Building information modelling: what is in there for the architects?

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ABSTRACT: Despite the rapid growth in capabilities and availability of BIM supporting technologies the industry has been slow to adopt BIM in practice. A number of factors inhibiting BIM adoption have been reported in literature such as work practice, resistance to change, lack of business initiatives, and so on. Most of these researches have focussed at specific disciplines of the AEC industry and surveys and questionnaires have generally been used to collect data. This paper reports on the findings of an action-oriented research that aims at developing strategies and measures for greater adoption of BIM in the industry. The findings reported in this paper build on the earlier research on BIM by adopting Focus Group Interviews (FGIs) as the source of data collection. FGIs provide a forum for the representatives from different disciplines in the AEC industry including architects, engineers, contractors, software application vendors, consultants, project managers, academicians and people from government agencies, to share their views on BIM adoption issues. The discussions were recorded on tapes and segmented and analyzed using a coding scheme developed specifically for the study.
This paper discusses the BIM related issues from the perspective of the architecture, primarily focusing on the awareness, perception and knowledge of BIM among architects. A discussion with respect to the other disciplines is also presented to demonstrate differences in perception across the design (architects/ engineers) and non-design (contractors/ facility managers) disciplines.

Conference theme: Design computing and cognition
Keywords: adoption, focus group interviews, perception, coding scheme

INTRODUCTION

BIM (Building Information Modelling) is an IT enabled approach that allows storage, management, sharing, access, update and use of all building data through out the project life-cycle in the form of a data repository. The information maintained and produced in the BIM approach includes both geometric as well as non-geometric data. Geometric data includes 2D drawings, 3D models as well as dimensional and spatial relationships. Non-geometric data can mean annotations, textual data, reports, tables, charts, freehand illustrations, graphs, images, audio-visual data, and any other forms of information generated during the project. BIM is expected to enable improved inter-disciplinary collaboration across distributed teams, intelligent documentation and information retrieval, greater consistency in building data, better conflict detection and enhanced facilities management.

The literature on BIM have primarily emphasized that functional capabilities and intelligence of design tools have increased manifold with the development of Object-oriented (O-O) modelling packages, and the intelligence of O-O CAD tools, combined with the development of IT and web-based technologies can enhance design collaboration, integration and efficiency. Nevertheless, BIM adoption in the industry has been slow. A number of factors inhibiting BIM adoption have been reported such as work practice, industry's resistance to change, lack of business initiatives, and so on. Most of this earlier research on BIM adoption has focussed on specific disciplines of the AEC industry and surveys and questionnaires have generally been used to collect data. This paper reports on the findings of an action-oriented research that aims at developing strategies and measures for greater adoption of BIM in the AEC industry. The findings reported in this paper build on the earlier research on BIM by adopting Focus Group Interviews (FGIs) as the source of data collection. FGIs differ from surveys and questionnaires since they provide a forum for the different disciplines in the AEC industry to share and clarify their views on various adoption issues such as expectations, hurdles, and requirements of BIM.

FGIs were conducted with experts from major disciplines of the AEC industry including architects, engineers, contractors, software application vendors, consultants, project managers, academicians and people from government agencies. A comprehensive background study of BIM literature and available BIM applications had been conducted to provide a benchmark for the FGI discussions. A coding scheme has been specifically designed to analyze the FGI data. The design of the coding scheme was based on the main issues and themes initially identified from an open-ended analysis of the background study and the FGI discussions. The coding scheme is developed (1) to identify the priority issues across the different disciplines, and (2) to understand the current level of awareness, knowledge and interests about BIM across different disciplines.

Based on the FGI analysis, the key issues across all disciplines include version management of project data, validation and data integrity, data organization, data security, standards and data format, communication and information exchange, roles and responsibilities, and training support. Architects emphasized the needs for changes in model development approach, BIM standards, and user-friendly interface for BIM applications. They also raised concern for the plausible increase in workload for architects due to the adoption of BIM, and any negative effects of BIM approach on traditional methodologies and techniques in architectural practice. It was suggested that architectural practices can adopt a phase-wise upgrade of their BIM capabilities, which can enhance their decision-making capabilities and control over project development.

