BIM at small architectural firms

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Abstract

In the architecture, engineering, and construction industry, the interest in Building Information Modelling (BIM) is growing. The frontrunners in the application of BIM are mostly larger firms and the question arises whether the use of BIM by smaller firms can be successful and profitable. Architects are not always convinced about the value and necessity using BIM; a commonly heard note is that BIM is to be used by large parties and it has too little benefits for smaller firms. This paper provides insight in the uptake of BIM use among small architectural firms in the Netherlands, and answers the question if and to what extend contemporary BIM technology is adopted by this group. Additional, recommendations are given for implementation strategies. In cooperation with The Royal Institute of Dutch Architects (BNA), research was done amongst all 1300 BNA-associated small (≤10 FTE) architectural firms, using an internet survey (response 22%). At 8 small architectural firms with BIM experience, employees were interviewed to enrich the data coming from the survey. The outcomes of the research seem promising for future application of BIM, also for smaller architects offices.

Keywords: BIM, **BIM adaptation**, **AEC sector**, **Small architectural practices**

1. Introduction

Building Information Modelling (BIM) is often assumed to force a real paradigm shift within the AEC world (Eastman, 2008; Prins & Owen, 2010). This as utilising full BIM potential supports –and requires- better and early collaboration between the partners in a building project, for instance like in so called IPD processes (Thomsen, 2009), and thus will result in more integrated and so likewise assumed better projects. The rise of the use of BIM within the AEC industry is expected to a rather quick adaptation. For instance Deutsch (2011) expected that already in 2012 the use of BIM within the AEC sector, would be at almost the same level as CAD after it's introduction in the late eighties of the previous century was approximately after 10 years in 1997. The Government Building Agencies (GBA) of Several Countries (Wong et.al, 2010) already requires the use of BIM by some or all parties for their projects. Recently, Bernstein (McGraw-Hill Construction Report, 2012) reports a 71% level of BIM adaptation in North America with the larger firms (contractors) on top with 91%.

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Remarkably amongst the non-users a growing resistance is reported, this especially amongst architects. In general BIM is assumed to led to more integration by better coordination, information exchange, process management and consequently cost and time reduction.

2. Literature survey

BIM technology often is assumed to result in a real paradigm shift within the AEC sector (Eastman, 2008; Prins & Owen, 2010) in terms of its potential for new ways of better collaboration and integration. However a lot of parties at the moment are struggling with the technology, or even still have to start using BIM. It might seem reasonable smaller firms, not having as much financial means as their bigger brothers, might face the largest problems here. Sources like Jernigan (2008), Succar (2010) and Lu & Li (2011) define as a precursor of the collaborative 'Big BIM, the so-called 'little BIM', which is limited to the use of BIM in internal processes. However, it needs to be mentioned that the transition between both terms is rather smooth and cannot be seen binary. The use of 'Open BIM' further supports participation in integrated projects, regardless of the specific software tools used by the involved parties. 'Open BIM', an initiative of buildingSMART International, is a platform unbound approach to the collaborative design, realization and operation of buildings based on open standards (e.g. IFC) and workflows (e.g. VISI) (buildingSMART, 2012).

