Univerza *v Ljubljani*
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DILAN DURMUS

SOCIAL MEDIA APPROACHES ON BIM COLLABORATION

MASTER THESIS

SECOND CYCLE MASTER STUDY PROGRAMME BUILDING INFORMATION MODELLING – BIM A+

Ljubljana, 2022

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SOCIAL MEDIA APPROACHES ON BIM COLLABORATION

SODELOVANJE PRI BIM S PRISTOPI SOCIALNIH OMREŽIJ

BIM A+ European Master in Building Information Modelling

Master thesis No.:

Supervisor:
Prof. Žiga Turk, PhD.

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Ključne besede: družbeni mediji; BIM; BIM sodelovanje; gradnja

Izvleček:

Gradbeni sektor je zelo razdrobljen. Projektne ekipe sestavljajo različni poklici med katerimi je zahtevana visoka stopnja sodelovanja in komuniciranja. Obstoječe študije kažejo, da ljudje v gradbenem sektorju ne sodelujejo dobro, ker nimajo želje, znanja ali orodij za to. S tem v zvezi imajo družbeni mediji pomembno vlogo, saj zagotavljajo neformalno komuniciranje, ki ljudem bolj ustreza. Zato se je zasebna uporaba družbenih medijev v zadnjem desetletju zelo povečala. Izhajajoč iz tega je namen te disertacije odgovoriti na dve vprašanji: (1) Kakšen je vpliv družbenih medijev na sodelovanje pri BIM (informacijsko modeliranje gradenj) in (2), kako lahko podpirajo to sodelovanje. Da bi odgovorili na ti vprašanji, je opravljen pregled literature, v katerem so zbrane in obravnavane študije, povezane z družbenimi mediji in sodelovanjem pri BIM. Ugotovitve kažejo, da družbeni mediji povečujejo komunikacijo med člani skupine z izmenjavo slik, idej in napredka pri delu. Poleg tega ustvarjajo skupnost strokovnjakov v sektorju BIM, strokovnjaki pa so v okviru projekta polje povezani v skrbi za uspeh projekta. Neformalna izmenjava znanja in informacij, ki jo omogoča tehnologija družbenih medijev, omogoča boljše razumevanje zahtev projekta in pomaga vodjem projektov pri izboljšanju napredka projekta, saj lahko bolje razumejo sposobnosti in potrebe članov ekipe. Na splošno pristop k sodelovanju pri BIM z družbenimi mediji zagotavlja boljše sodelovanje projektnih skupin. V prihodnje bi kazalo preučiti, kako orodja BIM narediti še bolj socialna ali kako splošna socialna orodja bolje prilagoditi za delo s podatki BIM.

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BIBLIOGRAPHIC– DOKUMENTALISTIC INFORMATION AND ABSTRACT

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Abstract:

Construction sector is known to be very fragmented. Project teams contain diverse professions who must collaborate and communicate, but often lack the will, the skills, or the tools to do so. In other areas of collaboration social media plays an important role because it is providing for informal communication which people are more comfortable with. As a result, the general use of social media has increased during the last decade. From this background, this thesis aims to answer two questions: (1) What is the impact of social media on BIM (building information modelling) collaboration and (2), how is it supporting this collaboration. To answer these questions, a literature review is conducted for choosing and discussing studies related to social media and BIM collaboration. Findings show that social media increases communication between team members by sharing images, ideas, and work progress updates. Moreover, it creates a community of BIM experts and of professionals who are sharing the same concerns for the success of the project. The informal knowledge and information exchange enabled by social media technology provides better understanding of project requirements, helps to project managers to improve the management because they can understand better the skills and needs of the team members. Overall, supporting the BIM collaboration with social media tools improves project collaboration. Future work should study how to make BIM tools more social or how to make generic social tools work better with BIM data.

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I would like to express my gratitude to my thesis supervisor, Prof. dr. Žiga Turk, for his support and encouragement during the development of my research.

I dedicate this thesis to my family; without their patience, understanding, support, and love, the completion of this work would not have been possible.

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AEC: Architecture, Engineering and Construction

BbCNs: BIM-based Collaboration Networks

BCF: BIM Collaboration Format

BIM: Building Information Modelling

CDE: Common Data Environment

ICT: Information and Communication Technology

IFC: Industry Foundation Classes

IOC: Inter-organizational Collaboration

IPD: Integrated Project Delivery

UGC: User Generated Content

eWOM: Electronic Word-of-Mouth

WOM: Word-of-Mouth

1 INTRODUCTION

In today's world, the Internet has become a necessary and critical tool for both individuals and organizations. People may communicate with each other easily, rapidly, and internationally by using the Internet, and organizations can manage their processes more competently, effectively, and increasingly with the help of Internet. Furthermore, as people utilize the Internet more, more data is generated via social media, and all these information sources have the potential to yield useful administrative data and even the discovery of new social phenomena (Boyd, 2015).

Media firms have progressed from offline materials to online resources thanks to the Internet, and online resources are now far more helpful than offline materials. The increase in content creation, participation, and communication among individual users, companies, and researchers is a result of technological advancements and improved Internet accessibility (Kaplan et al., 2010). As a result, social media platforms evolved to web-based community platforms that allow users to create and discuss material in order to share their common interests and knowledge (Lee, 2018).

People may collect, publish, and disseminate public messages freely and worldwide through social media, which opens new communication possibilities (Stieglitz et al., 2013). People can use social media to express their feelings, opinions, knowledge, and personalities for socializing, expressing, and informing themselves in a more ubiquitous, effective, and fast way; businesses can reach and attract more customers for improving their managerial procedures and customer satisfaction, or they can obtain useful and remarkable insights from user posts, comments, and customer reviews. As a result of these factors, the concept of social media is becoming increasingly important in people's lives and business activities.

The quick diffusion of events and incidents across the countries has had a significant impact on the concept of media; as a consequence, the usage of social media has started to allow for the extraction of information that may benefit the construction sector in a timely and even cost-effective manner.

1.1 Research Context

In 21st century, few areas of society have remained untouched by the advent of digital technologies. The Architecture, Engineering and Construction (AEC) industry has been one of the last industries, which has experienced the Digital Revolution, or Industry 4.0, in today's technological parlance (Agarwal and Sridhar, 2016). Applications which are part of our everyday lives have also become part

of our everyday business. At the same time, there are also applications, which have been developed specifically for the purposes of certain industries.

In the AEC industry one of the most transforming digital technologies is Building Information Modelling (BIM) (Azhar, 2011). It is a combination of technologies and processes to deliver design and support construction, operation, and maintenance of the building in a collaborative way. To address numerous economic, environmental, and sociological concerns, the rising complexity of buildings is paralleled by the introduction of new procurement methods and procedures, construction technologies, materials, and construction processes. The use of BIM requires sound understanding of the processes, but also necessary skills in the related technology use (Turk and Klinc, 2020).

Because of the construction industry's unique project-based character, various participants with different skills and knowledge are required to jointly achieve project goals. However, the project teams face the difficulty of inefficient communication due to the diversity of team members and increasing complexity of the drawings (Turk and Klinc, 2020). In the temporary teams with strong time limitations, team members frequently lack face-to-face communication. In light of this, the project managers are beginning to utilize mobile information and communication technologies (ICTs) within the project activities and tasks (Hasan et al., 2019).

Social media, in particular, has penetrated people's everyday lives as well as workplaces as a representation of mobile ICT (Song et al., 2019). Scholarly attention has been paid to profound changes in companies as a result of social media use in several sectors, such as knowledge management (Jia et al., 2020), communication (Leonardi, 2014), and virtual collaboration (Zhang et al., 2018). Construction firms have started to see the benefits of social media applications in different areas of project management, including improved project communication, information integration and digital business (Azhar and Abeln, 2014). However, the social media usage in the construction teams, particularly the preadoption variables and postadoption consequences remains underexplored. It is resulting in unwillingness to implement social media in construction organizations. This situation is leaving a communication and information gap.

From a technology point of view, there is a large amount of existing research on social media adoption at the individual level. Although a few studies have focused on organizational social media adoption, little is known about the factors that influence social media adoption in construction projects from a contextual perspective (Hasan et al., 2019). Even though the effects of social media on organizational or team performance have been studied previously (Ma et al., 2021), it is more essential to investigate changes in the project teams' communication effectiveness because ineffective communication among project team members has become a critical threat to project success.

1.2 Objectives and Research Questions

Since it is increasingly used as an effective source for collecting information and obtaining insights of individuals or specific topics more easily, quickly, and efficiently rather than the traditional qualitative research techniques (e.g., surveys, interviews), it is emphasized the emerging importance and growing usage of social media for communication. Furthermore, it is decided to narrow the research interest especially for the analysis of social media platforms where people communicate and share their interest rapidly and effectively. Because most of the studies have shown that one of the most important issues is communication during a project lifecycle. Additionally, even though the most recent concept of AEC sector, BIM, is about collaborating, communicating, and sharing information along different project teams, communication gap remains as a challenge in the teams of construction-based practise.

Based on these circumstances; two research questions identified, analysed, and answered for this research, which are described as:

Research Question 1: What are the impacts of social media for BIM collaboration?

Research Question 2: How social media can support BIM Collaboration?

1.3 Method of Research

This section describes the approach that was adopted for answering the research questions, in view of the study objectives highlighted in the first chapter. The approach consisted of three main phases described below:

i) Exploration of literature: this was the first phase which involved defining the relevant and required information based on the dissertation keywords i.e., building information modelling, social media, and BIM collaboration. The search for literature, organizing and storing the relevant information was also performed in this phase.

ii) Analysis and interpretation: this phase involved breaking down, studying, and synthesizing the information in the selected literature in order to gain a better understanding of the concepts presented by the author.

iii) Findings and discussion: this were the final phase which involved presenting the synthesised work with more focus on social media acceptance on AEC sector, building information modelling, collaboration and its challenges in BIM-enabled teams and projects.

The Figure 1 below shows a graphical illustration of the phases described above.

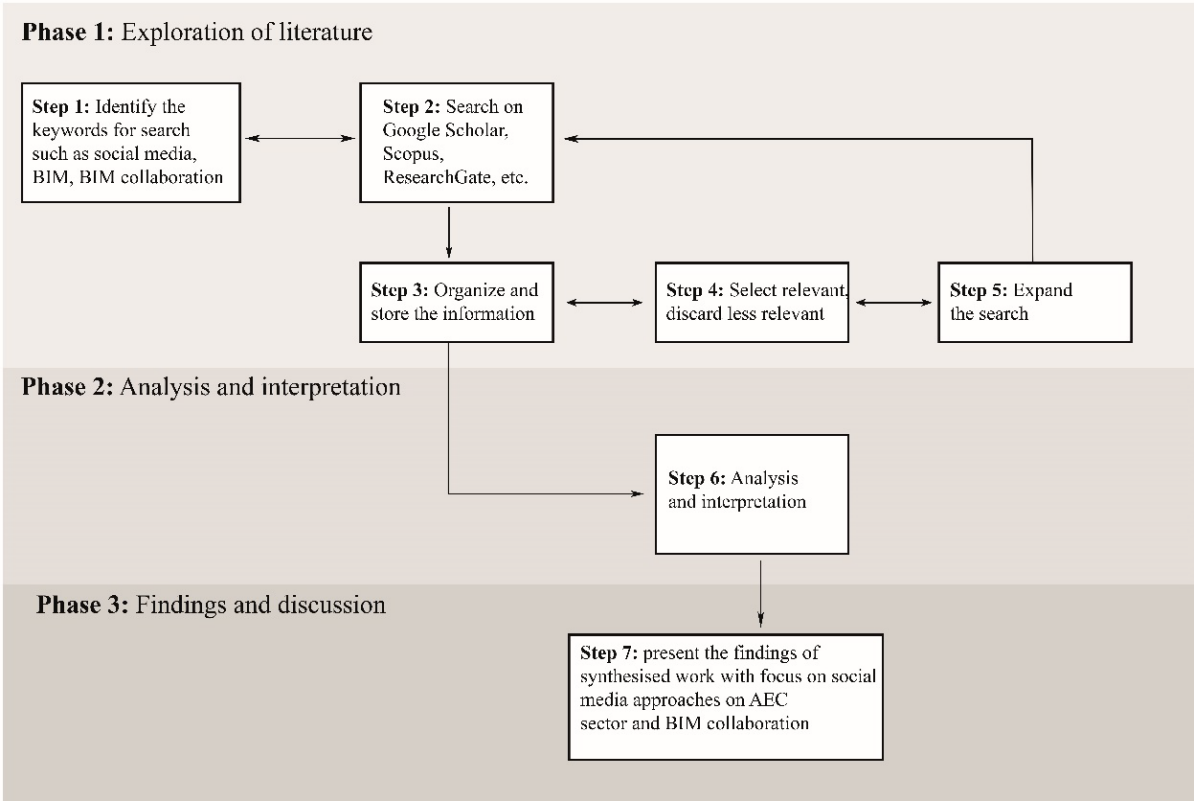

Figure 1: Methodology for literature review

After defining the research questions, it is important to establish the relevant keywords for the extent of the research. Therefore, firstly the database needs to be selected in order to have an opinion about the numbers, and themes for the appropriate studies. It is decided to use Scopus database for searching appropriate studies along with determining the criteria for inclusion and exclusion. Scopus enables researchers to access numerous studies from the plentiful journals on several academic repositories, such as ScienceDirect, ResearchGate, and Google Scholar.

In order to familiarize with the research context, firstly it is important to get opinion and obtain insights about the topical perspectives of social media, social media platforms, user generated content and electronic word of mouth, AEC sector, building information modelling and collaboration. Firstly, a preliminary keyword search is ran based on its presence on the titles, abstracts, and keywords without any restrictions. Since social media and BIM are novel developing research subjects for broad type of

sectors; there are different keywords associated with this context. The preliminary keyword research deals with detecting the number of articles from the searches of various keywords on sole group or two groups. The secondary keyword group consists of the conceptual keywords related to the broader context of social media and BIM. The results of preliminary keyword research are presented in Table 1 and secondary keyword research is presented in Table 2:

Keywords	**Number of Study**	**Evaluation**
"SOCIAL MEDIA"	132,415	*Too Broad*
"BUILDING INFORMATION MODELLING"	9,462	*Too Broad*
"SOCIAL MEDIA" AND "BUILDING INFORMATION MODELLING"	13	*Limited*
"SOCIAL MEDIA" AND "BIM"	32	*Limited*
"SOCIAL MEDIA" AND "BIM" AND "COLLABORATION"	7	*Limited*
"SOCIAL MEDIA" AND "BIM COLLABORATION"	1	*Limited*
"SOCIAL MEDIA" AND "CONSTRUCTION SECTOR"	7	*Limited*
"SOCIAL MEDIA" AND "AEC"	15	*Limited*

Table 1: Primary keyword search on Scopus

Keywords	**Number of Study**	**Evaluation**
"WEB 2.0"	15,005	*Too Broad*
"SOCIAL MEDIA PLATFORMS"	12,366	*Too Broad*
"USER GENERATED CONTENT"	6,665	*Too Broad*
"ELECTRONIC WORD-OF-MOUTH"	2,004	*Too Broad*
"COLLABORATION BARRIERS"	80	*Limited*
“BIM COLLABORATION FORMAT”	7	*Limited*
“BBCNS”	6	*Limited*
“COLLABORATION BARRIERS” AND “BIM”	3	*Limited*
“SOCIAL BIM”	7	*Limited*
“BIM 2.0”	3	*Limited*

Table 2: Secondary keyword search on Scopus

The primary keyword research shows that there are too much research “SOCIAL MEDIA” and BUILDING INFORMATION MODELLING” separately but number of the research for the intersection of these keywords are limited. The secondary keyword research shows that there are a lot of research about concepts of social media, however social aspects and collaboration issues of BIM still needs to be explored.

1.4 Structure of Thesis

The structure of the paper and the flowchart of the research are presented in Figure 2.

The dissertation starts with Introduction which presents a general overview of the research on the topic of social media and its adoption in construction sector and especially BIM for collaborating and communicating.

The second chapter, *Literature Review*, covers the review of existing literature to explore the current knowledge and identify gaps. It comprises two main subsections, starting from providing relevant background information and key definition of the terms of social media and its ecosystem, followed by the definition of BIM, its challenges and BIM collaboration.

The third chapter, *Findings*, describes the addresses the results and implications identified in terms of the application of social media approaches for BIM collaboration by looking into the studies based on the specific search and literature review. It is discussed that the need for social media to improve communication in the construction industry and social media effects on knowledge sharing and BIM workflows. Accordingly, it is addressed the collaboration barriers and how to enhance social media in AEC sector.

The fourth chapter, *Discussion*, through the detected findings and implications in terms of the application of social media approaches and beneficial insights of social media platforms for the BIM and BIM collaboration research discussed.

The last and fifth chapter, *Conclusion*, summarizes the contributions of the presented work, suggestions, and potential future work.

