SCHOLARSHIP OF BIM AND CONSTRUCTION LAW: MYTHS, REALITIES AND FUTURE DIRECTIONS

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Abstract
Misinformation about BIM is rife. There are claims about BIM being a *tool,* a *software,* a *philosophy*, a *system,* a *platform,* and *a set of interacting policies, processes and technologies*. BIM has been espoused as though it is revolutionary; a dedicated practice for object-oriented design, accurate [or automated] estimating, and a virtual planning tool that is reliable for construction contracts. This chapter argues that the attributes often credited to BIM are not entirely accurate; thus, could jeopardize the very foundation of BIM understanding in construction law education. The practical drawback regarding this is that BIM is not shaped by actual contract data but by virtual [imaginary] project data, bounded by software *cognition protocols*. In addition, BIM is not supported by an established contract instrument either. Although a section of recent construction literature has shown significant excitement about BIM in the political space, business communications, teaching and learning [praxis inclusive] and not least, for theory formulation; the reality is that not all the information about the potentiality or actual attributes of BIM is legally correct. Neither useful education nor training or research should be based on misinformation. Therefore, it is important to straighten extant claims and distil extant knowledge about the legal implications of BIM's actual deliverables. This chapter explains key realities and the challenges in legal constructs around BIM, and elicits appropriate directions for future research and for curriculum development regarding various aspects of professional and business liabilities in BIM. The implications of these are important to development of students and graduates, as well as to politics, construction professional practice and educational management.

Keywords: Building Information Modelling (BIM), contract language, curriculum development, intellectual propertization, professional liabilities, transactional economics

Often the surest way to convey misinformation is to tell the strict truth - Mark Twain [1835 – 1910] (Twain, 2013).

Beware of ignorance when in motion; look out for inexperience when in action, and beware of the majority when mentally poisoned with misinformation, for collective ignorance does not become wisdom – William J. H. Boetcker [1873 – 1962] (*The William J. H. Boetcker Collections* by Bill Boetcker (Undated))

Introduction

BIM has been defined in different ways. Although, empirical studies that articulate the definitions of BIM in detail are limited, nuances in BIM's definition can derail incipient minds unless clarified. Olatunji (2012) clarifies the confusion in some of the variants by analysing them contextually; as to whether BIM is a technology, a system, a philosophy, a software or a platform. Olatunji argues that it is not possible for a phenomenon to mean the same thing to many disciplines. For example, in a definition by Penttilä (2006), adopted by Succar, Sher, and Aranda-Mena (2007) and already cited in thousands of scholarly studies, BIM is defined as a set of interacting policies, processes and technologies producing a methodology to manage essential building design and project data in digital format throughout building's lifecycle. Race (2019) argues that BIM is not defined by the keywords in Penttilä's definition precisely; at least not at the time of the definition, nor 14 years after. Race argues that 'policies', 'processes', 'methodology', 'technologies', 'manage', 'project lifecycle' and 'digital data' only broaden the multi-disciplinary applications of BIM, and that they are not excluse to BIM. Race concludes different disciplines have had specific interpretations of BIM, and that no single definition is completely satisfactory to all.

The apparent confusion triggered by the multiplicity of opinions regarding BIM's definition is not entirely inappropriate. BIM's true additionality is in its conceptual applications that extend beyond the boundaries set in extant superficial definitions. The centrality of this portrays BIM as a digital system for facilitating a data-rich, object-oriented, intelligent and parametric representation of a construction project, and from these, views and data appropriate to various users' needs are extracted and analysed to generate information and enhance decision-making on project economics, and improve project delivery processes (Olatunji, 2012:131). This version of BIM definition embraces multiple disciplines. The definition presents BIM beyond a design-centric tool, and instead as design and information management practice. In addition, BIM applies beyond 'building'; it applies to broad areas of building and infrastructure construction of all types. Similarly, 'project data' goes beyond designing; the component of BIM relating to information management is important to both design and non-design disciplines, including contract performance and relationship management disciplines (Kagioglou et al., 2001; Meng, 2012; Stewart, 2007).