Research to the experienced advantages and barriers of BIM within several national contexts' has been done before in Australia, the UK, the USA, Germany and France (Bernstein and Pittman 2004, Yan and Damian 2008, Gu et al. 2009, Gerrard et al. 2010, Deutsch, 2011), as well as it is widely covered within more general research literature (Hartmann et al., 2008; Succar, 2009; Thomsen, 2009; Harris, 2010; Nederveen et al., 2010; Owen et.al., 2010). The most mentioned advantages for the use of BIM by architects are improvement in coordination, process and product integration, less rework, reduction of avoidable costs, increased production and fewer requests for information and change orders, catalyst for innovation, supply chain integration and sustainability. The presumed disadvantages and barriers that restrain architects from implementing BIM are examined as well by different authors. According to Howell and Batcheler (2005) the reduction of costs and time is not sufficiently proven yet. Software vendors often list the use of the traditional 'Design-Bid-Build' organizational model as a barrier for implementation of BIM. Thomsen (2009) supports this point of view. In his publication on Integrated Product Design (IPD), it is shown that an integrated way of working, like IPD, can avoid problems with self-interest of parties (Prins, 2004; 2009) and legal issues. Another view, mainly focussed on a lower level of implementation, is that some benefits can also be reached without an integrated approach (Deutsch 2011). The effort that has to be put into the design in case of BIM usage shifts from later design stages to earlier design stages resulting in an expected overall gain of time. This might not seem a problem at first sight, but most clients refuse to adapt their fee structure to this new situation what could be a serious problem, especially for smaller firms. This, even more, seems to be the case, when also the division of hours spent between the parties involved is changing. Deutsch (2009) and Schultz (2011) report on 'five fallacies' concerning the use of BIM amongst architects: productivity loss, costs for learning how to use the new technologies, hindrances with the regular processes, profitability is more at the client side

than at the designers', failure risks. Chao-Duivis (2009) and Deutsch (2011) mention in addition some juridical aspects as intellectual ownership and liabilities, which are often experienced as unsolved at the moment.

Research to the impact of BIM on small firms within the AEC industry, especially architectural firms, has not been done in this way. Above listed researchers haven't focussed on small firms especially, however different sources address the need for special attention for small firms (AIA; Haliburton, 2010). To measure whether or not one is using BIM isn't really sharply delimitated. In some publications BIM use already starts when one uses 3D-object modelling. Actually in the early nineties' of previous century applications like Architrion and ArchiCad already were 3D object based. Even for the early AutoCad, and –originally Unix-Like – MicroStation packages, special domain bound 3D object based applications were built, running additional on top of these –vector based- software. Measuring BIM application is also problematic due to the different so-called BIM maturity levels, which can be distinguished (Succar, 2010, Berlo & Sebastian, 2010). In line with Eastman (2008) and according to a lot of following authors, BIM use starts when the actual BIM model contains object-based information of least two different disciplines and the BIM model is shared by at least two or more disciplines whether or not concurrently working together with the same model. In this research we included the stage before in which practices use 3D object based modelling to advance their processes and internal collaboration within the office. Typically for architects' offices in a lot of countries within and outside Europe is the relative amount of small offices. According to a report of the Architects' Council of Europe (ACE, 2008), of the in total 130.000 private architectural practices, more than half (54%) of these practices are one-person firms. A further 35% have between 2 and 5 architectural staff. Eight per cent of practices have between 6 and 10 architectural staff and 3% have 11 to 30. Only 1% of architectural practices have more than 30 staff. Within the Netherlands 87% (1300 out of 1500; numbers are only valid for BNA registered offices, which are around 70% of all Dutch architectural practices) of the architects' offices is smaller than 10 persons. Of this population around 58% are one to two persons' firms. For these Small -and Medium- sized Enterprises (SME's) it is reasonable that the investment in BIM software, hardware and training might be a substantial barrier to start implementing it within their daily practice. In addition momentarily the credit crunch put the whole AEC sector under pressure. In addition to this, it can be assumed that the new paradigms connected to the implementation of BIM technologies are forcing practitioners to redefine their business models (Smith and Tardif, 2009; Hardin, 2009; Prins & Owen, 2010; Haliburton, 2012). As far as in the literature survey these adaptations are made explicit, no sources could be found presenting evidence based guidelines focusing in special on architectural SME's. Smith and Tardif (op. cit.) even more note the general lack of knowledge on the needed change of business models while utilizing full BIM potential, which given the literature survey done within this research project, is a still valid observation nowadays. It is widely accepted that the existence of small architectural firms, in particular due to the nature of their small size, is a typical necessity for the creativity and innovation potential of the architectural domain. Especially young designers who have strong visions and high innovation potential often choose to establish a design office of their own. So as the wider construction industry seems rapidly adapting BIM, smaller practices have to follow but it seems reasonable these smaller offices due to their rather unique social

structure (Mintzberg, 2001; Kalay, 2006; Haliburton, 2012) will adopt and adapt to BIM technologies in a different manner than larger practices.