1. Background Study

Background study for the research involved a critical literature review and a comprehensive desktop analysis of available commercial BIM applications. The key findings of the review and desktop analysis are summarized below.

1.1. BIM tools and applications:

BIM technology is a natural progression of the further applications of information technology and objected-oriented (O-O) systems in the AEC industry. The development of O-O CAD packages has allowed greater intelligence in the CAD models. This enables associativity, modelling constraints and relationships within the objects and the object properties (Ibrahim and Krawczik 2003, Lee et al 2006). These constraints and relationships have been used to develop tools and features for performance and cost analysis, clash detection, conflict resolution, scheduling and intelligent documentation (Bajzanac 2005, Ellis 2006, Popov et al 2006, Mitchelle et al 2007).

A wide range of applications supporting BIM are available commercially. The range of applications varies from product suites (e.g. ArchiCAD, Revit and Bentley) that can be used by multiple disciplines across different phases of the project lifecycle to products for a specific discipline and applicable to a particular phase of the project. Only a few of these products are IFC (Industry Foundation Class) compliant. This inhibits their use with other packages that cannot read the data format.

The development of networked technologies has further enhanced the potential and capabilities of BIM applications. Web-based product services can be very useful (Ibrahim et al 2004, Campbell 2007) and their numbers are increasing in the AEC industry. Commercially available web-based products include product libraries, document management systems and BIM model servers.

1.2. BIM adoption:

Lack of initiative and training (Bernstein and Pittman 2004), the fragmented nature of AEC industry (Johnson and Laepple 2003), varied market readiness across geographies, and reluctance to change existing work-practice (Johnson and Laepple 2003) have been identified as some of the issues for slow adoption of BIM in the AEC industry. In an industry where most projects are handled in multi-organizational teams the lack of clarity on responsibilities, roles and benefits in using the BIM approach is an important inhibiting factor (Holzer 2007).

Surveys conducted recently (Khemlani 2007b, Howard and Bjork 2008) suggest that collaboration in the AEC industry is still based on exchange of 2D drawings, even though individual disciplines work in 3D environment and the demand for object libraries is growing. These surveys reveal that tool preferences vary with firm size, and there is a greater demand for technologies supporting distributed collaborative works across all firm sizes. However, there is a lack of confidence in standards such as IFC.

2. Focus Group Interviews

FGIs have been conducted in two major capital cities with active participation of representatives from various sectors of the AEC industry. The two FGIs together cover all major players including architects, engineers, project managers, contractors, consultants, software application vendors, facility managers, academics and delegates from government agencies. The main goal of the FGIs is to uncover and analyze the industry perceptions of BIM adoption across the different disciplines. Discussions in FGIs and the earlier BIM literature review suggest that the reasons for the low adoption rate of BIM in the industry are not only technological. Other factors that influence BIM adoption include: work practice, organizational structure, business interest, user training and so on. It has been recognized that the introduction of BIM would require a different approach to data organization and structuring. Some legal/ contractual measures will also be required to deal with safety and work practice related issues.

The FGI discussions were recorded on tapes and then segmented. The segmented data and background study were analyzed firstly using an open-ended approach to identify the main themes. Based on the main themes identified a coding scheme were developed and applied to the workshop data for detailed analysis.

Each FGIs gather leading organizations that have adopted BIM to some extent in a group environment in discussion for approximately 2-3 hours, chaired by the research team as moderators. The two FGIs involved twenty-one participants in total. Break-up of discipline wise representation and participation is shown in figure1. Participation is measured as the frequency of issues discussed/raised or commented by representatives of a specific discipline. Discussions were recorded on tape and analysed in detail using a coding scheme. FGIs aim to identify the industry needs, concerns and expectations regarding BIM adoption. In summary, the FGI discussions reveal that the level of BIM awareness and knowledge across disciplines differ; nevertheless the main issues inhibiting BIM adoption have been identified.