In the past two decades, BIM has remained a popular digital modelling platform. Many studies have reported BIM as the commercial reality of the future of construction – according to Luciani (2008), this future began over a decade ago. For example, Olatunji (2019) describes BIM as the commercial reality of today's construction education; in that, construction graduates that are not BIM-ready are not likely to be job-ready and may not have limited opportunities in a future that is driven by BIM. Similarly, some studies have portrayed BIM deployment as critical to construction's future and, as the main vernacular of survival of construction businesses in a modern world. Examples of these are the works of Aouad, Lee, and Wu (2006) and Volk, Stengel, and Schultmann (2014) who emphasize the additionality of BIM to the future of the construction industry. They argue that BIM improves the outcomes of construction projects through collaboration, data-rich communication and integration. A perception by Hope (2012) is that construction businesses that do not adopt BIM will die. Olatunji, Sher, and Gu (2010) argue against a perception that suggests BIM will lead to the extinction of traditional professional practices, based on speculations that some revolution will take place as BIM's automated processes become popular.

It is important to note that many conclusions regarding the potentials of BIM are speculative. Considerable evidence has continued to emerge, showing that such speculations are both misinforming and distractive to construction scholarship. It is crucial that the future of construction education and scholarship is not fuelled further by such inaccurate speculations; in particular, in relation to performance and relationship management of constructon projects,. For example, BIM has been espoused to reduce construction and associated social costs, wastes, estimating errors, design errors, disputations and project durations (Ku and Taiebat 2011; Wong and Fan 2013; Aibinu and Venkatesh 2014; Azhar 2011; Xu and Qian 2014; Bensalah, Elouadi and Mharzi 2017; Wu and Issa 2012). Such claims are frequent enough to persuade clients into setting them as legal objectives of BIM to which project stakeholders must become answerable. Such claims seem harmless, however the evidence underlying them is inconclusive and may mislead. Although there are warnings that such speculations should be intepreted with caution, speculative conclusions are still rife. They have continued to grow but studies that critically evaluate them are not common. The purpose of this chapter is to uncover some of the myths that may jeopardize the authenticity of construction law education and scholarship in the context of BIM, and to provide useful suggestions regarding future directions.

Potentialities of BIM in Contract Administration and Construction Law

The Speculations, Myths and Objective Realities

It is not utterly inappropriate for researchers to be positive about the potential novelty of an incipient phenomenon. Terrin et al. (2005) have captured this bias aptly by concluding that such biases often lead to overly optimistic research conclusions. It may not be the intention of researhers to misinform; it is critically important however that uptakers of such conclusions are cautious as they intepret and apply certain findings and suggestions from literature. Particularly, Amor and Faraj (2001) and Amor et al. (2007) have given such warnings regarding BIM. If the axiom "*Ignorantia juris non excusat"* (Latin for "ignorance of the law excuses not") holds true, scholarship of legal education regarding BIM must draw a line between speculations, misinformation and the realities of novel knowledge around BIM. What are these speculations and the specific industry interpretations around them? Some examples are provided below:

1. **BIM works best when primed with integration, collaboration, interoperability, value sharing, robust data and seamless communication.** This is supported by the considerable suggestions in empirical studies by Aranda-Mena et al. (2009); Aranda-Mena et al. (2008); Azhar et al. (2012);

Klaschka (2019); Manning and Messner (2008); Moon et al. (2011); Olofsson et al. (2008); Wang et al. (2014). The drawback in these suggestions is that none of these is ever known to be the hallmark of the construction industry – see Ashcraft (2008) and Olatunji and Akanmu (2014). An established framework on how the acclaimed BIM attributes apply, or are measured, is not evident. A perspective added by Olatunji (2016; 2011b; 2014) and Olatunji and Akanmu (2015) is that the uncertainties around how these expected capabilities apply are enough to derail whatever good intention any project stakeholder may have towards BIM. For example, it is still not clear whether projects that are not driven by the attributes credited to BIM cannot fail, or whether the attributes are impossible without BIM. For greater clarity, construction literature is limited regarding the broad body of theories that shape the attributes that are speculated to promote project outcomes when BIM is deployed. For example, Kvan (2000) argues there is no clear definition of collaboration in construction literature. In addition, Ashcraft (2008) thinks trust and collaboration within or across construction disciplines is not a cultural asset. Olatunji (2011b) argues that it is possible to overcome these challenges. However, the road to the desired change is not possible unless construction contract instruments are built around success enablers in BIM, in the context of owned, joint, shared, several and accrued liabilities [see Wright (1987) and Wright (1992) and Olatunji and Akanmu (2015)]. The single most significant cross-pollination of legal education and BIM knowledge is in the ability to understand these capabilities and in developing appropriate instruments for their utilization. When limited scholarship is dedicated to these, it is safe to conclude that the impact of the acclaimed success enablers in BIM is not yet scalable; thus, inconclusive.