3. Methodology

The aim of this research was to investigate first the actual BIM use amongst small architects' offices. Secondly, to investigate the experiences of these –assumed early- architect SME adaptors concerning the use of BIM in terms of challenges and pitfalls. Thirdly to determine, whether or not, specific guidelines for architectural SME's could be retrieved out of the experiences of the early adaptors. The research was done in three parts: a short explorative literature study (described in paragraph 2), an internet based survey, and expert interviews to reflect on the survey findings. The survey was developed, in collaboration with the Royal Institute of Dutch Architects (BNA), and was send out to all (BNA-registered) 1300 architect SME's (≤10 FTE) within the Netherlands. Of this population 58% has up to 2 fte, 27% has 2 till 5 fte and 15% has 5 till 10 fte.

Almost 300 offices responded to the questionnaire. Based on the literature research, the survey and the interviews afterwards, the state of BIM use among small architectural firms is reported and suggestions for implementation strategies are given, both on the level of small architectural firms as well as on the level of professional representative bodies like the BNA. The goal of the survey was to get insight in the current state of BIM use and to explore the pros and cons that small architect firms experience or expect. The questions within the survey consisted of series of subjects, partly based on the BIM Maturity Index (Succar 2010), and the Dutch based BIM QuickScan (Sebastian and van Berlo 2010). Questions about experiences, performance, incentives and barriers are added based on the literature study. To increase the willingness to complete the questionnaire, routing is used depended on the BIM maturity level. Specific questions are asked to respondents who are experienced in the field of BIM and to respondents with less experience. This division also leads to closer insights into the percentage of uptake of BIM, as will be explained in the 'results' section of this paper. The subjects of the questionnaire were devised in: Leadership, Hardware & Infrastructure, Collaboration, Human Resources, and Products & Services. Points were awarded to answers on questions within these subjects to compute a maturity level from 0 to 4 mainly according to Succar's (op. cit.) maturity levels. The scope of the levels reaches from 'very little BIM use' to 'optimised BIM integration'. Level 0 is the pre-BIM stage; level 1 represents just using BIM software for 3D modelling, at level 2 one starts collaborating – foremost internally- with the use of BIM technologies; at level 3 real network based integration is taking place, level 4 are all those uses outreaching level 3 in terms of real innovations. Compared to the terminology of Jernigan (2008), who separates 'Big BIM' from 'Little BIM', level 2 is quite similar to 'Little BIM'.

The results from the questionnaire were discussed with architects with BIM experience at eight architectural firms. This list was made up in consultation with the region managers of the BNA and based on an equal distribution over the size categories.

4. Results

4.1 Results from the survey

The questionnaire was spread among 1300 small BNA-offices. A response rate was reached of 22% (n=283). The segmentation of the offices, categorized by size class, is consistent with the overall segmentation of the researched population as given in figure 2. The routing of the questionnaire devides the respondents in two categories:
A) Respondents that call their firm 'frontrunner' and have at least 2 BIM-projects delivered or/and respondents with more than four BIM-projects delivered.
B) Firms with less BIM-projects delivered or no BIM experience at all.
Apart from the general questions, specific questions were asked to the groups on their BIM use. See figure 1 for routing procedure and numbers.