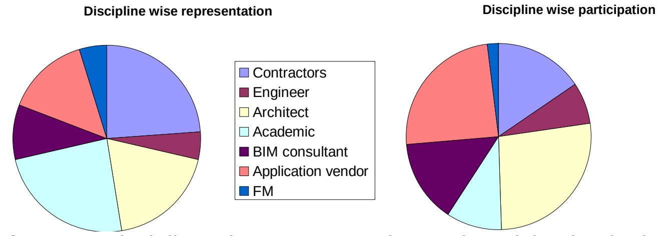

Figure 1: Discipline wise representation and participation in the FGIs

3. Coding scheme

3.1. Design of the coding scheme

The coding scheme has six categories: discipline, context, type, content, comment and keywords as shown in Figure 2.

Discipline			Context				Type								Content								Comment	Keywords
			initiated	reply	follow up	chair	suggestion/ ideas	concern	opinion/ viewpoint	observation/ analysis	query	inform	strategy	wishlist	technical	cultural/ work practice	structuring / Data organization	training	legal/ contractual	organizational- team	process/ method	Business case		

Figure 2: The coding scheme

Knowledge about BIM varies across the different disciplines within the AEC industry. **Discipline** category is used to code the data based on the disciplinary and functional background (roles in the industry) of the speaker. Marking of each segment, based on the disciplinary background of the speaker, gives useful information about the importance of the different aspects of BIM (in terms of the content) within each discipline.

Context category is used to mark the circumstances under which a given segment of data has been discussed. Classifications within Context category includes: "initiated" (if the segment of data was for starting a new subject of discussion); "reply" (if the segment of data was for answering a question); "follow up" (if the segment of data was in continuation of an ongoing subject initiated earlier in the discussion); and "chair" (if the segment of data was a statement to control the flow of discussion, and in general was often given by the moderator). These classifications can imply the following:

- A subject initiated by a specific discipline is in general expected to be higher in priority for that very discipline. For example, the discussion on the lack of supports for conceptual design was initiated by an architect. Similarly, the issue of the changing format of IFC specifications was initiated by an application vendor who as a service provider has been undertaking the management of IFC data for the clients.
- Most often, the identification of the discipline from which the reply to a specific query or statement comes suggests which discipline has knowledge and awareness of the specific topic. For example, as expected when the issue of security of the data on model server was raised the reply came from an application vendor.
- Follow up allows identification of other disciplines that participate in a specific topic of the discussion. For disciplines that do not participate in a specific topic at all, it may suggest the lack of relevance or interest for that discipline on the specific topic. For example, the discussion on tool supports for conceptual design phases has very little or no participation of the contractors and civil engineers, while the main participants are architects, academics, and application vendors.
- The "chair" marked segments mean that the statement is used to moderate the discussion, and even if that means starting a new topic it may not be suggestive of the priority of the speaker for the topic. Rather, such changes in discussion topic are either forced due to time constraints or to keep the discussion within the scope of the research.

The classification within **Content** category of the coding scheme is expected to provide clustering of the data to identify the keywords and issues discussed based on the aspects of BIM. The content category therefore codes the segments based on the subject of discussion and identifies the dominant topics. Accordingly, there are eight classifications within the content category: "technical", "cultural/work practice", "structural/data organization", "training", "legal/contractual", "organizational-team", "process/method", and "business case".

Discipline, **Context** and **Type** categories are used to cluster the data such that we can identify the pattern of BIM awareness, interest and knowledge across related disciplines. Marking **Keywords** allow identification of major issues across the categories, and we can set priority for keywords by evaluating the frequency of occurrence in the data. For example, the categorization may suggest that technological issues are the most prevalent topics of discussion, or that there are more concerns on data management issues raised by architects and application vendors. While it does suggest the priority of different topics, the specifics within each category need to be identified. This is where keywords are useful. A detailed analysis suggests that most concerns on data structuring and organization are related to version management. This is done by listing the keywords in each segment. In this case, version management has the highest frequency of occurrence. Similarly, other specific issues within each category are identified such that we can set priorities for the aspects to be further examined.

The annotations and examples of each category are presented in Table1.

