Expansion of the website developed during the UniSA pilot project for dissemination of initial review findings and later the curriculum guidelines and resources.

As part of this stage, discussions will be held with a range of industry stakeholders such as the BIM Working Group of the Built Environment Industry Innovation Council, and buildingSMART (a worldwide network of built environment companies and academic institutions) as well as the accrediting bodies for each of the professional disciplines to get their buy-in, cooperation and active feedback during the development the project. These stakeholders will also provide links and networks to aid dissemination of the curriculum developed on completion of the project. It should be noted that the project team already has excellent links with all of these industry groups and education networks.

**Stage 2 – Review and benchmarking of current practice (Months 4-8)**

During this stage the literature review and initial survey conducted in the pilot project at UniSA will be used as the basis of a more extensive review of the current status of collaborative and BIM education in AEC programs in all Australian Universities. The review will include an examination of current course and program structures to determine what existing collaborative education practices are in place, as well as where and when prerequisite knowledge for BIM concepts is introduced. For example, the review will determine if and at what stages students are typically introduced to fundamental building construction processes, analysis using computer packages, 3D modelling and visualisation etc. During the review, particular attention will be paid to any current curriculum examples
that could inform the curriculum development proposed by this project. The review will involve interview, survey and document/website examination components.

Ethics approval for this work has already been obtained for the pilot project at UniSA and an extension of this approval will be sought to incorporate other Australian universities. The review outcomes will be analysed to determine the current extent of collaborative education between AEC disciplines in Australian universities and the level of awareness and utilization of BIM. This will inform the development of the proposed curriculum, particularly with regard to the level of prior knowledge of both students and academics. This will help to determine the appropriate level at which any curriculum interventions, including new courses or course modifications, should be targeted. At the end of this stage it is expected that the project team will agree on the curriculum goals and strategies to be adopted in the project. The review results will also be published on the project website.

**Stage 3 – Collect exemplars (Months 6-10)**

In conjunction with the review in Stage 2, exemplars of collaborative building design and BIM education will be collected from both Australia and overseas. The exemplars will be those that demonstrate methods for teaching collaborative building design and/or using BIM that have been evaluated as successful. Such exemplars will help to determine the most appropriate methodologies and stages at which to introduce the concepts of collaborative design and BIM to undergraduate programs and will provide a foundation for the development of the new curriculum that will be the major outcome of this project.

**Stage 4 – Develop, pilot and evaluate curriculum (Months 6-20)**

This is the most significant and intensive stage of the project. Curriculum development issues that will be considered in this stage include:

- The development of an overall framework for the introduction of collaborative design education, facilitated by BIM, to undergraduate curricula in all AEC disciplines
- Development of modules and curriculum strategies within the framework that can be used by each discipline in earlier year courses as well as a “capstone” collaborative course curriculum
- Building in flexibility of delivery mode for all suggested curriculum modifications and proposed courses to allow for standard semester, intensive face to face, online/distance delivery, and cross-institution collaborative delivery
- The possible extension of the curriculum developed in the project for use in professional development short courses by the relevant industry sectors

Those interviewed during the review in Stage 2 will be asked about the most useful format(s) for dissemination of the curriculum resources developed by the project (on-line, handbook, DVD etc.) as well as the most likely delivery mode and time at each institution. There will be ongoing consultation with the industry stakeholders from Stage 1 as well as with the Reference Group members as the curriculum is developed. A specialist graphic designer/web resource developer will be employed in the latter part of this stage to help with resource development and a project intranet site will be used to store all resources. Whilst much of the project team communication will be electronic, it is also anticipated that three face to face meetings will occur during this stage.

An early task in this stage will be to trial the locally available BIM tools (software) to explore the appropriateness of their use in building design education. There are a range of
commercially available tools currently being used for BIM, with some favoured by particular sectors of the industry, some available as education platforms and all with advantages and disadvantages. The intention of the project is to develop a curriculum that is platform-independent, i.e. that will still achieve the required outcomes regardless of the software platform used. This has the advantage of preventing over reliance or monopoly of one tool to the exclusion of others, which has inherent risks of both cost and of materials becoming outdated when software changes. The focus of the curriculum will be on developing transferable skills of collaboration and technical capability, rather than on training students how to use a particular software platform. However, to do this it is essential that the features and abilities of the range of likely platforms are evaluated first, so that a generic curriculum that can be used regardless of software platform can be developed.

