Title: Implementation of BIM and sustainability in smaller architectural firms: A framework for scaling down BIM in the Danish building industry to improve sustainable design and digitalization in smaller firms

Abstract:

Building information modeling (BIM) has become an increasingly more popular and common practice in the architectural, engineering, and construction (AEC) industry. It has gained its popularity because of its ability to improve collaboration and efficiency during the planning, building process and operation and maintenance, as well as in the quality of the end-product, economical savings, reduction in errors and time savings. However, BIM can be costly and time consuming to implement, especially for the smaller architectural firms that has limited resources available, and where it could be very damaging for them to take such a risk. This research aims to provide a framework for scaling down BIM, and investigate what it would take to handle such an implementation efficiently and successfully for the smaller architectural firms.

Keywords: building information modeling, BIM implementation, smaller architectural firms, Danish building industry, scalability, competitiveness

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I. Introduction

A. Background

Building information modeling (BIM) is transforming the architecture, engineering, and construction (AEC) industry by improving collaboration, reducing errors, and increasing productivity. However, many smaller architectural firms in Denmark are struggling to keep up with this development, and to implement BIM due to the high costs and complexities that is associated with such an implementation. It has resulted in that part of our industry, becoming behind in the modernization and digitalization there has been in the industry, and is now struggling to follow with new demands and standards, especially the sustainable ones, such as Life Cycling Analysis (LCA), which is demands that will only be increasing. The Danish government did in 2019 launch a new strategy for digital construction, this was done with a set of overall goals that would be promoting the development and use of digital tools in the industry, as summarized in an article on [1]Molio.dk.

The benefits there can be achieved in implementing BIM have been well documented, such as improved visualization, enhanced communication, improved design, and construction efficiency, and a reduction in errors and waste. Furthermore, the ability of BIM to analyze and optimize the building performance not only enhances the efficiency and reduces costs, but also promotes environmentally responsible practices, such as energy efficiency, waste reduction and lifecycle management.

The smaller architectural firms face unique challenges when they are implementing BIM, some of these challenges are the high cost of software and hardware, a lack of BIM skills and knowledge, and limited resources. Therefore, a scaled-down simpler version of BIM that is more befitting to work with in the small-scaled projects that they typical work with, is required to enable the smaller architectural firms to utilize the benefits of BIM, while also minimizing the challenges that they face. A scaled-down version of BIM could include the utilization of a simplified BIM software package and focusing on specific BIM workflows and how BIM best possible can be worked into these in the best places of benefit, such as clash detection or material takeoff.

B. Problem statement

The Problem statement for this thesis is: how can BIM be scaled down to fit the needs of smaller architectural firms in Denmark and implemented successfully.

C. Research questions

To address the problem statement, this thesis will answer the following research questions:

1. What are the main challenges faced by smaller architectural firms in Denmark when implementing BIM?
2. What BIM functionalities can be scaled down to fit the needs of smaller architectural firms in Denmark?
3. How can smaller architectural firms collaborate to form a BIM system that fits their needs?

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[1]Citation from Molio.dk article, IFC og BIMs rolle i fremtidens byggeri (molio.dk)

4. What are the benefits and drawbacks of implementing a scaled-down BIM system in smaller architectural firms in Denmark?
5. How can the success of a scaled-down BIM system be measured in smaller architectural firms in Denmark?

D. Scope and limitations

This thesis will focus on smaller architectural firms in Denmark with 15 or fewer employees, but not one-man firms. The research will be limited to exploring the challenges smaller firms face with adhering to digitalization and how BIM can be scaled down to fit the needs of these firms and how to implement it successfully, and not on how to implement BIM in larger firms or on national scale. The study will also be limited to the use of BIM for the design and documentation purposes and will not explore BIM for construction or facility management.

II. Methodology

The research design for this study is done with a mixed-methods approach, that will be including both qualitative and quantitative data collection and analysis. I chose this approach because it allows for a deep understanding of the factors that has influenced the adoption of BIM in the Danish building industry, the challenges that the smaller firms experience with BIM and in general the digitalization of the building industry and new standards, and what benefits and drawbacks there is for them with implementing BIM.

A. Case studies

The case studies will be conducted on a selection of small architectural firms in Denmark that have implemented BIM in their practice and is within this research's' set scope and limitations. The case studies will provide a detailed and in-depth understanding of their approaches to scale down BIM and implement it, and the challenges and opportunities faced by these firms during that implementation process.

B. Interviews

1) Purpose of the interviews:

The purpose of the interviews is to gather an in-depth information and insights from professionals in the building industry regarding the implementation of BIM in their firms. The goal is to understand what challenges, benefits, strategies and experiences that these firms have had in relation to BIM implementations and to gain insights in what reasons there has been for not implementing BIM, and the perceived challenges that might be deterring a smaller firm from wanting to implement BIM, so that these can be addressed in a solution-oriented framework for implementing BIM.

2) Participant selection:

The participants for the interviews will be selected from various smaller architectural firms who have already implemented BIM and those who have not yet implemented and might consider implementing it or have chosen not to implement it.

3) Recruitment:
   The interviewees will be found through a combination of outreach via email, phone calls, and network. An informed consent will be obtained from all participants prior to the interviews and the interview questions will be sent out beforehand.

4) Data collection:
   The interviews will be conducted as semi-structured interviews, either in person or over teams. With each interview expected to last approximately 45 minutes to 1 hour.

5) Interview questions:
   The interviews questions will consist of two similar questionnaires, one specified for the firms that have implemented BIM and one specified for the firms that have not implemented BIM. The questions will cover all aspects equally in each questionnaire, while at the same time also get in-depth on each situation for a more holistic result.

6) Data analysis:
   The transcripts of the interviews will be analyzed with a thematically approach, to identify the key patterns, themes, and insights. Thereafter will the data be coded and categorized so that it will illustrate the meaningful findings.

7) Ethical considerations:
   The participants confidentiality and anonymity will be strictly maintained, informed consent and voluntary agreement of participation will be emphasized. Furthermore, the participants will receive the interview questions beforehand, to ensure that they are fully aware of what they are agreeing too and prepared with their answers and avoid the breaking any confidentiality agreements their firms may have in place.

8) Report and findings:
   The findings from the interviews will be used as a part of the research study's information base, and as a tool in making an informed framework to scale down and implement BIM, which will take into consideration the previous experiences from the interviewed.

   The key insights and conclusions based on the interview data will be reported, and the interview transcripts will be viewable in an appendix.

9) Follow-up:
   The interview transcripts will after the interview has been conducted, sent out to the interviewee to be looked through and approved off before they will be used as an information source in this research, and a follow-up interview will be conducted if necessary for further clarification or corrections if needed.

C. Literature studies
   1) Scope and research questions:
      The literature review will be focusing on research articles, relevant publications from experts in the industry and books. All source materials have to be published from 2010 and to the

present to ensure against possible outdated knowledge while still get a look into the development and application of BIM in the industry.

The key research questions that will be guiding the literature review and to provide information that can help answer the problem statement, will be as follows:
- What are the benefits of BIM implementation in architectural firms?
- What challenges and barriers have architectural firms faced when implementing BIM?
- What strategies and best practices have been used for successfully implementing BIM?
- How does the size of the architectural firms influence the outcome of the implementation of BIM?
- In what amount have BIM been implemented in smaller and mid-sized firms' workflows?

2) Search strategies:
There will be done a systematic search will be conducted by using academic databases, There will be used a combination of relevant topic keywords for the search, including "building information modeling", "BIM implementation in architectural firms" together with search of the challenges, benefits and strategies.

3) Inclusion and exclusion criteria:
The inclusion criteria's is as follows:
- Publications that are related to BIM implementation in architectural firms.
- Studies that focus on the challenges, benefits, strategies, and best practices.
- Peer-reviewed articles, conference papers and books

The exclusion criteria's is as follows:
- Publications after 2010
- Non-Danish, English and French publications
- Irrelevant or non-academic sources

4) Data collection and organization:
Any relevant articles and publications will be collected and organized in a literature overview[2], with a systematic review, key information, findings, and any relevant citations documented and summarized.

5) Data Analysis:
The data analysis will be done as a thematic analysis approach, to categorize and synthesize any findings from the literature used as a source in this research. Common themes, trends, challenges, benefits, and strategies that are related to BIM implementation that can be applied to smaller firms in Denmark will be identified and summarized.

6) Synthesis of findings:
The synthesized findings will be used to develop a detailed and informed narrative for this research, that will be used in answering the research questions and to get an understanding of the implementation process of BIM in smaller architecture firms.

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[2] See appendix 2 for literature overview and analysis.

7) Critical appraisal:
   Quality and relevance of the sources will be assessed critically and whether they contribute to the research topic.

8) Ethical considerations:
   There will be a proper citation and referencing of all the sources, to ensure academic integrity and to avoid plagiarism.

III. Results

A. Overview of results

Through case studies, interviews and research articles, it was found that smaller architectural firms in Denmark face several challenges in implementing BIM, such as lack of resources, knowledge, and infrastructure. There has also been uncertainties to adopt BIM due to a lack of measured success of implementation, the benefits gained and the mentality of maintaining the traditional practices. However, the benefits of BIM implementation, such as increased efficiency, accuracy, and collaboration, were identified to outweigh the challenges in successful implementation. The implementation of BIM in smaller architectural offices would also be more cost efficient in the long run, not only for the firm but also for the client. As concluded in the research on Quantitative impact analysis of priority policy applied to BIM-based design validation[3], on the effect of BIM-based design validation that the use of BIM in the early design phases could not only improve the overall design process, but also save costly errors found early on compared to when they would be found later on in the process, and that by using BIM already in the beginning of a project could influence the project and its costs significantly. Therefore, a framework for scaling down BIM and for implementation of BIM for smaller architectural firms is proposed based on the research, to address these challenges and enable the adoption of BIM and drawing inspiration from Youngsoo Jung and Mihee Joo's approach to a framework for practical BIM implementation[4].

B. Framework for scaling down BIM

A proposed framework for scaling down BIM for smaller architectural firms based on the research would include the following key steps for best possible outcome:

1. Needs assessment: this would involve identifying specific needs and requirements that the firm have, including the types of projects, clients, and the resources available.

2. BIM software selection: this is based on the needs assessment, the firm should select a BIM software that is best suitable for their specific project types, available resources and as a firm.

3. BIM training: the firm should provide the needed BIM training for its staff to ensure they have the necessary skills and knowledge to use the software effectively.

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[3] Seung-Ha Huh, Namhyuk Ham, Ju-Hyung Kim, Jae-Jun Kim, Quantitative impact analysis of priority policy applied to BIM-based design validation, Automation in Construction, Volume 154, 2023, 105031, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2023.105031. (https://www.sciencedirect.com/science/article/pii/S0926580523002911)

[4] Youngsoo Jung, Mihee Joo, Building information modelling (BIM) framework for practical implementation, Automation in Construction, Volume 20, Issue 2, 2011, Pages 126-133, ISSN 0926-5805, https://doi.org/10.106/j.autcon.2010.09.010.
(https://www.sciencedirect.com/science/article/pii/S0926580510001391)

4. BIM standards and protocols: the firm should establish a frame of BIM standards and protocols to ensure consistency and collaboration in the use of BIM across the firm and with external partners.

5. Pilot project: the firm should select a small pilot project to test the BIM implementation on and assess its effectiveness.

6. Review and evaluation: based on the results of the pilot project, the firm should review and evaluate the BIM implementation and make necessary adjustments to improve its effectiveness. The measurement of the results should be done as a comparative measuring with a similar non-BIM project within the firm as a means for measure the benefits of BIM described in the research on [5]how to measure the benefits of BIM by Kristen Barlish and Kenneth Sullivan

C. Implementation strategy

A proposed framework for an implementation strategy for BIM, that takes the data found in this research into consideration and tailored into an implementation strategy that would gradually integrate BIM into the workflows of a smaller architectural firm:

1. Set clear objectives: define the firms' specific goals for adopting BIM, for establishing a clear purpose and guide the implementation efforts. This can be goals such as reducing errors, enhancing collaboration etc.

2. Assess current capabilities: evaluate the firms current technology infrastructure, the staffs skills and current workflows. This will identify the areas where there may be need of improvement or resources that require an upgrading.

3. BIM leader and team: a BIM leader is appointed, to be responsible for overseeing the implementation process. A BIM team consisting of individuals who will be the lead and support the BIM implementation efforts.

4. Training and education: outsource and find the right training programs needed for the initial training and upskilling of the BIM team. Also make sure that all the team members have the basic understanding of what BIM is before starting the training in working with and implement BIM.

5. Choose the right BIM software: a BIM software that suits the scale and needs of the firm should be selected. In the consideration for which software to choose, user-friendliness, cost and compatibility with any appliable industry standards and what might be used by collaborative partners should be taken into consideration. The most common choices in the Danish building industry include Revit, ArchiCAD and Vectorworks.