Table 1:

Categories		Annotation with examples
Discipline		The role/ work background of the participant. e.g. architect, facilities manager, application vendor, etc
Context		In what circumstances was the statement given
	Initiated	Starting a new subject of discussion e.g. "*Let us discuss role of BIM in conceptual design*"
	Follow up	In continuation of the ongoing subject e.g. "*yes, for example…*"
	Reply	In response to a specific statement e.g. "*for that automated model checkers are there…*"
	Chair	Statement to control the flow of discussion, most often used by the moderator e.g. "*let us move to other issues*"
Type		The purpose of the statement

	Suggestion/ideas	Discussing solutions e.g. "*replace document by information as document has a connotation to it*"
	Concern	Doubts and inhibitions e.g. "*frustrating part is having different regulations across states* "
	Opinion	Indicative statement e.g. "*as industry picks up they will be forced to adopt..*"
	Observation	Information based on experience e.g. "*In civil works, disciplines tend to work in isolation*"
	Query	Asking about e.g. "*What happens when the project phase changes?*"
	Inform	Information on "as-it-is" e.g. "*for that automated model checkers are there*"
	Strategy	Discussing measures and approach e.g. "*one way is to force them*"
	Wish list	Expressing wants "would like to" e.g. "*20 yrs down the line you should be able to say what paint you had on the wall*"
Content		The main subject of statement
	Technical	About tools, formats/standards, features and capabilities e.g. "*current systems not capable of dealing with different levels of detail*"
	Cultural/work practice	About the way or working e.g. "*…not willing to change the way they work* "
	Structural/ data organization	Ways to organize data, what form, grouping of data, and so on. e.g. "*we can have things like private and public space* "
	Training	Skill and knowledge acquisition e.g. "*architects learn many techniques in training that are not used with these tools*"
	Legal/ contractual	Regulatory e.g. "*organization that owns the information has the rights to change permissions* "
	Organizational- team	About the team-responsibilities, roles and collaboration e.g. "*that would be related to the access rights. Isn't it? What you will see is relevant to what your role is*"
	Process/ method	Protocols, procedures and methodology e.g. "*you often start with the architect ..in the sense it starts with a 3D model with diff disciplines adding info*"
	Business case	Economic and market feasibility- benefits e.g. "*who builds the model…who benefits from it ….there is something about willingness*"

Examples of coded segments are shown below in Table2 to demonstrate the use of the coding scheme and its categories.

Table2: Example of a chunk of coded segments

Comment/ segment	Discipline	Context	Type	Content	Keyword
"Frustrating part is having different regulations across states …."	Design manager	Initiated	Observation	Legal/ contractual	Regulations
"How do we get one agreed standard?"	Contractor	Follow-up	Query	Culture/ work-practice	Standard
"Force them to do that…."	Design manager	Reply	Opinion/ strategy	Culture/ work-practice	Force

In the first segment shown in Table2, a design manager starts a discussion, which is a concern related to legal/contractual issues and stated based on his observations. Accordingly a value of one is added under these classifications and the rest are filled in with zeroes (as shown in Figure2). Similarly each segment is coded and marked. By counting the number of ones marked against each classification we get the total number of segments that fall under each classification. This coding scheme allows comparison of the workshop data based on the chosen classifications. Keywords are noted and grouped under common themes. The number of occurrences for each theme is noted to set priorities.

3.2. Data pattern and correlation

Three kinds of correlations can be mapped. The **Discipline vs. Content** mapping indicates what contents are the dominant issues to specific disciplines; the **Type vs. Content** mapping indicates awareness, interest and knowledge about the content; and the **Discipline vs. Type** mapping indicates awareness, interest and knowledge across specific disciplines.

4. Main findings

4.1. Key issues

The key issues discussed in FGIs are listed below. These issues are grouped based their relevance to contents. Some overlaps are possible across the groups and within each group they are listed in order of their importance as reflected in the FGI discussions:

4.1.1. Work-practice and process related issues:

Data organization: With the digital storage of data that allows greater flexibility and economy of physical space, data management and organization is becoming a serious concern for the industry, particularly from the work-practice perspective. Standard practices and procedures need to be developed to deal with possible data explosion, data classification and grouping, representation and usability. Version management, as discussed below is another important issue that is closely related to data organization.

