

THE EFFECTIVENESS OF WEB-BASED TECHNOLOGY PLATFORMS IN FACILITATING CONSTRUCTION PROJECT COLLABORATION: A QUALITATIVE ANALYSIS OF 1,152 USER REVIEWS

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SUMMARY: *The construction industry accounts for 9% of global GDP. Efforts at addressing construction's inherent inefficiencies have over the last decade increasingly involved the deployment of web-based collaborative tools. Consequently, much research has been devoted to assessing these platforms; including interoperability, workflow management and technological limits. What has not been considered to date are the views of web-based tool users themselves as to the functionality, potency and usability of the various platforms available on the market. Currently, there are 5,300,000 documented users of web-based collaborative tools. If web-based collaboration is to be further enhanced, the views of users must be known. This study explores this dimension. Financeonline's top six tools were considered: CoConstruct, PlanGrid, Autodesk BIM 360, Procore, e-builder and Aconex. Around 200 reviews for each tool were collected from 'Business Software Reviews from Software Advice,' resulting in a total dataset of 1,152 complete reviews. Text-mining analysis was applied to this dataset, using RapidMiner Studio 7.5. Thirty key terms with a frequency of over 100 occurrences were retrieved; terms such as software, manage, inform, support, easy use, function, track and friendly. These constitute the subject of the reviews. These terms were then analyzed for sentiment qualifiers; either positive or negative. A total of 804 sentiments were positive, 322 negative and 26 neutral. This study thus highlights that while 70% of user reviews of web-based collaborative tools are positive, there remains much room for improvement. Areas for improvement are also indicated by this study.*

KEYWORDS: *Collaboration technology, construction, web-based collaboration tools, text mining, sentiment analysis.*

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1. INTRODUCTION

The construction industry accounts for 9% of Global GDP (McKinsey & Company, 2017), having an added value of \$3.6 trillion (US dollars) and annual revenue of almost \$10 trillion, which is estimated to generate revenue up to \$15 trillion by 2025 (Forum, 2016; McKinsey & Company, 2017; StartupAUS, 2017). Despite its significance, the construction industry is affected by poor design information coordination and inefficient communication that give rise to project delays, change orders and conflicts (Bouchlaghem, 2012). These problems are further exacerbated by the sector's highly fragmented nature (Botton & Forgues, 2017), uniqueness of each project and unstructured working conditions. As a remedial solution, technological innovations are adopted which can result in a 1% productivity rise worldwide and save \$100 billion (Forum, 2016; McKinsey & Company, 2017; StartupAUS, 2017). Chief amongst a plethora of technological developments, Building Information Modeling (BIM) is defined as a modeling process and connected set of procedures to yield, link and analyze data-rich models. Palpable benefits of BIM include: better-quality planning, improved design, economical construction, and better operation and maintenance processes. When using BIM, one or more virtual computer models for construction are shaped digitally, that contain detailed geometry and rich data required to support the construction. BIM, as an emerging technological innovation, relies on smooth collaboration among project team members (Merschbrock & Munkvold, 2015). BIM-enabled projects are heavily reliant upon collaboration tools, as knowledge management or digital support technologies for workflow management and data exchange. A BIM presenting model server is likely to simplify the exchange of data in a multi-model situation. This is achieved by supporting the numerous applications involved in a building project's life-cycle plus design tools, analysis tools, facility management tools, electronic document management systems (EDMS) etc. (Shafiq et al., 2013; Singh et al., 2011). EDMS cf (Edwards et al., 1996) and web-based project management applications are another form of collaboration technology. These aforementioned packages are considered as collaboration tools in this study. As technological developments exponentially increase, collaboration technologies, tools and processes enhance productivity and reliability as they are supporting construction process, management and collaboration (Hardin & McCool, 2015).

Evidence shows that web-based collaboration tools and associated mobile application implementation are rising and 72% of US construction professionals are utilizing smartphones at work (O'Malley, 2015). The Associated General Contractors of America (AGC) and Sage Group 2016 Business Outlook Survey indicated that 63% of construction businesses are implementing cloud-based platforms to improve information access from a different location (Kracunas & Wetmore, 2016). Anecdotal evidence suggests that this implementation figure is set to increase. The number of existing collaboration tools varies according to different sources from 325, 349 or 374 tools (Capterra, 2018; Crowd, 2018; Softwareadvice, 2018). Along with the number of tools, the ranking of the best/ top tools also varies according to different sources thus compounding a dilemma of selecting an appropriate tool. Moreover, the inconsistency of tools' ratings and variation of internal methodology results in different decision outcomes.