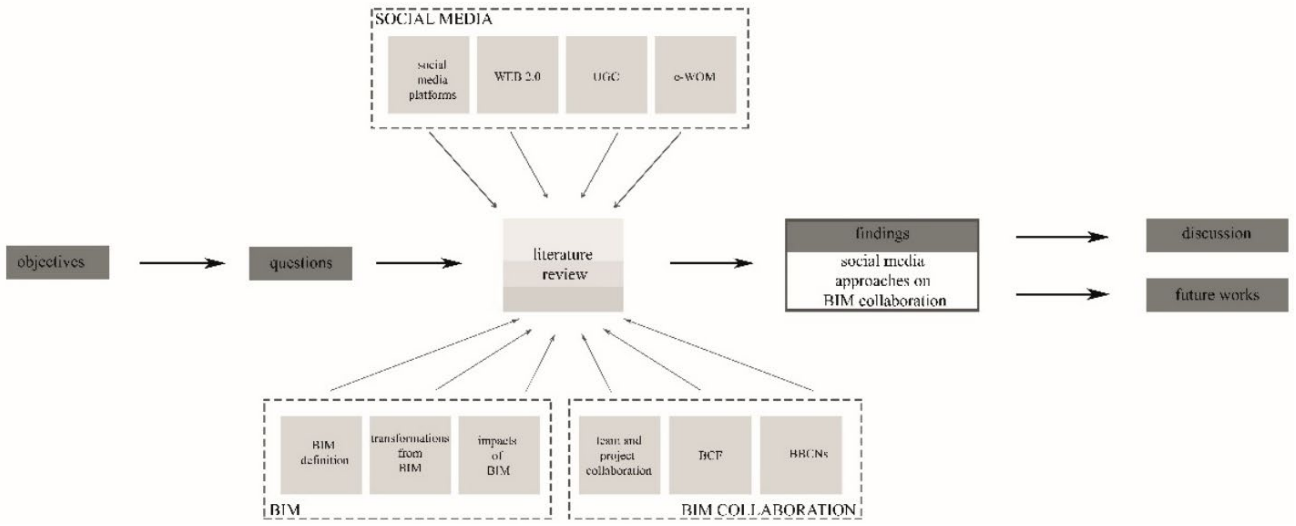

Figure 2: Flowchart of the research

2 LITERATURE REVIEW

In this thesis, a literature review has been conducted for social media and building information modelling (BIM) along with the examination of BIM collaboration.

2.1 SOCIAL MEDIA

This part addresses the first major components of the research theme: social media and its characteristic. Firstly, there is a detailed review conducted about the concepts of social media and social media platforms and web 2.0, then the topic has been enlarged with the user-generated content (UGC) and electronic word-of-mouth (e-WOM).

2.1.1 Social Media and Its Ecosystem

"Media" can be considered as a collective terminology for instruments that facilitate human communication. While the Internet and Worldwide Online have always been used to assist social connection, the advent and quick spread of Web 2.0 functions in the first decade of the new century permitted an evolutionary leap forward in the social component of web use. This, together with reducing prices for online data storage, allowed for the first time to provide Internet users with access to a variety of user-centric places that they could fill with user-generated content and possibilities to collaborate for creating virtual social networks.

According to Kaplan and Haenlein (2010), social media has become a significant reality for almost everyone in the recent decade. Many individuals use social media sites across the world, and the number of people who use these sites is growing rapidly. Despite its rapid spread, many are unable to characterize it accurately. To understand the concept of social media, it must be first understood the story and substance of social media. The first social media platform was built in 1979 by Tom Truscott and Jim Ellis at Duke University using Usenet[1]. It was a type of global conversation system where internet users could submit public remarks. However, the most recent version of social media emerged during the previous 20 years. Bruce and Susan Abelson developed "Open Diary" towards the end of the 1990s, and it was an early example of a social networking site. Following the availability of high-speed internet, the use and popularity of social networking sites increased, and users generated various sorts of social network material, such as MySpace (2003), Facebook (2004), and Twitter (2006). After these websites, the term "social media" has been more attractive.

[1] In 1980 Duke University graduate students Tom Truscott and Jim Ellis established USENET, one of the first computer network communications systems. Truscott and Ellis conceived USENET as a "poor man's ARPANET."

Social media services rapidly evolved as a business and social phenomenon by addressing latent demands. For example, Facebook, which founded in 2004, today has 2.91 billion active monthly members globally (Figure 3). Twitter, which was founded in 2006, now has 436 million monthly active users who send almost 500 million tweets every day (statista.com, 2022).

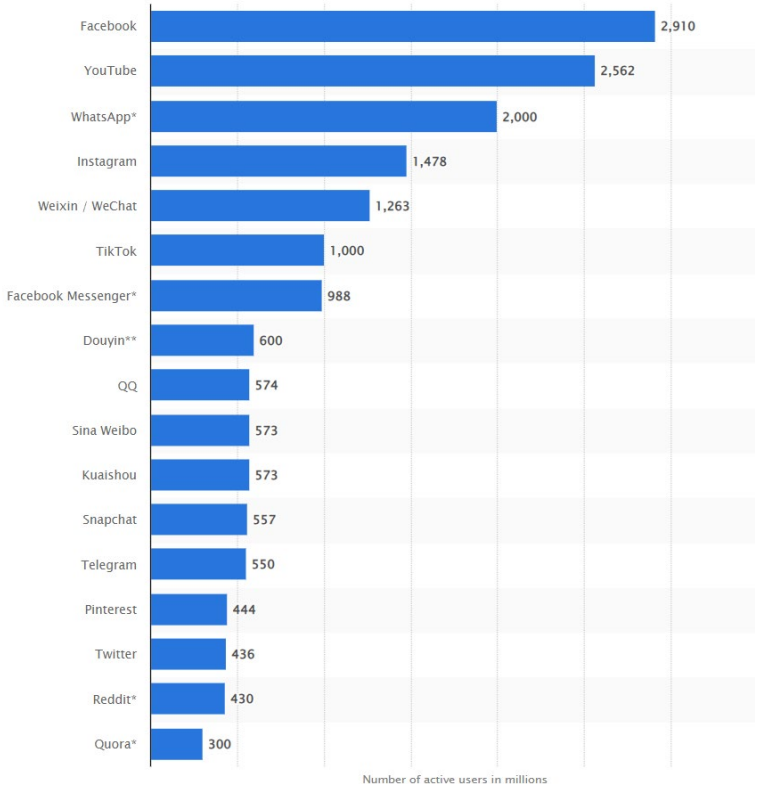

Figure 3: Leading Social Media Services Worldwide by Active User Accounts (Notes: Source: Statista.com as of January 2022.)

The proliferation of stand-alone and integrated products and services of social media makes describing the technology tricky (Obar et al., 2012). What services exactly called as social media? If Facebook and Twitter are considered as two of the main social media sites where social media starts and where does it end? What exactly are secondary platforms? Wikipedia or Amazon.com or, for example, the NewYorkTimes.com?

The notion of social media presents two key issues. First, the rapid expansion and evolution of technology brings into question our capacity to create direct borders around the notion. Social media technologies consist of various computer and mobile-based platforms that are constantly being created, released, sometimes re-launched, and ignored in worldwide nations and at different levels of public awareness. Second, social media platforms provide comparable types of communication to those enabled by other technology. If it is about bringing people together and facilitating communication and cooperation, could the telephone be called as social media? What about the fax machine? Email?

Social media, according to Kaplan and Haenlein (2010), is a category of Internet-based services that expand on the conceptual and technological roots of Web 2.0. Leonardi et al. (2013) supports this definition of social media with important viewpoints which are:

1. interact with specific peers or send messages to everyone in the company

2. explicitly or indirectly identify certain co-workers as communication partners.

3. publish, update, and sort text and files attached to themselves or others; and

4. at any time, access the messages, connections, text, and files communicated, posted, modified, and sorted by anybody else in the organization.

Considering all definitions above, it can be said that social media refers to a set of technological innovations including both hardware and software that enable low-cost content generation, interaction, and interoperability among online users (Abzari et al., 2014 p.822).

2.1.2 Web 2.0

Web 2.0 is the beginning point for the next generation of social media (Kennedy et al., 2007). It affects critical points in the web world. According to Kaplan and Haenlein (2010), the key reason why it is necessary for social media is because all the material and applications are not created entirely by the user. Instead of solo production, Web 2.0 offers a collaborative method. Every participant interjects and gradually modifies the topic. Web 1.0, for example, produced personal webpages and Encyclopaedia Britannica Online. These materials were transformed into wikis, blogs, and participatory initiatives as a result of Web 2.0.

Tim O'Reilly and Dale Dougherty came up with the term in late 2004 at the O'Reilly Media Web 2.0 Conference. O'Reilly (2005) states that the concept of Web 2.0 originated during a brainstorming session at a conference while he was debating the future of dot-com firms with other web developers. Thus, it is widely assumed that the name "Web 2.0" originally appeared at that inaugural Web 2.0 conference. Web 2.0 concept has established from several angles and by various researchers over the previous decade (Grosseck, 2009), and it remains contentious.

According to Nakamaru (2011), Web 2.0 is a phrase used to represent "a paradigm shift" (p. 1) in the way utilizing the Internet. Warschauer and Grimes states that Web 2.0 refers to more than simply a new version of current Web technology; it also refers to substantial adjustments made to the Web platform's fundamental communicative apps. Aside from that, Tu, Blocher, and Ntoruru (2008) define Web 2.0 as "a Web technology that intends to increase creativity, information sharing, and collaboration among users". Following that, Web 2.0 is regarded as a broad concept that defines a collection of remarkable technologies that are now under rapid development.

It will have a significant impact on how firms use the Internet and enterprise-level IT systems in the next years. Also, the term Web 2.0 symbolizes that it is the next generation of technology for humans. In comparison to Web 1.0, this delivers a dynamic system from the web environment and this solution is less expensive than traditional software. Furthermore, Web 2.0 represents user-controlled group of open-source, interactive, and online applications that improve the users' experiences, knowledge, and market power as participants in business and social activities (Constantinides and Fountain, 2008).

Web 2.0 apps make it easier to build informal user networks by allowing for the efficient development, distribution, sharing, and editing / refining of information. Constantinides and Fountain (2008) state that Web 2.0 produces significant changes in the marketing sector on behalf of consumers. It shifted market power from organizations to consumers. The main reason for this is that consumers may now access more information than in the past. As an example, consumers used to be uninformed of the drawbacks of firms or products, but now they can obtain all of this knowledge in a matter of seconds thanks to numerous online sources.

According to Constantinides and Fountain (2008) we may understand the effect of Web 2.0 by the preference for open-source software over personal platforms. This advancement results in the accessibility of technology and links not just businesses and customers, but also competitors. Moreover, it increased web users' connections. With Web 2.0, many people may work simultaneously on a spreadsheet or document while a computer in the background keeps track of who changed what and when. Wollcott (2007) further notes that, thanks to Web 2.0, anyone may now publish their own newspaper instead of reading pressed newspapers.

The primary characteristics of Web 2.0 are (Wollcott, 2007):

• Web-based apps are accessible from any location

• Simple applications solve particular problems

• The value of the content is more important than the software used to display it.

• Data sharing is easy.

• Allocation of data is bottom-up.

• Individuals are able to create, collaborate, edit, categorize, exchange, and promote information with the social tools.

2.1.3 Categories of Social Media Platforms

The main definition of social media platforms is that they are publicly accessible online services where people may interact and exchange discussions and material about things they have in common. (Akram

and Kumar, 2017). These platforms are composed up of numerous dynamic types of online community-based services for sharing user information and experiences; hence, there is no single definition for social media platforms (Lee, 2018). Individual users, user connections, and user publications are considered as the primary objects of social media platforms in order to create profit and advantages from the analysis of these user features. Based on the users and their connections, social media platforms assess or authenticate user relationships or interactions by displaying and formalizing them in a computerized data structure. Lee classified social media platforms in his study as social networking services, blogs, social bookmarking services, content sharing sites, and opinion sharing sites (Lee, 2018).

Social Network Sites: A social network is an online service that allows individual users to create a personal profile, share connections, invites, activities, and experiences with a predefined list of people, and send instant messages or e-mails to other users inside their system (Boyd and Ellison 2008; Kaplan and Haenlein, 2010). A vast quantity of social data is collected through social network sites, and the majority of these websites give API services; hence, these websites are regarded as the most commercial and accessible social media platform (Batrinca and Treleaven, 2014; J. Choi et al., 2020). The characteristics of social networking sites can be identified from one another, and these social networking sites can be utilized for a variety of objectives. For example, Facebook can be used to monitor companies' or competitors' marketing efforts and to understand consumers' preferences or opinions based on their posts or comments on brand pages, Snapchat can be used to examine millennial user-related marketing campaigns, and LinkedIn can be used primarily to find and attract particularly skilled or professional new customers (Kane et al., 2014; Lee, 2018). The social media visibility of either users or companies can be analysed from the profiles of social network sites in terms of number of likes, posts, and comments; or the most recent trends can be analysed from the hashtags within the social network sites in order to obtain specific valuable insights about the users or companies.

Blogs: Blogs are the social media version of personal web diaries, with brief descriptions and updates from a single user for interacting with others and sharing their experiences and expertise (Kaplan and Haenlein, 2010; Lee, 2018). Blogs are usually found in text format; however, additional data formats, such as photographs and videos, are often exchanged inside blogs (Kaplan and Haenlein, 2010). WordPress, Quora, Tumblr, and Twitter are some of the most popular blog platforms for businesses or individual users (Lee, 2018). There is also a type of blogging known as microblogging, which contains short contents such as quick texts, links, and phrases; the most well-known examples of microblogging are Twitter and Tumblr, but some other social network sites, such as Facebook and LinkedIn, include status updates, which can also be considered a microblogging feature (Stieglitz and Dang-Xuan, 2013). In microblogging posts, the limit of characters allowed is limited. Twitter, for example, was originally designed to distribute brief status updates and news by permitting just a 140-character limit inside each post, known as tweets; this character limit was increased after November 2017. (Li and Xie, 2020). In

terms of management research, Twitter may be utilized for a variety of objectives, including investigating product launches, updates, and promotions, examining user social media participation, and analyzing business performance (Lee, 2018).

Content Sharing Sites: Content sharing websites allow users to create and share various sorts of multimedia content, such as images, videos, audios, and presentations, with other people (Kaplan and Haenlein, 2010; Lee, 2018). Content sharing is regarded as a significant source of information distribution in social media platforms for ensuring the effective function of social networks (Shi, Rui, and Whinston, 2014). Content sharing sites' data also include unstructured textual data inside the metadata, such as the names and descriptions of these distributed multimedia materials; content sharing sites include Instagram, Flickr, YouTube, Vine, Spotify, iTunes, and SlideShare (Kaplan and Haenlein, 2010). The primary type of multimedia content can vary among content sharing sites depending on their intended purposes; for example, Instagram and Flickr are primarily focused on image sharing, YouTube deal with video publishing, Spotify and iTunes distribute audio files, and SlideShare is typically focused on publicizing presentations. In accordance with the organizational research, Instagram may be used to analyse the effects of ads, track user usage of brand-related photographs, and comprehend public reactions to certain situations. YouTube may be used to learn about user preferences for certain businesses, investigate behavioural targeting scenarios, and assess the negative consequences of viral films (Lee 2018).

Opinion Sharing Sites: Opinion sharing sites (online review platforms) feature online customer reviews made by users in order to express and express their opinions about various items, services, and organizations, such as tourism, hospitality, and food industries (Lee, 2018). Opinion sharing sites have grown in importance and power as UGC resources by integrating empirical and diverse data for online reviews of customers about their experiences, opinions, and complaints about the products or services they have purchased or experienced; most opinion sharing sites offer API services for data collection (J. Choi et al., 2020). Through analysing the effects of electronic word-of-mouth (eWOM) to investigate user decisions and preferences and the outcomes of marketing campaigns, online reviews can provide remarkable sources for management researchers; and these websites can be community-based, such as TripAdvisor, Yelp, and Lonely Planet; or they can be transaction-based, such as Expedia and Booking.com (Lee, 2018).

Social Bookmarking Sites and Social Tags: Social bookmarking sites are a collection of social media tools that allow users to save and organize online information resources by analysing, verifying, and sharing bookmarks with other users in order to express their personal opinions about these online information resources. Some other scholars see these websites as collaborative initiatives or online discussion groups (Kaplan and Haenlein, 2010; J. Choi et al., 2020). Reddit and Pinterest are examples of social bookmarking sites; users may use these websites to promote the launch of new products and

services. (Nam, Joshi, and Kannan, 2017; Lee, 2018). Reddit is a social bookmarking service that allows its users to submit posts on various themes for upvotes and downvotes in order to arrange the view of website pages (Akram and Kumar 2017; J. Choi et al. 2020).

Social tags are regarded as a major source of social media data from social bookmarking systems. These tags are described as specialized keywords made by users in order to convey their perceptions and provide greater relevance on various sorts of things inside the designated online contents in social media platforms (Nam, Joshi, and Kannan, 2017).