Version management: There are three different version management issues: (1) When application vendors develop a new **version of the application** some times there are significant differences from the previous versions. This brings in problems such as data loss and compatibility issues if different versions of the software are used by different team members. (2) **Version of project data:** if BIM is to be adopted using an integral database where each discipline maintains, modifies and updates the data, then technical measures, work procedures and methods need to be put in place to ensure data integrity, allowing different versions of the project to be managed throughout the project life-cycle. (3) **Version of IFC:** At present the IFC standards are still evolving, and the format has changed significantly in the last five years often making many of the earlier IFC data almost unreadable in the present format. Service providers who maintain IFC data for the clients may have to update the stored data's format for the clients accordingly. Such updates may not be easy if the changes are significant.

Validation and data integrity: Even though 2D drawings can be generated out of intelligent 3D CAD packages (Lee et al 2006), the lack of trust on completeness and accuracy of 3D models has remained a major concern for the practitioners involved. As a result, data exchange across the disciplines is limited to 2D drawings. Development of intelligent model checkers, which is an important aspect of BIM approach have eased the concern. However, agreed protocols, and standard evaluation and validation procedures are needed for acceptable design reviews and approvals using 3D models.

As-built data: Ability to support **facility management** is considered as an important value-added feature for the BIM approach, making a strong business case. The information stored and maintained during the project is useful for later access and retrieval. This database is useful in updating and identifying the information needed for maintaining the building facility. However, in most construction projects changes are made during the construction phase. Hence, the final output may have some variations from the initial design, represented in the form of the BIM model. At present there is no process in place of updating the designed model to incorporate the changes made during construction. This is particularly important because it is the actual as-built information which is required for facility management.

As-built drawings may become important for **regulatory** purposes like sustainability assessment and other performance measures. Once the BIM model is updated with the as-built data, it can be used for comparison of projected building performance against actual performance to **evaluate design quality**. These types of comparisons will allow more accurate analysis tools by providing more effective and detailed evidence.

Quality of as-built data is important. When the surveyors provide data for the built facility, the BIM managers need to register the quality of the surveyed data. Measures like grouping sets of data as sub-models for different parts of the model, based on the quality of the survey can be adopted. These measures are closely related to version and data management.

4.1.2. Technical issues:

Standards: Interoperability issues across different commercial software remained a dominant topic during the FGIs. Shortcomings in IFC certification of commercial software were highlighted. Issues discussed echo the findings reported by (Aranda-Mena and Wakefield 2006).

Most product libraries and specific BIM applications that are commercially available, target specific commercial applications with a wide market base, for example, Autodesk Revit. This means that such libraries cannot be shared or used by other packages. Besides a standard format for data exchange, there is a greater need for standard vocabulary for the consistency of data when exporting from one package to another.

Register communication and information exchange: Information exchanged between the BIM users through different media is not captured in a BIM model. Participants suggest that BIM servers should allow message flagging and notifications between team members. Though not explicitly discussed, some of the ideas discussed are similar to the concepts of Enterprise Wiki (Kalny 2007).

Security: Apprehensions exist about data security of model servers. These include concerns about Intellectual Property (IP) and protection of copyrights. Concerns relating to network security may have technical limitations, but concerns on design protection (IP and copyrights) can be alleviated by greater awareness and legal measures. IP issues in BIM are legal issues, which are no different to IP issues existing in current practice.

Compatibility of GIS and BIM models: Data exchange between a GIS model and BIM model should be supported, which is missing at present. This is important to many large scale projects.

4.1.3. Other issues:

Roles and responsibilities: BIM approach requires changes in distribution of roles and responsibilities. Some traditional roles such as drafting may become obsolete, replaced by modellers. New roles, such as BIM managers have emerged to support greater coordination in developing an integrated model.