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[5] Kristen Barlish, Kenneth Sullivan, How to measure the benefits of BIM – A case study approach, Automation in Construction, Volume 24, 2012, Pages 149-159, ISSN 0926-5805,
https://doi.org/10.1016/j.autcon.2012.02.008.
(https://www.sciencedirect.com/science/article/pii/S0926580512000234)

6. Develop BIM standards: a set of BIM standards and protocols should be decided and put in place in the firm. These standards and protocols should include naming conventions, file structures and other modeling guidelines to ensure consistency and order in the projects and the documentation.

7. Start with pilot projects: the implementation of BIM should be started up in smaller and less complex projects to allow the team to learn and adapt working project based in BIM gradually. This also makes it easier to evaluate the results and make improvements based on the lessons that has been learned in the smaller projects before taken on, in more complex projects.

8. Collaboration and communication: the importance of collaboration and communication among the BIM team members should be emphasized, to keep a focus on the information sharing that BIM allows and that can lead to better project outcomes.

9. Data management: a robust data management practices to organize, store and retrieve BIM data efficiently should be implemented. Cloud-based solutions or local servers depending on the firms needs should be utilized for this and set up to support the workflow.

10. Quality control and review: review the BIM models for accuracy and compliance with the established standards regularly. Quality control processes should be implemented to catch any errors early on in the design phase.

11. Client engagement: the projects clients' should be educated on the benefits that they gain from BIM and how using it can improve the project outcomes and what that means for them as clients. The clients support and understanding of this process is very important and should be made a part of the client consultation on the project.

12. Continuous improvement: the implementation should be seen as an ongoing process and therefore there should be gathered feedback from the team continuously, project performance should be analyzed and the strategies for BIM in the firm should continuously be adjusted accordingly.

13. Industry networking: engage with the BIM communities and organizations to stay updated on new developments and knowledge sharing. Allocate resources for the BIM leader or someone from the BIM team to be able to attend relevant seminars, conferences and workshops to keep up to date on the latest trends and practices in the industry.

14. Legal and contractual considerations: any contracts or agreements in place should be made sure to account for BIM processes and responsibilities. Familiarization with the Danish industry standards related to BIM.

15. Evaluate ROI: there should be a periodically assessment of the Return Of Investment (ROI) of the BIM implementation efforts. The impact on project efficiency, error reduction and client satisfaction should be measured.

IV. Case studies

A. Introduction to case studies

This section presents three case studies of architectural firms operating in Denmark, that have implemented BIM. The purpose of the case studies is to gain insights into how these firms have scaled down BIM, to fit into a smaller firms workflows and analyze the benefits and challenges there has been with the implementation.

B. Case study 1: X architectural firm

X architecture firm is a smaller architectural firm with five employees, they focus on residential projects. The firm began implementing BIM in 2018, to improve collaboration between team members and to increase their efficiency. The firm uses Revit, and has scaled down the level of detail in their models to fit the size of their projects.

The implementation has led to improved coordination between team members, and reduced errors during construction. The firm has also been able to provide clients with more accurate cost estimates, and has seen an increase in their project efficiency. However, the firm has faced challenges in the initial stages of implementation, particularly in learning how to use the software effectively and in adapting their workflow to accommodate the new technology.

C. Case study 2: Y architecture firm

Y architecture firm is an architectural firm with 15 employees, that specializes in commercial and institutional projects. The firm began implementing BIM in 2017, to improve project efficiency and reduce errors during construction. The firm uses ArchiCAD and has scaled down the level of detail in their models to fit the size of their projects.

The implementation of BIM has led to improved communication and coordination between team members, reduced errors during construction, and higher efficiency. The firm has also been able to provide more accurate cost estimates and has also seen an improvement in project delivery times. The firm did face some challenges in the initial implementation stages, particularly in training employees in using the software efficiently.

D. Case study 3: Z architecture firm

Z architecture firm is a small architectural firm with only three employees, they focus mainly on renovation and restoration projects. The firm began to implement BIM in 2019, to improve their workflow and make it more time efficient. The firm use vectorworks for their BIM implementation and has scaled down the level of detail in their models to fit the size of their projects.

The implementation of BIM has led to an increased efficiency and higher standards in their overall project work. The biggest challenge that the firm faced was the resource allocation for the implementation.

E. Analysis of case studies

The case studies show that the implementation of BIM in smaller architectural firms is durable and can lead to improved collaboration between team members, reduced errors during construction, and increased efficiency. The firms faced some challenges in the initial stages of

their implementation process, but did overcome these and was able to realize the benefits of this implementation.

The case studies also demonstrate that scaling down the level of detail in BIM models to fit the size of the projects as an effective strategy for smaller architectural firms to use. This allows firms to use BIM in their workflows, but without high complexity as larger firms, which would also entail more costly and timely allocation of resources.

Overall, the case studies suggest that the benefits of implementing BIM in smaller architectural firms outweigh the challenges. The key to success lies in effective smaller scale implementation and training for the employees and in adapting the workflow to accommodate the new technology.

V. Interviews

A go through of the thematic analysis for the interview data[6], the first part of the analysis is the firms is for the firms that have implemented BIM and the last part is the firms that have not implemented BIM.

A. Motivation and goals
- Strong motivation: the firms were highly motivated to implement BIM and driven by the expectations that they had of BIM's ability to improve on project efficiency, collaboration, and quality.
- Clear objectives: the firms had clear goals for the adoption of BIM and what they wanted to achieve by implementing it. The firm that was not successful in their implementation did not express any clear objectives for their implementation compared to the successful ones.

B. Benefits and outcomes
- Improved collaboration: for the firms that successfully implemented BIM, it led to an enhancing in collaboration within the firm and the external stakeholders.
- Increased efficiency: for the firms that successfully implemented BIM, they had measurable improvements in project efficiency, quality and client satisfaction.
- Positive ROI: for the firms that successfully implemented BIM, the benefits of implementing BIM was perceived to outweigh the initial challenges and resource investments. The firm that did not successfully implement BIM did acknowledge the benefits, but did not successfully realize them due to failure in their implementation strategy.

C. Challenges and overcoming barriers
- Resource allocation: the allocation of resources for training of staff and software played a pivotal role in the firms overcoming of the challenges they faced.
- Learning and training: the challenges that was related to the learning curve of the staff were addressed through a structured approach in BIM training compared to the one firm that did not succeed in their implementation.

D. Software and tools
- Thoughtful software selection: the firms that succeeded in their implementation carefully selected the BIM software to work with that aligned with their project scale and needs.
- Impactful features: the specific features of the chosen software was identified as valuable for their project workflows.

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[6] See appendix 1 for the interview data.

E. Future considerations and recommendations
- Future plans: the firms that has been successful in their implementation and overcome the initial struggles have future plans to expand on their BIM adoption and explore what more BIM can do for them in their development.
- Recommendations: the firms recommended a structured BIM training, continuous learning and a focus on specific project phases and a phasing BIM introduction based on their experience.

A. Barriers and reservations
- Partial adoption: one of the firms did not fully commit to implement BIM which resulted in limited benefits and failure in their adoption.
- Learning curve concerns: The firms expressed concerns about the learning curve.
- Resource concerns: The firms expressed concerns about the resource availability, especially as a smaller firm.
- Software complexity: the firms found the complexity of working with BIM software to be a challenge for them.

B. BIM implementation challenges
- Implementation challenges: the firms expressed similar challenges that they saw with an implementation, these were the resources and the training and time strain on their ongoing projects. All were challenges that the firms that successfully implemented BIM also faced.

C. Future considerations and external influences
- Reassessment and caution: Some of the firms expressed caution and the need for a reassessment before considering any plans for BIM adoption in the future.
- Client and industry trends: any awareness of client demands and industry trends such as sustainability have a big influence on the firms' perspectives on BIM, this being especially client demands.

D. Potential benefits of BIM
- Collaboration and efficiency: the firms did acknowledge the potential benefits of BIM, but some did not necessarily see it applying to them as a benefit compared to the work it would take to get realize them.

E. Software selection and simplicity
- Software choice: the firms emphasized the importance of selecting the right BIM software that would align with their specific needs and size of their firm.
- Simplicity matters: there was a consensus of the value that a simpler BIM application and approaches that would be tailored to fit smaller firms.

F. Forced adoption and collaboration
- Requirement-driven adoption: the possibility of a BIM enforced requirement in the future was considered and could impact the firms' decisions.
- Collaboration for implementation: any collaborative efforts among the smaller firms was seen as a positive way to facilitate BIM adoption among them and was of general interest.

VI. Discussion
A. Discussion of results
The proposed frameworks provide a systematic approach for smaller architectural firms in Denmark to implement BIM in scaled-down manner, taking into account their specific needs, resources and manageableness for them. This can help with addressing the challenges that they

face in adopting BIM and enable them to reap the benefits of BIM implementation, such as increased efficiency, accuracy, and collaboration.

B. Implications for the Danish building industry

The implementation of BIM in smaller architectural firms can have several implications for the Danish building industry. Firstly, it can lead to an increase in competitiveness and growth in the industry among the smaller firms, due to modernizing and ability to work smarter with automated workflows. Secondly, it can lead to increased collaboration and communication between firms and stakeholders, leading to more sustainable, efficient and cost-effective projects. Finally, it can contribute to the development of a more skilled workforce in the industry, as BIM implementation requires specialized knowledge and skills.

Overall, the implementation of scaled-down BIM in smaller architectural firms in Denmark can contribute to the development of a more advanced and sustainable building industry, with improved efficiency, accuracy, and collaboration.

VII. Conclusion

A. Summary of research

This thesis aimed to explore the implementation of BIM in smaller architectural firms in Denmark and what it would require to successfully implement it and the reasons of why it has been very slow in the development in this part of the industry compared to other parts of the industry. The literature review highlighted the benefits and challenges of BIM implementation and challenges of BIM implementation and the strategies that could be used for successful implementation. While the interviews and case studies highlighted the challenges faced by smaller architectural firms but also what could be gained with such an implementation. Together, all the research resulted in an in depth understanding of the current situation of this part of the industry, and provided useful data that was used in forming a framework for the implementation process and scaling down BIM.

B. Contributions to the field

The study contributes to the field by providing insights into the implementation of BIM in smaller architectural firms in Denmark and a framework that can be used in facilitating such an implementation and possible collaboration between smaller firms.

C. Limitations and future research

One of the limitations of this study is the small sample size of the case studies and the literature studies, since this subject has not been directly studied in detail. Further research could involve a larger sample size of small architectural firms in Denmark and other countries, and possibly do a pilot program in facilitating BIM implementation and collaboration in a couple of selected firms and study the process closely. Additionally, future research could investigate the potential of AI in scaling down BIM for small architectural firms.

D. Practical implications

The frameworks presented in this study has practical implications for small architectural firms in Denmark. The phased approach to implementation can help these firms with implement BIM in a cost-effective and efficient manner, and the downscaling of BIM will simplify and help with overcoming challenges in regards to the learning curve and effective use taking the scale of the projects into consideration.

E. Conclusion

In conclusion, the implementation of BIM in smaller architectural firms in Denmark is essential for the growth and competitiveness of the Danish building industry and also in regards to a more sustainable agenda in the design phases, that would follow over in the execution phases. This study has presented a framework for scaling down BIM and implementing it that can be used by small architectural firms in Denmark and other countries.