2. **BIM possesses revolutionary solutions to problems confronting the construction industry.** What are these problems and how do they relate to BIM? Flyvbjerg et al. (2018) identified construction's stubborn problems to include frequent delays and budget overruns. They conclude most large construction projects are completed at much higher costs than their initial estimates, and as less-deserving outcomes in terms of quality, utility and ecological value. In addition, Love et al. (2016) identified design errors as another critical challenge in major construction projects. According to Egan (1998), construction costs are high, and this requires collaborative innovations through technologies. Signor et al. (2017), Myrna and Charles (2012) and Bowen et al. (2012) have provided reasonable explanations regarding how corruption adds to the cost factors of construction. Evidence from Arcadis (2019) report also suggests protracted disputation is another significant factor. Whilst Eastman et al. (2011), Barnes (2019) and Woodley (2019) claim that BIM reduces propensity for contractual disputes, Hsu et al. (2015), Olatunji and Akanmu (2015) and Alwash et al. (2017) affirm that BIM's propensity for disputes is not different to traditional project environments unless BIM becomes more certain.

   Many studies have looked into the potentiality of BIM to reduce construction costs and duration, and improve project safety and stakeholder satisfaction – for example, see Bryde et al. (2013) and Cheng et al. (2015). Akanmu et al. (2016) propose an autonomous system that integrates BIM and radio frequency identification (RFID) technology to track on-site activities in real-time and to optimise remote monitoring such that project controllers are able to foresee delays and prevent them. A convenient conclusion from extant studies is that technologies can facilitate a harvest of robust information and can improve decision-making. However, they do not vacate the cost burdens of amorality and complexity, as well as the cost of labour, material, safety and project quality. Whereas BIM could help towards these, its potentiality depends on target legal objectives and how such objectives are achieved. In addition, whereas certain potentialities are credited to BIM, they are meaningless legally if project contracts are not constructed around BIM deliverables as intended. This would include some clear articulation of the contract intentions of virtual models, active agents, digital scripts, hyper-models and simulation iteration. The challenge however is that contract administrators of construction projects have struggled with their transitioning to BIM, from non-BIM deliverables such as 2D drawing, analogous planning tools, and paper-based authoring and authorizations. It is important for legal instruments to set appropriate contexts for target performance objectives such that contractual constructs do not appear blunt and purposeless – for example, BIM does not reduce cost of materials and labour if client's requirements remain ambiguous and erratic. Thus, it is difficult to conclude from an informed legal perspective that BIM proffers conclusive solutions to the traditional challenges of construction project delivery; one way to facilitate the impact of BIM is to ensure BIM deliverables are trained to legal instruments and vice versa.