The curriculum and associated teaching and learning resources developed during the project will be trialled at each of the partner institutions. The delivery modes will vary in each institution due to differences in student cohorts and structure of each school. For example, Newcastle has a significant number of distance education students and hence will trial non-traditional delivery methods such as intensive courses during University vacation periods and/or online delivery. Intensive evaluation during and after the delivery of the trial implementations will be used to refine the curriculum prior to its wider dissemination. This evaluation will involve recognized education evaluation techniques such as independent classroom observation (for face to face delivery modes); student and teaching staff feedback questionnaires and focus groups; and pre- and post- concept testing where appropriate. The evaluation will primarily be undertaken by members of the project team from one institution evaluating the implementation and outcomes of the curriculum at the other partner institution. The curriculum evaluation and review process will involve convening sessions at critical times during curriculum development and implementation, when the project team will meet to provide detailed feedback and discussion.

It is acknowledged that it will not be possible to evaluate the effectiveness of the entire curriculum developed during the life of the project. For example, interventions or modifications to introduce students to the concepts of collaboration might be implemented in the first or second year of programs, whilst a collaborative, inter-disciplinary BIM course might be positioned in the final year. Hence, within the project duration, students who have experienced the second year curriculum will not also undertake the final year course. However, if each component is evaluated appropriately, some picture of the overall outcomes in the longer term should still emerge within the life of the two-year project.

**Stage 5 – Staff development (Months 20-24)**

Without appropriate staff development and engagement, the curriculum development from the project may be wasted if it is left to teaching notes and a website to translate the project outcomes into practice. Given the duration of the project, there will be limited opportunity for formal staff development to be implemented as a project activity after the curriculum has been trialled and evaluated. However, staff development is an integral part of the dissemination and embedding strategy detailed below.

**Stage 6 – Final evaluation and reporting (Months 20-24)**

A final evaluation of the project will be conducted at this time in conjunction with the reference group, against the stated aims, deliverables and outcomes. The evaluation will be incorporated within the final report that will be published through the ALTC website.
Dissemination and embedding strategies

The dissemination and embedding strategy for this project will involve two key stakeholder groups. The first is the network of educators in each of the relevant building design fields. Each of the building design professions has a key education network: AAEE (Australasian Association of Engineering Education), AUBEA (Australasian Universities Building Education Association) and AASA (Association of Architecture Schools of Australasia). Each of these networks holds annual conferences and has websites and electronic forums, all of which will be utilised to provide information about the project and encourage participation and input from interested parties. The second group of interested stakeholders is the AEC industry, including relevant industry networks such as DIISR, BEIIC BIM working group and buildingSMART as well as the professional accrediting bodies such as Engineers Australia and RICS. The websites, forums and e-networks of these stakeholders would be utilised in a similar manner to publicise the project, invite collaboration and participation.

The project will also engage with the two National Deans’ bodies, The Australian Council of Engineering Deans and the Australian Deans of the Built Environment and Design. The Dean’s Councils will provide a forum for engaging wide support from the universities but also a forum for feedback on project and its outcomes. These bodies would also provide an effective conduit back into the universities to assist in raising awareness of the project and to assist in reaching the implementation of the outcomes into the appropriate curricula.

The involvement of the project team and partner universities in the project from an early stage represents a crucial first step in dissemination and adoption of project outcomes. All of the project team have close links and/or leadership roles within these education associations and industry networks, so this will facilitate both dissemination and embedding of the project developments. Initial dissemination methods will include the distribution of project information in written form to universities, education and industry networks and magazines; links to the project website from those of the education and industry networks and presentations/workshops at their national conferences. This strategy offers a chance to get other stakeholders involved, to establish informal partners and to extend ownership. Other advantages include the ability to publish works-in-progress, progressive reports, interim evaluations and preliminary review analysis.