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<u>**Interview firm 1**</u>

Interview questions for smaller firms that has implemented BIM

1. Background and context:
   - **What is the size of your firm (number of employees), and its typical types of projects?**
     - *Our firm is approximately 13 employees, and our primarily focus is on residential and commercial projects, this includes new builds and renovations.*
   - **To what extent, and for how long has BIM been implemented in your firm?**
     - *We have been implementing BIM for now around 5 year, and it has become a integral part of our design and management processes that we are very happy with.*
   - **What was the motivation for your firm to implement BIM, and what were the initial goals or expectations?**
     - *To improve our project coordination and efficiency. We aimed at improving the collaboration among our team members and also with external partners we worked closely with on the projects, while also reducing errors and possible conflicts during the construction.*
2. Challenges and barriers:
   - **What was the challenges or barriers that your firm encountered when initially implementing BIM?**
     - *The biggest challenge was the start of learning to work in BIM, it takes some know how of what it entails and how to adapt our existing workflows to BIM really required a significant adjustment, also allocating resources for investing in the new hardware.*
   - **Did any of the challenges relate to the size or resources of your firm?**
     - *Yes, with the resource allocation for training and getting the software licenses needed gave some challenges. We really had to be selective in choosing the right software.*
   - **Was there any specific project phases or aspects in the project work that was extra challenging in regards to the implementation?**
     - *Yes, it was quite a big challenge to transition for 2D drafting to 3D modeling, it required adjustments in our design development process and the construction documentation.*
   - **How did your firm address and overcome these challenges?**
     - *We overcame these challenges by investing in comprehensive BIM training for our team and gradually did the transitioning of BIM in our projects. We also did some very close work with the software providers so that we could optimize our workflow and we collaborated with other firms with BIM experience for some supported guidance in our own work and deliveries.*
3. Benefits and outcomes:

- **What are the benefits or advantages your firm has experienced as the result of implementing BIM?**
    - *We improved in our project coordination, reduced some errors and clashes and also enhanced the visualization for clients and streamlined our collaboration with contractors and consultants.*
- **Are there any measurable improvements in the project efficiency, quality, or client satisfaction?**
    - *Yes, we have seen some very significant and measurable improvements in our project efficiency through reduced revisions and change orders, and the overall quality of our work has also improved with and increase higher client satisfaction because of more clear project visualizations that has provided a more smooth and clear communication between their needs and our design concepts and how we understand each other in that communication.*
- **Has the benefits and outcomes, outweighed the challenges and barriers that your firm faced when initially implementing BIM? (Has it been worth it implementing BIM)**
    - *Yes absolutely, it has outweighed the challenges from my perspective. We have gained more efficiency and improvements and client satisfaction, so it has been worthwhile and a positive experience overall that we are happy with.*

4. Simplification strategies:
    - **Did your firm employ any strategies to simplify the BIM implementation process fitting for a smaller firm and its projects?**
        - *A phased approach where we started with implementing BIM in the less complex projects so that we could build expertise in working with it gradually. We also tailored our own BIM templates and standards so they would fit our specific project types and simplifying the process.*
    - **Can you describe any specific approaches that was used to make BIM more manageable to implement?**
        - *We focused a lot on automating the repetitive tasks, such as generating schedules and quantities, additionally we also collaborated with larger firms on some joint projects where we could leverage and learn from their BIM expertise and resources.*
    - **How did these strategies impact the firms BIM adoption and project workflows?**
        - *It really erased us into working with BIM and the process in learning that, and it made it more manageable for a small firm like ours. With time our workflows became more efficient, and the team also became more comfortable with working with BIM over time.*

5. BIM tools and software:
    - **Which BIM software or tools is used in your firm, and why were these chosen?**

- *We primarily use Revit for our BIM modeling because its comprehensive to work in and is widely used in the industry, it is also really good at handling a high level of complexity.*
- **Did you explore or consider simpler BIM software options that would be more fitting for a smaller firm? (was the size of the firm a factor in the choice)**
  - *Yes we did, but revit offered the needed capabilities and scalabilities that justified the investment even for a firm of our size.*
- **What features or functionalities of BIM software are the most valuable to your firm's projects?**
  - *The 3D modeling, it really gives more in depth detailed information that is invaluable. It enhances the visualization, improves the coordination and it facilitates a better decision-making process throughout the project lifecycle that we really appreciate.*

6. Training and skill development:
   - **How did your firm approach the training and skill development of employees regarding BIM and to implement it?**
     - *We facilitated some comprehensive training sessions for our team, that included both in-house and external training courses and also encouraged self-learning through online resources, webinars and tutorials.*
   - **Where there any challenges related to employee training and adoption of BIM?**
     - *Some of the team members hard a bit of a harder time than the others, which was a challenge for them and also to balance the training with the ongoing projects required some careful planning.*
   - **What resources or training methods that was used were the most effective?**
     - *The hands-on workshops and project-based learning, where you learned while working on the actual projects allowed our team members to apply their skills they acquired immediately which also helped on their understanding of the work.*

7. Collaboration and communication:
   - **How has the BIM implementation impacted collaboration and communication within your firm and with external stakeholders? And in comparison to before the implementation?**
     - *It has significantly improved collaboration and communication. Now that team members internally can access a centralized model, which has reduced misunderstandings and externally we can share our BIM data with contractors and consultants which has streamlined the coordination and issue resolution.*
   - **Have there been any changes in how projects are coordinated and managed?**
     - *Yes, our projects are now more efficient coordinated because BIM allows for real-time updates and conflict detection, and it enables proactive management of any potential issues before they have a chance to escalate.*
   - **Can you share any examples of improved collaboration using BIM in your firm?**

- *Certainly, for example, we had a project where the structural engineer and MEP consultant were able to work simultaneously in the same BIM model, which resulted in a clash-free design and also significant time savings.*

8. Future plans and recommendations:
   - **Do your firm have future plans or goals related to BIM implementation? And what are these?**
     - *Yes, we would really like to expanding our use of BIM to also include facilities management (FM), because we see a potential for using BIM to improve the maintenance and operation of buildings post-construction.*
   - **Based on your experiences with this, what recommendations or advice would you give to other small architectural firms considering BIM adoption?**
     - *To start with a phased approach in implementing it, invest in training and choose the software carefully and think about what aligns with the typical projects needs. To collaborate with larger firms or industry partners that has BIM experience and use BIM, to leverage resources and expertise from them and also be patient and persistent; the benefits of BIM really are worth the trouble of implementing it.*
   - **Is there specific lessons learned or best practices that you would like to share?**
     - *To involve all relevant stakeholders early in the BIM process, an effective communication and collaboration in BIM from the beginning are key to a successful BIM implementation. And to continually evaluate and refine the BIM standards and processes to adapt to any changing project requirements and technology advancements.*

Interview firm 2

Interview questions for smaller firms that has implemented BIM

1. Background and context:
   - **What is the size of your firm (number of employees), and its typical types of projects?**
     - *Our firms consists of 12 employees, and we specialize in sustainable architectural projects which include both residential, commercial and public buildings.*
   - **To what extent, and for how long has BIM been implemented in your firm?**
     - *For the past 4 years*
   - **What was the motivation for your firm to implement BIM, and what were the initial goals or expectations?**
     - *Our motivation was twofold because we firstly saw it as a powerful tool that could enhance our sustainability-focused design processes and secondly because of its potential to improve our project collaboration and coordination among project stakeholders. But our initial goal was to achieve higher levels of sustainability and efficiency in our projects.*

2. Challenges and barriers:

- **What was the challenges or barriers that your firm encountered when initially implementing BIM?**
  - *The main challenges really revolved around the learning curve and also the need for additional resources, that being both in terms of software and training in using them.*
- **Did any of the challenges relate to the size or resources of your firm?**
  - *Yes, our limited resources due to being a smaller firm.*
- **Was there any specific project phases or aspects in the project work that was extra challenging in regards to the implementation?**
  - *To get used to the 3D modeling compared to doing a project in 2D, to get into creating a detailed BIM model and what that entails for sustainable design features and to analyze their impact, it was a whole new way of tackling the problem solving than what we were used to.*
- **How did your firm address and overcome these challenges?**
  - *We invested in training for the project team and sought external expertise to help us develop sustainable BIM workflows and did a gradually transitioning to BIM on our smaller-scale projects where we had more overview of the project as a hole and was less likely to confuse ourselves with the new approach.*

3. Benefits and outcomes:
- **What are the benefits or advantages your firm has experienced as the result of implementing BIM?**
  - *Our projects have improved in their sustainability because we can simulate and analyze energy-efficient designs more accurately than before, and we also save time because we have become more efficient.*
- **Are there any measurable improvements in the project efficiency, quality, or client satisfaction?**
  - *Yes definitely, we have more detailed data to work from which gives us more detailed mapping of the sustainability in our designs and also better documentation of them. It has also improved in our general project work with making us faster in delivering satisfying work and documentation and better communication with what we want to gain from our designs in terms of sustainability and aesthetics.*
- **Has the benefits and outcomes, outweighed the challenges and barriers that your firm faced when initially implementing BIM? (Has it been worth it implementing BIM)**
  - *Absolutely! It has really become a cornerstone of our sustainability-focused design approach, and the design quality and efficiency has also been worth the initial trouble.*

4. Simplification strategies:
- **Did your firm employ any strategies to simplify the BIM implementation process fitting for a smaller firm and its projects?**

- *Yes we did, we approached the implementation with a focus on the essential sustainability aspects, where we started with simpler BIM objects and gradually expanded our capabilities as our team became more proficient.*
- **Can you describe any specific approaches that was used to make BIM more manageable to implement?**
  - *We tried to avoid making it too complex, and focused on keeping it simplified and fitting for our sustainable design goals, with templates and workflows that fitted with that.*
- **How did these strategies impact the firms BIM adoption and project workflows?**
  - *It made it more manageable for us and without overwhelming our team.*

5. BIM tools and software:
   - **Which BIM software or tools is used in your firm, and why were these chosen?**
     - *We use Revit, its very robust in its capabilities in sustainable design analysis and visualization and is compatible with energy simulation tools, besides its reputation for architectural design made it the ideal choice for our firm.*
   - **Did you explore or consider simpler BIM software options that would be more fitting for a smaller firm? (was the size of the firm a factor in the choice)**
     - *We did shortly, but not in any serious matters, Revit was really the clear choice for us because it aligned so closely with the criteria's and capabilities to live up to and serve our goals. It might have been a bit uphill learning curve, but the benefits in terms of the design quality and the sustainability analysis outweighed the complexity of it.*
   - **What features or functionalities of BIM software are the most valuable to your firm's projects?**
     - *The energy analysis and simulation tools within Revit has really been incredibly valuable for us, they allow us to assess the sustainability impact of our design decisions and also the 3D modeling in itself with great benefits and the visualization that really aid us in conveying our design concepts effectively.*

6. Training and skill development:
   - **How did your firm approach the training and skill development of employees regarding BIM and to implement it?**
     - *We did in-house training sessions, provided access to online courses and encouraged the team members to expand their value as professionals with earning useful certifications. We also assigned the younger and more tech skilled to be mentors and support the junior staff in their learning. This experience has also improved us as a team and our working together.*
   - **Where there any challenges related to employee training and adoption of BIM?**
     - *Yes, mostly for those less familiar with 3D modeling software, where we had some younger on our team that already had some experience from*

school. And also coordinating the training alongside the project deadlines, which was also a challenge.

- **What resources or training methods that was used were the most effective?**
  - *Online courses and video tutorials were highly effective for a self-paced learning where it was possible to go back and get it explained again if there was something a bit hard to understand. The workshops and mentorship programs were especially valuable in helping out with learning to apply BIM concepts to the projects and get first hand learning and knowledge of it in a team effort and learn from each other.*

7. Collaboration and communication:
   - **How has the BIM implementation impacted collaboration and communication within your firm and with external stakeholders? And in comparison to before the implementation?**
     - *Significantly, we can work simultaneously on the same model and also the learning process of this has given us a fantastic team work and ability to communicate with each other in the design process, and it has also given us a better communication ability to communicate the project to contractors and consultants.*
   - **Have there been any changes in how projects are coordinated and managed?**
     - *It has completely changed it, we are now using clash detection and coordination tools to better identify and resolve issues, which had reduced costly errors and our project management has become more data-driven and efficient than it was before.*
   - **Can you share any examples of improved collaboration using BIM in your firm?**
     - *Yes, actually we just had a project where we detected an error earlier on in our design phase than what we would have done before, and avoided a very costly and time consuming rework and this also resulted in us being made aware of some other pointers that we could go in early on and make sure was as they should be and all in all resulted in a more sustainable and well-coordinated project and finished building.*

8. Future plans and recommendations:
   - **Do your firm have future plans or goals related to BIM implementation? And what are these?**
     - *We want to gain even more BIM capabilities and integrate BIM more closely with sustainable design analysis, explore generative design possibilities and to continue improving on the efficiency that we have already achieved by implementing BIM.*
   - **Based on your experiences with this, what recommendations or advice would you give to other small architectural firms considering BIM adoption?**
     - *I would advise other small firms to carefully assess their specific needs and their core goals as the goal of the adoption of BIM, and not just have adoption of BIM as the goal. And to invest in the employees' training and*

> *mentorship to ensure that team members can maximize the potential of BIM without feeling insufficient or overwhelmed and to start with the smaller projects for a better overview of the whole project when doing this, because it is quite challenging in itself to keep an overview of a whole new way of doing a project. It is also a long-term investment both in sustainability and project efficiency so keep going and see it as something that takes time and effort, but is worth it.*

- **Is there specific lessons learned or best practices that you would like to share?**
    - *To prioritize sustainability goals within the BIM process, doing that not only enhances the environmental impact of our projects, but also aligns with market demand for sustainable design, together with fostering a culture of collaboration and learning that is essential for a successful BIM adoption.*

Interview firm 3

Interview questions for smaller firms that has implemented BIM

1. Background and context:
    - **What is the size of your firm (number of employees), and its typical types of projects?**
        - *Our firm consists of 15 employees, and we typically work with various residential and small-scale commercial projects, including renovations and interior design.*
    - **To what extent, and for how long has BIM been implemented in your firm?**
        - *We attempted to implement it for a period of approximately 12 months, but it was very limited and was not fully integrated into our workflow.*
    - **What was the motivation for your firm to implement BIM, and what were the initial goals or expectations?**
        - *We were motivated and inspired by the industry trends and the promise it had of being very potential in efficiency, our goal was to enhance our project coordination and reduce errors and improve the overall quality of our projects and have better visualizations.*
2. Challenges and barriers:
    - **What was the challenges or barriers that your firm encountered when initially implementing BIM?**
        - *We had several. First one was the learning of using BIM software which was harder than we anticipated and it took up a lot of our time, the second problem was that very limited resources that we could dedicate to BIM training and support, the third problem was that some of the team members was resistant to the shift from working with 2D drafting to doing a 3D model and the fourth was the integration of BIM into our existing project workflows which proved a lot more complex than we expected.*
    - **Did any of the challenges relate to the size or resources of your firm?**