3. **BIM projects deliver better outcomes than where BIM was not used.** Examples presented in the works of Aranda-Mena et al. (2009), Azhar (2011) and Love et al. (2014) explain the benefits of developing projects with BIM, and how adopters can realise such benefits. However, according to Holzer (2007), the benefits that associate with BIM do not exist in isolation; instead they are primed on speculative conditions. The conclusive empirical evidence regarding how BIM works in its best conditions, or a part thereof, is still incipient. A single most significant drawback in this is that instruments of the law are not designed to service deliverables that are academic in nature. Contracts must be definite, firm, provable, devoid of deniability and must enforce the fault lines of risk delineations. For greater clarity; if BIM is meant to deliver outcomes that are definitely superior to non-BIM projects, how much should the difference between BIM project and non-BIM projects be before the superiority between them becomes enforceable legally? For greater clarity, acceptance value of BIM will improve if stakeholders are able to differentiate the benefits of their investment decisions in BIM, and be able to enforce them contractually. Where the promises around BIM deliverables are not clearly enforceable in the eye of the law, it will be impossible to prove the benefits of BIM deployment using conclusive empirical evidence. In addition, it is logical to also ask: would BIM diminish the probable expectation that every non-BIM project would not perform to the level of BIM? Where a non-BIM project equates BIM deliverable, should there be compensation for an exceptional outcome, and by how much? What are the characteristic attributes of BIM that make it superior to the conventional process, and are impossible for traditional processes to achieve? Who pays for this superiority, and how? Should BIM deliver outcomes that are less desirable than the outcomes of non-BIM projects, does that make BIM a failure? In sum, does BIM guarantee exceptional project outcomes? Where this is not possible absolutely, are there contractual templates that enforce compensations and alignment? If not, should one be created; how, why and how not?

4. **Policy chains geared towards forced BIM adoption propel systemic benefits to project economics.** According to Succar and Kassem (2015), BIM can be mandated by authorities across their jurisdictions. Thayaparan (2012), Dainty et al. (2017), Ho and Rajabifard (2016), Travaglini et al. (2014) and Papadonikolaki (2017), Edirisinghe and London (2015) and Wortmann et al. (2016) have discussed the countries where the adoption and implementation of BIM on some categories of public projects have been mandated. It is like a race to determine which country mandates BIM deployment earliest: where a country has not made a categorical statement in favour of BIM advancement, they seem to risk their membership of BIM-policy elitists. However, an evidence narrated by Edirisinghe and London (2015) is such that market forces are rather more potent in facilitating BIM's penetration than conferring an advantage to BIM through a subtle force. Though BIM is mandated in North America, Edirisinghe and London found a large portion of the industry are yet to comply.

   There are few dimensions to market reaction to BIM. According to Olatunji (2014), it is important for BIM to prove its worth to the market. If at all a mandate is necessary, such action must support other autonomous tools that advance innovation in the construction industry – examples of these include dynamic modelling and remote sensing tools and exoskeletons, amongst others (see Akanmu et al. (2016) and Akanmu et al. (2020). In addition, BIM adoption and implementation are measurable – see a set of metrics developed by Succar et al. (2012). Arguably, adoption and implementation planning are as important as compliance enforcement. Such planning will delineate transitions from one level of adoption to another, as well as respective expectations, deliverables, resource requirements and not least important, contractual enforceability are not yet clear. Beyond the mandating, the industry needs incentives and structural support for its transition. According to Olatunji (2011a) and Olatunji (2019), this requires training and an appropriate sensitization of market drivers. Provisions for bifurcations such as caveats for dummy expectations should be integrated into BIM contracts such that where project outcomes are not as precise as promised, they are tolerated in the form of zero vision and should add to the embodiment of the industry's transition from one level of BIM capability to another.
5. **BIM is key to the commercial reality of modern construction education and professional practice.** A study by Olatunji (2019) explains this axiom. Education providers seem to think they are inadequate without BIM content and ethos. The centrality of Olatunji's study is that BIM is not meant to be a replacement nor a substitute for existing education. However, contents that are hitherto essential must now give way to BIM. This is excusable in the context of innovation. However, a typical drawback in this is that BIM does not have to assume superiority over traditional contents; in that, students who are exceptionally capable in BIM cannot be less competent in non-BIM contents. Achieving a balance of the two paradigms is not easy to achieve. Where the industry struggles to improve BIM adoption, graduates are at the risk of seeing the industry that is not capable or ready to service their technical capability. In addition, BIM theorists seem to assume that the future of the construction industry is only in the hands of BIM and BIM only! The reference to the 'future' in this is in the context of the 'present', and this begun about one and half decade ago! (see Ballesty et al. (2007); Holzer (2007). Again, at the risk of self-repetition, being positive of technological innovation