Previous studies have focused on the: effectiveness of collaboration tools (East et al., 2008); technological aspects (Zhang et al., 2017) ; identification of barriers and frameworks for improvement of collaboration and communication (Mignone et al., 2016); and communication between project teams (Hosseini et al., 2017). In addition, teamwork improvements via utilizing collaboration tools (Chung et al., 2009; Costa & Tavares, 2012) have also been explored, along with the identification of the antecedents and drivers of collaboration technology adoption. This body of work has hitherto either relied on individual case studies or on informal evidence provided by 'successful stories' reported in the trade press. In these studies, the project team faced various individual, environmental and technological challenges while implementing digital processes (Merschbrock & Munkvold, 2015). There are many factors that may repress knowledge sharing throughout industry. Although the former studies identified the barriers and challenges of collaboration tools, the collaboration tools users' perceptions were not considered in detail. Consequently, this research aims to address this gap, through: analyzing the reviews of six prominent collaboration tools users' reviews; identifying the positive and negative aspects in general; and revealing the frequently appeared aspects of the tools. The study contributes to the prevailing body of knowledge by providing a cross sectional snapshot picture of existing users' perceptions, which will be invaluable in assisting vendors and system developers as well as digital managers and project leaders of construction projects who strive to augment performance.

2. BACKGROUND

2.1 Collaboration in the construction industry

According to Wood and Gray (1991, p. 146): “Collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms and structures, to act or decide on issues related to that domain.” To fulfill common objectives, collaboration occurs within an atmosphere of trust, openness and honesty by several individuals who undertake a process of sharing collective knowledge, expertise and skills (Mignone et al., 2016). In the construction industry, multidisciplinary collaboration is a key success factor for all the parties involved in delivering projects (Singh et al., 2011; Zhang et al., 2017). Effective collaboration among parties is required to ensure mutually beneficial relationships among parties to jointly create appropriate rules and structures (Oraee et al., 2017). Collaboration allows geographically dispersed project teams to work together to: increase efficiency in the process collectively; provide greater profitability to the organization (S.Moses et al., 2008); and enhance the performance of the construction sector (Comiskey et al., 2017).

That said, collaboration in the construction industry is challenging due to a wide range of reasons and lack of collaboration engenders numerous continuity problems (Oraee et al., 2019). Specifically, many stakeholder organizations within the sector are stagnant, thus leading to highly fragmented industry with low productivity and dominated by small businesses (Costa & Tavares, 2012). Effective collaboration can overcome these challenges by integrating among design and production processes cf.(Ahsan et al., 2007; Bi et al., 2019). Failure to do so results in time and cost overruns, poor coordination, less than optimum information sharing, and inadequate, inappropriate and inconsistent communication (Durdyev & Hosseini, 2018). Moreover, lack of collaboration results in a proliferation of adversarial relationships among project stakeholders. Misunderstandings, misinterpretations of data and increased rework may result in project delays attributed to ineffective collaboration practices (Mignone et al., 2016). In short, collaboration is quintessentially important in ensuring efficient and effective construction procedures (Costa & Tavares, 2012) and it is indispensable to the success of construction projects (East et al., 2008; Mignone et al., 2016).

2.2 Construction collaboration tools

The proliferation of Information Technology (IT), and the advent of web-based applications in construction activities profoundly transformed the collaboration in construction industries in recent years (Oraee et al., 2017). Moreover, Information communication technology (ICT) development and maturity resulted in an increasing trend of transferring activities from offline to online (Ma et al., 2018) and enabled standardized communication between different actors in Construction (Adriaanse et al., 2010; Hosseini et al., 2017).

Globally, construction management software is forecasted to grow at a compound annual growth rate (CAGR) of 9.19% between 2018 and 2022 (Markets, 2019). Consequently, Data exchange over the web is gaining popularity within the construction industry (Anna Wagner et al., 2020). Likewise, with the emergence of cloud-based technologies, many connected job sites can transfer and make available every aspect of project information to all the relevant parties anywhere in the world (Deloitte, 2020). For contemporary projects, Computer-based collaboration has become the standard for scattered team members across different locations (Oraee et al., 2017). Furthermore, Incorporation of integrated BIM modules assembled in hybrid platform support collaborative web tools and BIM server resulted in a collaborative working environment (Charalambous et al., 2017; Costa & Tavares, 2012).

Along with continuous development in information and communication technology (ICT), projects are increasingly more complex and involve larger capital investments, dispersed project participants, and tighter schedules (Hosseini; et al., 2018). Consequently, Virtual meetings, tele- and audio-conferencing technology, instant messages, 3D, virtual and mixed reality are considered synchronous collaboration platform and have become the norm for contemporary projects (Hosseini; et al., 2018; Ma et al., 2018; Oraee et al., 2017).

In short online collaboration, platforms can be denoted as the amalgamation of web-based technologies which offer a shared interface by linking multiple interested parties, and provide a platform in a digital form to share, exchange and store project information and work in collaboration on a basis of subscription fee, license plus maintenance, negotiated fixed cost or exclusive business partnership agreement (Charalambous et al., 2017). According to Adriaanse et al. (2010) “A Digital coordination and collaboration tool used for communicating and

sharing project information between participating organizations in construction projects” is defined as an inter-organizational ICT. Moreover, Cloud Computing, software-as-a-service (SaaS), and Service-Oriented Architecture (SOA) concepts are also associated with online collaboration platforms (Charalambous et al., 2017). Comiskey et al. (2017), indicated “Common Data Environment (CDE) as an internet-based cloud hosting platform accessible to all construction team members’ access shared project information”. Collaborative technology also refers to tools and systems specially designed for better facilitating the group work both in the office and remotely.