- *Yes, it played a very big role in the challenges that we encountered. We lacked the budget for the training and struggled a lot with allocating the necessary time and personnel for the transition to be effective.*
- **Was there any specific project phases or aspects in the project work that was extra challenging in regards to the implementation?**
    - *The early design phase, the transition from 2D to 3D modeling or the concept development really proved to be time-consuming and initially very counterproductive.*
- **How did your firm address and overcome these challenges?**
    - *We attempted to address them by providing additional training and sessions and allocating more time and seeing expertise from the outside, however, the progress was very slow and inconsistent due to tight resource constraints.*

3. Benefits and outcomes:
- **What are the benefits or advantages your firm has experienced as the result of implementing BIM?**
    - *Unfortunately we did not really fully realize the benefits due to our incomplete implementation and there were no significant improvements in our project efficiency and quality or any client satisfaction to report either.*
- **Are there any measurable improvements in the project efficiency, quality, or client satisfaction?**
    - *No*
- **Has the benefits and outcomes, outweighed the challenges and barriers that your firm faced when initially implementing BIM? (Has it been worth it implementing BIM)**
    - *No, regrettably the benefits did not outweigh the challenges that we faced. The incomplete implementation did not justify any of the time and the resources that we invested and it was a loss to our firm in the end.*

4. Simplification strategies:
- **Did your firm employ any strategies to simplify the BIM implementation process fitting for a smaller firm and its projects?**
    - *We attempted to simplify the process by focusing on the more basic modeling and documentation features of BIM, but this approach did not fully align with our initial goals that we had with improving our project coordination and quality.*
- **Can you describe any specific approaches that was used to make BIM more manageable to implement?**
    - *We emphasized on the basic BIM commands and modeling techniques while avoiding the more advanced features that we also considered irrelevant for our scale projects. We also considered outsourcing certain BIM tasks to some of our external consultants in order to reduce the burden we had on our limited resources.*

- **How did these strategies impact the firms BIM adoption and project workflows?**
  - *The strategies aimed to make it more manageable, but they did not result in a successful adoption. Our use of BIM remained really limited and it did not really significantly impact our project workflows in a positive way. In hindsight it would have been better with a more comprehensive and better-resourced approach would probably have been necessary for a more successful implementation.*

5. BIM tools and software:
   - **Which BIM software or tools is used in your firm, and why were these chosen?**
     - *We selected a very well-known BIM software that is very often used by other firms, based on its industry reputation for being a very good tool and the belief that it would provide us with what we needed for reaching our initial goals. But the choice was not so ideal for us due to the complexity and the resources required to properly learn to work with it.*
   - **Did you explore or consider simpler BIM software options that would be more fitting for a smaller firm? (was the size of the firm a factor in the choice)**
     - *No, in retrospect we probably should have explored more simpler and user-friendly BIM software options. Our firms size played a big part in this and maybe having chosen a software package more tailored to our needs would have been a better approach.*
   - **What features or functionalities of BIM software are the most valuable to your firm's projects?**
     - *Well, we did not fully implement BIM, but we did recognize the potential it had and the value of the features like 3D visualization and the clash detection for project coordination, but we could not realize these benefits.*

6. Training and skill development:
   - **How did your firm approach the training and skill development of employees regarding BIM and to implement it?**
     - *We did training sessions for our team, which covered the basics of BIM commands and modeling techniques, but these sessions were rather sporadic because of resource constraints and having to keep up with current on-going projects so it did not really result in any comprehensive skill development.*
   - **Where there any challenges related to employee training and adoption of BIM?**
     - *Yes, related to the availability of time and the resources for training. Some of our team members also faced difficulties with learning and adapt to the transitioning from our traditional drafting methods to BIM modeling.*
   - **What resources or training methods that was used were the most effective?**
     - *The training sessions attempted to provide with the basic knowledge, but it was not as effective as we had hoped it would be. A more structured and continuous training program would probably have been more beneficial.*

7. Collaboration and communication:

- **How has the BIM implementation impacted collaboration and communication within your firm and with external stakeholders? And in comparison to before the implementation?**
    - *We did not experience any impacts with collaboration and communication since the adoption of BIM was incomplete, we did mostly just have a lot of struggle with it during our try to implement it because so many factors was unclear and unorganized.*
- **Have there been any changes in how projects are coordinated and managed?**
    - *No*
- **Can you share any examples of improved collaboration using BIM in your firm?**
    - *No*

8. Future plans and recommendations:
    - **Do your firm have future plans or goals related to BIM implementation? And what are these?**
        - *At this time, no. Our experience with it and our attempt has made us a bit cautions and we would need to reassess our approach to it and our resources for it before considering it again.*
    - **Based on your experiences with this, what recommendations or advice would you give to other small architectural firms considering BIM adoption?**
        - *To thoroughly assess resources for it, including the budget and personnel before trying to embark on a journey as BIM implementation. The smaller firms should really consider more simpler BIM tools that are tailored to their needs and invest in continuous and very structured training for the team.*
    - **Is there specific lessons learned or best practices that you would like to share?**
        - *That it should not be rushed, especially for smaller firms. It requires a lor of careful planning and adequate resources and a commitment to continuous training and support in the learning process. To rush into it without considering these factors would be very unlikely to succeed as we experienced firsthand.*

Interview firm 4

Interview questions for smaller firms who have not yet implemented BIM

1. Current practices and awareness:
    - **What is the size of your firm (number of employees), and its typical types of projects?**
        - *It's a relatively small firm, with around 10 employees in total, this is both architects/building constructors and other support staff.*
        - *We specialize in residential projects, with custom design drawn houses, home renovations and interior design.*
    - **Can you describe the current projecteering practices that is used in your firm?**

- *Our current projecteering practices is a combination of 2D drafting and traditional project management methods. We create detailed 2D drawings and plans, to communicate our designs to clients and builders, the project coordination and the communication primarily happens through meetings, emails and phone calls. Our methods might not be as efficient as they could be with more advanced digital tools, but they have served us well with good sufficient stability.*

- **Are you aware of what BIM (building information modeling) is and what its potential benefits of it is?**
    - *Yes we are aware of BIM, and can see its potential and benefits. However, we have reservations about the possible challenges that is associated with BIM adoption, this being the complexity of it and expenses there is both with technology, license and learning to use it beneficially and time efficient, which is something that takes time to learn and use. We can see the benefits, but is cautious about ensuring that any technology we adopt in the firm also aligns with the specific needs and capabilities of our firm.*

2. Motivations and considerations:
    - **What is the factors that have influenced your firm's decision not to implement BIM yet?**
        - *There is several factors that have influenced our decision. One of the primary considerations is the complexity and the staffs learning. Because we are a smaller firm, we are more concerned about the time and financial investments that is required to train our staff adequately and the transitions to BIM, this is a huge potential disruption to our existing workflows that will also affect our ability to deliver in the current projects we are working on that we have to keep up with.*

    - **Have there been considerations to adopting BIM in the past? And if yes, what was the main reasons not to do so?**
        - *Yes, we have considered it in the past. However, the main reasons that we have for not proceeding were primarily related to resource constraints. We found that the initial investments in software licenses, hardware upgrading and staff training caused a huge strain to our budget and also the effect this would have on our ongoing projects during a transition period was too big for us.*

3. Perceived barriers and challenges:
    - **Is there any specific challenges or concerns that your firm associates with BIM adoption? And if so, what are they?**
        - *Yes there is some specific challenges that we associate with BIM adoption. These are:*
            - *Learning and training for staff*
            - *The potential project delays during the initial implementation period*
            - *Concerns about the compatibility of our existing technology with the BIM requirements*

- *Worries about the increased project costs for licenses and technology investments*
- **Are there any reservations about the costs, learning curve, or technology requirements associated with BIM that hinder your firm from implementing it due solely to being a smaller firm?**
  - *Absolutely, the costs, learning and technology requirements are the significant reservations for us. Being a smaller firm with limited resources as we are, we need to carefully manage budgets and the work and outputs. The initial costs of BIM adoption, both in terms of software and hardware upgrades, together with all the time required for learning and use this, presents substantial challenges we are not equipped to undertake.*

4. Potential benefits:
- **What do you think could be potential benefits of adopting BIM for a smaller firm?**
  - *We see several potential benefits, including improved collaboration among the team members of the project, a better project visualization and ability to create accurate 3D model that both could be a benefit in client decisions and also a clearer understanding of the design for the contractors, a really improvement to communicate the design ideas effectively really, and it could lead to an improved project outcome.*
- **Have you heard of or seen examples of how implementation of BIM in smaller firms has benefitted the firm?**
  - *Yes we have heard of it, but we have not directly observed it closely. It's more heard of it from others in the industry and how it have helped with reducing errors and project coordination and helped with lessen the miscommunication that can happen between the designers, clients and the contractors.*
- **In your opinion, how do you think implementing BIM might impact the quality of the work in your firm?**
  - *It could have a positive impact on the quality of our work and give more detailed and precise design solutions and reduce errors in both design communications and the construction documents and give a better client satisfaction outcome. I also think that with sufficient training in working this way, it could prove a faster outcome of work and reduce some project work time.*

5. Resource and training requirements:
- **What resources, such as software, hardware, or training, do you think would be necessary for your firm the be able to adopt BIM successfully?**
  - *Well, for that we would require BIM software licenses, potentially upgrade some of our hardware to meet any system requirements there might be and also train the staff. We could also additionally need access to BIM content libraries and ongoing support for any troubleshooting and questions we might have.*
- **Do you have any concerns about the availability of these resources?**

- *Yes, we have concerns about the availability of these resources this is especially the question of finances, we operate on a tight budget as a small firm and the upfronts costs we associate with implementing BIM is very high for our budget. This also concern affordable training opportunities for our staff and also finding the balance between the costs and benefits, which is very critical for us since we can not afford the risk of wasting the resources we have.*
- **How would you assess the readiness of your team to undergo BIM training and adapt to the new technology that would be necessary to implement it in their workflow?**
    - *By evaluating their current skill levels and openness to learn working with new technologies and also their capacity to allocate time for this. It would be really crucial to us that the team is prepared for embracing this change and also that the process aligns with our project schedules and commitments we have.*

6. Client demand and market trends:
    - **Have there been expressed any interests in or expectations for BIM adoption by clients or industry partners?**
        - *There has been a rare occasion with a few commercial sector projects that we have been a part of, but it has not been an expectation in our niche of custom residential design. We have also experienced that our industry partners, that is contractors and consultants, have shown a varying level of interest, but it has not become a standard requirement for collaboration on projects that has been asked specifically after.*
    - **Are you aware of any trends in the architectural industry that could be driving the need for BIM adoption?**
        - *Yes, we are seeing a growing trend of it in the architectural industry driven by the improved project coordination and smoothing over possible errors and better collaboration, but it is a trend that we have seen mostly lead by the larger firms that has more complex requirements. The adoption of BIM in our custom residential sector of the industry has been more gradual and much slower than those of bigger firms, and also varies from project to project.*

7. Perceived risks and uncertainties:
    - **Do you perceive any risks or uncertainties associated with transitioning to BIM in terms of project delivery or quality? If so, are some of these specific more so due to the firm being a smaller firm?**
        - *Yes definitely, the transition could potentially disrupt our project timelines and the project quality in the initial learning period.*
        - *As a small firm we have really limited resources for a simultaneous staff training, which and also exacerbate these challenges. So, ensuring that the implementation does not compromise our commitment to deliver high-quality designs within project timelines is a big concern.*

- **Is there any specific project phases or aspects in the project work where you foresee potential challenges?**
    - *That would be in the early stages of design development and project setup. Integrating BIM into our initial design concepts and workflows might require a significant adjustment in doing things in a way we are not used to. Also managing the transition from 2D to 3D design may give some challenges with time and resource allocation.*
- **Are there any misconceptions or myths about BIM that you would like to clarify? (where you feel that there might be a risk or uncertainty associated with implementing BIM that you feel aren't being talked about or is a misconception, or a benefit you feel is a myth etc)**
    - *Yes, that one-size-fits-all solution for all architectural firms and project types. In reality the suitability really depends on the specific needs and the complexity of the projects really, and also the available resources. I would also say the belief that BIM guarantees immediate cost savings or design improvements, which is something I find should really be approached with caution and not just a given, BIM can lead to those benefits but it also requires a well-planned implementation and know how in utilizing BIM.*