is not entirely inappropriate. However, the misinformation in this is whether the industry is ready for the future promised through BIM, though a few decades late. Commensurate constructs of the law will help demystify this. For example, contract provisos must identify specific landscapes of BIM deliverables across the many sub-disciplines in project development process. In addition, they must articulate responsibility and limitations of sub-disciplines under specific conditions of co-creation, as well as appropriate understanding and compensation for professional services. For greater clarity, members of the project team do seldom use BIM the same way and to the same complexity across different project development stages – see Olatunji and Akanmu (2014). How does this affect how project teams are renumerated? In addition, should a BIM-able graduate earn same renumeration as a BIM-unable graduate? Should BIM professional services attract same scale of payment as traditional services? Answers to these questions are not conclusively evident in modern construction literature, and this draws away from the established basic tenets of a contract; a consideration that is appropriate towards an exchange of services, being a fundamental condition that premises the validity of a contract.

6. **The effectuality of virtual models and consequential disclaimers** is another important example. BIM projects are still driven largely by the traditionality of construction contracts, though the premise upon which BIM deliverables are based are all enshrined in virtual models. For greater clarity, construction project contracts are still driven by drawings, rather than models; by analogous plans, rather than simulation models; by bills of quantities, rather than industry foundation classes; and by conventional cost plans and conventional estimates, rather than by hyper-models, model scripts or schemas. BIM deliverables are desirable; however, they are unlikely to have conclusive influence unless they possess definitive contractual values. For this to happen, deliverables of digital models must be measurable with certainty. For greater clarity, an imaginative virtual process model must be enforceable on its promises in ways that are not indemnifiable by disclaimers. Modellers should be responsible for their promises, including the credits and the liabilities thereof. In an analysis by Olatunji and Akanmu (2015), disclaimers cannot excuse modellers of the consequences of the outcomes of their artefacts. When they mislead, misinform or misguide, they should be enforceable in contract liabilities. A safe conclusion from these is that until virtual models are enforceable in construction contracts, their legal and investment worth needs to be proven. For this not to become a lacuna that will trigger disputations, it is important for construction law scholars to examine the legal efficacy of virtuality and virtualization with a view to establishing clear boundaries around their objectives and the legal ramifications of their outcomes.
7. **BIM metadata is often (mis)taken as the absolute representation of actual project artefact.** This is consistent in the definitions of BIM by Aranda-Mena et al. (2008); Love et al. (2014); Olatunji (2012); Penttilä (2006); Thayaparan (2012). However, contrary arguments have emerged; model artefacts are shaped by software developer's imaginative data. According to Chien and Yeh (2012b), Olatunji (2013) and Olatunji and Akanmu (2014, 2015), designers are not able to innovate beyond the remit permissible by their authoring tools. In addition, model data are not driven by actual project data, rather by data that are pre-loaded in authoring tools which may not reflect the actuality of any particular project. For example, most projects experience significant amount of variability due to

variations in siteworks, groundworks and substructural work; whereas, most modelling tools have limited data on soil types and geotechnical variances. In addition, according to Amor et al. (2007), BIM adoption does not mean an absolute elimination of design errors. Models do have errors too; when they happen, they can be more misleading than the problems accurate models are meant to prevent (Love et al., 2011a; Love et al., 2011b; Love and Smith, 2016).

Legal implications of professional errors are well documented. They are not excusable in a modelling environment regardless of the good intention of using BIM. What is important is the ability of the law community to assist the construction practice community in understanding its limitation in a virtual environment, and to work out ways to protect all stakeholders. An effective BIM contract will require this to succeed.