An important outcome of dissemination during the project establishment stage is the opportunity to arouse initial interest, receive comment, a potential to gain extra data/exemplars and the capacity to modify the project based on feedback. The dissemination strategy intends to involve academics who are in a position to bring about change in teaching and learning practices at their institutions. Some refinement and adjustment is expected to evolve throughout the life of the project, particularly because of feedback promoted through dissemination initiatives and through interaction with the reference group. Central to the dissemination policy is engagement of project collaborators with potential users of project outcomes, particularly during project development. The networks established during the initial stages of the project will provide an additional source of critical feedback outside of the project team during the curriculum development phase. It is hoped that these networks may also provide sites for trialling the curriculum in addition to the project partner institutions, and/or evaluation opportunities.

Once the curriculum resources have been developed and trialled, it is essential that they be widely disseminated, accepted and implemented at all Australian institutions offering AEC
education. The proposed strategy to achieve this involves enabling others through practical activity. Project collaborators will present at relevant conferences, report project findings and provide evidence to support the adoption of the collaborative building design curriculum changes in AEC programs. The curriculum resources and evidence of their usefulness will be promoted widely through the education and industry networks through written reports in newsletters, industry journals, web news items and links to relevant websites. Staff training seminars/programs to facilitate the adoption and implementation of the proposed curriculum will be developed (although it is intended that the resources developed will include extensive ‘teaching notes’ and examples so that their use is self explanatory). It is unlikely that the staff development phase will be completed within the duration of the project, but the involvement of the relevant discipline education networks throughout the project should enable this to be taken up and facilitated by them after the formal project is completed.

Finally, if the adoption of collaborative building design utilising BIM is to be fully realised within the AEC educational community then it must be supported through the professional and accreditation bodies. The project would see as a primary embedding strategy that the need for collaborative building design utilising BIM tools is clearly articulated as a requirement of each professions’ accreditation process. The project would thus engage the professional bodies in the development of such attribute statements and support the implementation of this as an accreditation requirement.

**Evaluation framework**

The success of the project will primarily be evaluated by successful achievement of project outcomes and deliverables as indicated by the “Indicator of success” column in the table below. However, the evaluation of the project will also include an evaluation of the project process and progress during its life. Evaluation at each of the Stages of the project will enable the project team to address any issues of concern and to make adjustments at one Stage before proceeding to the next. Ongoing evaluation of the success and progress of the project will be undertaken by the project team and reference group, along with the independent evaluator as required by the ALTC. Evaluation of the curriculum itself has been incorporated into the project stages detailed earlier.

**Project management**

The project will be led by Associate Professor Julie Mills at the University of South Australia. *A/Professor Mills* has extensive experience in management in the academic context having been Head of School or Program Director for several years as well as being responsible for numerous projects (including ARC and ALTC), all of which have resulted in timely completions. Project responsibilities will be distributed among *project team* members with duties spanning development, implementation, evaluation, reporting and quality control. The background and experience of the project leader and team clearly demonstrates that they have the technical competence to undertake the project and the proposed methodology will fully utilise the individual strengths of the team members. The *Reference Group* will be responsible for providing additional oversight and expertise to the project and particularly assist with industry input as independent reviewers of the curriculum resources developed and the dissemination and embedding strategies discussed above.
The *Research Associate* position will be a 0.6 full-time appointment for the life of the project. From past experience this is a more efficient and successful way to ensure that the project outcomes are achieved than providing minor time release to staff members. The appointee will interface with all members of the reference group and regularly liaise with project leaders. The appointee will be located at the lead institution and will become the main contact for the ALTC and partner institutions. Duties will include: conduct of studies, production of reports and evaluations, record keeping, ethics applications, literature searches, administrative responsibilities, website maintenance, workshop and meeting organisation, data analysis and timeline management. The appointee will take overall responsibility for day to day activities and will report weekly to the project leadership team.