Microblogs, social network sites, and content sharing sites also provide social tags as a supplement for images, videos, posts, tweets, and links, allowing their users to generate, search, and observe trending topics to portray and categorize social communications, and to participate in online discussions (Nam, Joshi, and Kannan 2017; Klostermann et al., 2018).

The social tags on these sites are also known as hashtags since they use the hash symbol "#" to signal more relevance for this textual data (Klostermann et al. 2018). The social tags used in these social media platforms express the mental depiction of users' experiences across individual-related and brand-related contents by specifically categorizing, labelling, and inferring these contents; these insights assist managers in observing user engagement, opinions, and sentiments, as well as examining the context of customer experience (Nam, Joshi, and Kannan 2017; Klostermann et al., 2018).

Collaborative Projects: They are defined as websites that consist of the combined and instantaneous content creations of a large number of end-users; wikis are an example of collaborative projects because they provide efficient tools for enabling a user community to publish and edit web contents, discuss, and convey their opinions, and observe the revision history of the topics within these pages (Kaplan and Haenlein 2010) collaboratively and easily. As a result, it becomes a more important instrument for organizational information exchange in the business setting. Wikipedia is often regarded as the most well-known example of a wiki.

Social Commerce Sites: There are also some social media platform websites that are classified as social commerce websites. These websites are regarded as the combination of e-commerce and social media platforms, with the goal of developing communications between businesses and their consumers by permitting unique and inventive sorts of channels. The phenomenon of social commerce enables businesses to alter their business practices and establish digital business strategies based on online communities in order to empower customers as active creators of UGC (Hajli, 2015). Many firms (e.g., Channel, H&M, Dell) can encourage their users to contribute their experiences and views about their products or services inside their online community-based websites or brand profiles on social network sites in order to introduce and promote their products or services (Hajli, 2015).

2.1.4 User Generated Content

Because of the advancement of the internet and online channels, as well as the increased use of various types of social media platforms, more people are able to create and share content in an instant, interactive, and collaborative manner; thus, the concept of user-generated content (UGC) has gained popularity in the modern era. UGC, according to Saura and Bennett, is "the material contributed by users in social networks and social platforms." (Saura and Bennett, 2019).

Since there are vast amounts of UGC distributed across social media platforms in various data formats, UGC is also regarded as an effective source of big data, giving valuable insights for businesses to identify online behaviours of customers (X. Liu et al., 2017).

UGC on social media platforms seems to be a very important concept for marketing since it provides useful insights into a myriad of subjects related to products, services, and promotions through textual or other data formats, such as tweets on Twitter, videos on YouTube, and images on Instagram (X. Liu et al., 2017; Klostermann et al., 2018). Before the development of UGC, marketers had to undertake expensive and time-consuming surveys to assess brand perception and customer experience (Klostermann et al., 2018).

Nowadays, UGC makes it easier for marketers to do this sort of analysis, and customers are more inclined to contribute their thoughts about products and services on social media sites. UGC is also an important concept in various fields, such as start-ups, strategy, production, and marketing, by detecting essential characteristics of successful start-ups, analysing competitive analysis, monitoring product quality and defects, and developing marketing campaigns (Choi et al., 2020).

According to the literature, customers consider information on social media to be more dependable than information supplied through traditional marketing communication methods. As a result, social media should be recognized as an essential component of any communication strategy, as well as a significant role in any form of brand activity (Hutter et al., 2013).

2.1.5 Electronic Word-of-Mouth (e-WOM)

Word-of-mouth (WOM) is considered as a significant communication tool for business, as consumers initiate this type of communication in order to express their opinions and suggestions about specific products or services of businesses, independent of any commercial impacts among themselves (Litvin, Goldsmith, and Pan, 2008; Akyüz, 2013).

e-WOM is like conventional offline WOM in that it involves the exchange of product or service experiences and data, but it differs from traditional WOM in that it is Internet-based (Akyüz, 2013).

e-WOM is often characterized as a process of communicating and sharing thoughts with the other users of the Internet, as well as exchanging service reviews (Barreto, 2014), which enables accessibility and permanence for information that was previously inaccessible in conventional offline WOM. e-WOM varies from WOM in terms of interaction speed, number of users reached, and adaptability (Cheung and Lee, 2012; Akyüz, 2013). For example, WOM can only be effective through personal contacts, friends, and family members of people, and it can be time-consuming; however, e-WOM is much more effective than traditional WOM in providing people with the opportunity to convey their opinions and understand the correspondence of these opinions with different people, such as on online customer reviews, to influence a larger number of people or to obtain more useful information about the product. As a result, e-WOM must be considered as a crucial factor in the evaluation of UGC.

There are various sorts of e-WOM channels that have a significant impact on people's connections; these channels can be synchronous or asynchronous in terms of engagement, or they can build one-to-one, one-to-many, or many-to-many relationships for consumers (Cheung and Lee, 2012). In terms of social media platforms, online review platforms generate e-WOM for providing customer opinions to users as an asynchronous channel by ensuring one-to-many communication; to have access to the opinions of satisfied guests; blogs provide many-to-many and asynchronous information by spreading the news for specific products from various types of users; Litvin and his colleagues explain the type of e-WOM channels in Figure 4:

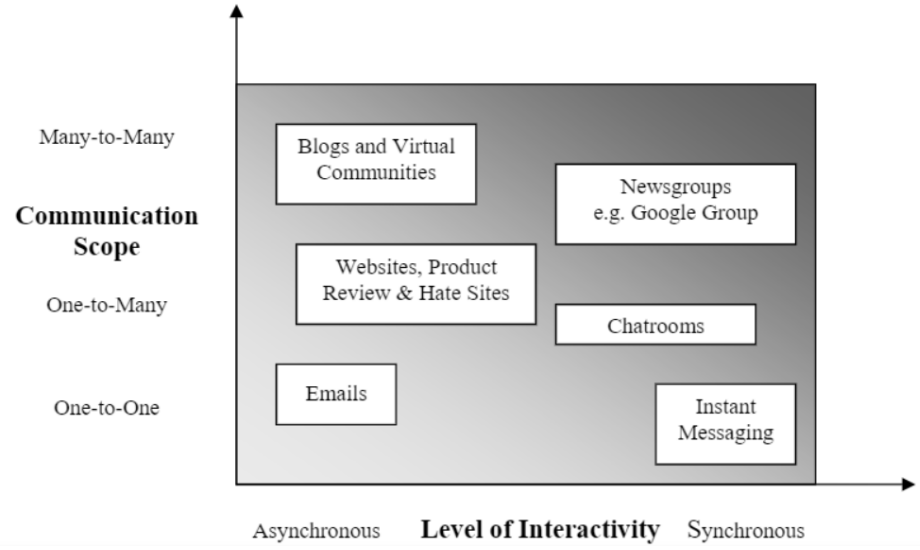

Figure 4: A Typology of Electronic Word-of-Mouth (eWOM) Channels
(Source: Litvin et. Al., 2008)

e-WOM may have a substantial effect on organizational performance; consequently, online reviews must be properly and continuously investigated to understand the primary variables influencing and disseminating e-WOM, as well as delivering insightful findings obtained through client use of e-WOM.

In words of the consumer, e-WOM can have a significant impact on the process of decision-making, loyalty, brand awareness, hotel comparison, and credibility; in terms of the company, e-WOM can have an important impact on revenue management, quality control, online reputation, the provision of recommendations for marketers and managers, and customer interactions (Cheung and Lee, 2012).

2.2 BIM AND BIM COLLABORATION

The second part of literature review addresses the other major components of the research theme: BIM and BIM collaboration. Firstly, definition of BIM has been explained and the challenges and transformations from BIM has been reviewed. Then the impact of BIM from inter-organizational perspective has been examined to make a clear understanding for collaboration between the project teams and BIM-enabled projects. Literature review has been concluded with the BIM Collaboration Format (BCF) and BIM-based construction networks (BBCNs).

2.2.1 Definition of BIM

Even though the original history of "Building Information Modelling" concept dates to 1970s (Eastman et al., 2011), nowadays it has multidimensional definitions. The semantics of the acronym BIM is not univocal but has a dual acceptation. First, technology is typically seen as an activity and process for developing various information models (Eastman et al., 2011). BIM, on the other hand, is considered as system-building information management - work and communication structures that improve quality and efficiency (NBIMS, 2007). Access to the worldwide Internet and its services, communication standards, diverse building classifications, and new ICT tools and services are perceived as major driving elements in BIM development (Christiansson et al., 2011). The main principle of modelling is to create a digital model prior to physical construction that allows for various simulations and analysis. BIM is now considered about as an integrated approach for product creation.

Azhar emphasizes BIM as a virtual process that encompasses all aspects, disciplines, and systems of a facility within a single, virtual model, allowing all design team members (owners, architects, engineers, contractors, subcontractors, and suppliers) to collaborate more accurately and efficiently than using traditional processes (Carmona and Irwin, 2007, as cited in Azhar, 2011). In this view, BIM is considered as the real workflow rather than a tool used in a workflow of the project. Moreover, benefits of this method include automatic fabrication, cost and material procurement, construction sequencing, clash detection, forensic analysis, and facility management (Azhar, 2011).

Companies that use BIM technology aim for increased work productivity, optimum design solutions for less waste of resources, lower energy consumption, and improved passive design techniques. It has the

potential to become a catalyst for integration, interoperability, and collaboration in the construction sector (Isikdag & Underwood 2010). Eastman et al. (2011) state that BIM has enabled a paradigm shift in the way information is communicated, transferred, and transformed, encouraging increased cooperation among the stakeholders who are interacting inside a Common Data Environment (CDE) during the lifecycle of a building or infrastructure asset.

The BIM model could have 7-dimensions, with the first three dedicated to spatial representation, the fourth to time and scheduling, and the fifth to cost estimation. Instead, there is no universal definition for the remaining two dimensions; 6D is specifically defined as "Phase of work management (use, maintenance, and disposal)," whereas 7D is associated with "Assessment of sustainability" (social, economic, and environmental). (Charef, R., Alaka, H., & Emmitt, S., 2018). So, BIM can be defined as "sociotechnical system" and cycles for enhanced utilization. The technological advancements of BIM have not only presented with new business solutions, but also with expanded dimensions for developing inventive solutions.

2.2.2 Extant Challenges and Transformations from BIM

The technology has enabled better collaboration and coordination among project teams, resulting in more efficient and effective project delivery. However, BIM is not without its challenges. As the industry continues to evolve, so the way we approach BIM.

One of the biggest challenges facing the AEC industry today is the lack of standardization (Criminale and Langar, 2017). Because BIM is still relatively new, there is no one “right” way to do things. This can create confusion and frustration for teams who are trying to use BIM on their projects. Without standardization, it’s hard to know what to expect from BIM or how to properly utilize the technology.

The usage of suitable Information Systems (IS) has been regarded necessary for information interchange across diverse stakeholders and might be utilized to combine the construction and design stages (Dulaimi et al., 2022). BIM is an information system which enables the participating parties for utilizing their preferred systems while exchanging comparable data in the IFC format, which is now the most widely used open data standard (Berlo et al., 2015). BIM has a significant impact on collaborative processes by changing information flow and encouraging tighter interactions. As a result of the usage of BIM, the roles of clients, architects, and contractors are expected to shift. BIM's evolving responsibilities include not just domain-specific and technical abilities, but also relational managerial issues.

Another challenge is the education and training required to use BIM effectively (Criminale and Langar, 2017). BIM is a complex technology, and it takes time and effort to learn how to use it properly. This can be a barrier for some companies who are hesitant to invest the resources required to train their employees. Finally, BIM can sometimes create more work for teams instead of saving them time. This

is typically due to a lack of understanding of how BIM should be used. If teams are not professionally trained in BIM or do not have a clear understanding of the technology, they can end up creating more work for themselves.

Dossick and Neff discovered that BIM improves transparency by displaying the links between Mechanical, Electrical, and Plumbing (MEP) engineers. However, BIM did not enable company-wide collaboration. The evolving nature of shared objectives and professional role integrations has consequences for construction professionals who may be called upon to execute activities outside of their specialized disciplines. Davies et al. emphasized that developing social competencies for cooperation, communication, negotiation, and teamwork with BIM requires a "mix of personality, experience, and training or education." Investing in social competencies might thus help to support growing BIM-related occupations.

Although BIM is predicted to offer significant benefits to the AEC sector, one of the most major challenges is considered as its implementation costs. Education and training expenses, administrative and start-up costs, and transition and behavioural costs are all perceived costs of adopting BIM technology. BIM requires the use of specific software and data storage, both of which incur considerable costs for a business (Liu et al.,2015).

Despite the challenges, BIM is still a powerful tool that can have a transformational impact on the AEC industry. With the right approaches on training and education and implementing the right standards, BIM can help teams to enhance their collaboration and coordination, resulting in more efficient and effective project delivery with an expected cost of the project.

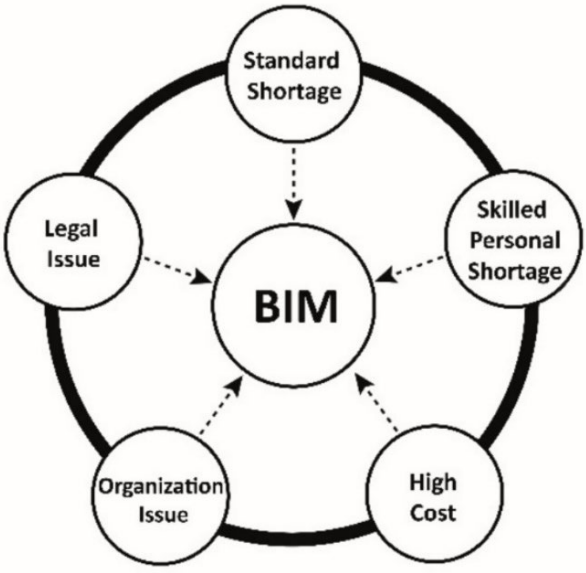

Figure 5: Challenges of BIM (Liu et al., 2015)

2.2.3 The Impact of BIM From an Inter-Organizational Perspective

In recent years, inter-organizational collaboration (IOC) has been widely recognized as a key success factor for the construction industry. The use of BIM is often seen as a potential enabler for effective IOC since it has the potential to facilitate communication and coordination among project stakeholders. However, there is a lack of empirical evidence on the actual impact that BIM has on IOC in construction. Construction projects necessitate inter-organizational collaboration because of their complex structure (Maurer, 2010). The most critical success factor is considered as trust between the project partners in inter-organizational project initiatives. The nature of the work in these inter-organizational initiatives requires stronger cooperation, coordination, and integration of construction teams and team members (Cicmil and Marshall, 2005).

Several studies have been conducted on the use of BIM in construction projects, with a focus on its potential to improve project management and coordination. BIM-enabled coordination can lead to improved project outcomes such as increased efficiency and productivity, as well as reduced costs and BIM-enabled IOC can improve team performance in terms of communication, coordination, and decision-making. In terms of the impact of BIM on specific IOC processes, several studies have found that BIM can facilitate data sharing and exchange among project stakeholders (Ashcraft, 2008). BIM can also improve communication and coordination among project team members (Yin et al., 2019). In addition, BIM has been found to support the effective management of change requests and the resolution of conflicts among project stakeholders (Ashcraft, 2008).

BIM implementation causes a variety of project-based, intra-, and inter-organizational challenges (Ashcraft, 2008). BIM impacts not only the technical and theoretical nature of construction works, but also the intangible and soft components of collaboration and communication, and therefore the relationship management of the team. So, adopting and implementing BIM is a multifaceted challenge. The idea of 'technological frames,' according to Orlikowski and Gash, denotes that actor can have various 'assumptions, expectations, and knowledge' regarding the usage of information systems, such as BIM. As a result, it would be worthwhile to look at the actors' beliefs and expectations regarding the usage of BIM. However, most BIM-related studies focus solely on the designer the facility owner, the contractor, or the engineers (Dossick and Neff, 2010), ignoring the BIM influence on the work of subcontractors and suppliers.

There is a dearth of knowledge of what BIM means to the participants in a multi-actor project network and how BIM affects the perspective of their roles. As a result, the construction sector may be thought of as a supply-demand network with many "action-reaction" relationships between its participants. As a result, a study of the meaning of BIM implementation in structured inter-organizational teams, particularly in legally binding partnerships with long-term relationships, might shed some light on how

responsibilities change as BIM is implemented. Such information is crucial since BIM-based collaboration requires better organized teams (Dossick and Neff, 2010).

Overall, the empirical evidence suggests that BIM can have a positive impact on inter-organizational collaboration in construction projects. BIM can facilitate communication and coordination among project stakeholders and can support the effective management of change requests and the resolution of conflicts.

2.2.4 Collaboration in Project Teams

The adoption of integrated technology provides an integrated manner of collaboration according to BIM rhetoric. Some of the collaborative relationship examples that have been improved are project alliancing, project partnership, and Integrated Project Delivery. However, according to some observers, the growing usage of BIM in construction projects has not significantly changed the core methods of working in disciplinary "silos." In their study on BIM usage observation, Neff and her colleagues find that work practices that enable improved collaboration and information exchange across organizational and disciplinary boundaries have not changed quickly, even though BIM usage has increased since 2007 (Miettinen et al., 2014).