8. **Synchronisation of traditional contract instruments in BIM comes with limitations**. BIM is collaborative; whereas collaboration is not the hallmark of traditional construction contracts (Kvan, 2000; Ashcraft, 2008). Non-collaborative contracts cannot drive the expectations of BIM. Whilst attempts have been made by researchers to explore what collaboration means to BIM and construction projects, outcomes have yet to translate into an established tool, robust enough to facilitate a crisis-free BIM contract – see Alwash et al. (2017), Chong et al. (2017) and Olatunji (2016). But what should a construct of BIM contract look like? This is the billion dollar question in the heart of BIM-construction law scholarship today. A section that outlines the practical implications of the current knowledge gaps in BIM literature has been created in this chapter to provide some guidance – the reader is referred to the section titled "Implications of knowledge gaps in construction legal studies and BIM".
9. **Innovation**; **authoring software and BIM, and bounded innovation on a software platform**. The beauty of object-oriented modelling is the ability to communicate complexity. Authors agree this requires a clear understanding of innovation (Gero and Kannengiesser, 2004). However, innovation is a question of freewill; the ability to self-express seamlessly and to communicate rigour without suppression. Some researchers have questioned whether geometric modelling or parametric modelling facilitates design innovation, as though one is better than the other – see Chien and Yeh (2012a); Yu et al. (2014). Either way, a notable constraint in virtual modelling environment is in the authoring platform; model authors are not able to innovate beyond the platform they operate in. This is not the only limitation; the ownership and the warehousing of their product is embedded in the copyright of their authoring platform. The right they have to create, transmit, market, use and apply their work variously on the software platform is neither absolute nor exclusive to them [such rights can be withdrawn, disabled, restricted, ceased or taken away from them in different ways and forms without an apology or prior notice or revocation]. Model authors are not able to transmit their shared ownership or transmit their access authority of software platforms to their clients. For greater clarity, modellers require licencing authorization to access and create models. Their access can neither be transmitted to their clients nor remain permanent for them to retain their creation or represent their work as long as they desire. A bug on the software could disrupt the integrity of a model – they are neither able to prevent nor control this unless through substitution. Security of the model could be compromised because of sinister actions or a compromise from sources other than the modeller.

Modellers can only guarantee their own access; they cannot shape or facilitate how their clients use their work and where they deploy them. Not least important, do they truly own their work or whatever they create on a software belongs only to the software? If model ownership and intellectual properties are valid questions in the construction of an adequate BIM contract, construction lawyers must find a rounded answer to this question.

10. **BIM, authoring authority and professional boundary spanning.** Researchers have discussed the importance of collaboration variously (Bainbridge et al., 2010; Thomson and Perry, 2006; Wood and Gray, 1991). To BIM and construction tradition, it means disciplinary boundaries are weakened and people are able to work and co-produce across and beyond their disciplines (Olatunji et al., 2010). This is one phenomenon that has continued to grow in popularity with BIM; people with functional or theoretical knowledge of BIM seem to assume the knowledge that belong to other spaces. They have done this in the name of boundary spanning rather than exercising reasonable professional judgment. Apparently, because construction audience are not able to tell the difference amongst *who says what* and *who has the authority to say what*, BIM has been espoused wrongly – many aspects of these have been dealt with in this section. Such misinformation should not prevent construction lawyers from identifying speculations from realities. To simplify further, who can be a modeller or a model manager? What professional qualifications and liabilities define their roles? Can a modeller or a model manager who is not licenced to authorise a design issue a model with an absolute authority? If every author cannot be an authoring authority, what manner or level of authority should reside in boundary spanning? Answers to these are important to legal validity model authoring. They also inform professionalism; that is, whether owners of disciplinary knowledge have reasons not to see boundary spanning as invasion and antithetical. They may choose to resist BIM for this reason. Not least important, it is important to clarify whether an advice issued by boundary spanners could be taken as valid and conclusive.

The additionality of these speculations is that they have far reaching implications to legal constructs. This is because they shape professional and scholarly misinformation on the subject. Until there is clarity around them, there are significant limitations regarding the objective reality around the intents of legal education in relation to BIM. In summary, it is appropriate and convenient to conclude that BIM is a positive addition to the construction industry. The propensity to adopt and implement BIM protocols in projects must be as though BIM capacities are to specific levels, and that the capabilities often credited to BIM in literature as still incipient. Whilst it is unprofitable to rule out the possibility of achieving the positive attributes expected of BIM, the law must take a different perspective. The law is meant to protect the good but with the strength to anticipate the risks of negativity and possess the capacity to attenuate their effects. BIM may not have had many disputations historically; in part, the non-contractual nature of BIM deliverables explains this. In an era when BIM rules construction professional practice, BIM disputes do not have to be protracted and heavily damaging, if BIM dispute scenarios are understood and are antipicipated as appropriate. Where BIM deliverables are espoused in relation to the management of costs, durations and contract relationships, it is important to consider digital information management in contexts that are specific to discipline-applications of BIM, including the broad areas of quantity surveying, management and administration of construction project, costs, contract and law.