**Anticipated outcomes and deliverables**

The table below provides details of the anticipated outcomes and deliverables of the project as well as the Indicators by which we would gauge that they had been achieved:

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>INDICATOR OF SUCCESS</th>
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<tbody>
<tr>
<td>Develop understanding of the awareness and teaching of collaborative AEC education in Australian Universities, and the current extent of the use of BIM within them</td>
<td>Literature and benchmarking review completed and posted on project website, Results evaluated and disseminated through industry and education networks.</td>
</tr>
<tr>
<td>The incorporation of collaborative design in architecture, building and engineering programs in Australia, utilising BIM tools</td>
<td>Curriculum developed by the project adopted by AEC programs across Australia</td>
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<table>
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<tr>
<th>Deliverables</th>
<th>INDICATOR OF SUCCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>News items, announcements of the project, website development and maintenance</td>
<td>News items and announcements published, website established</td>
</tr>
<tr>
<td>Review of current levels of collaborative AEC education and BIM awareness in Australian universities (Aim 1)</td>
<td>Review completed and findings published on project website and conferences</td>
</tr>
<tr>
<td>Collection of exemplars from leading academic institutions in the field of collaborative building design and BIM education (Aim 2)</td>
<td>Posting of these exemplars on the project website and dissemination through the strategies described above.</td>
</tr>
<tr>
<td>Evaluation of locally available BIM tools for use in collaborative building design programs (Aim 3)</td>
<td>Guidelines for software selection incorporated into the curriculum guidelines circulated to and endorsed by the stakeholder networks.</td>
</tr>
<tr>
<td>Development of a framework for the introduction of collaborative design education utilising BIM to undergraduate AEC curricula. This will include guidelines as to the most appropriate stages at which to</td>
<td>Framework published on project website and related conference/journal papers. Framework disseminated through workshops at relevant association conferences and at partner institutions.</td>
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</table>
introduce BIM concepts. Framework and guidelines to be disseminated to the wider building design education fraternity (Aim 4)  
Framework endorsed and adopted by stakeholders, in project partner institutions and other Australian universities with building design programs.

Collaborative building design course(s) between architecture, building and engineering developed and implemented. This will include complete curriculum resources that incorporate flexibility of delivery mode and software platform (Aims 4 and 5)  
Pilot delivery and evaluation of such course(s) at the project partner institutions. Interest in delivery at other Australian universities offering building design related programs. Publication and wide dissemination of curriculum resources.

Scholarly publications (conference, journal) and final report on the project (Aim 6)  
Publications accepted. Report completed and widely disseminated.

References


Attachment 1: Project budget and timeline

**Budget:**

<table>
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<tr>
<th></th>
<th>Budget Stage 1/Year 1</th>
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<th>Budget Stage 2/Year 2</th>
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<td></td>
<td></td>
<td>10256</td>
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<td>Project and Ref Group meetings - travel, accom, meals and catering. Travel for RA and/or project leader to other relevant meetings</td>
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<td>Software purchase or license fees</td>
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<td>Transcription of benchmarking and evaluation interviews</td>
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<tr>
<td>Production and dissemination of materials - printed, online and &amp; dvd</td>
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<tr>
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<tr>
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**TOTAL PROJECT BUDGET**

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<th>ALTC</th>
<th>Other</th>
<th>Total</th>
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<td>206,000</td>
<td>31000</td>
<td>237,000</td>
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Budget justification:

**Personnel**

*Research associate* (RA): Tasks as detailed in the project methodology. Rate has been calculated at 0.6 FTE fixed term contract for 2 years, at Research Associate Step 1, assuming 4% annual salary increase, and including 28% on-costs. Hence $63489 x 0.6 x 1.28 = $48759 for year 1, and $63489 x 1.04 x 0.6 x 1.28 = $50710 for year 2.

*Curriculum resources developer:* This allocation is for a second casual position in the later stages of the project. The appointee will have primarily responsibility for the development of the physical hard and soft copy curriculum resource material under the direction of the project team and RA. It is anticipated that this person will have graphic design/web development skills. Rate has been calculated at 0.4 FTE for 4 months at ARAS 1, including 16.5% on-costs, but it is also possible that this work may be awarded on a lump sum contract basis to an independent contractor. Hence $63489 x 1.04 x 0.4 x 1.165 x 4/12 = $10256 for year 2.