In this study, web-based construction collaboration tools are denoted to all the online collaboration platforms, digital collaboration and coordination tools, construction management software, Cloud-based Common Data Environment (CDE), Collaborative working environment and so on which altogether enhance collaboration in Construction.

2.3 Collaboration tools Benefits

Web-based collaboration tools have different features and applications to assist the coordination of business processes and enable collaborative workflow, data access, multiple team, and office locations integration (Captterra, 2020). Project management and customer management functionality along with accounting, scheduling, and portfolio management services often incorporated in these tools (FinancesOnline, 2020). The benefits of web-based collaboration tools have been discussed in the following segment.

2.3.1 Efficient Document and Project information Management

Document management applications of web-based collaboration tools assisted in storing, organizing, and managing documents in a digital way within construction projects (Adriaanse et al., 2010). Moreover, effective information management and exchange (Comiskey et al., 2017) can be achieved through collaboration tools. BIM and digital technologies foster the integration of activities and strengthen the management of projects (Papadonikolaki et al., 2019) as well. Engineering Project network Team members currently link project members electronically and transfer and process project data to and from disperse participants (Hosseini; et al., 2018). Furthermore, document control capabilities of tools improve accountability by ensuring tracking and version control and minimizing liabilities through a virtual paper trail for plans (softwareadvice, 2020). In brief, collaboration tools in construction enhance document and project information management.

2.3.2 Improved Communication and Collaboration

Collocated teams highly dependent on technology (Hosseini et al., 2017) to exchange data and communication between team members. Working as a central repository for project information web-based collaboration tools facilitated the sharing of resources between geographically dispersed teams and enhanced communication (Charalambous et al., 2017). Moreover, Inter-organizational cooperation, coordination, and communication can be supported by product Modeling application of tools for instance 3D modelling, 4D modelling, Building information modelling (Adriaanse et al., 2010). As web-based collaboration tools enhance the overall communication, according to Hosseini et al. (2017) team effectiveness will be improved as well because team effectiveness highly dependent on the quality of communication, and the quality of the information and exchanged data. Furthermore, Team resulted in improved data privacy (Comiskey et al., 2017). Consequently, improved information flow, elimination of various kinds of waste within the construction projects (Charalambous et al., 2017), and real-time visibility of project life cycle (Captterra, 2020) resulted in Improved collaboration (Ma et al., 2018).

2.3.1 Enhanced Workflow Management

Technical advancement in cloud computing and the web have fast-tracked rapid growth of globally dispersed project teams on construction projects (Hosseini; et al., 2018). Monitoring and recording the progress of tasks, managing the flow of documents and information can be done by Workflow management application (Adriaanse et al., 2010) of web-based tools. Consistency level, efficiency, coordination, and quality improved due to workflows, best practice processes, document standards and metadata engaged by Common Data Environment (CDE) (Comiskey et al., 2017). BIM and digital technologies foster the integration of activities and strengthen the management of projects Data accuracy and better information management (East et al., 2008). In brief, web-based collaboration tools enhance collaboration through better management of workflow.

2.3.2 BIM Integration

The recent incorporation of integrated BIM for example online 3D model viewers enhanced communication through shared BIM which offers to cross-check more effectively (Charalambous et al., 2017). Collaboration tools integrating BIM can easily address Data sharing, access, and processing requirements issue of BIM adoption (Charalambous et al., 2017). BIM and related digital technology work as a catalyst to ensure more transparency, tighter integration, and increased productivity (Merschbrock & Munkvold, 2015).

The number of web-based collaboration tools in the present market is ranging from 200-375 according to different software reviewing online platforms (Capterra, 2018; Crowd, 2018; FinancesOnline, 2018b). This trend illustrates that over time, the number of tools is increasing, and features of tools are dynamically shifting to accommodate new user requirements, and technological advancement. As a consequence, new systems released by software vendors amplified the situation where users have several different systems to fulfil their information requirements (Merschbrock et al., 2015).

2.4 Previous studies and gap

Despite the extensive availability of collaboration tools, the problems regarding collaboration in construction remains an ongoing challenge (Mignone et al., 2016). Table 1 reports upon previous studies on collaboration technologies adopted in construction-related research to identify the focus and summary of findings.

TABLE 1: Major studies related to collaboration tools.