Apparently, following rife speculations about BIM, certain myths have permeated construction literature, which should be debunked so they do not draw integrity away from BIM education. They need to be understood approriately such that they are not confused with the alternative realities about them. Examples of such myths are given below:

1. BIM facilitates accurate estimates (Choi et al., 2015; Kehily and Underwood, 2017); however, the alternative reality is that BIM metadata is not structured to meet the requirement of any specific discipline, nor any particular estimating standard (Amor et al., 2007). Wheras, model data are structured as product models, estimates are based on process methodologies, requiring allowances for considerations beyond the outturn product.
2. Traditional contracts are confrontational; BIM facilitates dispute avoidance (Aidibi, 2016). This popular perception is difficult to prove as there are no ways of measuring BIM's ability to prevent disputes when BIM deliverables are hardly enforceable in construction contracts.
3. BIM's robust data repository elicits openness, just about all the information required for a project to succeed (Ismail et al., 2016). However, evidence by Chu et al. (2018) suggests this is of limited help as model data could be excessive and often do not offer clear directions regarding their best impacts.
4. BIM requires collaboration and enforced policies to succeed (Aranda-Mena et al., 2008). However, there is limited evidence to conclude that traditional methods will not achieve exceptional outcomes if supported with the instrumentality of collaboration and forced macro-policies.
5. BIM is akin to integrated project delivery; it facilitates multidisciplinary integration; a repository for lifecycle data – see Glick and Guggemos (2009). According to Amor and Faraj (2001), this is often misconceived. Model development protocols are still fragmented; interoperability and value sharing issues are rife.

Implications of knowledge gaps in construction legal studies and BIM Research

The single most important challenge of BIM in the construction law is in the need to identify the challenges of BIM's contract language design. Apparently, extant contract standards still grapple with this. An appropriate legal instrument in BIM need to address the missing link between BIM's capacity for co-production as against traditional contracts' fragmentation bias. The right instrument for BIM contract will develop an articulation of contract condition and support infrastructure, and review them as to whether they support BIM's actual attributes or not, now or whether there is a future for such. In particular, such instrument should have a place for the following:

- **Shared ownership** (collaboration): digital models are co-produced virtual artefacts, intended to replicate real life potency, the emergence of which involves the participation of multiple disciplines and different contract parties. The outcome of this is a unitary artefact; a repository of design or modelling data, as well as robust management and lifecycle data. Researchers have often sought to know who the true owner of a shared digital artefact is – for example, see Bloomberg et al. (2012), Olatunji (2011b) and Wong et al. (2014). Some have argued the ultimate owner of a digital artefact is client because they pay for the model-authors' services. However, clients, the supposed owners of their digital artefact, have no authority to use the model they own for reasons beyond the intentions permitted by their designers unless they are so authorized. Some studies have also argued that model authors do not own their contributions. This is because all the data they use and the platform in which they express their work are owned by a different party, to whom they are licensees. A convenient neutral point is to assume parties who co-contribute to a unitary artefact should own the part they contribute, and such ownership should be absolute except surrendered wilfully. The practicality of this is often questionable: right's buyout should specify the elements of the rights under exchange, and rights and events or deliverables preceding and beyond a buyout should be specified, to which each party must understand and agree.