*Project Manager:* It is anticipated that the Project Manager (Mills) will spend the equivalent of 1.0 days per week or 20% of time on the grant. Allowance has been made for funding from ALTC for teaching relief for half of that time, with the remaining shown as in kind contribution from the institution. This is based on the assumption that the majority of the administrative, management and reporting activities for the grant will be carried out by the RA under the direction of the project leader and team. The rates have been calculated based on salary of $116573 FTE at Academic Step D4 for Mills. Calculations include 28% on-costs and assume a 4% salary increase in Year 2. Sample calculation for Year 1 for Mills = $116573 x 0.1 x 1.28 = $14921.

*Project team:* For the project team members at UniSA and University of Newcastle it is anticipated that their time commitments will be between 0.1 and 0.05 FTE depending on their specific roles. This will be provided as in-kind support by their universities, hence has not been shown in the budget. However, the budget does include all costs associated with their travel and accommodation for project team meetings.

**Project support**

*Project team and reference group meetings:* As detailed in project methodology. Two meetings per year have been budgeted for the project duration, involving the project team (6 people), research associate and the reference group (assume maximum 3 people). Since at least 4 members of this group are located in Adelaide and meeting facilities can be provided at the University of South Australia, the meetings have been budgeted to be held in Adelaide as follows:

- **Air and ground travel:** Project team return fares, 2 from Newcastle @$700 each; Reference group return fares allow 4 from Sydney @$500. Ground travel (taxis, parking etc) allow 6 people @$100 average per meeting – total per meeting = $4000 hence $8000 for 2 meetings each year.
- **Accommodation, food and allowances:** Based on 2 days/1 night allowance at ATO rates = $460 per person per meeting, 6 people x 2 meetings per year = $5520, round down from previous experience of actual claims to $4000 per year. Additional catering for meals at meetings based on ATO rates for meal allowances for Adelaide attendees for 2 days per meeting = $370 per day x 2 x 2 = $1480, round down based on previous experience to $1000 per year. Hence total of $5,000 per year combined.
From previous ALTC grant experience funds can often be saved with discount fares, so this total should also include adequate funds for attendance at other meetings as decided such as opportunities to meet with Deans Councils, accreditation boards etc.

**Project activities**

All items are detailed in the project methodology.

- Purchase of licences of education versions of a range of BIM software for evaluation and use in curriculum development to ensure a curriculum that is platform independent and compatible with all widely available software options. Some software is already available at the partner institutions hence this cost is subsidized by that option. Allow $6,000 each year.
- Transcription of benchmarking and evaluation interviews, allow 40 hours @$25 per hour in Year 1 = $1000.
- Production and distribution of curriculum materials - printed, online and & dvd, allow $5000 in year 2 (note that design cost is included in personnel).
- Travel, accommodation and registration for attendance at professional associations' conferences to present findings and workshops on the proposed and trialled curriculum. Allow for 2 project team members to attend each conference closest to their home universities (e.g. AAEE, AUBEA etc), some costs will be met by institutions, assume 4 attendances @$1100 each per year.
- Independent evaluation costs, allow total consultant fee of $10000, spread over Years 1 and 2.
- Allowance for purchase of relevant books, reports, printing and consumables during the project $500 per year.

**Institutional overhead levy**

The University of South Australia has a policy of waiving institutional levies on successful ALTC grants.

**Institutional support**

The lead institution will provide office space, software and hardware, and library resources with inter-library loan facilities. They will also provide access to a web server to allow for web-site development and also the use of their on-line survey facilities if needed. The lead institution will host the project team meetings and provide meeting rooms for these. The lead institution contributed human and material resources to develop the full proposal and covered the financial costs of the pilot project grant that was used to provide initial data and piloting of the project ideas. Partner institutions will provide space and computer access for testing of curriculum materials. Each partner institution will provide facilities for remote conferencing as needed. They will also provide access for project team members to any relevant BIM software for which that institution has licenses (provided this is allowed under the license agreement).

All institutions will provide academic, technical and IT support, administrative facilities and vehicles where necessary. Ethics committees at each partner institution will assist partners with appropriate ethics approvals to recruit participants and to conduct project studies. In addition each institution is providing in-kind support through the salary and on-costs for the time that each of the project team members will be involved with the project. Each institution will also allow access to students to trial the curriculum materials developed. This
will either be within an elective course within established programs or as part of existing core courses that will be modified to allow the curriculum trial.