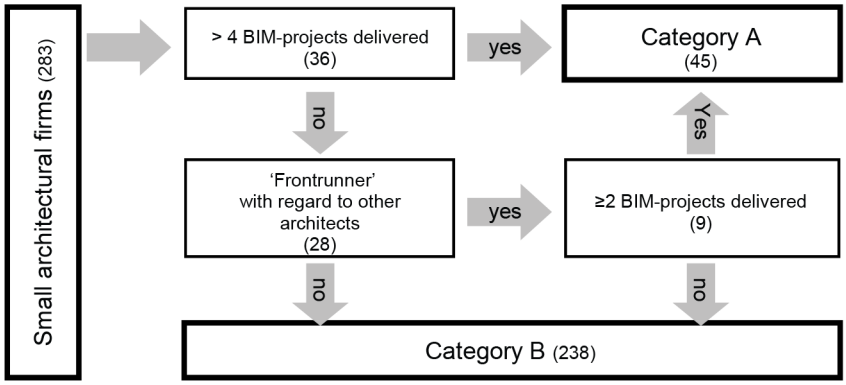

Figure 1: Categorization of respondents

Sixteen per cent of the respondents met the requirements for category A and were labelled 'experienced'. Table 1 provides the details on the amount of projects executed per category, using BIM technology. The level on which BIM is applied in those small architectural firms is relatively low. Only the experienced group (category A) reaches an average level 2. Among the less experienced firms, the first steps of BIM implementation were made by starting to use BIM software. Table 2 and 3 and figure 2 show that the use of BIM-compatible software as well as the use of BIM modelling methods is present in the less experienced group although at relative low rates (only 15% of the B category uses full 3 D object modelling within their projects). More in special table 3 provides insight in the own judgement of the responders on their maturity level. Thirty-five firms that already delivered BIM-projects, didn't meet the requirements for category A. In terms of the use of BIM software by smaller practices in the Netherlands, ArchiCad is the most widely used package followed by Revit (Autodesk). A recent report on the use of BIM in the construction industry in the Netherlands (Berlo & Dijkmans, 2012) revealed (surprisingly given all data-exchange problems in the recent past) that Vectorworks is one of the most often used BIM software packages industry-wide.

Table 1: Number of BIM-projects per firm

	No projects	1 project	2 projects	3 projects	4 projects	5 projects	6 projects	7 projects	8 projects	9 projects	10 projects	> 10 projects	> 20 projects	> 30 projects	**Total**
Category A	0	0	0	3	6	9	1	2	1	1	10	5	2	5	**45**
Category B	201	16	13	3	5	0	0	0	0	0	0	0	0	0	**238**
Total	**201**	**16**	**13**	**6**	**11**	**9**	**1**	**2**	**1**	**1**	**10**	**5**	**2**	**5**	**283**

Category A: Experienced firms (see Figure 3)

Category B: Firms with no experience or little experience (see Figure 3)

Collaboration by using BIM technologies amongst small architectural firms is underdeveloped, it only occurs incidentally and in most occasions parties aim at data exchange within the same software family and within their own office. Most interviewees point out concerning their future expectation that BIM methodology is about collaboration, but almost none has reached this level yet. Some interviewees don't even describe their current approach as 'BIM', they call it, and most probably right, just 3D-modelling and plan to upgrade their level to 'real' BIM in the near future.

Table 2: Position of respondents

Position of respondents' firms with regard to other architectural firms?				
	Awaiting	Follower	Frontrunner	**Total**
< 2 FTE	118	93	19	**230**
2 - 4 FTE	0	8	9	**17**
> 4	1	6	29	**36**
Total	**119**	**107**	**57**	**283**

Table 3: Crosstab way of modelling by category

		Category		
		A	B	**Total**
Most used way of drawing/modelling within the firm?	Full 2D	0	48	**48**
	CAD with visualizations in 3D	2	93	**95**
	Both 2D CAD and object based 3D	14	62	**76**
	Full object based 3D	29	35	**64**
	Total	**45**	**238**	**283**