Author	Focus	Source of data	Summary of findings
(Anna Wagner et al., 2020)	Conducted a study on semantic web technologies in the construction domain and geometric descriptions analysis.	Literature review.	Identified different approaches and currently available implementations of geometric descriptions in semantic web technologies and grouped them into four different approaches and recommendations.
(Papadonikola ki et al., 2019)	Investigated the insights of collaboration with BIM among multidisciplinary actors in BIM-based projects.	Case study	By critically analyzing the case projects the study represented structure and agency of Collaboration on BIM-based projects. The findings indicated that multiple interpretations of boundary objects by different communities of practice and various artifacts of BIM resulted in poor communication and poor collaboration.
(Danfulani Babangida & Khaidzir, 2018)	Evaluation of perspective of Design Collaboration	Literature review (qualitative content analysis)	Four key themes such as teamwork, building information modeling framework, evidence-based design practice, and modality have been identified as support of collaborative design. Identified lack of a definitive framework of design collaboration.
(Hosseini; et al., 2018)	Investigated the ramification of virtuality on the Engineering Project networks (EPNs) team and evaluated the functional performance.	Mixed method.	Through a Multidisciplinary literature review, a theoretical model has been created to analyze the impact of virtuality on EPNs. Empirical data has been utilized to validate the model. The findings of the study revealed that virtuality significantly affected team effectiveness and influenced several mediators. However, the level of influence was much lower than previously anticipated by the body of knowledge.
(Al Hattab & Hamzeh, 2018)	Examined BIM adaptation and its influence on design workflow improvements.	Agent-based modeling and social networking and case study analysis.	Based on Social interactions and information flow dynamics the study investigated BIM adoption ramification on workflow improvement. The findings indicated that explicit improvement of a workflow cannot be achieved only by utilizing BIM as a production tool. Fundamental conditions such as collaboration and changes in traditional mindsets were required to achieve the full potentiality of BIM.

Author	Focus	Source of data	Summary of findings
(Yali Zhang et al., 2018)	The role of Mobile social media in Inter-organizational projects and Virtual collaboration.	Conceptual framework, Interview.	The findings of the study indicated that tool usability, task fit, and team connectivity contributed to the effectiveness of virtual collaboration.
(Ma et al., 2018)	Focused on developing a collaboration platform for integrated project delivery (IPD) to enhance efficient collaboration.	Prototype development and validation.	To enhance collaboration and Integrated project delivery, this study focused to develop a prototype model of a dedicated collaboration platform for IPD. After combining a few meetings. This collaboration platform was successful to replace the “Big room”. The findings contributed to lessening associated difficulties of IPD implementation.
(Orace et al., 2017)	Focused on Investigating relevant research gap in collaboration within BIM-based Construction Network. (BbCNS).	Mixed method Systematic review.	A “collaboration Pentagon” consisted of Context, process, task, team, and actor utilized as a theoretical lens. The Bibliometric analysis studies have been categorized based on the theoretical lens. Further analysis revealed most of the collaboration research focused on technology. Moreover, under-researched areas have been identified along with research gaps.
(Zhang et al., 2017)	Investigated the interoperability issues such as data ownership and data privacy.	Prototype and case study	The study proposed a multi-server information sharing approach. Based on a private cloud, the approach congregated a global controller to track the location, ownership, and privacy of the model. To support information sharing in a distributed environment data consistency conversion, sub-model extraction, and integration have been considered. Further validation of the approach done by case study analysis.
(Comiskey et al., 2017)	Investigated Common Data Environment (CDE) collaboration platforms utilization in the education sectors.	A qualitative method based on a case study.	Based on a three-year longitudinal study, this research focused to analyze multidisciplinary collaborative student BIM project which experimented with three different collaboration platforms. Thematic analysis revealed key trends, advantages of different platforms, and learning outcomes requirements. Moreover, challenges in terms of familiarity and assessment integration were highlighted.
(Abanda et al., 2015)	BIM system categorization	A systematic review, questionnaire survey, focus Group and email survey.	A wide range of BIM software systems underwent comprehensive critical appraisal. A holistic approach adopted sought to study the BIM systems, and categorized 122 applications. A list of examples of applications that were usually common in the architecture, engineering, construction and operations (AECO) industry were presented, followed by BIM and collaboration system.
(Merschbrock & Munkvold, 2015)	Factors of enabling digital collaboration in a construction project.	Case study.	Based on diffusion of innovation theory, key factors were identified that influence digital collaboration in a hospital project. Factors such as change agents, new roles and responsibilities, a cloud-computing infrastructure, BIM contracts and a BIM learning environment. The findings would assist in BIM implementation and collaborative work in construction projects.
(Brown et al., 2014)	Collaboration technology adoption in general.	Field studies.	Proposed a model integration theory to explain the adoption and use of Collaboration technology. Collaboration technology characteristics, individual characteristics, group characteristics, and situational characteristics indicated as predictors of performance expectancy, effort expectancy, social influence, and facilitation condition of collaboration technology adoption in general.