Several studies imply that the building industry's fragmented and scattered structure generates antagonistic attitudes that do not support the types of collaboration based on trust (Bishop et al. 2009). Organizational and legal difficulties appear to be major impediments to long-term partnership (Dossick and Neff, 2010). The creation of multi-party relational contracts based on risk and reward sharing is one attempt to overcome this challenge.

A steady or gradual modification of existing organizational and collaboration processes would be an ideal organizational integration alternative. This necessitates an awareness of real-world BIM implementation issues. Miettinen et al. discovered in a Finnish project that the participant organizations were convinced that IPD while excellent goals for building more efficient collaboration, would not be practically implemented in the projects in the close future. Instead, the organization began to explore for new methods to extend its engagement with BIM. One option created and tested was a two-day intensive and meticulously planned collaboration to provide design possibilities for the customer (Kerosuo et al., 2013)

Collaboration is required for the successful execution and delivery of any project. Collaboration is relevant to several project management knowledge domains, such as integration, communication, and resource and stakeholder management (PMI, 2017). According to PMI, one of the most important roles of project managers in forming effective teams is to encourage cooperation and build a collaborative team culture. Walker et al. emphasize that collaboration reduces obscurity during the projects and assists

in the identification of risks and uncertainties. Collaboration is also strongly related to project team performance; consequently, project managers must understand what factors impact the collaboration of the team members in the construction projects (Caniëls et al., 2019).

Gray defined collaboration as a process in where partners dealing with different areas of an issue actively examine the differences and develop corrective solutions which extends each party's narrow perception of what is feasible. In addition, Ey et al. defined construction project cooperation as "...'shar[ing] resources' such as people, information, technology, and expertise for the better advantage of the partnership's members." Matthews et al. discuss collaboration as an agreement between various experts to share skills, including accessible data, knowledge, and expertise, in performing specific tasks with the goal of attaining the larger objectives of the projects which are stated by its client, or other project actors.

2.2.5 Collaboration and BIM-Enabled Projects

AEC is a project-oriented industry in which multiple organizations must collaborate through project-specific collaboration ties (Gann and Salter, 2000). Construction tasks are thus essentially dependent on team member participation. In contrast, in construction project teams, a lack of collaboration leads to misunderstandings, data misreading, weak communication, and, as a result, more rework. (Nikas et al., 2007; Hosseini et al., 2017). As a result, collaboration is regarded as "the cornerstone" in construction projects for boosting performance, unifying resources and processes maximize profits, and improving product quality. (Ey et al., 2014).

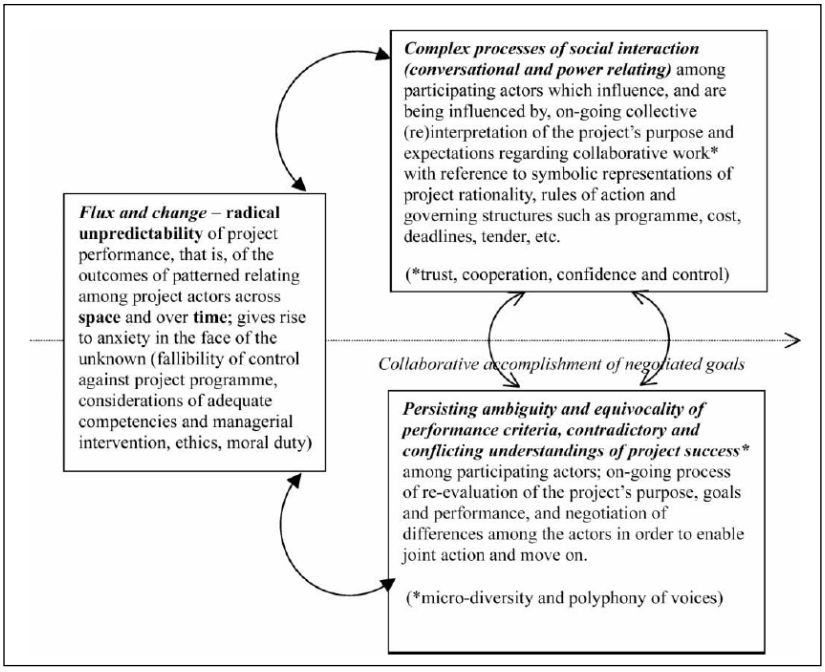

Figure 6: Understanding the complexity of construction projects: a conceptual framework (Source: Cicmil and Marshall, 2005)

BIM's technological advantages in supporting a collaborative atmosphere have been a primary driver to build projects in their journey toward BIM deployment since its inception. (Bassanino et al., 2014). Indeed, BIM is marketed as the definitive answer to building supply chain communication issues (Howard et al., 2017). Opposite of the widespread belief, studies prove that BIM-enabled projects are plagued by difficulties with team member collaboration (Mignone et al., 2016).

In principle, BIM offers a huge opportunity for improving collaboration. (Ashcratf, 2008; Dossick and Neff, 2011). On the other hand, once BIM is introduced, there is still a lack of awareness about what enablers and organizational factors must be considered for collaboration to exist (Matthews et al., 2018; Sackey et al., 2015). This issue is acknowledged by industry journals, who claim that, despite BIM's fundamentally collaborative character, the benefits of collaboration are realized only in a limited fraction of BIM-enabled projects. (Cao et al., 2015). Indeed, industry professional groups devote substantial efforts to improving cooperation among stakeholders in BIM-enabled projects (Stirton and Tree, 2015).

In BIM-enabled construction projects, work is performed by BIM-based Construction Networks (BbCNs), which are formed of specialist individuals from several disciplines who work on BIM-related projects (Oraee et al., 2017). The effectiveness of BbCNs is based on the proper transmission of information and robust communication amongst stakeholders (Love et al., 2011), both of which are essential for maintaining collaboration.

BbCNs have emerged as the central focus of collaboration on construction projects, by the courtesy of the rise of BIM as the cutting-edge technology for fostering collaboration. (Grilo et al., 2013; Mignone et al., 2016). Even the growing adoption of collaboration tools and technology, collaboration in BbCNs has been identified as an underperforming area. (Oraee et al., 2021). Mignone et al. noted that lack of communication has caused the ineffectiveness and low performance in the project teams and as a result it has lead design clashes and several failures (Sackey et al., 2015). According to the studies, collaboration in BbCNs needs a lot of attention to be encouraged in BIM-enabled businesses and construction projects. With regards to BIM's ability of low-performance cooperation, McGraw-Hill Construction (2017) discovered that the top five forecasted BIM investments recommended by significant AEC stakeholders were investments in building collaborative procedures with other parties. The data from the survey shows that one of these contractors' top five future BIM investment plans is to increase internal and external cooperation across project main stakeholders. Ashcraft (2008) declares that without collaboration, a BIM-enabled project is simply "scratching the surface" of what the software is capable of. This underlined the critical need of stakeholders to use interoperable methods, software, and tools for BbCNs (Grilo and Jardim-Goncalves, 2010).

2.2.6 BIM Collaboration Format (BCF)

The AEC sector is fragmented; many different specialists generate data that they share with one another. Each expert is concentrated on their own assignment as well as working with other professionals involved in the project. Previous studies have shown that employing a variety of aspect models, sometimes known as discipline models, can be more effective than requiring everyone to use the same software platform (Berlo et al., 2012).

However, experts believe there is an increasing need to send more information about the objects in a BIM model, regardless of how the model is perceived—as an amalgam of aspect models or as entirely integrated and centralized. The ability to share information about the condition of certain products or components of the model is a common desire among community members (Berlo and Krijnen, 2014).

Furthermore, as construction projects get more complex, it is necessary for the project manager and client to have access to a more complete picture of the project's progress in real time. The project manager and client thus need a consolidated view of how many items are viewed as final and how many still need to be authorized, in addition to the status of individual objects. In addition, they want to know which project partners are in charge of the majority of the unresolved problems and what the priority of the outstanding issues is.

The BIM Collaboration Format (BCF) is a buildingSMART standard that allows divergent software applications and planners to communicate about these "issues" in a digital model. BCF issues are linked to building components and are physically located in a model, but the format has just a weak association with the actual BIM model. Although the format is ideal for the task given, it does not permit getting data from the BCF in addition to the BIM model.

BCF is a standardized method of conveying "issues" amongst disparate software programs. A server-based approach that uses the BCF API[2] standard to share data and a file-based process where "issues" are written into ZIP packages using the BCF XML[3] schema is considered as two fundamental methods for data exchange. It is built on RESTful API concepts. It eliminates the need to send and receive files via email or a data device by enabling users from many disciplines to debate the reported "issues" online (Berlo and Krijnen, 2014).

The Institute of Applied Building Informatics, Solibri, and Tekla created BCF originally to communicate difficulties amongst various software applications inside of a digital building model.[4] In the first iteration of BCF, issues are organized in sub-folders within a ZIP file and are presented in an XML format. After that, the file may be shared and imported into other software programs that follow the standard. Round-

[2] https://github.com/buildingSMART/BCF-API
[3] https://github.com/buildingSMART/BCF-XML
[4] https://technical.buildingsmart.org/standards/bcf/

tripping is another feature of the BCF XML format which enlarges the same file with new issues and updates the current issues. As a result, the Issues are kept in fewer files, preserving their apparent structure.

The exchange of files by email or data storage media is a fault in linked processes and workflows even though the round-tripping method reduces misunderstanding and helps in tighter (Berlo and Krijnen, 2014). To solve these problems, the BCF API was created to replace file-based issue interchange in the digital building. This is accomplished by leveraging a server infrastructure that enables client programs to access to RESTful APIs. The data is acquired and processed in JSON format rather than XML. A wide range of project stakeholders may be included in the planning process because to the BCF server providers' ability to get, read, and update Issues using other software applications or websites (Schulz et al., J 2021).

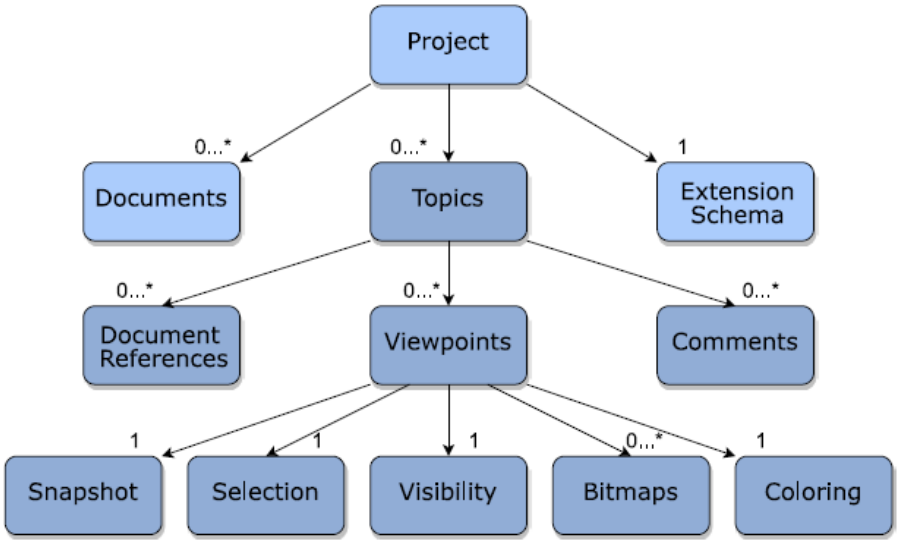

Figure 7: General structure of the BCF. The dark blue boxes form the Issue. Each hierarchy level represents a request to the server in the BCF API. (Source: Schulz et al., J 2021)

2.2.7 BIM-Based Construction Networks (BBCNs)

BIM has the ability to improve project processes in design, procurement, prefabrication, construction, and postconstruction, which is why it is increasingly integrating the construction sector (He et al., 2016). The deployment of BIM-based construction networks (BbCNs), where teams made up of people from specialized organizations are engaged to undertake BIM-related tasks, is a common method for delivering BIM-enabled building projects (Grilo et al., 2013; Mignone et al., 2016). These teams frequently include members of diverse professions and organizations with specialized skills and knowledge to address the different BIM needs of the projects (Grilo et al., 2013; Hosseini et al., 2017). BbCNs makes it necessary for team members to collaborate and share project data and information with

all key stakeholders across all disciplines for objectives to be achieved (Merschbrock, 2012; Stirton and Tree, 2015).

Construction projects now use BIM-based construction networks (BbCNs) as their primary working unit (Mignone et al., 2016; Oraee et al., 2017). One of BIM's selling advantages is its capacity to improve cooperation among these BbCNs (Dossick and Neff, 2011). For the success of BIM-enabled projects it is essential to have an effective collaboration in BbCNs. As a result, collaboration within BIM is critical in building project management. However, sustaining collaboration with the members of various disciplines and organizations has observed inefficient within the context of BbCNs (Matthews et al., 2018). Collaboration in BbCNs is a complex phenomenon influenced by several factors, including technological factors like interoperability (Yalcinkaya and Singh, 2015), social aspects of teamwork such as culture, and contractual and organizational aspects (Manderson et al., 2017; Turk, 2016). Research indicates that members of BbCNs continue to struggle with collaboration (Liu et al., 2017; Oraee et al., 2017). This places BIM-enabled projects at risk for a variety of issues, including as miscommunication, incorrect data interpretation, and increased rework (Nikas et al., 2007). Weak communication is one of the key dangers to BIM-enabled projects (Ashcraft, 2008). Despite the main consequence of poor collaboration, there are still many gaps in the literature on BbCNs collaboration need to be filled. This is because there has not been much work published that focuses especially on BbCNs collaboration (Oraee et al., 2021).

3 FINDINGS

Through investigating the studies based on the specific search and eligibility processes of systematic literature review, the findings and implications are detected and described in terms of the application of social media approaches and insights of social media platforms for the domain of BIM collaboration. First of all, the need for social media to improve communication in the construction industry and how the construction industry meets this need were discussed. Following that, it was explored how social media may help the construction industry, particularly with the sharing of BIM knowledge. After discussing the social media effects on knowledge sharing, it was examined that how social media can contribute to the BIM workflows after this shared knowledge. In the same chapter it was also discussed the possibility of an integrated work-flow system, and it prepared a base for an understanding for the next topic of engaging different stakeholders with social media such as architects, project users and even the citizens of the neighbourhoods for the decision-making phase of building designs. And lastly, the different social aspects of BIM were discussed in phases by evaluating the interrelationships of these phases.

3.1 Social Media Acceptance in AEC

Because of the construction industry's unique project-based nature, different participants with diverse skills and knowledge are required to achieve the project objectives for a collective approach. Construction project teams include various professions are assembled to perform planned, specific tasks in a limited time and they disintegrate after the project execution (Buvik and Tvedt, 2017). However, the challenge of communication issues in these project teams is aggravated by this diversity and the increasing number of team members (Turk and Klinc, 2020). As a temporary entity-based team with intense time limitations, the team members usually lack face-to-face communication (Senescu et al., 2013). Considering this, project managers for the construction industry are beginning to incorporate mobile information and communication technologies (ICTs) into their work (Hasan et al., 2019).

Other industries have used social collaboration tools like SharePoint, IBM Connections, and Confluence extensively for information sharing, including the automobile, industrial, information technology, and oil and gas industries. However, the cyclical nature of building projects, people's aversion to change, and the industry's significant fragmentation make it challenging to adopt such platforms. Historically speaking, the construction industry has been slow to accept ICT developments. The industry has built tools to capture explicit information produced on projects but not domain knowledge (Grover et al., 2016).

Management (Jia et al., 2020; Nisar et al., 2019), communication (Leonardi, 2014), and virtual collaboration have all attracted scholarly attention because of significant changes in companies related to social media use (Zhang et al., 2018). Despite some studies focusing on social media adoption from

an organizational perspective, few is known about the factors that influence social media adoption through the context of construction projects (Hasan et al., 2019).

The construction sector has been dealing with the ever and sophisticated demands that require the most effective use of resources. As a result, the construction sector is also a sector that operates as a reference network. In other words, people tend to collaborate with people they know and trust, who know the answer when they asked a question. It is all about social communication. In a traditional working life, an individual may meet a small number of people each week, but with social media, people can find professionals from all over the world, chat with them online and ask them specific questions anytime, day or night. As a result of this communication shift, project life cycles are slowly decreasing. As a result, the construction industry has evolved, with the segmentation of production duties into various subprocesses divided among many stakeholders who belong to different organizations with diverse policies, objectives, and practices. To accomplish this alteration, the construction sector must rely on foreign expertise and technology, resulting in the creation of virtual teams of people attending from various locations. As indicated in Figure 8, such teams are anticipated to consist of qualified personnel representing the appropriate divisions within the organization.