Training support: Participants raised concerns on the lack of training and awareness on BIM applications. Improved and contemporary training modules are required for practitioners as well as students. CAD courses taught at design schools do not complement the present industry needs. In most architecture schools CAD courses are separated from the design studio, and the design methodology taught in schools often fails to **integrate CAD in the design phase**. Although some alternative approaches such as parametric design have been introduced as digital means to conceptual

design, such cases are still limited. The workshop analysis also indicates the lack of teaching staff with knowledge and experience of modern CAD packages and the reluctance of adopting new technologies and their use in the design curriculum.
Students also need to be trained in applying **computer-supported collaborative tools** in team projects to appreciate the collaborative processes as well as understand and experience the potential benefits. In practice, architects work in a team and often coordinate team activities. In architecture schools although students also involve in team projects, the coordination of team projects is normally manual, face-to-face and within the single design discipline. Students need to be trained to explore state-of-art computer-supported collaborative tools and to collaborate across disciplines.
Apart from the key issues discussed by the workshop participants, the analysis of the data suggests that even though there is a general agreement on the potential benefits of BIM for all disciplines, the actual benefits and usability of the approach is not clear. There is lack of clarity on how BIM can be integrated with the business practice. There is a common misconception that the entire work-practice has to be changed for the BIM approach to be adopted. This is primarily because the users fail to realize that BIM approach can be used for only parts of the project lifecycle. That is, users do not realize the flexible scope of BIM in an AEC project.
Different business models will be required to suit varied industry needs (Wakefield et al 2007). BIM model can be maintained in-house or outsourced to service providers. In the later case additional legal measures and agreements will be required to ensure data security and user confidence.

4.2. Architects perspective
Figure 3 shows the discipline-wise break-up of the issues being discussed in FGIs. Architects were one of the most active groups with their discussions primarily focusing on technical, process, work-practice and data organization issues. A **Type vs. Content** analysis of the data revealed that (a) most of the technical discussions from the architects related to concerns and queries, demonstrating lack of confidence and awareness of the tools (b) most of the process and work-practice related discussions were concerns, information sharing and suggestions, demonstrating a keen interest in BIM adoption but lack of confidence at the same time in terms of how it fits into their current practice.