Author	Focus	Source of data	Summary of findings
(Abanda et al., 2013)	Investigated the development and trend of semantic web applications in the built environment.	Literature Review	To evaluate, improve, and identify new research areas this study focused on understanding the different applications of Semantic Web. Reviewed 120 referred articles on built environment semantic web applications. The findings indicated a classification of different semantic web applications and identified research progress on ontological concepts, and innovative concepts such as linked data. Other findings identified a shift from traditional construction applications to Semantic Web sustainable construction applications.
(Shafiq et al., 2013)	BIM-based model collaboration system.	Focus group interview.	An exploration of user requirements for BIM Collaboration presented to categorize the Model collaboration system and discuss the features. This study was based on discussion and analysis of Model collaboration for the construction industry
(Costa & Tavares, 2012)	Social e-business concept and social network model.	Case study.	Presented social e-business process, that integrated web-based collaborative tools, emphasized social capital and social networking. A proposed satellite model defined a functional approach to enhance social network behavior in a web-based project platform in the construction industry.
(Adriaanse et al., 2010)	Utilization of Inter-organizational ICT in Construction projects of the United States.	Theoretical framework, model development, and industry interviews.	Successful utilization of inter-organizational ICT- document management applications, workflow management applications, and product modeling applications have been explored by providing solutions for ICT use related barriers and developed a model based on Theories.
(Robert Klinc et al., 2009)	Engineering Collaboration 2.0: Requirements & Expectations.	Case study	Investigated the key reasons why the AECO sector is not adopting enterprise technologies. Barriers included aspects relating to cultural, technological and security, awareness and generational differences. The work concluded that there is no one-size-fits-all model.
(East et al., 2008)	Identified taxonomy of verification and validation of tools.	Survey.	Provided taxonomy on objectivity, sample size, frequency and purpose to evaluate verification and validation methods to investigate the accuracy and benefits of a collaborative business platform. The main aim of this study is to explore how to evaluate the benefits and users' expectation from the web- based collaborative tools by considering barriers and proving a framework and taxonomy.
(Mohamed & Stewart, 2003)	Studied users' perception of a web-based communication tool adopted on a large construction project.	Questionnaire survey and case study.	Based on five performance measure perspectives, for instance, operational, benefits, user orientation, strategic competitiveness, and technology perspective framework and questionnaire were developed. By evaluating the framework through a case study, the findings indicated that the Web-based tool had a positive contribution to operational perspective, enhanced coordination, and communication. However, the findings revealed project participants were less satisfied regarding the level and frequency of Web-based tool training.

Table 1 indicates that the majority of the studies of collaboration tools focused on the various technological aspects (Abanda et al., 2015; Anna Wagner et al., 2020; Yali Zhang et al., 2018; Zhang et al., 2017). For instance, web-based semantic technology and applications (Abanda et al., 2013; Anna Wagner et al., 2020), mobile social media technologies (Yali Zhang et al., 2018), different systems categorisation (Abanda et al., 2015), collaboration tools

validation (East et al., 2008) and interoperability issues (Zhang et al., 2017) have been explored. According to Oraee et al. (2017) collaboration in construction has been investigated mostly through the technology-oriented lens. Another group of researchers emphasized on the interrelation of collaboration tools and project teams and networks (Al Hattab & Hamzeh, 2018; Hosseini; et al., 2018; Oraee et al., 2017; Papadonikolaki et al., 2019). For instance, Hosseini; et al. (2018) examined the ramification of virtuality on project teams. Furthermore, Design and collaboration tools (Danfulani BabangidaIdia & Khaidzir., 2018), collaboration tools adaptation, implementation, and barriers (Al Hattab & Hamzeh, 2018; Brown et al., 2014; Merschbrock & Munkvold, 2015), collaboration tools and education (Comiskey et al., 2017) have been identified as various research streams of collaboration tools. Mohamed and Stewart (2003) studied web-based communication tools user perceptions, and Merschbrock et al. (2015) investigated designers information system selection process but the methodologies were based on survey, and case studies.

The aforementioned studies either considered technological aspects, advancements, working processes, adoption, implementation, barriers, success, and failure of collaboration tools. Most of the studies are either based on individual case studies or informal evidence provided by successful stories reported in the trade press. Moreover, studies listed in Table 1 either adopted a qualitative or exploratory approach. The former studies have identified the barriers and challenges of collaboration tools, and different technological aspects but the collaboration tools users' perceptions have hitherto not been considered in detail. As project-teams face various individual, environmental, and technological challenges while working with new technology or technology-based working processes (Merschbrock & Munkvold, 2015), the importance of exploring user perceptions of tools is vital. By identifying the knowledge gap, this study focused on investigating the user perceptions of collaboration tools adopters by conducting a quantitative text mining and qualitative content analysis approach.

3. RESEARCH METHODS

The study objectives necessitate exploring the end-users' perceptions of tools by direct quantitative analysis of reviews to identify patterns and latent connections of the different attributes. The research relies on analysis data related to the most common collaboration tools. The natural human language of the reviews is unstructured and required a method that will process the dataset to reveal patterns. Text mining can handle a large number of unstructured texts to reveal underlying patterns and trends. Furthermore, qualitative content analysis is conducted to investigate the dataset. This study explores the insights of users' reviews to unveil the underlying sentiments. A robust quantitative and qualitative analysis employing text mining and content analysis has been conducted. The positive and negative sentiments reviews were analysed through text mining to identify the most frequent words. Furthermore, Content analysis assisted to unearth the issues faced by the users.