**Project timeline:**

Details of the tasks to be carried out in each stage have been included within the project methodology section. The table below is used to indicate the overlapping nature of some of the stages as well as to demonstrate how the costs for each stage have been sorted into the yearly budget.

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<td>22-24</td>
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</table>

- Stage 1
- Stage 2
- Stage 3
- Stage 4
- Stage 5
- Stage 6
Attachment 2: Project team and Reference group

Project leader

Julie Mills is an Associate Professor and Program Director in Civil Engineering at the University of South Australia and a Fellow of Engineers Australia. She entered academia in 1996 after fifteen years as a structural engineer in private industry. Her teaching has focussed on the development of innovative, project-based learning approaches to provide authentic and engaging learning experiences for students in all year levels, particularly in the areas of Structural Engineering, Engineering Design and Professional Practice. Julie is known nationally and internationally for the excellence of her teaching in engineering and her contributions to the scholarship of engineering education and equity, particularly in the areas of project-based learning and gender inclusive curriculum. The excellence of her teaching has been recognised through university and national teaching awards including the 2009 National Excellence in Teaching award from the Australasian Association of Engineering Education (AAEE) and a Carrick Citation in 2006 “For outstanding contributions to student equity and diversity and to project-based learning in engineering education”. Her work in gender inclusive education has culminated in the publication of a recent first author book *Gender Inclusive Engineering Education* (Routledge, 2010). She currently leads an ALTC Competitive Grant project CG8 696 on *Gender Inclusive Curriculum in Engineering and Construction Management*. In addition to the book, her scholarly contribution to the engineering education and equity field includes her PhD (completed 2002), and an extensive refereed publication record cited in all of the A and A* journals in the field. She has extensive project management experience including major grant and school management in the university context as well as in her professional career as an engineer.

Project team members:

University of South Australia

Nicholas Chileshe is a Senior Lecturer in Construction Management at the University of South Australia. A Civil Engineer by profession, he has worked in the UK construction industry and has 12 years’ experience in academia, having previously worked in the UK at Sheffield Hallam University (UK) from 1999 to 2009. His primary research interests and expertise are in the areas of construction and project management, total quality management, structural equation modelling, curriculum development and e-Learning. Nicholas was a double recipient at the Emerald Literati Network Awards for Excellence 2008, in both the “Outstanding Reviewer of the Year” and the “Highly Commended Paper” award categories. Dr Chileshe received a research grant from the Centre for Inter-professional e-Learning (CIpeL), funded by the Higher Education Funding Council for England (HEFCE) for the project “Antecedents, Benefits and Consequences (ABC) of e-Learning: A Multidisciplinary Education Approach”.

Elizabeth Smith is a lecturer and early career academic in the School of Natural and Built Environments at the University of South Australia. Prior to commencing with the University of South Australia in 2006, she was a research and consulting engineer with the Turbulence, Energy and Combustion Group based at the University of Adelaide, and before that she worked as a manufacturing engineer in the plastics industry. Elizabeth has particular expertise in engineering education involving new technologies and e-learning techniques.
She is involved in the teaching of professional practice and engineering design courses and has published in both engineering education and fluid dynamics.

**Darren Fong** is a Lecturer in CAD in Art, Architecture and Design at the University of South Australia. He has wide experience in the field of drafting and design, gained while working at a variety of architectural and engineering firms. Darren has worked part time as a course coordinator at the University of South Australia for 15 years while maintaining professional links with industry, and continues to work part time as an Interior Designer at an Architectural Practice. His research interest lies in the effective teaching of technology to large groups of students. His close links with industry ensure that experiential learning is at the forefront of his teaching and drives future graduates to be prepared for the workforce. Darren has the support of his industry employer with this project and they are also willing to assist with its success.