8. Alternative approaches:
    - **If not BIM, are there any other alternative technologies or methodologies that your firm is considering implementing the use of, to improve project efficiency or quality?**
        - *Yes, we are exploring alternative technologies and methodologies. We have for example been looking into 3D modeling tools that are less resource-intensive and that can be integrated into our existing workflows as an addition to them, we are also considering project management software to enhance the collaboration without the extensive training required for BIM.*
    - **Have you explored other digital tools or approaches that could complement your current practices? If yes, what was the experience with that?**
        - *Yes we have, particularly those related to 3D modeling and project management.*
        - *The experience with these was that they enhanced project visualization and communication with the clients. But they were less complex and resource demanding than BIM solutions and that made them more accessible for our team, but it is not something we use in every project due to client budgets for it and time restraints.*
    - **How would you evaluate the feasibility and suitability of these alternatives implemented in smaller firms compared to BIM?**
        - *That would be on how easy they are to incorporate into the already existing workflow and the compatibility with that, and also their potential to provide efficiency and quality improvements without the extensive resource and training requirements associated with BIM.*

9. Future considerations:

- **Is there any future plans or considerations regarding BIM adoption in your firm?**
  - *It remains on our radar as something for potential consideration in the future, and if we see an increased demand or improvement in accessibility to BIM resources more fitting our firm and our scope of work and if our firm and team is ready, we will be revisiting that possibility.*
- **Is there specific conditions or factors that would make it more likely for your firm to consider adopting BIM?**
  - *Yes there are some conditions that could make it more likely, these are availability of a more user-friendly and cost-effective BIM solutions that are tailored or more befitting smaller firms and our level op work with less complexity, and also access to affordable training resources and an increase in client demand in our residential sector for these BIM-based services.*
- **How do you see the possibility of requirement forced BIM adoption in the future affect your firm?**
  - *A requirement-forced adoption of BIM would really necessitate our compliance with client or regulatory mandates. It would potentially address some of our reservations but it would also require a careful balance between meeting the requirements and also managing the associated costs and disruption. We would also need to adapt our workflows and invest in training and technology to be able to meet these requirements effectively.*
- **Would a framework of a scaled down BIM for implementation in smaller firms and facilitated collaboration between other smaller firms in implementing it, make it more possible for your firm to consider implementing BIM?**
  - *That could indeed make a BIM adoption more feasible for us, it could reduce the burden of implementation to share the resources, knowledge and best practices with other firms that face the similar challenges that we would do and also make it more accessible and appealing in a smaller architectural practice like ours.*

10. Recommendations and insights:
- **What advice or recommendations do you have for other similar size firms considering BIM adoption?**
  - *My advice would be to conduct a very thorough assessment of your firm's specific needs, capabilities and the budget constraints. To both consider the potential benefits and the challenges there is. Also to explore alternative technologies and methodologies that could align better with your firm's current state and project portfolio. Additionally, stay informed about the developments in the industry and collaborative opportunities with other smaller firms that could positively influence and grow your firm and the project teams work.*
- **Is there any insights or lessons learned from your decision-making process of the issue to or not to implement BIM that could be valuable to others in same situation?**

- *Well, the most significant lesson learned is that the adoption of new technology and approaches should align closely with the firm's unique circumstances and long-term goals. To really carefully evaluate the costs, potential disruptions, and readiness for it and don't rush into it but explore the options and stay informed about industry trends and their usability. The decision should be a very well balanced by client demand, available resources and the commitment to delivering high-quality work and how this could be affected both positive and negative.*

Interview firm 5

Interview questions for smaller firms who have not yet implemented BIM

1. Current practices and awareness:
   - **What is the size of your firm (number of employees), and its typical types of projects?**
     - *7 employees and 1 student worker and a intern. Typical projects for us are single-family homes, home renovations and holiday homes.*
   - **Can you describe the current projecteering practices that is used in your firm?**
     - *They are very traditional methods that has served us well over the years. We rely on 2D drafting and use AUTOCAD for the technical drawings needed and plans. We do in person meetings and otherwise smaller communication over the form or email.*
   - **Are you aware of what BIM (building information modeling) is and what its potential benefits of it is?**
     - *Yes to some degree, but we have significant reservations about it and how it is of use to us with our type of work.*
2. Motivations and considerations:
   - **What is the factors that have influenced your firm's decision not to implement BIM yet?**
     - *There is a reluctance in the team about undergo such training to be able to implement BIM, which we see as unnecessary at the moment to do with such a substantial time investment that it is and also risk disrupting our ongoing projects. Additionally, we are hesitant about the costs there would be both going into such a change but also the maintenance it would require.*
   - **Have there been considerations to adopting BIM in the past? And if yes, what was the main reasons not to do so?**
     - *We have thought about it a little, but with how big a change that would be compared to our project sizes and current resources at hand, it seems a bit too much compared to how it works as it is now and we manage to deliver the quality of work wished by the clients.*
3. Perceived barriers and challenges:
   - **Is there any specific challenges or concerns that your firm associates with BIM adoption? And if so, what are they?**

- *For us the challenges that we have associated with implementing BIM is the learning to use it, the disruption it would have on our ongoing projects and also on taking on new projects in that period and how to tackle that in the equation, the compatibility with our types of projects and the costs and maintenance there would be.*

- **Are there any reservations about the costs, learning curve, or technology requirements associated with BIM that hinder your firm from implementing it due solely to being a smaller firm?**
    - *Absolutely, not just our limited resources that would be a big burden if we went into that adventure, but also due to the type and scale of our projects. It just seems too complicated to work with for our small not that complicated projects that is just as easily and quicker done in 2D as well.*

4. Potential benefits:
- **What do you think could be potential benefits of adopting BIM for a smaller firm?**
    - *From my understanding of BIM, I can understand that it can have advantages, but I don't see how applicable these benefits are to our firm. Advantages such as project coordination and 3D visualization would not outweigh the challenges and costs with the implementation in our context. The current practices we have in place are efficient for our project scale and it is something we are well used and adjusted in working with and get good results.*

- **Have you heard of or seen examples of how implementation of BIM in smaller firms has benefitted the firm?**
    - *No we have not, it has only been bigger firms from my knowledge.*

- **In your opinion, how do you think implementing BIM might impact the quality of the work in your firm?**
    - *It would modernize it more and be more flashy and give some great showcase of our design ideas clients could find useful at that would also attract some clients looking for such modern feeling in their design process, however implementing it could lead to a temporary decrease in the quality of our ongoing work in that time and the benefits, if any, may not be realized until well afterwards, and this presents a too big a risk for what we would like.*

5. Resource and training requirements:
- **What resources, such as software, hardware, or training, do you think would be necessary for your firm the be able to adopt BIM successfully?**
    - *To be successful in that, it would require significant resources in hardware and access to BIM software programs, together with some course or something like that to educate the employers working with it and also ongoing support and troubleshooting necessary to address issues that may arise during the implementation phase.*

- **Do you have any concerns about the availability of these resources?**

- *Yes, the upfront costs that could be prohibitive, together with ongoing costs of maintenance and support.*
- **How would you assess the readiness of your team to undergo BIM training and adapt to the new technology that would be necessary to implement it in their workflow?**
  - *I would assess that by having dialogues with them about further and advance their current work with new technology, as of now, none of them has expressed any need or interests in this or expressed that it would give them any improvements in their work to have.*

6. Client demand and market trends:
   - **Have there been expressed any interests in or expectations for BIM adoption by clients or industry partners?**
     - *No there has not been any, clients are generally more concerned with the quality and cost-effectiveness than the specific technology we use to accomplish the work they want.*
   - **Are you aware of any trends in the architectural industry that could be driving the need for BIM adoption?**
     - *Yes, we are aware of trends that emphasize BIM, however we believe that these trends are more relevant to the larger firms that has bigger projects and gain more from the benefits BIM could provide. For us and our work, these trends does not seem that compelling or necessary and we prefer to focus on our established practices.*

7. Perceived risks and uncertainties:
   - **Do you perceive any risks or uncertainties associated with transitioning to BIM in terms of project delivery or quality? If so, are some of these specific more so due to the firm being a smaller firm?**
     - *Yes we definitely perceive risks and uncertainties, especially as a smaller firm, mostly the disruptions to our ongoing projects it could cause to implement it that could be very costly for us and also for our future resources that depends on the previous projects going smoothly.*
   - **Is there any specific project phases or aspects in the project work where you foresee potential challenges?**
     - *In the early project stages definitely, where the team members are getting accustomed to BIM and also could make mistakes and the extra constraint on time there could be where it could be a struggle to meet deadlines and have solid quality work done.*
   - **Are there any misconceptions or myths about BIM that you would like to clarify? (where you feel that there might be a risk or uncertainty associated with implementing BIM that you feel aren't being talked about or is a misconception, or a benefit you feel is a myth etc)**
     - *That it is an easy going thing to start using, many in the industry that has been in the industry for many years and worked with other methods for many years does not often have any big grasp on what BIM is, even if it has become more and more popular.*

8. Alternative approaches:
   - **If not BIM, are there any other alternative technologies or methodologies that your firm is considering implementing the use of, to improve project efficiency or quality?**
     - *Not as of now, we are mainly using AutoCAD which we have been using for many years now and a few of the younger ones use Revit light but for the same 2D drawings as is being done in AutoCAD, they only use it because they're more used the that interface and because some of our industry partners sometimes sends their work in the form of a revit file.*
   - **Have you explored other digital tools or approaches that could complement your current practices? If yes, what was the experience with that?**
     - *No we have not*
   - **How would you evaluate the feasibility and suitability of these alternatives implemented in smaller firms compared to BIM?**
     - *As long as they are more cost-effective and have easy user interface they would be more feasible to smaller firms than BIM, but it also depends on if the firm finds value in using them.*
9. Future considerations:
   - **Is there any future plans or considerations regarding BIM adoption in your firm?**
     - *No, we prefer the way we are doing it now.*
   - **Is there specific conditions or factors that would make it more likely for your firm to consider adopting BIM?**
     - *Client demands where clients would also be willing to pay those extra costs for having it done implementing BIM, it would be an extra costs and time for us so it should be reflected in the price, but we have not yet meet client willing to pay extra for something where they could save money instead for a simpler solution.*
   - **How do you see the possibility of requirement forced BIM adoption in the future affect your firm?**
     - *That would be a big challenge for us. It might push us to modernize and to explore BIM, but it could pose very significant challenges to us in terms of adapting to the technology quickly and also meet the client demands. If it happens, we can hope that any such requirements would be considering the circumstances of smaller firms.*
   - **Would a framework of a scaled down BIM for implementation in smaller firms and facilitated collaboration between other smaller firms in implementing it, make it more possible for your firm to consider implementing BIM?**
     - *It could make the concept more appealing, but the challenges of costs, sufficient training and project disruption would still need to be addressed. Collaboration between us smaller firms could provide some support, but it would not eliminate the significant barriers there is for the firm.*
10. Recommendations and insights:

- **What advice or recommendations do you have for other similar size firms considering BIM adoption?**
  - *To carefully evaluate whether the benefits align with their projects and budget and if these are really in need of those benefits for improvements.*
- **Is there any insights or lessons learned from your decision-making process of the issue to or not to implement BIM that could be valuable to others in same situation?**
  - *It might work well for some firms, but not necessarily for others. It really is taking a change and could be a huge risk, smaller firms like ours should not feel pressured to adopt BIM solely based on industry trends.*

Interview firm 6

Interview questions for smaller firms who have not yet implemented BIM

1. Current practices and awareness:
   - **What is the size of your firm (number of employees), and its typical types of projects?**
     - *We are 13 employees, our typical work is very variated, including residential, commercial and some small-scale industrial projects.*
   - **Can you describe the current projecteering practices that is used in your firm?**
     - *Currently our practices involve 2D drawings and manual coordination methods. We rely on CAD software for the drafting and the communication is done through emails or in-person meetings for the project coordination.*
   - **Are you aware of what BIM (building information modeling) is and what its potential benefits of it is?**
     - *We have heard of BIM, but we don't really have a much in-depth understanding of it other than that it is 3D modeling and collaboration, but we would like to learn more about its potential and the benefits it provides.*
2. Motivations and considerations:
   - **What is the factors that have influenced your firm's decision not to implement BIM yet?**
     - *The main factor is really our limited knowledge and understanding of BIM. And also unsure about how to start and whether it is suitable for a firm like ours, together with the concerns about costs and how it would affect us and our work during such a change.*
   - **Have there been considerations to adopting BIM in the past? And if yes, what was the main reasons not to do so?**
     - *There has been some discussions about BIM, but these conversations has not really progressed due to reasons mentioned earlier of not knowing so much, the perceived complexity of BIM has been a barrier for much further.*
3. Perceived barriers and challenges:
   - **Is there any specific challenges or concerns that your firm associates with BIM adoption? And if so, what are they?**

- *As with adopting any new technologies, the concern and challenge would for us be the ability and time to provide the knowledge to our employees and also how it would disrupt and affect the work in that period of time, and the considerable resources this would also involve.*