Text mining is a remedial solution to discover knowledge from collections of unstructured text (Hosseini et al., 2018). An increasing number of online reviews are posted daily on the internet which is a great source of data for making a variety of management decisions (Bi et al., 2019).

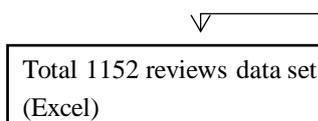
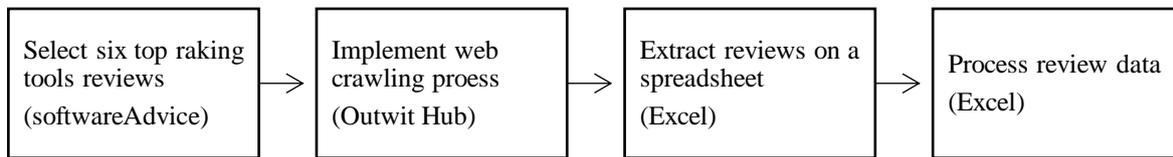
3.1 Data Collection

Five million, three hundred thousand users have been identified to use at least one of the collaboration tools (Capterra, 2018). This indicates the importance of collaboration tools but also the extent of usage. According to pertinent websites, ranking for the top ten tools is based either on customer number, social presence, price, ratings, or internally developed ranking algorithm (Capterra, 2018; Crowd, 2018; FinancesOnline, 2018a) Web-based construction collaboration tool listing websites like Capterra focused on a sponsor, highest-rated, and most reviews to rank the tools (Capterra, 2018). On the other hand of Financesonline ranking system is based on an internally developed SmartScore™ algorithm which has considered main functionalities, collaboration features, customization capabilities, available integrations, and so on for ranking the tools. Based on the ranking of Financesonline [viewed on 20.11.2018], the top six tools were CoConstruct, PlanGrid, Autodesk BIM 360, Procore, e-builder, and Aconex. The ranking contained within the website considered the collaboration features of the tools. For this reason, the aforementioned six tools were considered for analysing users' reviews. For extracting the reviews another review website 'Business Software Reviews from Software Advice™', was considered and accessed on 15.12.2018 to collect data of reviewers as this website accumulated reviews of a particular tool from a variety of sources (Softwareadvice, 2018).

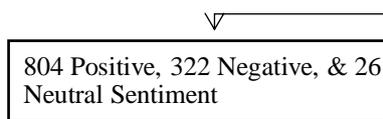
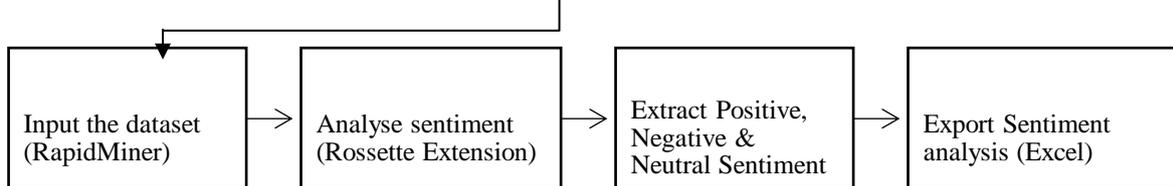
3.2 Analyses

The study objectives necessitate exploring the end-users' perceptions of tools by direct quantitative analysis of reviews to identify patterns and latent connections of different attributes. The research relies on analysis data related to the most common collaboration tools using the same procedure adopted by (Hosseini et al., 2018) and (Miner et al., 2012). Details of the research techniques, design, and procedure are illustrated in Figure 1.

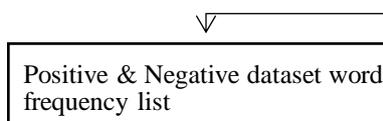
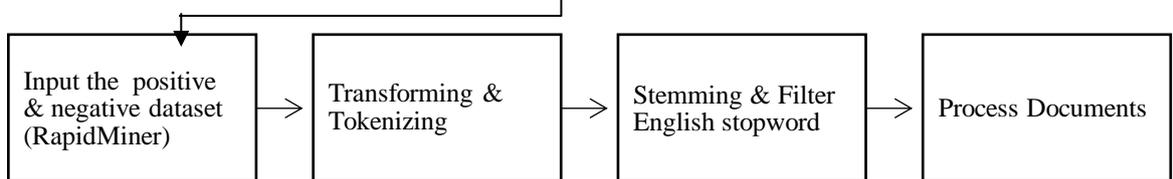
Step 1: Information Retrieval



Step 2: Text Mining (Sentiment Analysis)



Step 3: Text Mining (Term Frequency)



Step 4: Content Analysis

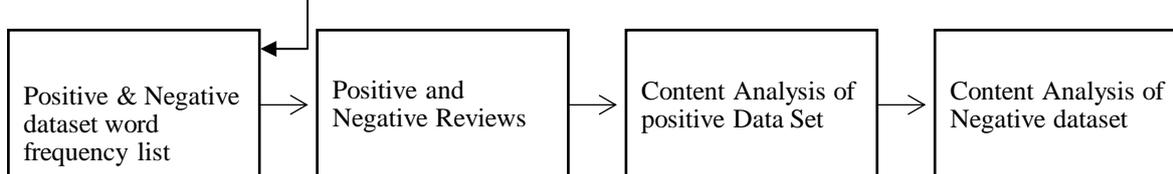


FIG 1: Research Methodology.