- **Intellectual Properties** (integration, interoperability and platform issues): there are different aspects to the property and the propertization of the intellectual assets underlying a virtual artefact – propertization being the process of establishing a property (see Radin, 2006 and Olatunji, 2013). Model authors co-create a joint digital artefact, requiring seamless alignment and integration of platforms and processes. Whilst they own their contributions, the attribution of the outcome of their co-creation would have both soft and hard boundaries. For greater clarity; suppose a project team involving the contractor, clients' cost consultants, designers, construction law team and other stakeholders choose to integrate their contributions into a digital model. Each member of the team will provide data – for example, the contractor, some clarity on construction methodology and risk considerations; the cost consultant, some objective consideration around cost and value dynamics; the designers, model data of the considered designed outcome; construction lawyer, the framing of contracts and the execution of same. When these disciplinary inputs converge, there are cross-boundary effects to which members of the project team could claim as their rights. For example, contractors and cost consultants would converge their inputs to develop the 5D; both parties and the client own the right to the outcome. The gap is: at what point does such an item becomes property of a party, and what are the processes of establishing such rights when deliverables are integrated? Thus, legal constructs around these should be established, and such constructs must identify liabilities and compensations as appropriate. Similarly, where properties and propertizations of intellectual rights are shared, determinate or transferable, it is important that contract constructs can specify the proportionality of liabilities and compensations where necessary.
- **Data security** (transferability): model data are often not owned by modellers. It is impossible for modellers to verify their sources and the integrity thereof, all the time. In addition, such data are for an assumed reality, to which an actual reality may have no indemnity. The sense of liability in this is whether uncertainty around the integrity of model data is excusable – for example, with disclaimer clauses. Furthermore, an integrated platform means multiple access points, requiring multiple layers of security consciousness. This does not only include transmission of vulnerabilities, but rather whether open source modelling data or unfettered access to data repositories by a wide range of parties does not increase models' exposure to vulnerabilities. For example, suppose a safe house or military facility is modelled, and all contributors have access to the model. They are able to keep their version of the model; if the model becomes compromised as a result of distributed access, will it be possible to trace the source of the compromise and who is liable? If the compromise is not about

data security but about the integrity of the data that shaped professional judgments made by others, what remedies are available to the end-users or other team members who suffer a loss as a result of the compromise?

- **Buyouts and valuation of services** (what is the right value/consideration for BIM services?): BIM is espoused to revolutionise traditional professional processes within the construction industry (Boon, 2009; Luciani, 2008; Succar, 2009). According to Olatunji et al. (2010), this means objects are used in place of line, and estimators will be able to export modelling data for costing; in the form of information management rather than information creation. Resource and skill requirements of BIM are different to traditional practices (Olatunji, 2012; Sher et al., 2009). Whilst traditional professional services have been evaluated and established in line with specific scales of fees, no such tool is yet popular with BIM. An example of a knowledge gap is in how professional services should be renumerated in BIM. What exactly does the client pay for in a buyout and what constitutes a fair buy? What limits and liabilities are attributable to individual efforts and co-creation of digital artefacts?
- **Contractual and non-contractual deliverables** (is a BIM contract for all deliverables? What are the exclusions?): certain elements of simulation models, augmented deliverables and metadata are not contractual definitively. Whilst some elements of design models may be for demonstration only, they relate to actual deliverables that are contractual. If the boundaries between contractual and non-contractual elements are unclear, this could provide a fertile ground for disputes. For example, whilst project duration is contractual, traditional contracts may be silent on simulation of alternative work methodologies and augmented resourcing. Where BIM contract does not recognise this, conflicts could arise.

Conclusions

BIM is a positive addition to the construction industry. However, legal constructs that support its deliverables are still incipient. Much of the knowledge gaps in BIM's legal deliverables are in theoretical biases around what BIM truly is and speculations about BIM deliverables. It is important that BIM up-takers understand what these are and how they apply to construction. As argued in the chapter, legal constructs of BIM must be clear about shared liabilities in collaborative environments. This involves ingraining clarity to the objectives of virtual modelling and setting-up appropriate instrumentalities that ensure expectations and outcomes from BIM are measurable and justiciable. This goal is achievable, the main constraint is that construction law scholars must first understand the implications of theoretical misinformation about BIM. This must happen in consideration of other autonomous technologies that work like, and work with BIM.

The following questions will assist readers to apply this chapter for the purposes of teaching and learning:

- What are the challenges of current BIM scholarship to contract administration?
- What are the benefits of BIM to project development?
- Explain the implications of shared liabilities in collaborative project platforms

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