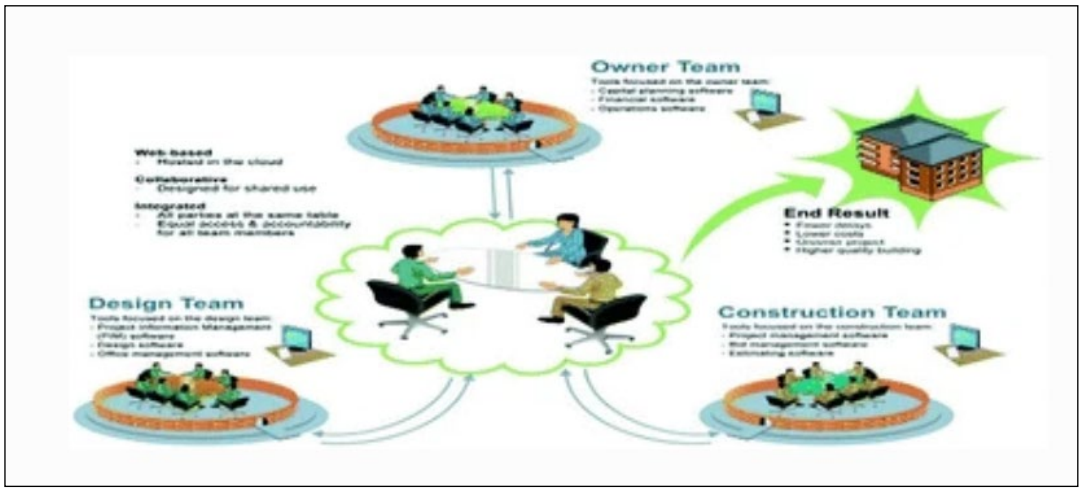

Figure 8: Concept of a virtual team (Source: Kaur et al., 2016)

As a result, this can become a very efficient way of doing business. For example, when talking to someone you do not know or exchanging ideas about something you do not know, you might naturally search for them online through social network sites; you can find profiles on Google or LinkedIn and even discover that another group of people are dealing about the same topic. As a result, you can join the conversation and participate in discussions on this topic online through opinion or content sharing sites. So, this means that social media and the internet can be used effectively to collaborate, conduct research, it can be used to learn or teach without even moving from the exact physical space.

So where do people have these conversations? There are all kinds of platforms all over the internet where you can post, share, and discuss information. Today, there are many social platforms such as Facebook, which is used by the majority of the general population, LinkedIn, Twitter, and Google+, which is used by the population in business life, as well as YouTube, which is also used extensively, Instagram, which has become popular recently, Pinterest or Tumblr, which is used as visual reference websites. These platforms, and hundreds more, were originally conceived as start-ups by techy people trying to find technical solutions for specific purposes.

But what about some common myths and prejudices about social media? The most common belief is that social media is full of junk and irrelevant content and posts. This is because there is so much content being produced; people do and share too much on social media. When it is only looked at from the outside, there can be a prejudice that a platform like Twitter, for example, only talks about celebrities or breaking news or the most popular phone brands.

Another common misconception is that social media is a waste of time, and it is all too easy to waste time with all sorts of things. So, it is a question of what is done with the tool rather than the tool itself. Grover et al. discuss that the main barriers preventing knowledge sharing via social media platforms are dread of the extra time and effort needed, worries that it could just be another underutilized information system, and the concerns of not receiving useful knowledge in return. However, it is possible to make some searches and get information without being included in such content. (Figure 9)

Figure 9: Information search on twitter through hashtags (source: twitter.com)

Social media can be used much more efficiently to find the right answers to questions. As if asking the person across the table, a content can be detailed, and the information needed can be found immediately on the internet; even so that extra time can be gained to think about the other thing.

Social media has invaded daily routines and workplaces of people both inside and outside as a reflection of mobile ICT (Song et al., 2019). Due to the perception that the construction industry is very conservative, it can be thought that social media will not be popular in the construction industry. But there is something that connects the things together and that is the fact that it is all about relationships between people in construction.

Even if the impacts of social media on team or organizational performance have already been studied (Ma et al., 2021), it is more important to look at how project team communication has changed since poor team member communication has become a threat for the success of the projects (Zhang et al., 2018). With this approach, if project teams consider social media as highly suited for dealing with project challenges such as information transmission, they may adopt it since they perceive project complexity in terms of project scale, objective or team necessitates such affordances. Furthermore, social media offers team members creating social bonds and exchanging information among project participants with channels (Ling and Lai, 2016), which supports the project coordination.

3.2 Social Media and BIM Knowledge Sharing

Nowadays BIM is an enormous topic; it is a very new issue; it is going to be an already huge disruptor in AEC industry and lots of people have misunderstandings about it and need to learn about it (Banks, 2013a). There are people with a lot of knowledge but most of the people in AEC industry do not have enough knowledge or experience on BIM, so how can this information be shared more? An effective way to do this is to use the internet because it is efficient, it allows people find things very easily, and it also gives a chance to people chat about it.

One of the problems with a topic like BIM is that there is too much information and how and where to find the information needed. At this point, the primary advantages of Web 2.0 comparing to the traditional knowledge-management solutions are simple usage, capabilities on search, availability of open-source, and its ability to re-create a virtual social environment through stimulating debates (McAfee, 2006). Such social platforms could capture both tacit and explicit information created every day in projects and share it with other stakeholders, resulting in cross-project learning. According to Panahi et al., the usage of social web technologies might be viewed as supplementary to enhance knowledge capturing and sharing.

So, it is especially important to create content to be able to share information. There are many key elements that influence professionals' knowledge sharing behaviour on social media platforms,

including personal (benefits, social media expertise), organizational (managers' and colleagues' engagement, guidelines, collaborative features), and technological aspects (user-friendliness and skills required) (Grover et al., 2016). Therefore, writing about one's expertise and sharing content not only helps to demonstrate credibility, but also allows the information to be shared with a wider audience, people interested in this specific topic can find this content through search. The key motivators for professionals are the desire to achieve collaborative goals, support colleagues, and acquire knowledge in return, all of which are intrinsic advantages (Vuori et al., 2012).

It is quite popular in these days, people on social media are creating hashtags to share or mention about a specific topic. What is a hashtag? A hashtag is a metadata tag that is prefaced by the pound sign or hash symbol (#). Hashtags are used as a form of user-generated tagging on photo-sharing and microblogging platforms like Instagram, Twitter, Facebook, and YouTube to facilitate cross-referencing of information for sharing a subject. In simple words, hashtags make a word, a piece of content clickable. That is, when a hash sign (#) is placed in front of a word or phrase, it allows access to all shares and content related to that phrase anywhere on Twitter or even on Facebook or somewhere else on the internet.

As an example, Sue Butcher, a Social Strategist in Construction industry, says that UK BIM group hashtag which was created originally for a group of people who are going to a conference in USA to keep in touch with the UK people at that conference for a specific purpose, but it has turned into a place where people can find other useful, helpful people who are interested in the UK in talking about BIM. She states that in case of using that specific hashtag, it is possible to get information about, for example, "common data environment" or a specific knowledge about a specific software (Figure 10). This hashtag makes the information reachable from all around the world and it provides interactions with people to get answers for the questions or it helps to get suggestions about the topics they have been talking about.

She also claims that, for those who do not willing to participate that public realm and do not want to participate in such conversations might just check the relevant people's name on Google or in another database and they can find a useful phone number, or an e-mail address and they can reach those people as offline, or they can make more private connections. So, it also proves that there are different methods to use social media.

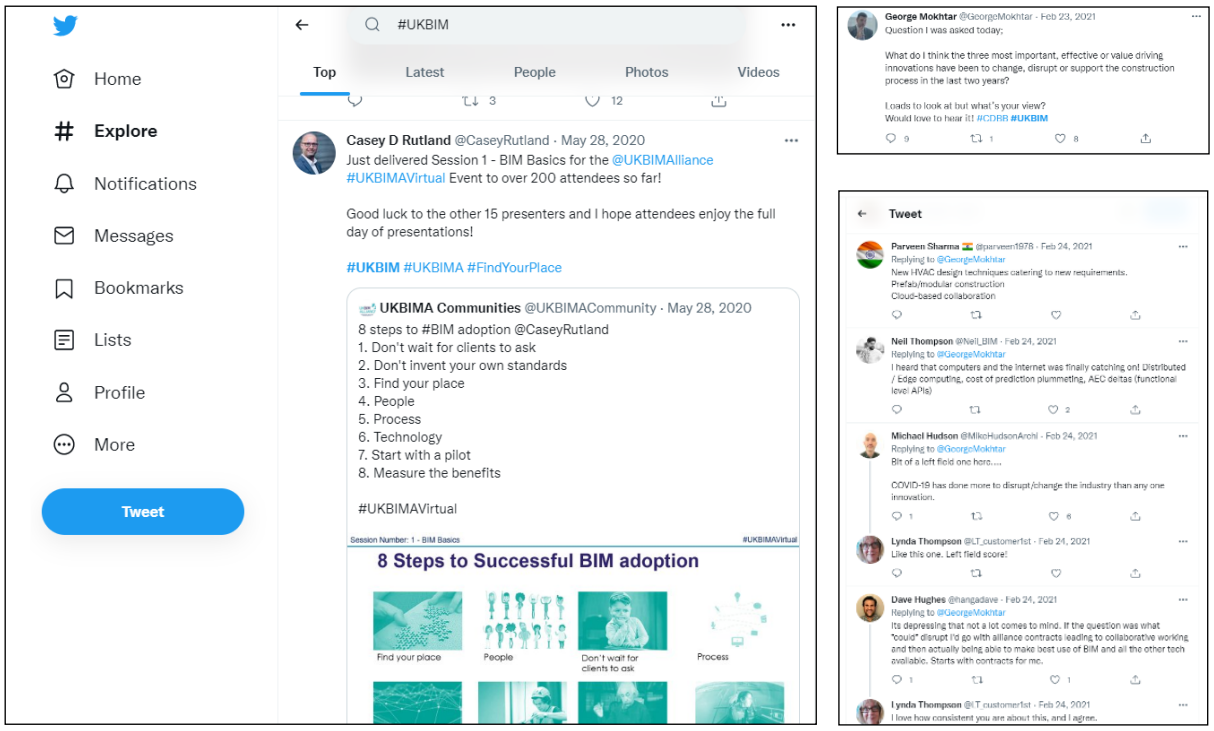

Figure 10: Discussions and information exhange on a BIM topic (source: twitter.com)

As another example YouTube, is a platform to share knowledge even for free, has become common to have conversations on the comments section under YouTube videos (Figure 11). So, it is also even a blogging platform where people can join a community and participate discussions such as the level of their BIM expertise (Figure 12) or the knowledge they have.

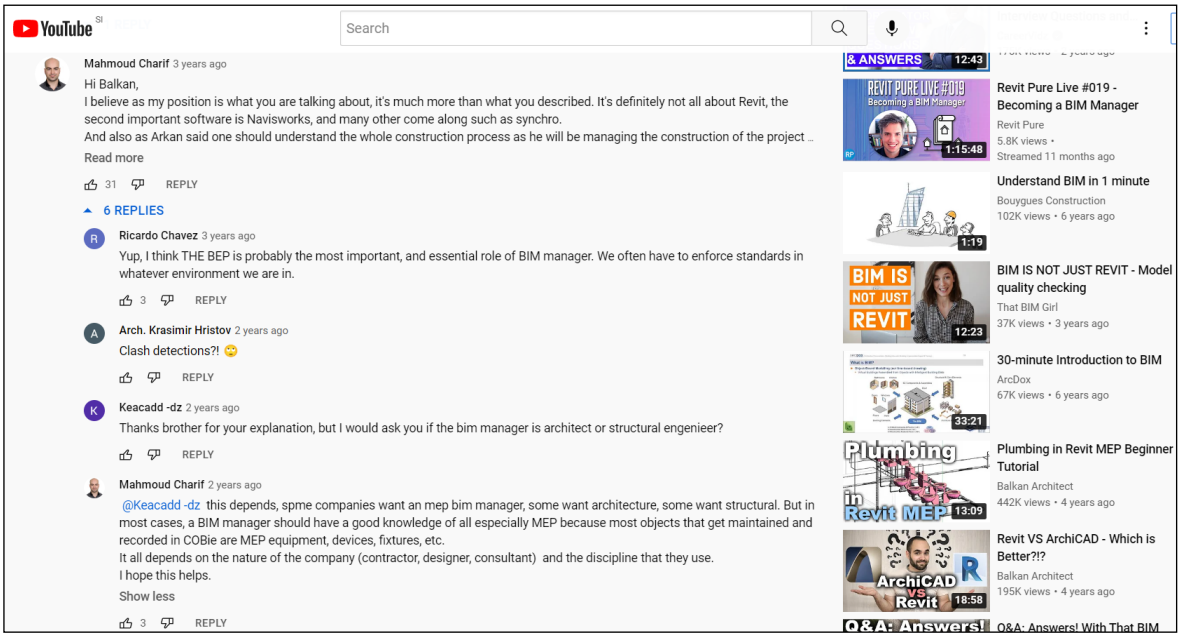

Figure 11: BIM knowledge sharing through social media comments section (source: youtube.com)

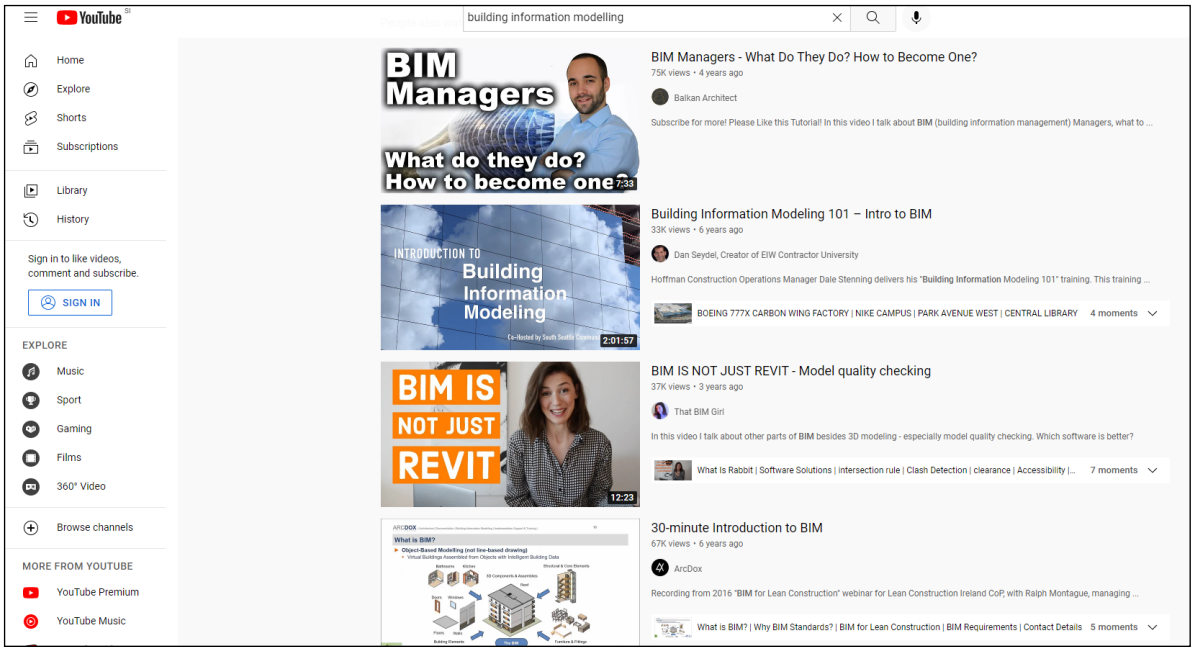

Figure 12: BIM discussions on different YouTube channels (source: youtube.com)

3.3 Collaborative Working for BIM Workflows through Social Media

As it is discussed on the previous chapters, BIM is not just about 3D models; it is about data and information, it is about collecting and working together on that information. Therefore, it involves people and a cultural relationship. So, BIM is about as a cultural change within the construction industry; it is about encouraging more effective, efficient working through collaboration and that is why social media, and the concepts of social media should be applied within BIM to enable an ideal connection between two.

For more than 20 years, the construction industry has been discussing collaborative working. In 1994, the Latham Report revealed strategic issues with the construction industry and began to discuss cooperating and teamwork (Latham et al., 1994). The 1998 Egan Report went a little farther and recommended replacing competitive tendering (Murray, 2008). Then, Constructing Excellence (CE), which is the cornerstone of cooperative working in the construction industry and has defined KPIs as well as several sample projects, was then formed in 2003.

What is collaborative working? Constructing Excellence has a definition for collaborative working: "Working together in a seamless team to common objectives that deliver benefit for all through mutually

beneficial (i.e., including commercial) alignment."[5] In other words, collaboration is working together where each benefit more than they would individually.

Constructing Excellence defines six critical success factors to the implementation of genuine collaborative working to be able to reach collaborative nirvana, it is necessary to have all these six things:

1.Early Involvement

2.Selection by value

3.Alligned commercial arrangements

4.Common Processes and Tools

5.Measurement of Performance

6.Longterm relationships

All six of these characteristics are essential for BIM to function successfully, and BIM provides the type of joined-up thinking that allows collaborative working to occur. So, it could be said that collaborative working is a pre-requisite for BIM, and vice versa.