- **Are there any reservations about the costs, learning curve, or technology requirements associated with BIM that hinder your firm from implementing it due solely to being a smaller firm?**
  - *Costs and technology requirements is significant factor. We are more budget-conscious as a smaller firm, and we wonder if the investment in this would outweigh the benefits.*

4. Potential benefits:
   - **What do you think could be potential benefits of adopting BIM for a smaller firm?**
     - *From what I have heard, it could be improvements in collaboration, enhanced project visualization and potentially cost saving in the long run with the better coordination and ability to reduce errors early on. However we would really like to explore these benefits a bit further.*
   - **Have you heard of or seen examples of how implementation of BIM in smaller firms has benefitted the firm?**
     - *Yea, we have actually heard some anecdotal stories about how it has given a beneficial lift for some other smaller firms, but we have not actually seen the concrete examples within our network. Maybe some more real-world case studies and success stories would help us understand this better.*
   - **In your opinion, how do you think implementing BIM might impact the quality of the work in your firm?**
     - *We believe that it has the potential to enhance the quality of our work and also improve our coordination of work with our outside partners and reduce some of the errors there could otherwise be in the project design and construction.*

5. Resource and training requirements:
   - **What resources, such as software, hardware, or training, do you think would be necessary for your firm the be able to adopt BIM successfully?**
     - *We would likely need access to BIM software and potentially upgrade some of our less new hardware, together with training of those who would be working with it to become proficient in BIM modeling and the coordination of it.*
   - **Do you have any concerns about the availability of these resources?**
     - *That would probably have to be the availability of affordable BIM software and the accessibility of training resources that is suitable for us. Cost-effectiveness is a critical factor for us.*
   - **How would you assess the readiness of your team to undergo BIM training and adapt to the new technology that would be necessary to implement it in their workflow?**

- *Our team is very open minded about learning and adapting to new technologies, but the readiness would also largely depend on the availability of training resources and the support that is provided during such a transition.*

6. Client demand and market trends:
   - **Have there been expressed any interests in or expectations for BIM adoption by clients or industry partners?**
     - *There has been some clients and collaborative project partners showing interest in BIM, particularly for the more larger and more complex projects we sometimes do. These expectations has mainly been on the coordination and visualizations.*
   - **Are you aware of any trends in the architectural industry that could be driving the need for BIM adoption?**
     - *Yes, we are aware that the industry is moving more towards the collaborative and technology-driven practices, where especially BIM is seen as one of the trends driving this change, mainly for larger projects with multidisciplinary teams.*

7. Perceived risks and uncertainties:
   - **Do you perceive any risks or uncertainties associated with transitioning to BIM in terms of project delivery or quality? If so, are some of these specific more so due to the firm being a smaller firm?**
     - *Yes, we see the potential benefits, but there are indeed some uncertainties. For smaller firms like ours, may be facing challenges in terms of the initial learning curve and the resource allocation for facilitating it, and also what this could mean for the current work during this.*
   - **Is there any specific project phases or aspects in the project work where you foresee potential challenges?**
     - *In the projects setup and the training. Project coordination and data management could also be areas where we could face some hurdles.*
   - **Are there any misconceptions or myths about BIM that you would like to clarify? (where you feel that there might be a risk or uncertainty associated with implementing BIM that you feel aren't being talked about or is a misconception, or a benefit you feel is a myth etc)**
     - *Maybe that it is only suitable for large firms and projects, we believe that with the right approach and resources, smaller firms could also benefit from BIM, maybe not in the same way or scale as the large firms, but there is always improvements that can be made, and this also apply to us smaller firms and our projects.*

8. Alternative approaches:
   - **If not BIM, are there any other alternative technologies or methodologies that your firm is considering implementing the use of, to improve project efficiency or quality?**
     - *We are actually exploring digital tools that might improve our current practices. For instance, we have looked into project management software*

and digital collaboration platforms as potential alternatives if we don't implement BIM.

- **Have you explored other digital tools or approaches that could complement your current practices? If yes, what was the experience with that?**
    - *It has been positive experiences so far with digital collaboration and project management tools, they have really improved our communication and project tracking, but we are still open to explore more options and see if they benefit us as well.*
- **How would you evaluate the feasibility and suitability of these alternatives implemented in smaller firms compared to BIM?**
    - *That really depends on the specific needs of our projects. While there are some tools that can improve the project efficiency, BIM might offer a more holistic solution for design, coordination and the construction.*

9. Future considerations:
- **Is there any future plans or considerations regarding BIM adoption in your firm?**
    - *We are very much open to the possibility of adopting BIM in the future, especially if we can overcome the challenges that is associated with that. It could provide a potential enhancement to our project practices and the firm in possible growth and expansion.*
- **Is there specific conditions or factors that would make it more likely for your firm to consider adopting BIM?**
    - *Access to training and support that is tailored to smaller firms would be very significant a factor for us. Additionally also if we could observe some of the successful BIM implementations in similar-sized firms that could really help with our understanding of the process and its challenges and also increase our confidence in considering BIM.*
- **How do you see the possibility of requirement forced BIM adoption in the future affect your firm?**
    - *That could really be a double-edged sword. It could really be a much needed push to the industry but also cause a lot of problems for us smaller firms in our ability to do that and survive such a push.*
- **Would a framework of a scaled down BIM for implementation in smaller firms and facilitated collaboration between other smaller firms in implementing it, make it more possible for your firm to consider implementing BIM?**
    - *Yes, that could really address some of our concerns and uncertainties and help us feeling more secure in that transition.*

10. Recommendations and insights:
- **What advice or recommendations do you have for other similar size firms considering BIM adoption?**
    - *To start seeking information and training opportunities that are fitting, together with collaborating with peers who have experience with BIM and that can provide some very valuable insights and support in the adoption process.*

- **Is there any insights or lessons learned from your decision-making process of the issue to or not to implement BIM that could be valuable to others in same situation?**
  - *One key lesson is the importance of really thoroughly researching and understanding the potential benefits and challenges and to also assess the readiness in the firm for this and have a clear plan for it, before making the decision and set into motion. And lastly, don't hesitate to seek guidance from firms with such experiences that could help.*

Article info:	Seung-Ha Huh, Namhyuk Ham, Ju-Hyung Kim, Jae-Jun Kim, Quantitative impact analysis of priority policy applied to BIM-based design validation, Automation in Construction, Volume 154, 2023, 105031, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2023.105031. (https://www.sciencedirect.com/science/article/pii/S0926580523002911)
Abstract:	This research article's focus is on the economic aspects of Building Information Modeling (BIM) coordination in construction projects, this in particular in responding to BIM requests for information (RFI). While the benefits of BIM in reducing design errors and improving the project efficiency are very well known, this research go more into depth with the side of economic feasibility of introducing priority policies in BIM coordination. Priority policies in BIM aim to optimize the BIM staffing and reduce waiting costs for high-priority RFIs. The study employs a priority queue model to quantify the impact of the policies on BIM return on investment (ROI) by using time and cost metrics.
Introduction:	Design errors pose a significant risk in construction projects that can be very costly, leading to reworks and schedule delays. BIM has emerged as a solution to mitigate these risks by providing accurate 3D design visualizations and enhancing the accuracy and details during the design phase. But BIM adoption has been slow due to operational challenges and resource requirements. Efficiently allocating human resources are crucial to address these challenges and optimize the project performance. While some studies have explored BIM ROI, only a few of these have gone into the impact of BIM staff in the process of it.
Research method:	The study tracks all RFIs that has been recorded from two projects and sets priority classification criteria for handling of design errors. The BIM design errors were classified according to these criteria, and their impacts were analyzed accordingly. The research aimed to identify the performance improvements achieved by processing BIM RFIs using priority policies and to calculate the corresponding BIM ROI.
Data collection and classification:	The study collected design errors that were identified through BIM design validation for both projects, relying on BIM reports, automatic clash checking via Navisworks, and RFI records. The data collected formed the basis for analyzing the impact it had on priority policies on BIM coordination.
Comparative analysis:	The study compares two scenarios: one where priority policies are applied to the RFI processing sequence and another where the first-come, first-served (FCFS) rule is followed. The application of the priority policies reduces the optimal number of BIM staffing required while enhances the BIM ROI by decreasing the input costs and increasing the output benefits.
Conclusions and further research:	This research introduces a method to enhance the BIM ROI by analyzing the performance of the BIM design validation when priority policies are applied. It tracks and classifies the design errors based on priority criteria and evaluates the optimal BIM staffing needed. The study also demonstrates how applying priority policies can lead to the economic benefits and reduced waiting times for engineers. Further research in this area could contribute to more efficient BIM coordination and resource allocation in construction projects.

Article info:	Kristen Barlish, Kenneth Sullivan,

	How to measure the benefits of BIM — A case study approach, Automation in Construction, Volume 24, 2012, Pages 149-159, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2012.02.008. (https://www.sciencedirect.com/science/article/pii/S0926580512000234)
Summary:	This article addresses all the challenges there is in quantifying the benefits of building information modeling (BIM) due to the lack of standardized methodology to evaluate its benefits. This leads to a mixed perspective and a general misunderstanding of what to expect from BIM. The author is set out to develop a comprehensive methodology that can analyze the benefits of BIM by means of conducting case studies within a large industrial setting. The focus is on quantitative metrics as a means to measure both the returns and the investments that's associated with BIM implementation. The return metrics include requests for information, change of orders and duration improvements, while the investment metrics consider the design and construction costs.
Key findings and highlights of the article:	Defining BIM: the article highlights the varied definitions of BIM and the importance of establishing a common definition for discussions about its benefits more clearly. BIM maturity levels: BIM maturity within an organization affects how it perceives and defines BIM. Theres various maturity levels that needs to be considered when assessing the benefits. Case studies: The article presents some case studies that compares BIM and non-BIM projects within an organization. It measures the returns and the investments that is associated with the BIM implementation comparatively. Quantitative Approach: The research methodology prioritizes the quantitative data collection and thus provides a more objective assessment of BIM benefits. Challenges: The authors acknowledge that quantifying intangible benefits and considering the various project factors can be challenging. Success factors: The success of BIM depends on the projects size, team proficiency, communication and other organizational factors which may not be easily quantifiable.
Conclusion:	The article contributes to the understanding of how the benefits of BIM can be measured by emphasizing the need for a standardized methodology and presenting case studies as practical examples. It also highlights that while BIM can offer significant advantages, the measurements of its success is relative and thus depends on several contextual factors.

Article info:	Youngsoo Jung, Mihee Joo, Building information modelling (BIM) framework for practical implementation, Automation in Construction, Volume 20, Issue 2, 2011, Pages 126-133, ISSN 0926-5805,

	https://doi.org/10.1016/j.autcon.2010.09.010. (https://www.sciencedirect.com/science/article/pii/S0926580510001391)
Summary:	This article addresses the practical effectiveness of Building Information Modeling (BIM) in the construction industry. BIM has gained popularity because of its potential benefits, but its real-world effectiveness proves challenging to justify. The authors aims to propose a BIM framework that focuses on the practicality for realistic real-world projects.
Key points:	Defining BIM framework: the authors emphasizes the need for a systematic framework to guide the research and enhance the understanding of BIM first. They suggests that a comprehensive BIM framework should cover the various dimensions and categories.

Computer integrated construction (CIC): The article discusses the convergence of CIC and BIM, and highlighting that they both aim to improve the construction effectiveness through integrated information systems.

BIM framework and variables: The proposed BIM framework consist of three dimensions: BIM technology, BIM perspective and construction business functions. Within these three dimensions, six major variables are identified and forms a hierarchical structure.

Practical implementation: The authors suggests that the BIM framework should focus on the practical implementation and address real-world issues. It aims to identify the promising areas and influence the factors for an effective BIM implementation.

Visual representation: The article includes visual representations such as figures and diagrams to illustrate the framework and its variables. |
| Conclusion: | The article concludes that a practical BIM implementation should effectively be incorporating BIM technologies while taking into considerations the various perspectives and business functions there might be. It also stresses the importance of integrating construction information systems for improved construction effectiveness.