The results that small architecture firms achieve by using BIM are experienced positive and – even in case of low maturity and integration levels – the use of BIM is reported to be profitable for all interviewed firms. The most often mentioned barriers and motives to hesitate implementing BIM are time and costs expected to be involved with it. The investment in both acts as a barrier for the inexperienced firms, while contrary experienced firms took cost and time reductions as a motive to start the implementation. Some of the interviewed architects confirm these findings stating although also in first instance facing time and cost as to be barriers, after having made the steps for implementing BIM and having had the first experiences, clearly these were worth the investments made. To investigate this in more detail, all category B firms were asked about their main reasons hesitating to implement and further develop BIM within their practices. Fifty per cent of the responders mention a lack of interest from their clients. This might be reasonable assuming these smaller firms often will

serve most non-professional clients with relative small not too complex projects. Direct and indirect costs involved are on the second and third place (42 and 36%). Figure 2 provides a detailed overview. It's remarkable that further analysing the data only 30% of the respondents expecting too high direct cost for implementing BIM only can define this proposition on a guess without having tested it based on experiences of colleagues or market research. The same figures appeared to be true as results of our questionnaire concerning indirect cost estimates.

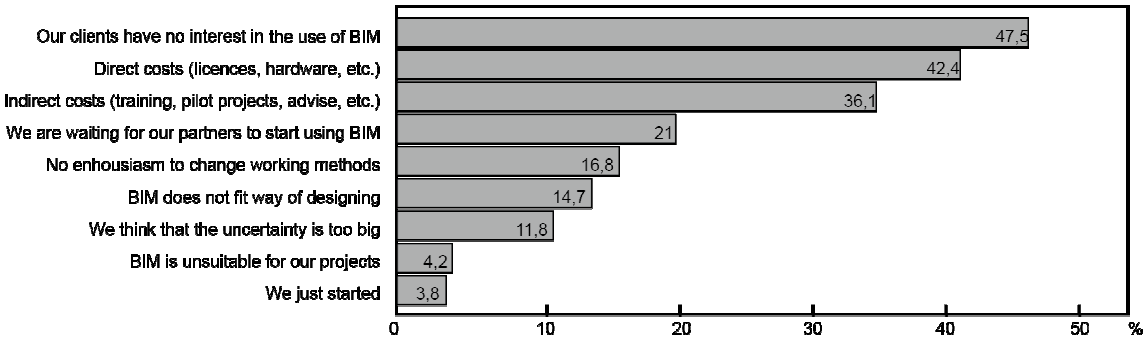

Figure 2: Reasons for not applying BIM (yet)

Within the A category of respondents the questionnaire asked for prime motivators for using BIM. Remarkable here, given the contrary expectations as expressed in other answers, are the expected cost savings (50%) although with 70% on top is future market position of the firm (figure 3). Further analysis of the data shows that only 3% of the responders frequently is confronted with clients asking BIM, 17% now and then, 19% seldom and 62% never. In terms of acquisitions, procurement routes and design contests, BIM requirements follow almost exactly the same numbers. The common made estimation in the literature that BIM leads to more integration is refused by 7 % of the respondents while 25% took a neutral position.

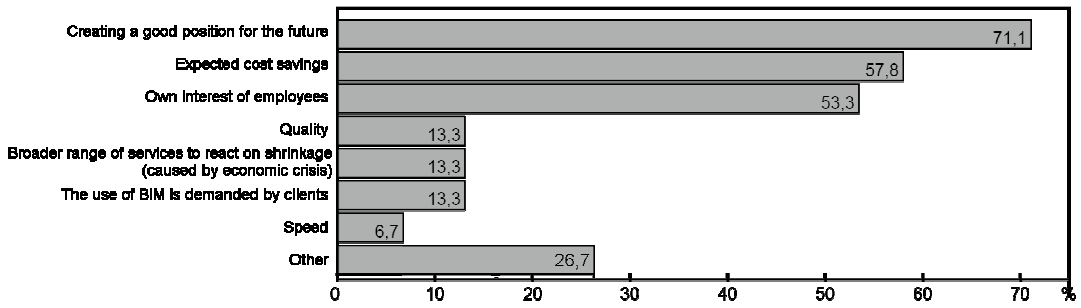

Figure 3: Motivators for applying BIM

Only 13% fully agreed with this proposition. The proposition that the hours spend by practices at the moment cannot be properly declaimed in time with the client seems to be true within the survey population. Only 30% is satisfied here, 30% is dissatisfied and 40% is neutral. This is equally spread within the A and B categories. Seventy-eight per cent of the respondents have stable partners for collaboration, like engineering consultants, cost engineers and constructors. It might seem a reasonable assumption that having such