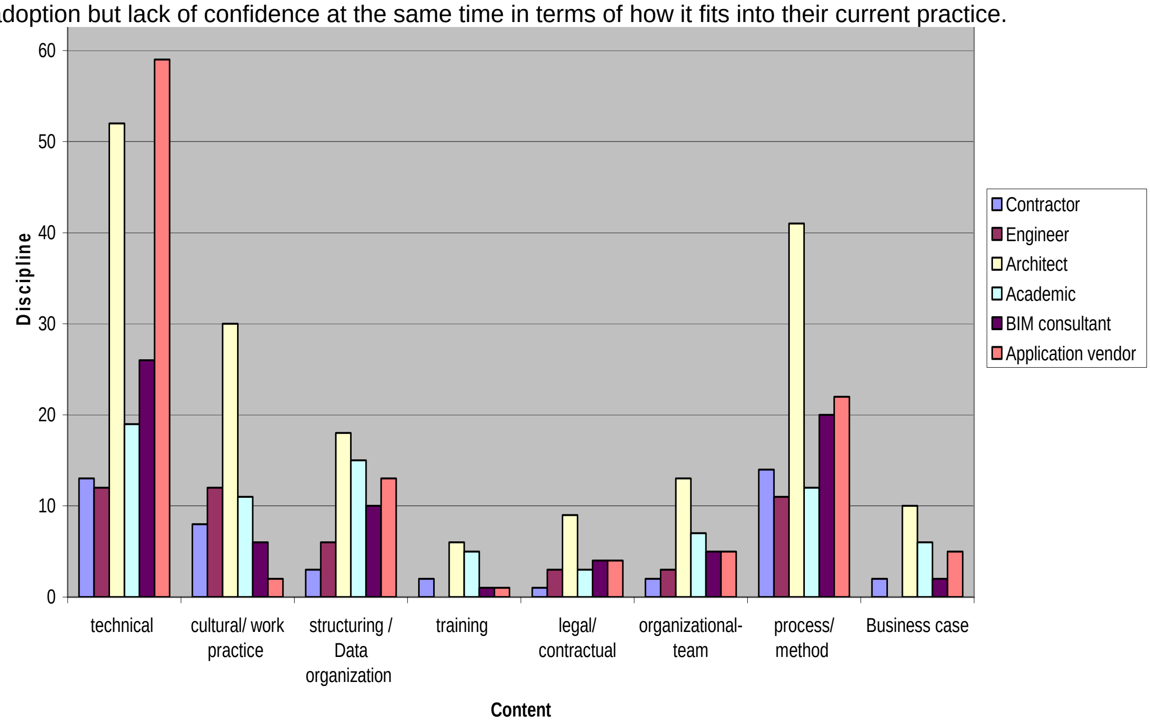

Figure 3: Frequency of issues discussed by particiapting discplines

Some of the key issues discussed by the architects include:
- Modelling approach: O-O model development requires a different approach than using traditional CAD packages. The importance of setting-up the model is often not realized, leading to inaccuracies and conflicts in later stage. Users developing an O-O model need to be trained in actual build and construct process. BIM approach can facilitate involvement of contractors and construction mangers in early design stages. This will allow modellers to get a feedback on their model development, aligning it to actual construction process. Users need to be aware of the potential pitfalls and risks involved in using traditional practices with new tools. Training modules should discuss the common mistakes made in developing O-O models. This has implications for (1) staffing and training of modellers in architectural firms (2) collaboration and information exchange between the architects and the contractors.
- Architects like some of the other disciplines acknowledge the need for standards such as IFC. However, from the usability side all they expect is a simple and intuitive interface. They are hesitant to understand the underlying concepts. These discussions echo the findings reported in literature (Aranda-Mena and Wakefield 2006, Howard and Bjork 2008).
- There is a general concern amongst the architects and the design disciplines that adopting the BIM approach would require additional work from the design disciplines and in the current business model there is no reward

for this additional effort. This additional effort is expected to include the additional data and information while modelling, particularly filling in the properties and attributes of the objects. It is generally agreed that if the commercial modelling tools support object libraries consistent with the national or international building standards, then such an effort can be considerably reduced. However, some changes to the fee-structures and business model will still be required to complement the increased work load.

- Traditionally there has been a debate over the use of CAD tools in early design phase. Many architects believe that CAD inhibits concept generation and design exploration. Lack of tools that can integrate freehand explorations such as sketching with geometric operations like drafting and modelling has been a concern. The experiences from such technical limitations are projected to BIM applications. Some architects argue that the use of BIM applications could extend the limitations of design exploration in CAD packages to constrain work-practice and design methods and processes. However, others argue that in any architectural practice the traditional methods and design techniques can co-exist with the latest tools. Examples are cited to demonstrate how some latest CAD packages and parametric tools have been used to enhance design exploration, enabling some of the designs that are difficult to visualize, conceive and realize otherwise. Similar arguments could be extended to all aspects of BIM tools and their potential contributions to the design and construction practice.
- There is a general agreement that increased BIM adoption and technical support demand greater co-ordination effort on architects, but at the same time it has the potential to enhance the architect's decision-making capabilities and control over the project development.
- Like rest of the disciplines architects are unclear about the scope of BIM. Most architects do not realize that BIM adoption is not a binary choice, i.e. there is no distinct boundary for BIM adoption. BIM approach is better represented as a range of implementation options starting from basic O-O CAD modelling to completely integrated, inter-disciplinary, server-based, and interoperable model. As most architectural firms have moved to O-O CAD packages such as ArchiCAD, Revit and Bentley, and hence, stand at the very early stages of BIM adoption. The familiarity with the O-O modelling should enable willing firms to upgrade their BIM approach to next level with relative ease, provided they understand options available to them. Figure 4 shows a schematic representation of the levels of BIM adoption possible with commercially available applications. As can be seen an absolutely integrated BIM approach, with all IFC compatible products integrated is high up in the scale. There is a range of possibilities with the add-ons that may include tools for cost analysis, performance analysis; design review tools and tools for specific functionalities and requirements. For a discussion on BIM supporting tools see Khemlani (2007a).