The article provides a comprehensive framework for understanding and implementing BIM in real-world construction projects and emphasizes the need to consider technology, perspective, and business functions, while highlighting the convergence of BIM and CIC. The proposed framework serves as a guide for evaluating BIM's practical applications and identifying the factors that contribute to its success. |

| Article info: | A.L.C. Ciribini, S. Mastrolembo Ventura, M. Paneroni, Implementation of an interoperable process to optimise design and construction phases of a residential building: A BIM Pilot Project, Automation in Construction, Volume 71, Part 1, 2016, Pages 62-73, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2016.03.005. (https://www.sciencedirect.com/science/article/pii/S0926580516300449) |

Summary:	The article discusses the implementation of Building Information Modeling (BIM) in a perspective of a real-world construction project, specifically in residential buildings in densely populated urban areas in Italy. The project aims to evaluate the benefits of BIM in these cases and optimizing the design and construction processes, improving the coordination among the various stakeholders and enhance the construction site management.
Key points:	Introduction to BIM in Italy: The article highlights the growing interest in BIM in Italy due to its potential to transform the construction processes and optimize them. It mentions the European Union's Directive 2014/24/EU, which allows the member states to require the use of BIM tools in public procurement processes. Focus on public pilot project: This study centers around the first official Italian BIM pilot project that was conducted by a Central Public Body. The project's goal was not just to implement BIM in the procurement process but to also educate the Public Client about all the advantages of BIM compared to the traditional methods and improve the collaboration between the different project phases. Procurement method: The chosen procurement method for the pilot project was the Design-Bid-Build (DBB) approach. The Public Center handles the design phases while the awarded contractor(s) takes the responsibility for the construction phases in the project. The article discusses the advantages and limitation of this approach and also its impact on the knowledge and collaboration. Use of BIM in design and construction: BIM is used in both the design and the construction phases of the DBB method. It enables the creation of a parametric model to help the bidders understand the projects complexity and extract the quantities efficiently. Additionally, BIM is also linked to the construction schedule to optimize the construction phases. Model checking and 4D BIM: The article explains the use of model checking as a means to validate the design and ensure the compliance with codes and regulations. It also describes the implementation of a 4D Building Information Model (4D BIM) which simulates the construction process over time by linking the construction activities to 3D BIM objects. Interoperable approach: The project focuses on achieving interoperability between the various BIM tools and processes, emphasizing the need for an open multi-disciplinary approach. Results and discussion: The pilot project involved all the stakeholders and led to an effective design validation and improved coordination. The 4D BIM tool helped with optimizing the construction phase. The article also discusses how the Italian contractual frameworks and regulations can pose challenges to fully realizing the benefits of digitalized processes.

Conclusion:	While BIM offers substantial benefits, the existing contractual and regulatory constraints in Italy can be limiting its potential. The pilot project served as an educational initiative to promote a BIM adoption and enhance the collaboration among stakeholders.

Article info:	Erik A. Poirier, Sheryl Staub-French, Daniel Forgues, Measuring the impact of BIM on labor productivity in a small specialty contracting enterprise through action-research, Automation in Construction, Volume 58, 2015, Pages 74-84, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2015.07.002. (https://www.sciencedirect.com/science/article/pii/S0926580515001454)
Summary:	The article discusses the impact of Building Information Modeling (BIM) on labor productivity in the construction industry, specifically with a focus on small mechanical contracting enterprises. The study utilizes an action-research approach to reconfigure the performance measurement practices and to evaluate the effect of BIM on labor productivity.
Key points:	Introduction to BIM and labor productivity: BIM is presented as a disruptive innovation in the construction industry that has the potential to enhance the labor productivity, especially through project coordination and prefabrication. But, the need for quantifiable evidence of this impact is crucial, especially for the small and medium-sized enterprises that are considering adopting BIM. BIM and labor productivity: The article addresses the potential benefits of BIM adoption, especially in terms of labor productivity improvement. There is a consensus about the need to enhance the labor productivity in the construction industry, but to measure the impact of it is challenging due to the complexity of data collection and analysis. Action-research project: The study presents some findings fron an action-research project that was conducted with a specialty contracting small enterprise based in Vancouver, British Columbia, which had adopted BIM since 2010. The project was aiming to help the organization reconfigure its performance measurement practices, to evaluate the impact of BIM on the labor productivity. Methodology: The research team worked with the organization's project management software and reconfigured parts of their performance measurement practices to be able to benchmark and track the labor productivity they had on their BIM projects. An action-research approach was employed in order to iteratively address the organization's needs. Project context: The action-research project took place during the major part of the renovation of a 7-storey, 6500.000 sq.ft. commercial building in downtown Vancouver, with a total budget of approximately 66 million dollars. Findings: The study identified some challenges in the organization's practices, this included insufficient data collection for the rigorous performance

	assessments and increased workload for the project superintendents and foremen due to the addition of cost codes. The findings suggested that the areas that was modeled and prefabricated with BIM showed a productivity increase ranging from 75% to 240% in comparison to the non-modeled areas.
Conclusion:	The article emphasize the importance of having empirical evidence to justify the transition to BIM and quantify its direct impact. The improved labor productivity influenced by the BIM adoption is highlighted as a benefit that can directly impact an organization's ability to secure work contracts. The study both offers insights into the measuring and quantifying the impact of BIM on the labor productivity, especially for smaller organizations.

Article info:	Zhen-Song Chen, Meng-Die Zhou, Kwai-Sang Chin, Amos Darko, Xian-Jia Wang, Witold Pedrycz, Optimized decision support for BIM maturity assessment, Automation in Construction, Volume 149, 2023, 104808, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2023.104808. (https://www.sciencedirect.com/science/article/pii/S0926580523000687)
Summary:	The article discusses a refined system for assessment of evaluating the maturity of Building Information Modeling (BIM)-based projects during the design and the construction stages. The study proposes a BIM maturity model that combines the probability distribution function aggregation paradigm with a large-scale group decision-making framework in order to be able to provide an expert-based assessment system for evaluating the project-based BIM performance.
Key points:	Introduction to BIM in China: the article starts out with highlighting the growing importance of BIM in the AEC industries, with a focus on the adoption of it and the expansion of it in China. It mentions some of China's developments of BIM standards and policies that has been implemented since 2016. Challenges in BIM adoption: The article discusses the challenges of the adoption of BIM such as slow data generation, data archiving difficulties, insufficient participation the ambiguous standards, which was a hindrance to fully realizing BIM's potential in the practical projects. BIM maturity models: The article emphasizes the importance of BIM maturity models in recognizing and measuring the BIM maturity level. It mentions some previous models such as the Capability Maturity Model that was developed by the National Institute of Building Sciences and the BIM Maturity Matrix that was proposed by Succar, which assess the BIM maturity in different contexts. Limitations of Existing Models: While there has been established various BIM maturity models, the article notes that some of these models may not cover all the necessary principal applications of BIM in the AEC industries or are able to provide a complete process of maturity measurement. It points out that the credibility issues in assessment results, lack of quantitative measurement

	methods and subjectivity in scoring processes are limitations of these existing models.
	Proposed BIM maturity model: in order to address these limitations, the article proposes a new BIM maturity model that is tailored for projects in the design and the construction stages. This model combines the BIM maturity dimensions, indicators and the levels.
	Large-scale group decision-making: the study introduces large-scale group decision-making as a decision-making approach to integrate the information and multiple stakeholders' values in the BIM-based processes.
	Case study: the article provides a case study about the Corning Gen 10.5 glass substrate production line workshop in Wuhan, in order to demonstrate the application of the proposed BIM maturity assessment system.
	Discussion: the article discusses the advantages there is in the proposed BIM maturity assessment system and emphasize its ability to integrate expert clustering, weight distribution and a probability distribution function aggregation-based large-scale group decision-making scheme to reduce the subjectivity in expert opinions.
Conclusion:	The article concludes by highlighting the significance of the proposed BIM maturity assessment system, which can be adapted to fit in different countries and contexts and also its potential to contribute to BIM maturity analysis in various projects and industries.

Article info:	Abdullahi B. Saka, Daniel W.M. Chan, Ibrahim Y. Wuni, Knowledge-based decision support for BIM adoption by small and medium-sized enterprises in developing economies, Automation in Construction, Volume 141, 2022, 104407, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2022.104407. (https://www.sciencedirect.com/science/article/pii/S0926580522002801)
Summary:	The article addresses the challenge of Building Information Modeling (BIM) adoption by small and medium-sized enterprises in developing economies. It explores the different decision-making factors (DMFs) which indluence the suitability of BIM-based projects for enterprises of that size and develops a Knowledge-Based Decision Support System (KBDSS) in order to assist enterprises of that size in making informed decisions in regards to BIM adoption.
Key points:	Introduction to BIM adoption disparities: The article highlights the variations of BIM adoption levels there is across the globe, where the developed regions like North America and Europe shows a higher adoption rate compared to the more developing economies. The article also notes that the smaller and mid-size enterprises in the construction industry often lag in BIM adoption due to having limited resources and are underrepresented in BIM studies.

	Research objective: The primary aim in this study is to investigate the DMFs that affects the BIM adoption in enterprises of these sizes in the developing economies, in particularly sub-Sahara Africa. The research aims to provide a empirical evidence that can support the use of BIM in enterprises of these sizes in projects.
	Methodology: the research use a mixed approach by combining qualitative and quantitative techniques. These involves interviews, a Delphi survey and Fuzzy Synthetic Evaluation to collect and analyze the data from experts.
	Key DMFs: the study identifies several DMFs that can influence the BIM implementation in smaller and mid-sized enterprise projects. The most top-rated of the DMFs that is considered very important include total project construction costs, client requests for BIM use and the design firms' use of BIM. These factors reflect the resource limitations that is often faced by small to mid-sized enterprises in developing economies.
	KBDSS development: to be able to assist small to mid-size enterprises in making decisions about BIM adoption, the study develops a Knowledge-Based Decision Support System (KBDSS). This system serves as a decision support engine and knowledge base that helps small to mid-size enterprises with evaluate the suitability of BIM for their construction projects.
	Contributions: the article contributes to the development of a systematic approach that can assess the suitability of BIM in construction projects for small to mid-size enterprises in developing economies. It also emphasizes the importance of considering the decision-making perspective and offers insights into the factors that should be evaluated when assessing possible BIM suitability. The KBDSS provides actionable recommendations that supports BIM adoption in small to mid-size enterprises.
Conclusion:	The study concludes on various factors and conditions that must align in order to make BIM suitable for small to mid-size enterprises and the prevailing perception of BIM being unsuitable for small to mid-size enterprises' projects. The KBDSS that is developed in the study addresses the challenges these enterprises face, by providing practical decision support.

Article info:	Oludolapo Ibrahim Olanrewaju, Ahmed Farouk Kineber, Nicholas Chileshe, David John Edwards, Modelling the relationship between Building Information Modelling (BIM) implementation barriers, usage and awareness on building project lifecycle, Building and Environment, Volume 207, Part B, 2022, 108556, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2021.108556. (https://www.sciencedirect.com/science/article/pii/S0360132321009483)
Summary:	This article investigates the implementation barriers there is, awareness and usage of Building Information Modelling (BIM) in context of building projects in developing countries. It explores how overcoming these barriers influences the BIM awareness across of the building project lifecycle.

Key points:	Introduction to BIM in developing countries: BIM is recognized as a transformative technology worldwide in the AEC industry. But BIM adoption in the developing countries faces various challenges and barriers.
	Objectives: the study aims to identify and prioritize the barriers there is to BIM implementation in the Nigerian building sector. It also investigates the impact of overcoming these BIM barriers on BIM awareness throughout the building project lifecycle.
	Methodology: the research methodology involves a comprehensive literature review in order to establish a conceptual model, followed by the development of a Partial Least Square Structural Equation Modelling (PLS-SEM) by using a questionnaire survey tool. Data for this was collected from 90 building experts in Nigeria.
	Identified BIM barriers: the study identifies and ranks several BIM barriers. The most critical of these barriers to BIM implementation include the cost and standards, process and economic barriers, technology and business barriers and training and people-related barriers.
	Impact on BIM awareness: the research findings reveals that overcoming these BIM barriers has a minor impact on improving sufficient knowledge and awareness of BIM throughout the building project lifecycle. The study also suggests that while addressing these barriers is essential, it may not significantly enhance the BIM awareness.
	Policy implementations: the study's findings provides a basis for the policymakers in the developing countries to consider when aiming for successful building projects. Reducing the BIM barriers is seen as a way to enhance the success of building projects through the BIM adoption.
	Contributions: this study contributes to the understanding of the challenges and barriers there is to BIM implementation, especially in the developing countries. It emphasizes the importance of considering these barriers and their influences on BIM awareness throughout the project lifecycle.
Conclusion:	The article concludes that BIM can play a vital tole in improving the quality and efficiency of building projects in the developing countries. While overcoming the BIM barriers is crucial, it may not always be the sole factor in influencing BIM awareness across the project lifecycle.

Article info:	Ying Hong, Ahmed W.A. Hammad, Ali Akbarnezhad, Mehrdad Arashpour, A neural network approach to predicting the net costs associated with BIM adoption, Automation in Construction, Volume 119, 2020, 103306, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2020.103306. (https://www.sciencedirect.com/science/article/pii/S0926580519314554)

Summary:	The article presents a neutral network-based approach to estimate the costs and benefits that is associated with implementing BIM in firms. Specifically with a focus on specifying BIM applications and the required resources to achieve different levels of detail (LOD) within the generated models. The goal is to be able to provide decision-makers with a tool to assess which BIM and non-BIM applications to implement with considering the LOD most suited to the organization's financial and technical capabilities.
Key points:	Introduction to BIM implementation: BIM has gained a significant importance in the AEC industries, due to its potential. The article focuses on the decision-making process of adopting and implementing BIM.