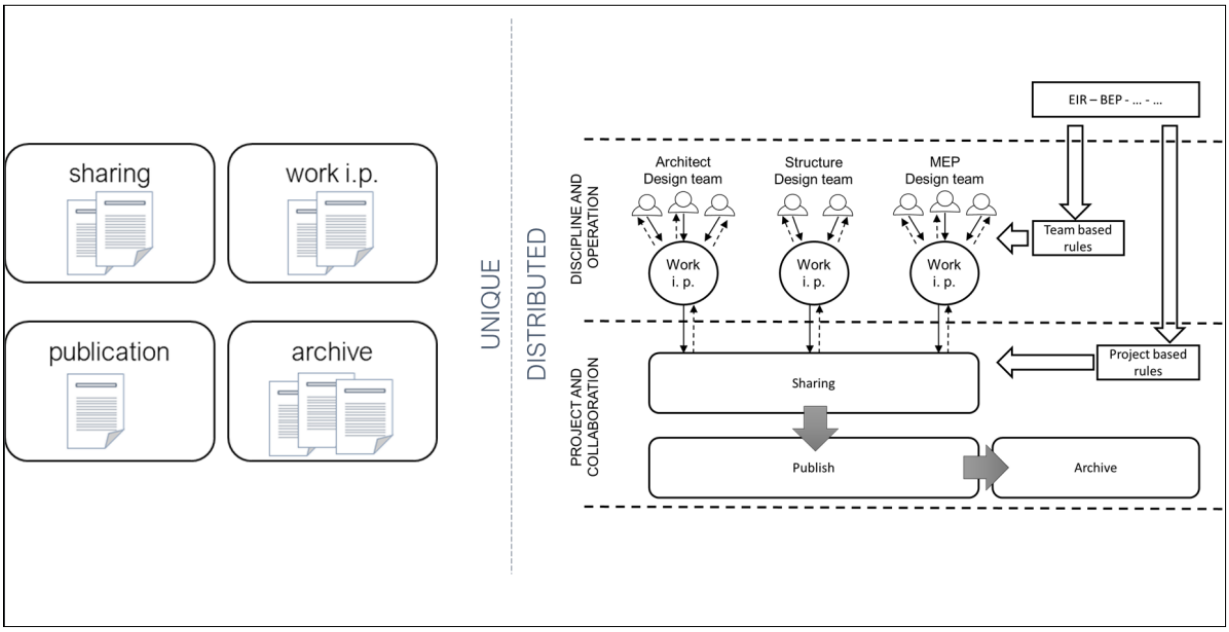

Figure 13: Common data environment structure (Mirarchi, 2021)

[5] Constructing Excellence, "Collaborative working: The principles" (London: Constructing Excellence, 2011).

For example, Figure 13 is a representation of common data environment structure with the work of architect design team, structure design team, and MEP design team connected with the shared information and with the people interacting with the information. In such case, what happens if something goes wrong? Presumably, one thing might be done is to e-mail someone who might know the solution. But in this case, there might be long treats of overly complicated interactions or there might be a security issue or even the mail might not reach the target person. Instead of that, as a solution, the problem might be shared on a social media environment; a screenshot of the problem or a link to the data or even the combination of those might be shared as a start. This approach might invite a lot of other people to involve in the topic so one person might offer a solution, the other one can give an information; it can be a link or even a word document or an image from the internet (Figure 14 and Figure 15). Those things might also be links to a product information, or another information shared by other people in somewhere else. They can get pulled into this environment and added on to this thread here. When the information needed is found, the person who raised the problem states that the problem has been resolved and the discussion would be closed.

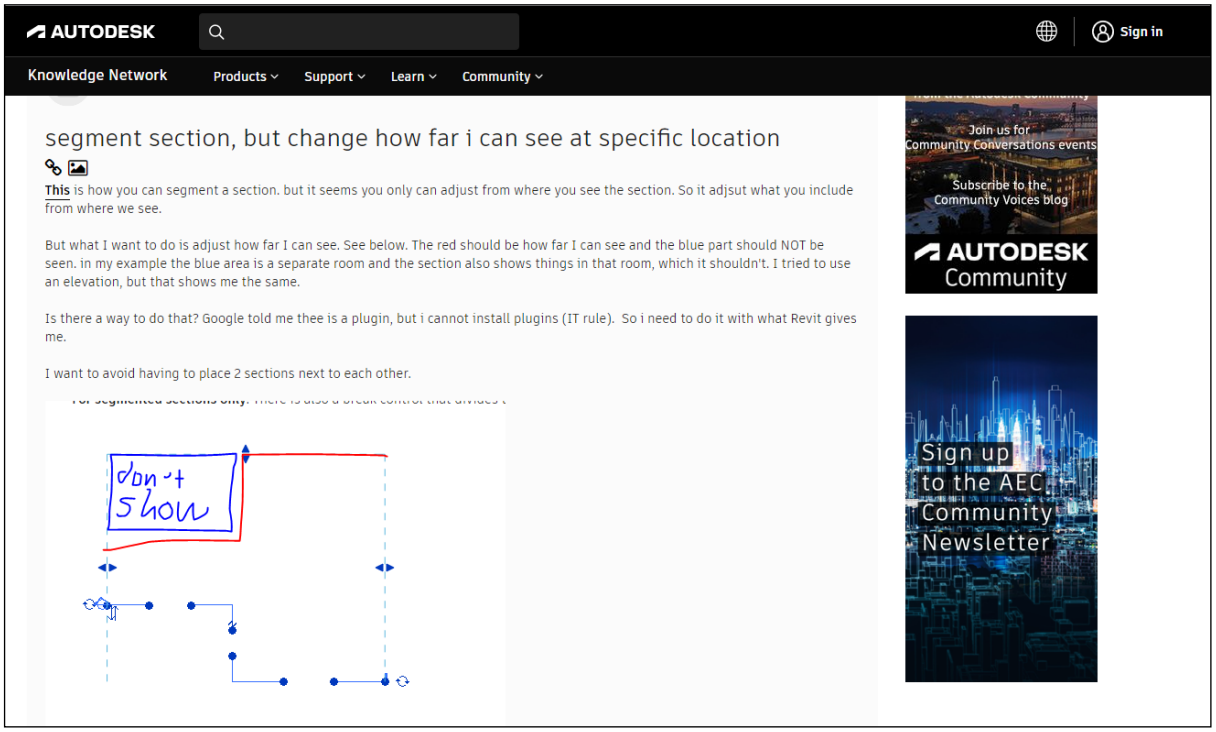

Figure 14: Problem statement about a software tool on Autodesk forums (source: forums.autodesk.com)

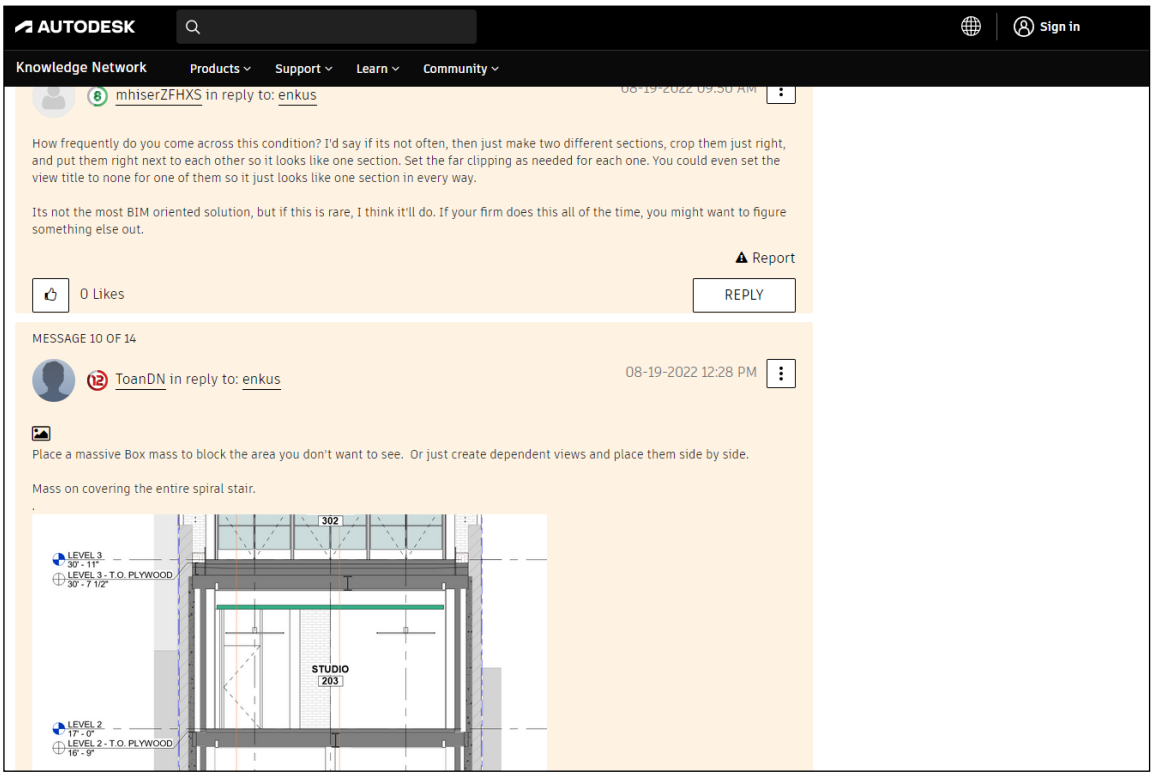

Figure 15: Information and knowledge sharing for the solution through Autodesk forums (source: forums.autodesk.com)

More than a decade ago, A technique was utilized by Dave and Koskela (2009) to assess a social media platform for a construction company; the platform permitted interactive knowledge sharing, offered substantial user interaction, and the supplied information was immediately put to use in the workplace. This research also pointed some of the issues connected with deploying a platform for latent knowledge capture, such as simplicity of use, team cohesion, the relevance of knowledge sharing in organizations, and managerial engagement. Tan et al. note that the following needs must be fulfilled for the live capture and reuse of project knowledge in their paper: accuracy of information obtained, simplicity of knowledge capture and reuse, and avoidance of legal issues, additional expenses, or worker workload. A web-based knowledge repository, an integrated work-flow system, and a project knowledge manager are the key components of their recommended live knowledge capture and reuse approach (Grover et al., 2016).

Then why AEC sector is not doing an effective collaborative working? Sue Butcher claims that it is about culture and behaviour. The reasons behind it there are already ordinary methods of doing things and the sector is resistant to change. But more importantly there is a thinking that the power to change things is vested in the large organizations, such as the institutions, such as the large contractors, and the media and most of the people in the society is sitting around, waiting for them to get on with it. But instead of thinking about things on a large scale, it is needed to think about rethinking construction on a

small scale. Instead of the big gestures, the attitude needs to change to collaborative working as individuals and to change things one step at a time.

With a closer look, social platforms like Yammer, Chatter, Slack, and many others have been developed by specialists all over the world. Even though all the platforms available for professionals, there are still not many people in the construction industry to start integrating social media tools with BIM to enable social collaboration to happen within that environment. As a matter of fact, using the social media platforms effectively is going to make a significant commercial benefit for professionals and it will make collaboration work effectively in construction industry (Butcher).

3.4 Social Media and Democratizing Building Design + Operation

How can social media be incorporated into the actual process and uses of buildings? For example, construction companies may need to use PR agencies to tweet pictures of buildings under construction or when completed, or construction companies may need to get involved in the planning process by doing a consultation. But these processes are extremely limited and very controlled and at the same time almost unidirectional. It needs to go further because social media is about people interacting, it is not just about broadcasting. What construction companies are currently largely overlooked with social media is precisely that they ignore social media and do not get involved in discussions.

AEC society need to move beyond that AEC society is more intelligent than that they need to think. It is more about how the process can be used to benefit the AEC sector as an organization and society as a whole.

Open innovation, with "crowdsourcing" as a primary strategy, is a method of internet-based citizen participation wherein designers may obtain new visions for their work from a large population, also known as a distributed problem-solving approach (Seltzer & Mahmoudi, 2012). Lane (2005) discusses crowdsourcing objectives, the need for active public engagement, and a diverse perspective of society in a study of citizen participation in planning. Healey (2003, 2006) frames communicative planning as collaboration among all process actors, including citizens, planners, and decision makers.

The New Library of Birmingham, a major public space and landmark building for Birmingham City Council, using a strategy that encouraged end-user feedback. Birmingham Library was modelled in order to real people to experience it before it was built. When the new Birmingham Library was being designed, a model was built of it in a platform called “Second Life” which is a three-dimensional immersive environment (Figure 16) in which people can walk around and explore things. What was done to construct the full model of the building design and then invite the public to enter and explore it. This meant that they could learn from the way the public used the building directly, and from people who, intuitively, naturally do what they would normally do.

Figure 16: Proposals for the New Library of Birmingham as seen in Second Life (image courtesy of Second Life, source: theb1m.com)

In her article 2015, Butcher has mentioned another example software called "sticky world"[6] which creates a three-dimensional environment in which people can visit and use it for things like community consultation and, people can go in and put sticky notes on the wall on their buildings and ask questions and put in comments. With this method, it is possible to see what people have said over the process; they use it for all sorts of ways in which is trying to encourage people to interact with buildings.

Figure 17: Examples of Sticky World, allowing stakeholders to move around proposed spaces and post comments on virtual sticky notes (images courtesy of Sticky World, source: theb1m.com).

[6] The software does not exist anymore on 2022.

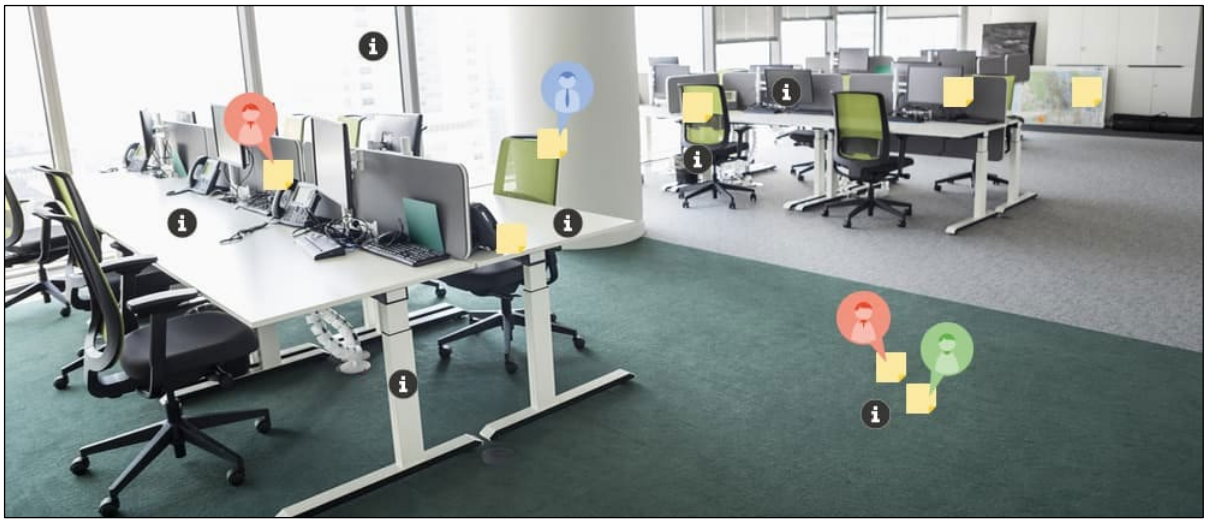

Figure 18: Examples of Sticky World in action, allowing stakeholders to move around proposed spaces and post comments on virtual sticky notes (images courtesy of Sticky World, source: theb1m.com)

What does this have to do with BIM? There is a lot of technical data that can be produced using BIM, and there is a lot of information that can be generated during the commissioning process of the building. Nowadays, commercial property owners are collecting live energy consumption data from their buildings to help their tenants save money and understand how they use energy. That can allow them to compete with their competitors by having an extra value added to what they are offering, and all that data is available already in a way which can be shared if it is willing to be shared.

In the same article, Butcher gives another example platform, called "Honest Buildings"[7] to use the concept of open data that is making data available for people to use in lots of diverse ways. One of the things has been managed to do is to get a lot of energy performance data and certification that relates to buildings and add that into the collection of buildings. Essentially it can be thought "Honest Buildings" as LinkedIn for buildings instead of for people, so it allows to connect individuals up to a building if the company is involved in a project. People can come along to see the energy performance data of the building. They can learn about the successes of it, they can learn about the techniques that were used in its production. There is also a commercial benefit in that as well because the people who participate in it also get their credibility mentioned.

[7] The platform has been changed into another service and it does not exist anymore on 2022.