partners stimulate the use of BIM (sharing experiences for future benefits). Applying the so-called Chi-square test however shows within our data there is not a significant correlation. Within the survey results also no significant correlation could be found between the amount of employees and category A and B practices. In line with this there was also no significant correlation between BIM maturity level and the amount of employees.

4.2 Expert-interviews

The survey results were discussed in 8 expert interviews. In addition to the comments already made within the previous paragraph this revealed the following insights:

Clients of small architecture firms differ much in size and typology. Private clients with smaller projects have a large share in numbers, but small architectural firms also work for professional clients. These professional clients develop bigger projects as well. Architectural firms within our population that do not use BIM see a lack of interest among their clients as the main barrier. Experienced firms endorse the lack of familiarity with BIM under clients; however they do not experience this as a barrier. In their experience, after having been confronted with the use of BIM, most clients are positive and willing to aim at BIM use in following projects. So not only the industry but also clients have to be informed about the benefits of BIM. To convince clients in general on the advantages the use of BIM technology might have for their projects, seems a challenge here. Clients also have to be convinced that for getting these benefits, the fee structure between consultants and phases needs to be adapted to the new way of working with BIM. Setbacks that occurred when implementing BIM were concentrated around costs and software. The large investment costs are experienced as drawback, but interviewees immediately compensated these drawbacks with the experienced benefits. The interviewed architects describe the problems with software as part of the development stage in which BIM-software is at this moment. Big investments in software applications, object libraries and hardware have to be under serious consideration. With that the gains of increasing productivity have to be taken into account. Organizations like BuildingSMART International develop international object libraries and local organizations like CUR B&I and industry organisations like the BNA cooperate with firms from the AEC industry to develop national implementations of these standards. The interviewed architects seemed well informed on these developments.

The most important step in the implementation of BIM is the convinced choice to start using BIM. The organizational structure of the office is important to mention since the strategy for a flat, operational adhocracy like organization (Mintzberg, 2001) characteristic for most SME's within the researched population, is different from the stratified hierarchical structures often seen in larger firms. Encouraging employees in an early stage and involving them thoroughly in the process shows good results. Cooperation with other parties with experience in the field of BIM happened mostly by coincidence but acted in all cases relevant as real catalyst for the implementation. Also –the very few- clients willing to start working with BIM are supporting the implementation process.

The choice which software and hardware to apply is part of the implementation process and should be well considered. The researched firms had different reasons for their choice:

experience with a certain software developer, compatibility with the systems already used, the aim for open standards and sometimes refusal to work with the bigger and more expensive software vendors. Another important part of BIM implementation is training. The researched firms report good experiences with a basic course, followed by training in real projects. Following Deutsch (2011), this gives much better results than training on unrealized pilot projects. A side effect of this approach is that these real projects bring in financial revenues and therefore keep down the lid on costs. Exchange of knowledge between experienced engineers and younger employees with less practice experience but more – academic based- modelling skills, is advocated.

Legal issues concerning contracts, intellectual property and the responsibility for the coordination of the model are well known (Chao-Duivis, 2009). These issues are also part of the experiences of the small architecture firms.

5. Conclusions and reflection

The main finding of this research is that the application of BIM is profitable for small architecture firms, even when practiced with a relatively low maturity level. At the moment, the use of BIM by small architectural firms is mainly limited to internal processes because of a lack of experience of the architectural firms themselves, their clients, as well as the other parties in the AEC industry they work with. However, the majority of those who undertook the effort to implement BIM within their organizations consider these 'little BIM' implementations already profitable.