**University of Newcastle, Faculty of Engineering and the Built Environment**

**Associate Professor Anthony Williams** is the Head of School of Architecture and Built Environment and has extensive experience in project management in the domain of professional education. He is a winner of multiple university teaching awards as well as a national award for teaching excellence. He has worked extensively in curriculum design and implementation both at program and course levels. He is highly regarded in this area having worked as a curriculum consultant nationally (QUT, Griffith) and internationally (AIIAS Philippines, PSB Singapore & Poly U Hong Kong). His recent research has involved the leadership of 4 ALTC Discipline Projects (Creativity, e-Portfolios to support Work Integrated Learning, and Construction Management Education and Architecture Education) and a Competitive Grant (Spatial Abilities). Anthony has published extensively in curriculum design and implementation, teaching methodologies to support Design Education and Assessment of Design Activities. His research area is in design team collaboration with recent projects involving identification of core skills for effective participation in virtual design teams. Associate Professor Anthony Williams will provide leadership and direction for the research defined in this proposal as well as the development of the outcomes, given his extensive curriculum design experience.

**Willy Sher** is a Senior Lecturer in Building and Assistant Dean Teaching and Learning. He is a co-investigator with Tony Williams in a current ALTC Grant entitled “Identification of Teaching and Instructional Issues and Opportunities for the Construction Management, Quality Surveying and Building Surveying Disciplines”. His research interests include professional development and skills development and tracking as educational processes. Willy is current Chair of the education panel of the Chartered Institute of Building (CIOB). He is currently supervising two BIM related PhD’s (“Building Information Modelling Framework: A Research Foundation for AEC Stakeholders” and “Construction Estimating Using Building Information Modelling (BIM)”).

**Research Associate:**

The intended research associate for the project is Ms **Jennifer Macdonald**. Jennifer has a Bachelor degree in Building Design Engineering, a Master of Philosophy in Strategic Information Management and 9 years of industrial experience as a structural engineer specialising in advanced structural analysis. She has extensive industrial experience of Building Information Modelling, including working on Terminal 5 at Heathrow Airport, which
was one of the first major projects in the UK to make extensive use of BIM. Since 2009 she has been the research associate on an ALTC grant CG8-696 held by Assoc Prof Mills, hence she is already familiar with ALTC administrative and reporting procedures. She has also been the RA on the University of South Australia Pilot Project related to this application and has been teaching part-time in the civil engineering group at the University of South Australia in courses that have included finite element modelling and AutoCAD. Jennifer will shortly commence her PhD part-time with a topic closely related to this grant. Her extensive experience in the use of BIM combined with her industry links through involvement with buildingSMART, her relevant teaching experience and ALTC grant involvement give her an ideal background for this role.

In summary, the team members have technical expertise in all of the areas that make up an inter-disciplinary BIM team – namely structural engineering, mechanical engineering, architecture and building construction. They have extensive links with a range of relevant industry stakeholders and professional accreditation bodies. Team members have expertise in a range of education areas including curriculum design, e-learning and project-based learning that are all very relevant to this project. All team members are committed to collaborative and practice-based teaching and with their complementary expertise they form an ideal team to undertake the project.

Project reference group:

The Chair of the Reference Group will be Associate Professor John Mitchell. John is the current Chair of buildingSMART Australasia, which promotes the development and use of applications that enable the exchange and sharing of information so as to improve the efficiency and quality of building design, construction, operation and maintenance. He also holds a half-time contract appointment as Associate Professor and Senior Research Fellow at the University of New South Wales, School of Built Environment. Trained as an architect, John developed an interest in the application of computing to the field of architecture and design, and later to the wider construction industry. He has many years of industry experience in this area in both Australia and overseas and has also been an expert reviewer for several projects in the European Commission’s IST Construction Research program. John has already been working with the The University of South Australia members of the project team on the pilot project.

The final composition of the reference group will be determined during the first stage of the project as discussed in the Project Approach and Methodology section. We aim to secure members with complementary and comparable skills and industry/education associations. The Reference group will include a leading educator from each of architecture, engineering and construction management, as well as representatives from relevant industry partners (the participation of King and Savage from the related ALTC discipline projects will be sought, or their recommended alternatives).
8 July 2010
Dr Carol Nicoll
Chief Executive Director
Australian Learning and Teaching Council
PO Box 2375
Strawberry Hills NSW 2012

Dear Dr Nicoll

Re: 2010 Priority Project Grant Program Proposal: Collaborative building design education using Building Information Modelling

This letter is to confirm that I fully support the work that will be undertaken by Associate Professor Julie Mills, Dr Nicholas Chileshe and Ms Elizabeth Smith on this project and support the inclusion for teaching relief within the grant.