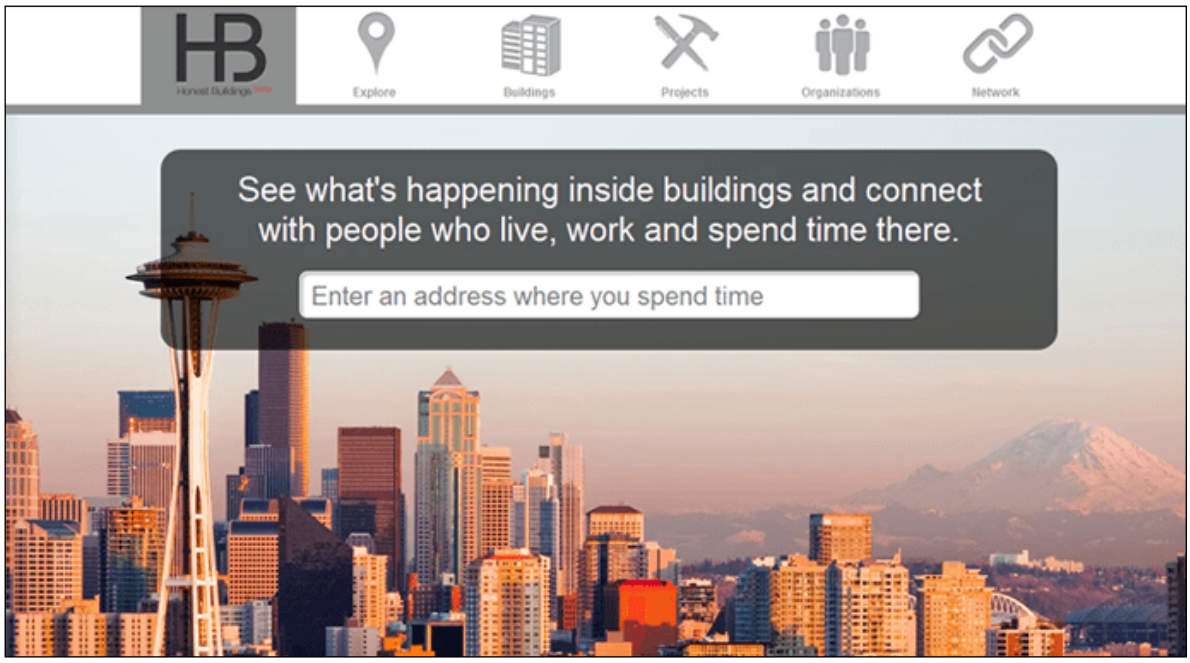

Figure 19: The Honest Buildings platform (source: theb1m.com)

3.5 From Lonely BIM to Social BIM

Even if BIM is a growing trend nowadays, many businesses continue to operate in conventional methods; they continue to act independently in the project process while they utilize software for project preparation and model sharing. In this approach, just one party takes full advantage of the model, and models do not fully comprehend their collaborative potential. (Benson and Hartzog, 2009; Sinclair,2012 cited in Suwal et al., 2013) So, the term “lonely” for BIM refers to this approach which is also defined as level 1 and early level 2 BIM projects (RIBA BIM, 2012) while the term "social" BIM refers to the integrated collaborative approach and process of product information modelling where all stakeholders interact to obtain the full benefits of BIM technology (Figure 20).

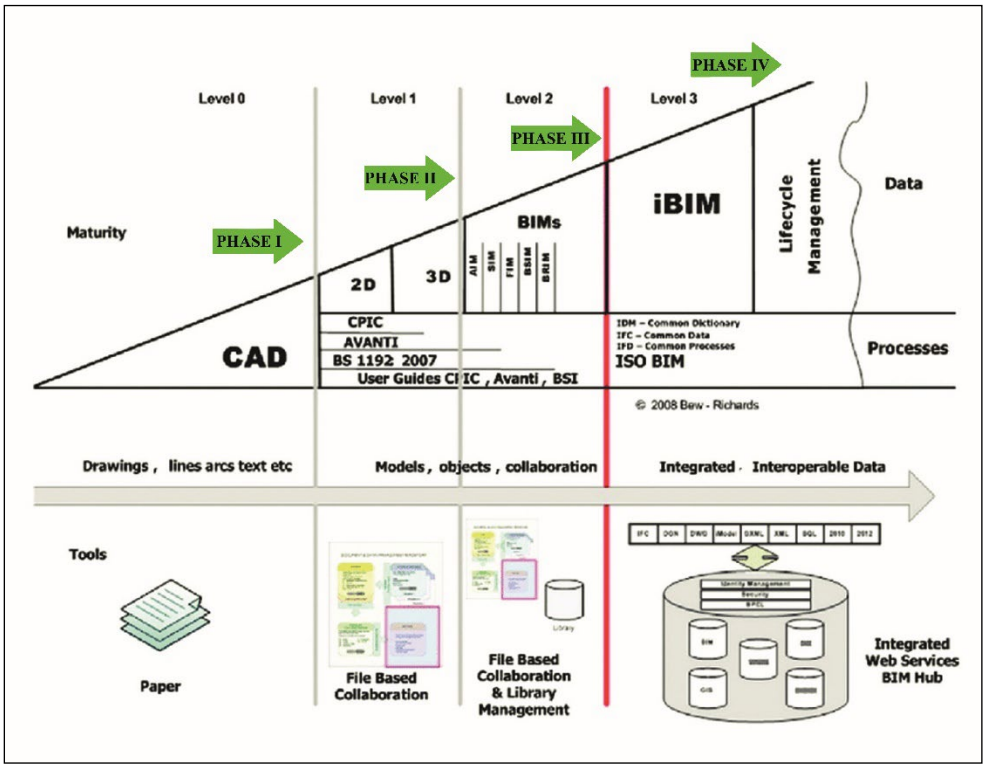

Figure 20: Bew-Richards BIM maturity diagram

Banks (2013a and 2013b) defines for the distinct phases of BIM adoption as BIM flavors, and illustrates the pyramid of this quadrants as follows in Figure 21 and Figure 22:

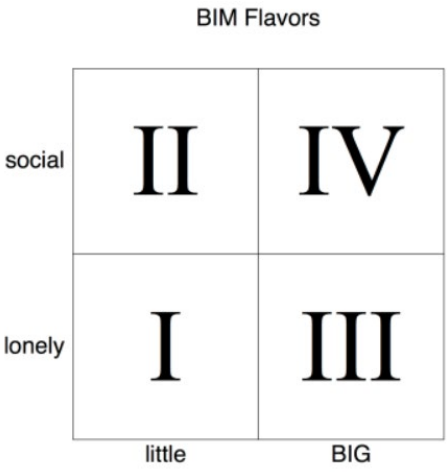

Figure 21: BIM Flavors (Source: Banks, 2013b)

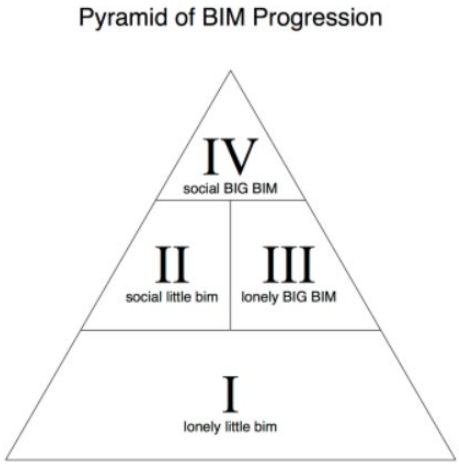

Figure 22: Pyramid of BIM Progression (Source: Banks, 2013b)

Quadrant I – lonely little BIM – PRODUCTION: It is the starting phase of BIM adoption in an organization. This adoption focuses in deploying BIM for enhanced productivity and better workflow within an organization to achieve various frontend BIM benefits like automated documentation, easy visualizations that CAD technology does not provide. Even though this approach allows the organization to manage more projects, lonely little BIM will become the baseline for all architectural work and will no longer be considered an advantage.

Quadrant II – social little BIM – COORDINATION: It improves coordination and communication between clients and consultants simultaneously. During lonely little BIM helps to make the company's documentation more accurate, social little BIM helps the AEC team to be more in harmony.

Quadrant III – lonely BIG BIM – DESIGN: The key benefit of Lonely BIG BIM is that it enhances the design process. With the ability to collect more data, design decisions may be better informed and may have a greater impact on the entire project. There is a change from assuming to knowing. Professionals may employ the I in BIM for creative reasons thanks to lonely BIG BIM.

Quadrant IV – social BIG BIM – INTEGRATION: The most unclear of the four quadrants is integration. It addresses real BIM with the integrated collaborative approach between all the stakeholders at almost all the project phases with a smooth workflow between various disciplines of authoring tools.

Quadrant I "lonely little BIM," With varying degree of BIM implementation and usage, lonely quadrants (I and III) focus towards the use of BIM for internal benefits and social quadrants (II and IV) defines the social aspects of collaboration. Quadrant IV "social BIG BIM." (Suwal et. al., 2013)

Shown in Figure 2, the transformation from traditional CAD-based workflow to full BIM use is illustrated by the shift from quadrant I to IV, while the arrows show the potential approaches currently utilized in the industry.

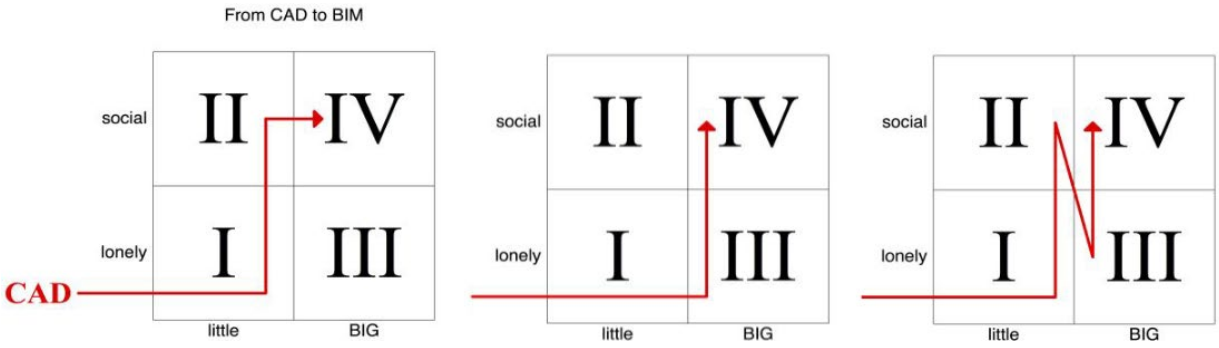

Figure 23: Various transitions of BIM from CAD to social little BIM on left I-II-IV, lonely BIG BIM in the middle I-III-IV, and social BIG BIM at right I-II-III-IV (Banks, 2013a)

The main constituents of these various flavors are shortly presented as follows (Banks, 2013):

I. lonely little BIM: The different BIM authoring tools in the lonely little BIM are used to create the project model and traditional printed set of documents. Because of its key benefits such as minimizing errors and effort through coordinated documentation, rapid 3D visualization of the project, and so on, BIM is generally utilized for boosting the workflow in individual companies (Suwal et al., 2013). The BIM developed is primarily intended for internal production advantages and is not shared with other disciplines. BIM authoring tools are mostly utilized as a fancy tool for virtual model creation which is transferred into different other visualization applications for further manipulation of the objects to produce different visualization media like realistic photo-renderings and walkthroughs.

I-II-IV social little BIM: In addition to lonely BIM, the social little BIM approach distributes BIM data with other collaborators and between various BIM authoring tools via little or one-time 3D data transfer, typically within the design phase or during the construction phase. This procedure does not contain needed BIM data for the operation and maintenance phase or the facility management phase. Furthermore, several features of collaborative BIM and nD characteristics are not considered.

I-III- IV lonely BIG BIM: Even the BIM data is shared with basic 2D conventional forms and printed set. Lonely BIG BIM extends beyond visual use. Its primary advantage is that it increases efficiency and effectiveness in the design process. BIM is used to generate and analyse comparative alternative solutions for informed design decisions. This technique uses a single small BIM with capabilities such as energy assessments, quantity take-offs, cost estimates, and so on, but is primarily focused on its usage for individual purposes.

I-II-III-IV social BIG BIM: The fact that all stakeholders employed an integrated collaborative strategy and there are many different writing tool disciplines makes this method considered to be true BIM. Throughout the project lifetime, the entire potential benefits and advantages of BIM implementation are actively investigated and taken advantage of. Additionally, it contains nD models that are shared between customers and partners for a variety of investigations, including in-depth energy analysis. (Suwal et al.,). Various features like clash detection, detailed energy analyses, constructability analyses are actively used during design and construction phases as well as data communication with other non-building related applications for building lifecycle is also conducted. This process defines and exposes the maximum benefits what BIM could give today.

Different social aspects of BIM can be generalized under a common title of Social BIM where the degree of socialization varies. These different BIM flavors of socialization are still growing today and will encompass new perspectives because of technological innovations for the construction industry.

4 DISCUSSION

Through investigating the studies based on the specific search and eligibility processes of literature review, the findings and implications are detected and described in terms of the application of social media approaches and beneficial insights of social media platforms for the BIM and BIM collaboration research.

In this chapter, first the collaboration barriers are discussed according to the conducted literature review. Then it is attempted to explain how to enhance social dimensions of BIM for better collaboration and the social media support on BIM collaboration.

4.1 Collaboration Barriers on BIM Based Construction Networks

As mentioned previously, the main subject of BbCNs is collaboration (Grilo et al., 2013; Mignone et al., 2016). Collaboration in BbCNs is still a challenge and it remains an unresolved issue (Oraee et al., 2019) even though it forms one of the key areas of BIM-related research.

Scholars have addressed a broad variety of sociotechnical aspects for resolving the inefficient collaboration difficulties in BbCNs, with an emphasis on human-computer interactions, technology-oriented perspectives, and people management (Matarneh et al., 2019). Oraee et al. (2019) claims that factors limiting collaboration in BbCNs are classified as primary constructs which are process, actor, context, team, and task and their sub-factors as illustrated in Figure 24:

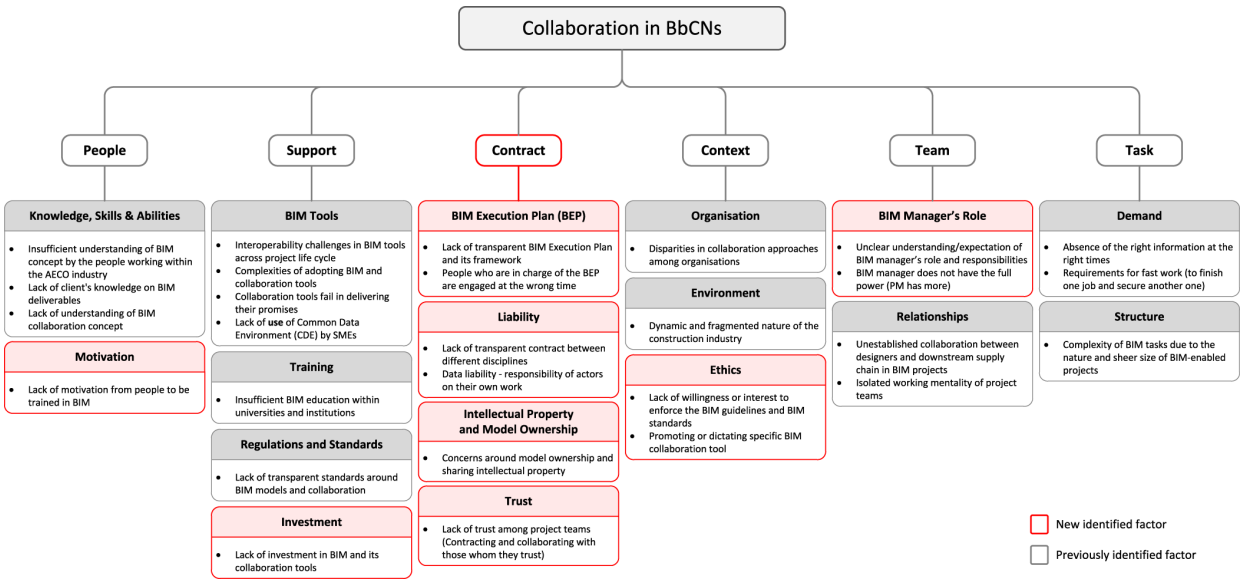

Figure 24: Collaboration in BbCNs (Source: Oraee et al., 2021)

According to the study which conducted by Oraee et al. in 2021, there are 6 main constructs of BbCNs:

i. People — In a survey-based study of Oraee et al, the most critical factor affecting collaboration has been detected as people, with the lack of "knowledge, skills, and abilities (KSAs)" of people working within the industry and the impact of "motivation" being emphasized. As a result, practitioners' KSAs were discovered to be the most important barriers to collaboration in BbCNs.

ii. Support — The second most significant construct influencing collaboration in BbCNs is the support component. Assistance was shown to have a major impact on teamwork by using suitable sources and facilities, such as technology support and training, starting applicable norms and laws, and investing in relevant BIM support tools. Oraee et al. state examination of the data reveals that support includes four subfactors: "BIM tools," "training," "regulations and standards," and "investment."

iii. Context — The "Context" was shown to have a major effect on BbCNs collaboration through the companies' context and the setting in which project teams operate. Furthermore, firms' attitudes on collaboration in BbCNs were evaluated influential. Interviewees in their research said that "Context" had three dimensions: "organization," "environment," and "ethics" (Oraee et al., 2021).

iv. Team — The BIM manager is essential to the success of BIM-enabled projects because of their significant impact on both project performance and BIM deliverables. In general, the industry is unaware of the responsibilities and job description of the BIM manager. This has a significant impact on both the success of the project and the cooperation efforts. They should have the necessary experience and knowledge in all the linked industries because their role demands bringing together the skills of numerous actors to execute a successful project. Design teams typically don't provide design documents and want to work less closely with other project teams. Project teams prioritize their own enterprises over other project teams because every firm has its own financial goals and objectives. Project teams' segregated working mentalities as a result present another obstacle to effective interactions in contrast to the nature of BIM.

v. Task — Collaboration is hampered by a lack of the relevant data at the right time to execute BIM activities. Project teams frequently assign duties to their members and other project teams; yet the information required to assure proper job accomplishment is missing. Due to a lack of constant and ongoing communication with other teams, team members typically not understanding clearly the requirements of the job they are assigned. The complexity of BIM tasks was seen as a key barrier to collaboration efficacy (Oraee et al., 2021). The survey indicates that, in contrast to conventional models, BIM-enabled projects are subject to complex laws and standards that are unique to BIM models. This increased level of complexity has an influence on the outcomes of collaborative efforts.

vi. Contract — Based on the interviews conducted for Oraee et al.'s study, it was found that the contract factor influenced BbCNs collaboration. Four key areas are noted in this new perspective on the influence of contracts on teamwork in BIM-enabled projects: the "BIM execution plan (BEP)", "liability", "intellectual property (IP) and model ownership," and "trust."