The amount of BIM use amongst small architectural practices isn't at real high numbers. At this moment in our survey only 22% of the smaller practices are at a level of full 3D object modelling. This at least was far lower than expected by the researchers. Not surprisingly and consequently only 13 % of the respondents experiences advantages of BIM in terms of integration. It seems, the wider belief in the research community and industry that BIM technology will introduce a real paradigm shift in terms of integrated working methods and consequently also will support integrated working procedures and/or procurement, isn't really shared yet by the population researched. The same seems valid for supply chain integration, as we found no correlation in our respondent group concerning the use of BIM, related to the level practices are used to work with the same partners for their projects.

The large majority of firms in this research didn't experience possible profits of effects integrating disciplines and processes between parties outside the own firm. This might be due to their own, rather low, maturity level as measured, the implementation level of the firms they cooperate with, or the level in general of BIM usage outside the architects' domain. At least it can be concluded here is route to go, and more research to be done.

The opportunities, advantages, disadvantages and barriers that emerge from this study are largely consistent with the results of Yan and Damian (2008) and Gerrard et al. (2010) in a wider field of larger architectural firms and other parties within the AEC industry. Therefore the assumption is made that results from research in this wider field have a strong relationship with the situation for small architectural practices as well.

Remarkably barriers, which are more specific for the category of practices studied, are the not knowledgeable clients they are confronted with. Educating the client audience might be put high on the agenda to support the use of BIM technology by smaller practices. Although it has to be remarked based on our interviews that clients, confronted with architectural practices using BIM, don't see this as a threat for their project. Another point connected to this is the fee structure, which at the moment is not adapted to the amount of hours spend while the division of hours is different from the traditional processes. It might be assumed for smaller practices this will lead to bigger problems in terms of their financial stability as for larger firms.

Those not utilising BIM at the moment see the amount of direct as well as indirect cost as one of the main barriers. However those practices already using BIM have contrary experiences to these cost assumptions. Most of them, independent the amount of employees are convinced also on short terms that the use of BIM is profitable.

None of our findings within the group of architectural practices smaller than 10 FTE, correlates significantly with further segmentations on the amount of employees. Size doesn't matter, seems a valid statement here. The same can be remarked concerning BIM maturity levels.

The potential of BIM technology goes beyond the responsibilities of de different parties and reaches the whole lifecycle of the building. Roles will become different, as well as the division of hours spend throughout the phases of the process. New tasks have to be defined to fully reap the benefits of BIM application during the whole lifecycle. For legal transparency and full integration within the project team, services rendered must be rewarded and the new roles should be introduced and laid down in the professional regulations. Especially for the smaller practices, which might face more difficulties as the larger ones, here is an import role for the professional bodies. Also especially for our target group, knowledge dissemination and education might considered to be essential.

Architects had an overall coordination mandate in the past and some still aspire to do so. BIM technology provides the change for architects as 'prime model makers' (Prins & Owen, 2010), to uptake their traditional tasks again, and doing so widen their portfolio of services to the market. Whether an architectural firm is able to do so depends on the typology of the firm and other parties could be able as well, but for those firms able to, here are challenges to develop their businesses. For utilising this growth potential the architects sector and thus the professional bodies have to develop and disseminate the appropriate knowledge and process models and regulations connected. An open approach to collaboration in building projects is needed to gain all the benefits BIM technology can provide. Classically parties in building processes have a certain resistance for unconstrained information sharing (Prins, 2004; 2009). The risk to lose control or to be held responsible for other's mistakes is one of the reasons for this. Rules and regulations should be developed to cope with these issues. As the AEC sector all over the world is rather active in this respect, dissemination of these developments ought to be a point of attention, given the remarkable small percentage found in this research of practices using, or even believing BIM can be of help collaborating with others aiming for integrated processes and products.

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