The natural human language of the reviews is unstructured and required a method that will process the dataset to reveal patterns. Text mining can handle a huge number of unstructured text and can discover knowledge (Hosseini et al., 2018). Furthermore, qualitative content analysis is conducted to investigate the dataset and the nature of data.

3.3 Information Retrieval

To create the data set, a web crawling method was implemented. The review website ‘Business Software Reviews from Software Advice™’, was accessed on 15.12.2018 to collect data of reviewers. Around 200 reviews for each tool resulted in 1,152 data set of reviews for the most popular six tools. Outwit hub (which is an open-data web scrapping tool) was implemented to extract data. Source code such as ‘review data, ‘company size’ was utilized to collect the multiple web pages review data information. The data set was further filtered merged and organized in a spreadsheet. The data were organized in a spreadsheet containing three columns: “collaboration tools name”, “Company Size”, and “Reviews”. A total of 1152 Reviews of six prominent tools were prepared for further analysis.

3.4 Text Mining: Sentiment Analysis

Broad speaking, sentiment analysis is a set of techniques and tools aimed at detecting, extracting, and discovering the opinions and attitudes of authors of a text about certain entities (Mäntylä et al., 2018). These snippets of text typically reflect the feedback and reviews provided by users of the entity and are seen as ‘a gold mine’ of information. That is, these fragments of textual narrative in the form of reviews and feedbacks comprise subjective sentences that contain factual information, and reflect beliefs and views of users about an entity (Feldman, 2013). The most common application of sentiment analysis technique is for reviewing the experience of products and services users have written on websites devoted to discussions about the products or services at hand (Mäntylä et al., 2018).

Unstructured data can be processed using one of the available operators for sentiment analysis methods in RapidMiner like Rosette (Arianto et al., 2017). Having textual data as input, Rosette can return sentiment categories associated with an entire document, or for individual passages within a larger body of the text. Rosette relies on natural language processing (NLP) techniques for automated recognition and understanding of the view and opinions expressed in a human-generated text. It associates the subjective opinion embedded in a given text with a label: positive, negative, or neutral (Rosette, 2019). Prepared 1152 reviews were analysed in RapidMiner Studio 7.5 utilizing Rosette extension.

3.5 Text Mining: Term Frequency

Text mining is a process that discovers interesting and non-trivial knowledge from text documents (Ertek et al., 2014). Text mining is defined as “an attempt to separate valuable keywords from a mass of other words” to identify meaningful patterns (Hosseini et al., 2018). For this present study, text mining analysis was conducted in RapidMiner Studio 7.5, which is an open-source data mining and business analytics software solution. After conducting the sentiment analysis, the positive and negative datasets were further analysed and processed to identify the term frequency.

3.6 Content Analysis

The qualitative content analysis determines the specific word frequency appear in a text and can assist to describe the meaning of the textual narrative. Content analysis has been defined as “a research technique for making replicable and valid inferences from text to the context of their use”(Yu et al., 2006). In case of the collaboration tools users’ perception, after conducting quantitative analysis through the text mining approach, content analysis was adopted to further investigate the most frequently appearing words connection and association within the positive and negative data set. According to Fellows and Liu (2015), content analysis is an appropriate data analysis technique in management and construction research.

4. FROM REVIEWS TO FINDINGS

4.1 Sentiment Analysis

Among the 1,152 data sample frame, 379 of cases represent large companies, whereas 353 belong to small-sized companies and 205 are representing medium-sized companies. Only 16 of the reviewers belong to micro companies as illustrated in Figure 2. The remaining sample did not have any information. This sample represents a reasonable balance of participants and coverage of all categories of major users of collaboration tools in the

construction industry, given that due to resource limitations, micro companies are not among typical users of collaboration tools. Among the reviews, 804 were positive about the collaboration tools, only 26 cases were neutral and 322 were negative as indicated in Figure 3.

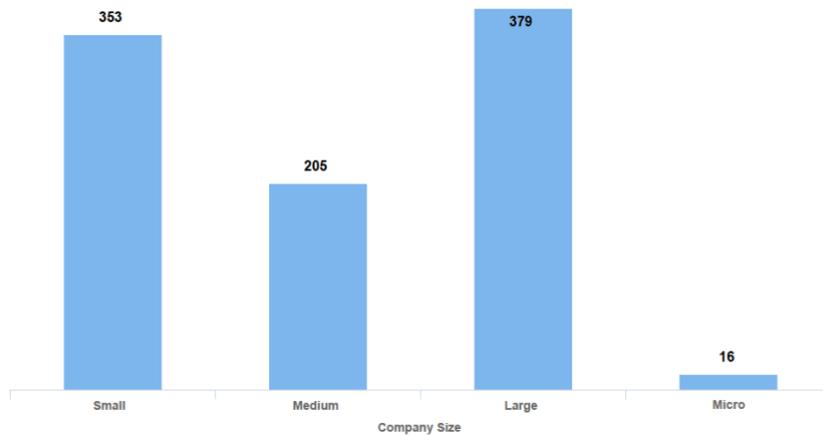


FIG. 2: Distribution of company size among the reviewers.