A variety of research aimed to improve collaboration by utilizing better and upgraded collaboration tools (Merschbrock, 2012). These technologies are mostly packages and systems that strengthen team collaboration by offering one common shared interface (Emmitt and Ruikar, 2013). Despite the growing availability of effective collaboration tools, the collaboration problem in BbCNs has not yet been resolved (Grilo & Jardim-Goncalves, 2010). According to Emmitt and Ruikar the problem is more related to human behaviour than to technology. In other words, even though all the mentioned conditions are met, collaboration will be influenced by the management and organization of human activities in BbCNs. In essence, 'people (rather than systems) collaborate' (Adamu et al., 2015).

4.2 Enhancing Social Dimensions in Building Information Modelling

According to the previous research, one of the most important challenges in construction projects is a lack of communication. Communication problems are usually caused by not involving the correct individuals at the right time, or by concealing information for personal or organizational advantage (Brown, 2012). BIM promotes the notion of integrated project delivery and using it from the very start of a project helps to maximize BIM benefits (Eastman et al, 2011, Azhar, 2011).

The projects are becoming increasingly user and customer oriented nowadays (Suwal, et al., 2013). However, novel technologies for active user engagement in projects are still in their early phases. Involving users early in a multidisciplinary team allows the team to determine the actual objectives of the project and solutions on how to best achieve it. (Baars, 2006).

Suwal et al. (2013) define the term "Social BIM 2.0" as a collaborative approach to working in which end users of construction products or residents of the project location participate for generating socially accepted innovative construction solutions using tools developed by Web 2.0 technologies and having the potential for BIM integration. In this technique, users are able to engage to the project decision after agreeing to the user agreement terms and conditions specified by the implementing organization by creating a new user account or connecting an existing social network account.

Users may discuss, post, comment on, and propose all sorts of ideas and solutions via various social media platforms, and they are rewarded for their active engagement. When user-generated solutions relate to BIM systems, they serve as a foundation for experts to instantly revise and build superior results. The basis to the notion of social BIM 2.0 is end user engagement in developing the possible optimum solutions.

Suwal et al. also states that BIM Collaboration Format (BCF), which adds a workflow communication capability linked to IFC models, is another technique to improve the social component of BIM. The intention is to separate communication from the real model. Instead of directly adding comments and information to an IFC model as a property set, the comments are defined using BCF with direct linkages to model objects. Each problem can include a snapshot of how the model looked in the application where the issue was last resolved, in addition to text, comments, and a list of objects. The standard describes how designers and other stakeholders may link messages, action items, perspectives, and snapshots to specific model components and send them to others. The receiving party, the planner, then utilizes the information in its own BIM authoring tool to identify and locate the component and see the same view as the sender. The OpenBIM Collaboration methodology allows an effective and completely traceable form of communication. This possibility of an open standard improves BIM's social qualities; residents, users, citizens, and other stakeholders should be allowed to remark, discuss, and provide input during the design process, but the final modifications in the BIM model are still being managed by the designer.

4.3 Social Media as Communication Medium

Leonardi et al. (2013) state that social media has been utilized by organizations for external communication as well as internal communication and social engagement, so, while planning and managing their work, design and construction firms must consider the social aspects of collaboration.

Turk and Klinc (2020) argue that physical structure is required for activities to culminate in a single coherent output. As an integration and coherence feature, the building information model then featured a three- or more-dimensional digital twin. Turk and Klinc develop a theoretical argument for the third component of this integrative axis: the social network that connects the individuals involved. Finally, the material structure, the digital twin, and the social network all work together to generate what is known as an axis of gravity (Figure25).

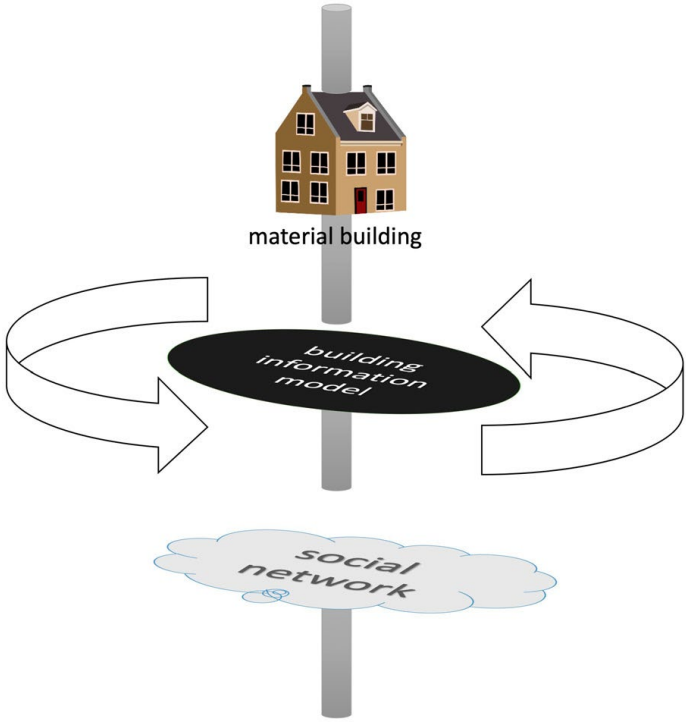

Figure 25: The three elements of the axis of gravity (Source: Turk and Klinc, 2020)

Since social media allows Internet users to access a variety of user-centric places to collaborate for creating social networks within WEB 2.0; the relation between the material building, BIM model and social networking can be extended as in the Figure 26:

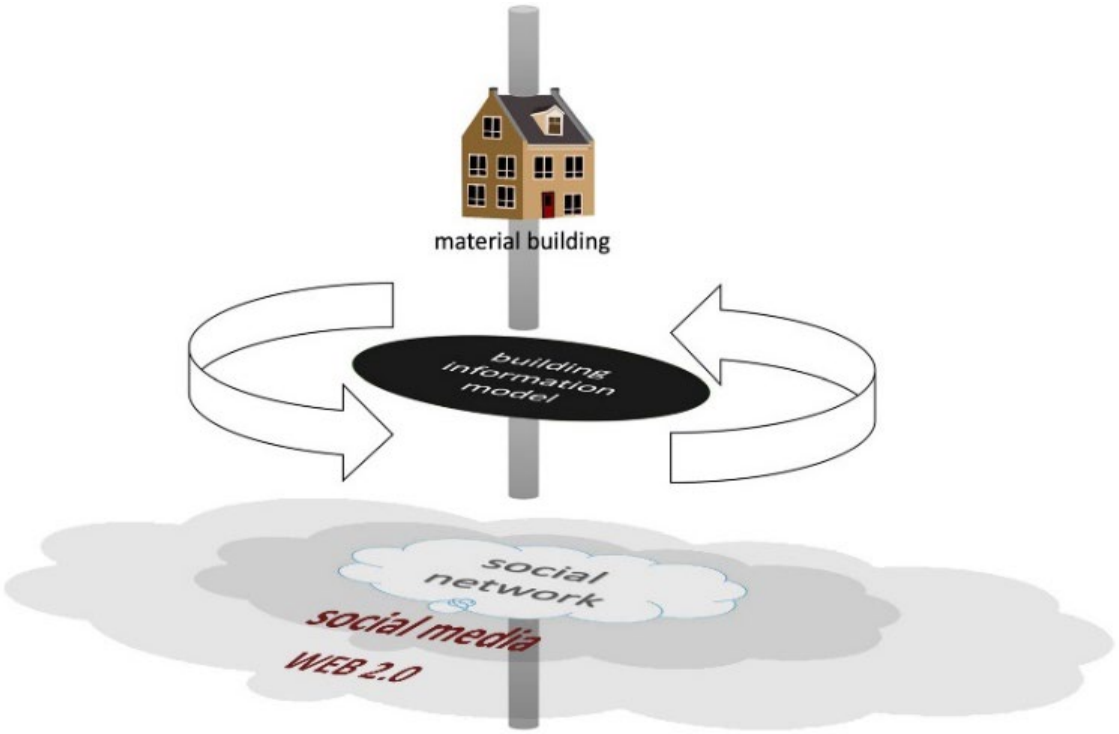

Figure 26: Extensions of the axis of gravity

Social media is a promising opportunity for communication between the project actors. The second generation of social media, 3D virtual environment, may be utilized for easy commenting features to collect opinions, comments, and feedback from customers or other participants. BIM applications can be provided with a social plugin to share models automatically to social media tools. This will result in a strengthened social perspective of BIM based tools. However, because each social media tool has its own set of functions and modes, it is vital to examine each one independently in order to develop richer theories that may guide construction practitioners on how to properly manage the use of this technology in project practices.

Technologically disruptive technologies like BIM and some are altering the basic foundations of AEC industry. Model based applications are widely used in professional collaboration between different stakeholders, whereas social media is a commonly accepted collaborative platform for user-generated content. In fact, the core of both technologies lies in communication, but their focus has differences. While BIM aims at professional collaboration some tools are manifesting user participation. In the future these technologies may be joined together in a meaningful way, for more improved and more socially acceptable creative built environment solutions. Figure 27 below shows the possible improvements on the BIM challenges with the start of social media acceptence and increase of social media use in the industry.

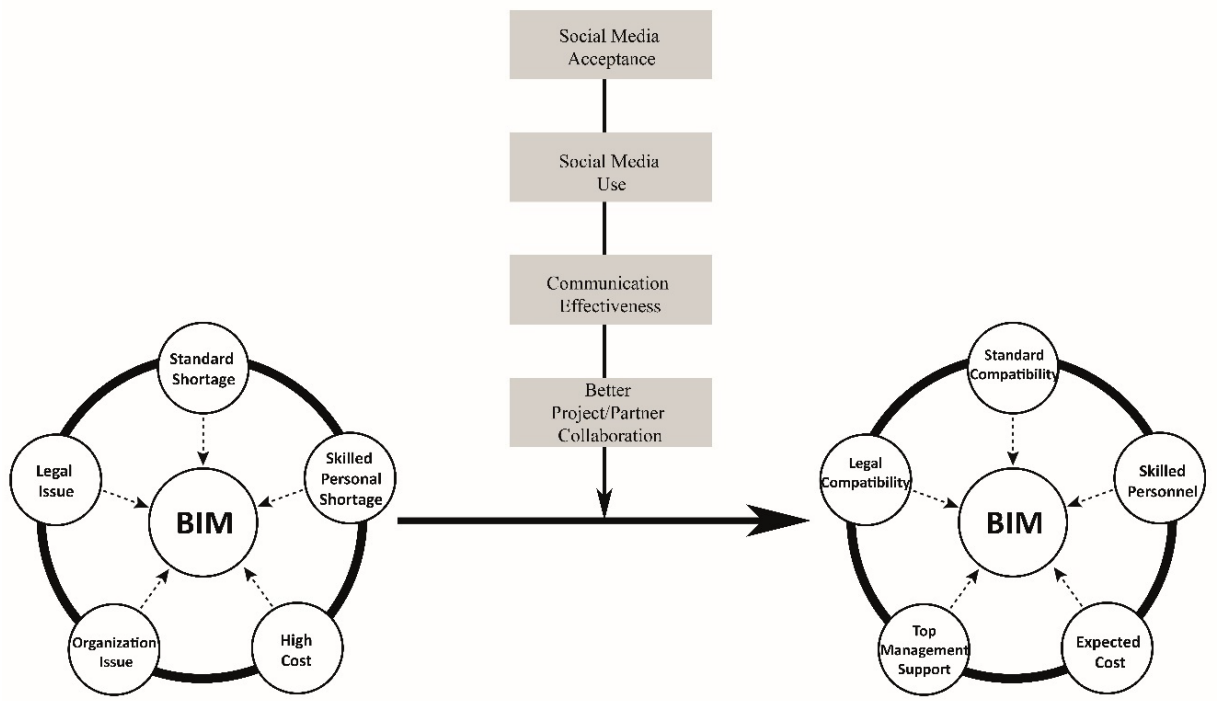

Figure 27: Improvements of BIM challenges with social media

5 CONCLUSION

Construction projects are heterogeneous, fragmented, and diverse (Turk and Klinc, 2021), As a result, construction project management is challenging for construction professionals who are in charge of building projects. In this context, numerous information technologies, such as building information modelling and social media platforms, have been used in recent years to help construction teams work more efficiently (Ma et al., 2021).

As previously said, knowledge acquisition is one of the most crucial work processes for building projects. Social media platforms, on the other hand, can be considered as a significant facilitator of information and knowledge flow. In comparison to search engines, social media allows for online knowledge discussions (Majchrzak et al., 2013), in which professionals or other project participants may easily gain connections, particularly tacit knowledge. Furthermore, social media helps to improve meta knowledge (i.e., awareness of who knows what and whom), which is difficult to obtain using search engines.

Based on the conducted literature review, the first research question asking the impacts of social media for BIM collaboration can be answered in three points:

1. Increased communication and collaboration between team members: social media provides a platform for team members to communicate and collaborate with each other more quickly and easily. This can lead to improved project coordination and a more useful information flow.

2. Better understanding of project requirements: social media can help team members to share and discuss project requirements more effectively. This can lead to a better understanding of the project scope and provides more efficient project engagement.

3. Improved project management: social media can help project managers to keep track of project progress and communicate with team members more effectively in terms of their skills and needs. This can lead to improved project management and a more efficient workflow.

In answer to the second research question asking how social media supports collaboration, literature review shows that social media supports BIM collaboration by allowing for easy sharing of content and easy communication between individuals. With this approach of allowing for easy sharing of images, ideas, updates, tips and tricks, social media helps to create a stronger connection between professionals and help to ensure that all ideas are shared and considered. It provides instant feedback to team members, so it helps to promote BIM collaboration. Moreover, social media can be used to promote BIM events, and to connect with other BIM professionals and help to create a community of like-minded individuals.

As a conclusion, all the materials that are really needed are there, BIM is there, and BIM provides the information and data needed. There are people chatting and talking about topics that can be learned from them, and there are tools, social media platforms, technology, software that can be used to enable the conversational process. All that needs to be done is to put them together because when they are put together, they can be better learned from the buildings. Accordingly, construction industry would be able to design better buildings, build better buildings, make existing buildings work better and more efficiently for less money and produce a better environment.

5.1 Future Work

Even the existing studies show that social media acceptance is not on the convenient level in the construction industry, it is obvious that the AEC professionals will be engaging with social media platforms in the close future better. Depending on this, future may make BIM tools and CDE tools more social or social tools may work better with BIM data. Practical studies should be conducted with surveys to prove how the communication is happening before and after social media and how it is affecting the collaboration of the project teams and BBCNs. It can be also investigated if social media helps to improve BIM maturity with knowledge and information exchange of a company or not.

Additionally, it should also be taken into consideration that increasing technology and improvements on BIM are creating more developed environments; now it can be predicted that social media is going to change it forms and usage in a near future because of the way people communicate, and human interactions are transforming rapidly. The improved digital twin experience and even upcoming metaverse reality is going to change how people communicate and engage each other in personal and professional level. Since BIM is a leading technology in built environments recently, it should be investigated what kind of social media platforms are going to be needed in the 5D industry and how they should be managed. Of course, it can be investigated in a theoretical frame but to be able to collect better data and provide better evidence in academy and industry, there should be surveys done with the professionals and experts and on-site research must be prepared.

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