Yours sincerely

Dr Ian Clark
Acting Head of School
School of Natural and Built Environments
Mawson Lakes Campus
University of South Australia
CRICOS Provider Number 00121B
8 July 2010

Dr Carol Nicoll  
Chief Executive Director  
Australian Learning and Teaching Council  
PO Box 2375  
Strawberry Hills NSW 2012

Dear Dr Nicoll

Re: 2010 Priority Project Grant Program Proposal Endorsement

I wish to advise that the University of Newcastle supports the proposed project Collaborative building design education using Building Information Modelling (BIM) to be led by Associate Professor Julie Mills at University of South Australia.

BIM is an emerging technology that will revolutionise building design and construction. This project will re-shape discipline-based courses and develop contemporary curricula that meet industry needs. It proposes cross-disciplinary pedagogies and cutting edge computer modelling tools and will be suitable for adoption by all Australian universities offering architecture, engineering or construction related programs.

The University of Newcastle is prepared to provide the in-kind contributions outlined in the proposal, including participation in reference group activities by senior members of staff in the School of Architecture and Built Environment and engagement of the School in pilot implementations of new courses. The University of Newcastle supports this project and the project team’s ability to achieve the specified outcomes.

Yours sincerely

Kevin McConkey  
Deputy Vice Chancellor  
(Academic and Global Relations)
Chief Executive Director  
Australian Learning and Teaching Council  
GPO Box 2375  
Strawberry Hills, NSW 2012  

Attention: Dr Carol Nicoll  

Re:  2010 Priority Project Grant Program  
Collaborative Building Design Education using BIM  

Dear Dr Nicola

Our industry organisation, buildingSMART strongly supports this project.

BIM - Building Information Modelling - over the last 2-3 years has emerged as one of the most important technologies for the built environment. The transition from a 2D drawing based process to a collaborative model based process is having a major impact on the way business will be conducted.

In the face of this paradigm shift, education for the built environment professions is lagging behind industry adoption and is emerging as a major constraint to growth and informed usage.

We are currently undertaking a survey of BIM adoption in the industry - the first of its kind in Australia; this is supporting an economic study being carried to assess the economic benefits the technology could make.

The proposed Research Assistant for this ALTC project, Jennifer Macdonald, is already assisting us in the survey and the proposed ALTC project will provide a mechanism to understand better where and what types of educational strategies need to be developed to support the collaborative skills needed by the building design industry of the future.

Accordingly we offer our positive support for this project,

Yours sincerely,

John Mitchell 
Chairman, IAI-AC
Dr Carol Nicoll  
Chief Executive Director  
Australian Learning and Teaching Council  
PO Box 2375  
Strawberry Hills NSW 2010

Dear Dr Nicoll

Re: 2010 Priority Project Grant Program Proposal Endorsement

I write to you as Chair of the Built Environment Industry Innovation Council (BEIIC) in support of the proposed project **Collaborative Building Design Education Using Building Information Modelling (BIM)** to be led by Associate Professor Julie Mills at University of South Australia.

As noted in her submission, I have recently written to all Deans of Built Environment faculties to find out to what extent the universities are embracing new technologies such as BIM and equipping our future professionals with cutting edge experience. BEIIC believes that BIM and other integrated design tools will ensure that the Australian industry stays competitive in the future.

We believe that BIM will revolutionise building design and construction, and will support a more collaborative culture in the industry. This project will assist in developing contemporary curricula to meet industry needs, and encourage young professionals to understand the value of working in cross-disciplinary teams prior to getting out into the workplace.

BEIIC is pleased to lend its support to this project.

Yours sincerely

Sue Holliday  
Chair  
Built Environment Industry Innovation Council  
21 July 2010