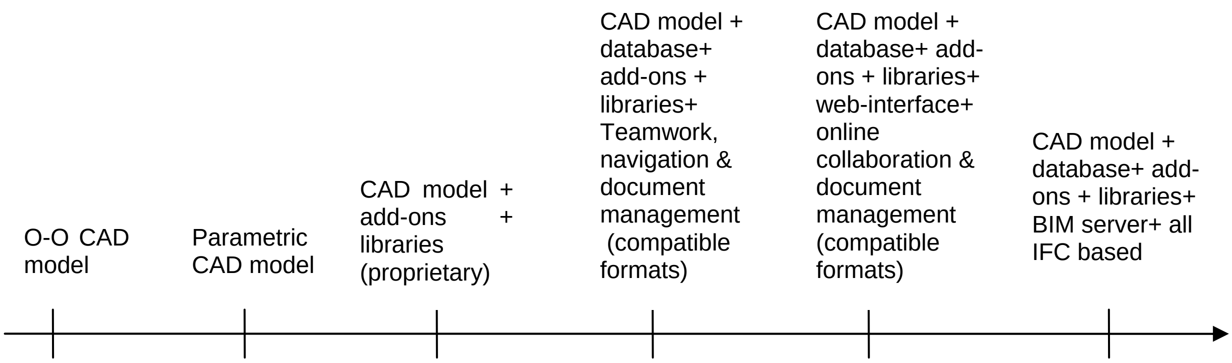

Figure 4: Scale showing BIM approach with increasing capability
(Adopted from a disbtributed document in Australian architecure industry: source unknown)

4.3. Differences between design and non-design disciplines

Design disciplines see BIM as an extension to CAD, while contractors and project managers expect BIM to be a more intelligent DMS (Document Management System) that can take-off data from CAD packages directly. While there are evident overlaps, BIM server vendors seem to be aiming to integrate the two requirements. Desktop audit suggests that the existing BIM servers are not yet mature for either purpose. However, even with the present capabilities BIM servers can be used for improved project collaboration. Some contradictions to the AECbytes survey are observed in the workshop data. Unlike the survey results IFC and interoperability are found to be a dominant concern. Lower importance of interoperability in the survey may be the result of (a) the assumed scope of BIM: Respondents in the survey may be using only one proprietary tool e.g. Revit or Bentley, that provides BIM approach within few disciplines (Architecture, Structure, MEP), and hence data format may not be an issue; (b) non-willingness of users to know about the technical aspects of interoperability. Discussions in the workshop suggest that users were hesitant discussing new and technical jargons. They emphasized the significance of standards such as IFC. However, from the usability side all they expect is a simple and intuitive interface. These discussions echo the findings reported in literature (Aranda-Mena and Wakefield 2006, Howard and Bjork 2008). Similarly, unlike the AECbytes survey, visualization still proves to be an important factor. Users such as designers, with CAD background, are expecting BIM servers to support integrated visualization and navigation that is comparable to the native applications they use. Users such as contractors and project managers, with DMS background, expect visualization and navigation to be an important feature of BIM servers that is missing in existing DMS solutions. Interestingly, barring a few exceptions (Popov et at 2006) most academic research and studies have emphasized BIM as an enhancement to CAD and downplayed the document management aspects to it. This could possibly be the result of investigations concentrated towards design disciplines.

CONCLUSION

This paper reports and discusses the results of two FGIs with experts from the majority sectors of AEC industry regarding the issue of BIM adoption, with a focus on the perspective of architects. The FGI discussion were recorded, segmented and analyzed using a coding scheme. Details of the coding scheme have been presented and discussed. Analysis of the collected data suggests that for BIM to succeed and be accepted in the industry all stakeholders have to be informed about the potential benefits to their disciplines. A number of factors inhibiting BIM adoption are identified, which includes: version management, model validation and data integrity, data organization, communication and information exchange, standards and interoperability, data security, work-practice and business models, emerging roles and responsibilities, BIM awareness and training support. Knowledge, awareness, expectations, and motivation for BIM adoption varies across the different disciplines in the AEC industry. Architectural practices can adopt a phase-wise upgrade of their BIM capabilities, which can enhance their decision-making capabilities and control over project development.

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