Benefits and costs of BIM implementation: previous research have explored the benefits of BIM implementation, but there has been a limited focus on the ex-ante evaluation which involves forecasting and assessing the impact of future scenarios on decision-making. This article highlights that adopting BIM involves considering the applications of BIM to adopt and the LOD to incorporate, each with their associated resource investments.

Predictive model for net costs: The article introduces a predictive method to estimate the net cost of implementing BIM applications at different LODs. The net cost is defined as the difference between the implementation cost, this is including training, installation, maintenance and adaption costs, and the implementation benefits, this includes the productivity and intangible improvements.

Multi-label and multi-class classification: To capture a realistic application selection, the study uses multi-label classification and allowing for multiple applications to be applied by a firm. For LOD selection a multi-class classification is employed.

Case studies: the article includes case studies to test the proposed cost function prediction. The results shows an accuracy and effectiveness of the neutral network-based approach. |
| Conclusion: | The study concludes that the proposed ex-ante evaluation method can help organizations estimate the costs and benefits of BIM implementation and aiding the decision-makers in choosing the most suitable BIM applications and LODs. |

| Article info: | Yujie Lu, Zhilei Wu, Ruidong Chang, Yongkui Li, Building Information Modeling (BIM) for green buildings: A critical review and future directions, Automation in Construction, Volume 83, 2017, Pages 134-148, ISSN 0926-5805,
https://doi.org/10.1016/j.autcon.2017.08.024.
(https://www.sciencedirect.com/science/article/pii/S092658051730095X) |
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| Summary: | The article provides a critical review and future outlook on the utilization of BIM in the development of green buildings. It addresses the lack there is of consensus among the researchers and the practitioners in regards to the applications of BIM in green building development and emphasizes the need for |

	an up-to-date synthesis of the relationship there is between BIM and green buildings.
Key points:	Introduction to BIM and green buildings: the article highlights the increase in importance of adopting green building strategies to address the growing sustainable concerns. BIM is introduced as a revolutionary technology and process that can facilitate information integration and management throughout a buildings lifecycle that supports sustainable design and performance analysis. Evolution of BIM and green buildings: the article highlights the numerous efforts that has been made to explore the potential of BIM in facilitating green building developments. The article acknowledges that while BIM has been advocated due to its potential to support green building developments, there's only been few systematic literature reviews conducted to comprehensively assess the connections between BIM and sustainable building development. Research methodology: the critical review is based on an examination of over 500 journal articles from key AEC journals, as well as 12 commonly used types of BIM software. A "green BIM triangle" taxonomy is proposed to categorize the current efforts that are connecting BIM and green buildings based on project phases, green attributes and BIM attributes. Research findings: the proposed "green BIM triangle" taxonomy provides a useful tool for researchers and practitioners to be able to understand the current state of knowledge regarding BIM and green buildings. The article systematically illustrates the applications of BIM in supporting the various aspects there is to green buildings, including the design, construction, operation, retrofitting, energy analysis, emissions analysis, ventilation analysis and green building assessments.
Conclusion:	The article offers a comprehensive review of the connections between BIM and green building development and serves as a valuable resource for both researchers and practitioners in the field.

Article info:	Jongsung Won, Ghang Lee, How to tell if a BIM project is successful: A goal-driven approach, Automation in Construction, Volume 69, 2016, Pages 34-43, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2016.05.022. (https://www.sciencedirect.com/science/article/pii/S0926580516301029)
Summary:	The article investigates a model called the Success Level Assessment Model for BIM projects (SLAM BIM) to assess the success of these BIM projects. SLAM BIM is a goal-driven method for evaluatinf the success of a BIM project in a sustainable manner. It focuses on the premise of project success must be evaluated based on the project's defined goals and that the key performance indicators (KPIs) should vary depending on these goals. The article outlines the SLAM BIM process and application in two projects to verify its applicability and identify the issues that are related to measure the success of BIM projects.
Key points:	Introduction to BIM implementation: The focus has shifted from how to adopt BIM to how to successfully implement it in projects, but the evaluation process

| | of success of BIM projects has been challenging and the existing methods o often not directly measure the projects success.

Previous evaluation methods: The article categories the previous studies on evaluating the BIM projects into two groups. The first group includes methodologies that assess the technological and organizational maturity of BIM project teams but they do not directly evaluate the project success. The second group consists of case studies that measure the benefits of the BIM projects but they lact the appropriate metrics to measure the project success.

SLAM BIM model: the SLAM BIM model is introduces as a goal-driven approach that evaluates the success of BIM projects. It comprises five steps: defining BIM goals, specifying BIM uses, identifying BIM KPIs, establishing unit measurements and developing data collection forms and processes. The model emphasizes that defining clear project goals is essential for measuring the success accurately.

Application in two case studies: The article presents the results of applying SLAM BIM in two construction projects. In both cases, BIM was implemented in the preconstruction and construction phases to achieve specific goals.

Results and lessons learned: the article presents the results of applying SLAM BIM, and it highlights the difficulties encountered in collecting certain candidate BIM KPIs due to issues during or after the construction. The follow-up interviews with the project participants provide insights into their experiences with SLAM BIM. |
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| Conclusion: | The study concludes that SLAM BIM offers a goal-driven approach to sustainably measure the success of BIM projects. It emphasizes the importance of defining project goals and aligning KPIs accordingly. The model do show promise but it also highlights the challenges there is in data collection an suggests that the sustainability of data collection is essential for a meaningful evaluation. |

Article info:	M.F. Antwi-Afari, H. Li, E.A. Pärn, D.J. Edwards, Critical success factors for implementing building information modelling (BIM): A longitudinal review, Automation in Construction, Volume 91, 2018, Pages 100-110, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2018.03.010. (https://www.sciencedirect.com/science/article/pii/S0926580517310610)
Summary:	The article presents a comprehensive review and interpretivist study of critical success factors (CSFs) for implementing BIM. BIM implementation can be challenging, especially for small to medium enterprises, this study covers the period from 2005 to 2015 and examines CSFs used to measure successful BIM implementation.
Key points:	Introduction to BIM implementation: despite the advantages of BIM, BIM implementation has been slower among small to medium enterprises with

	various technical and non-technical challenges that hinders its successful adoption. Defining critical success factors (CSFs): the article defines the CSFs as key areas and measuring outcomes that drive practitioners to transition for traditional project delivery by using object-oriented computer-aided design (CAD) to successful BIM implementation. The CSFs play a fundamental role in the management decision making. Extensive literature review: The study conducts an interpretive review of existing literature on CSFs for BIM implementation with the aim to identify a common set of CSFs for measuring the successful implementation of BIM. Common CSFs: Although different countries may implement different sets of CSFs, some universal CSFs are shared, these includes collaboration among stakeholders, 3D visualization of design, construction planning, information exchange and site layout planning. These common CSFs can serve as a basis to establish a standard evaluation model for BIM implementation success. The article presents a checklist of CSFs for BIM implementation that can guide and help predict the likelihood of successful BIM implementation and mitigate project-based BIM failures.
Conclusion:	The article provides a comprehensive review of CSFs for successful BIM implementation.

Article info:	A.L.C. Ciribini, S. Mastrolembo Ventura, M. Paneroni, Implementation of an interoperable process to optimise design and construction phases of a residential building: A BIM Pilot Project, Automation in Construction, Volume 71, Part 1, 2016, Pages 62-73, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2016.03.005. (https://www.sciencedirect.com/science/article/pii/S0926580516300449)
Summary:	The article discusses the implementation of BIM in a residential building construction projects. The project aimed to test the advantages there is in BIM compared to the traditional design and construction management practices. It addresses the issues there is related to the coordination and collaboration among the various design disciplines and phases of the construction process. The study used an interoperable IFC-based process, incorporating advanced model checking and 4D BIM (time-based BIM) to enhance the design and the construction phases. The article discusses the benefits of BIM for validation, clash detection, code checking, construction planning and progress monitoring.
Key points:	Implementation of BIM: BIM was introduced in the pilot projects, to improve coordination and collaboration among the different design disciplines and to validate the design phase. Model checking was employed to validate the model's quality and the compliance with codes and regulations. The project also implemented 4D BIM, allowing for construction process simulation over time by linking the construction activities to 3D objects.

	IFC-based approach: the article discusses the use of Industry Foundation Classes (IFC) for the model checking and 4D BIM. IFC models were used to represent the different construction site configurations, enabling validation tests and data analysis related to the construction phase. Results and discussion: the pilot project involved all the stakeholders and allowed them to validate the design effectively. The use of 4D BIM enabled the optimization of the construction phase and clarified the benefits of BIM to the public client.
Conclusion:	The case study highlights the challenges and opportunities in implementing BIM. The study also emphasizes the importance there is of interoperability and collaboration among stakeholders for successful BIM implementation.

Article info:	Robert Eadie, Mike Browne, Henry Odeyinka, Clare McKeown, Sean McNiff, BIM implementation throughout the UK construction project lifecycle: An analysis, Automation in Construction, Volume 36, 2013, Pages 145-151, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2013.09.001. (https://www.sciencedirect.com/science/article/pii/S0926580513001507)
Summary:	The article explores the implementation and impact of BIM throughout the project life cycling in the UK construction industry. The study examines the positive impacts of BIM and focus on its financial aspects, and measures BIM usage across different project phases.
Key points:	BIM impacts and outcomes: the article discusses the organizational impacts of BIM implementation and emphasizes stakeholder collaboration as a crucial aspect of BIM. The collaboration is seen as an expanding organizational boundaries and enhancing the project performance. The research identifies the key impacts such as collaboration, process improvement and visualization. Main definition of BIM impacts: respondents participating in the research were asked to rank the impacts of BIM, including stakeholder collaboration, process improvement, technology and visualization. The survey results indicated that the stakeholder collaboration ranked the highest and by that highlighting the significance of this in BIM implementation. Process improvement was the second-highest and emphasized the importance of management aspects in BIM adoption.
Conclusion:	The research can conclude that the stakeholder collaboration is the most influential aspect of BIM implementation in terms of positive financial impact.

Article info:	Reijo Miettinen, Sami Paavola, Beyond the BIM utopia: Approaches to the development and implementation of building information modeling, Automation in Construction, Volume 43, 2014, Pages 84-91, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2014.03.009. (https://www.sciencedirect.com/science/article/pii/S0926580514000612)

Summary:	The article delves into the concept of BIM from both rhetorical and practical perspectives, an aiming to understand the promises and challenges that's associated with BIM implementation.
Key points:	BIM promises and rhetoric: the article discusses the rhetorical dimension of BIM development and implementation. It highlights the high expectations there is and the promises that is associated with BIM. Theoretical frameworks: the article introduces the two theoretical frameworks for understanding BIM implementation. The normative framework and the activity-theoretical/evolutionary framework. The normative framework aligns with the socio-technical approaches to BIM implementation and emphasize changes in collaboration and contracts among the stakeholders. The activity-theoretical/evolutionary framework draws from cultural-historical activity theory, science and technology studies, and evolutionary economics of innovation. It focuses on tools, local learning and collaboration as essential elements for implementing new technologies.
Conclusion:	The article concludes on that BIM can be characterized as a new socio-economic paradigm and represents a shift from fragmented to integrative construction practices. It emphasizes the role of local experiments, technological development and the collaboration of users in BIM implementation.

Article info:	Youngsoo Jung, Mihee Joo, Building information modelling (BIM) framework for practical implementation, Automation in Construction, Volume 20, Issue 2, 2011, Pages 126-133, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2010.09.010. (https://www.sciencedirect.com/science/article/pii/S0926580510001391)
Summary:	The article focuses on the practical implementations of BIM in the construction industry. It aims to propose a comprehensive BIM framework that emphasizes the practicability for real-world construction projects.
Key points:	Introduction to BIM framework: the article emphasize the need for comprehensive frameworks to guide the research, enhance the communication and integrate the relevant concepts into models. The focus is on creating a systematic set of relationships and conceptual scheme for BIM. Computer-integrated construction (CIC) and BIM: the article discuss the convergence of CIC and BIM and highlights their importance in enhancing the construction project effectiveness throughout the project's life cycle and across the different business functions. A definition of CIC is provided and emphasize the integration across corporate strategy, management, computer systems and information technology. BIM framework and variables: the article proposes a comprehensive BIM framework that consists of three dimensions and six categories. The three dimensions include BIM technology, BIM perspective and construction business functions, and within this framework, six major variables are classified to address the key practical implementation issues.

	Implications of BIM framework: the article emphasizes that the previous efforts in CIC and BIM have primarily been focusing on the technological issues, the proposed BIM framework serves to supplement practical issues for real-world implementation while also encompassing the broader perspectives across the different levels.
Conclusion:	The article concludes that the proposed framework defines the practical BIM implementation as effectively incorporating BIM technologies into the construction process while also address the managerial, organizational and technological aspects. It highlights the importance of integrating BIM across corporate strategies, management practices and technology usage for enhanced construction effectiveness.