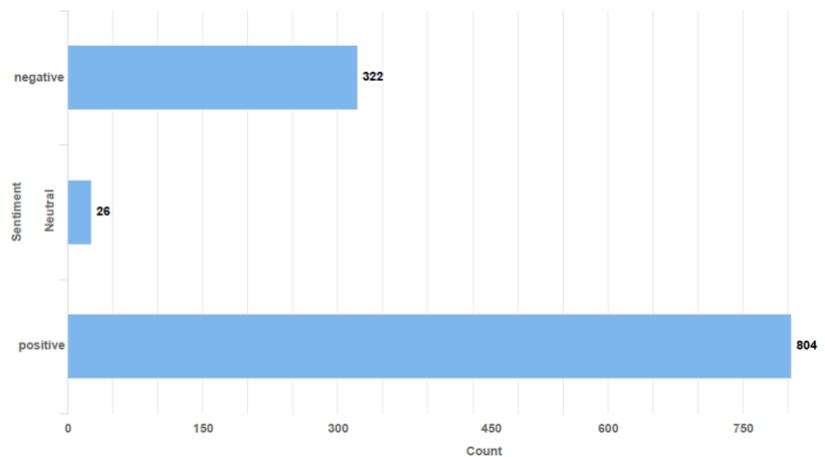


FIG. 3: Sentiment analysis result of dataset.

4.2 Text Mining (Term Frequency)

Term Document Matrix (TDM) is a procedure that converts textual data into a TDM (Hosseini et al., 2018). Words are operated into “tokens” as text mining algorithms treat words in a sentence as unrelated objects (Hosseini et al., 2018). According to Hosseini et al. (2018), the tokenizing process is to convert text into bags of tokens and tokens create the TDM, in which each token is an attribute and each document is a case. Figure 4 indicated the steps of TDM creation followed by Filtering stopwords which removed common terms for instance “a”, “and”, ”etc.”

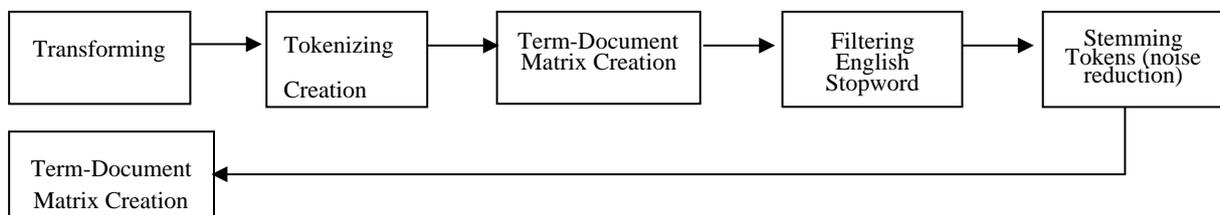


FIG. 4: Text Mining Process

Large complex data sets of textual documents contain a substantial amount of irrelevant and noisy information (Ertek et al., 2014). A frequency-based feature application has been utilized to create meaningful tokens and to remove noise for this particular dataset. This resulted in a Document containing Total occurrence and Document occurrence of most frequent words both in positive and negative data set.

4.3 Content Analysis of Positive Dataset

Succeeding the sentiment analysis, the frequency of words that appeared most were thematically grouped into a positive and negative data set (refer to Tables 2 and 3 respectively). For the large positive data set, a list of 90 words that have frequently appeared have been identified. Among the list word like 'great', 'construct', have not considered. Among 90 words identified, those words that have appeared more than 100 times are provided in Table 2, along with total number of occurrences and document occurrences. Topmost frequently mentioned six words have been considered for content analysis.

TABLE 2: Major studies related to collaboration tools.

Word	Total occurrence	Document occurrence	Associated concepts
Project	543	321	Project management tool, construction project management tool, project delivery, integrated project, project management coordination, project need, project team, project coordinator, clicking between projects, project-related documents, project organization, Accessibility of project information, project stakeholders and total control over projects.
Great	414	289	Great software, great tool, great streamlines communication, great overall experience, great way to document progress, overall performance great, bidding is great, great customer service, training videos great, great for collaborating, great experience, great for workflow, great for keeping track of communication and great time-saving.
Software	409	255	Estimation software, learning, competitors, convenient, software mobile app, great and integration software, building software, software user friendly, construction management software, accounting software and cloud-based software.
Document	333	182	Contract documents, reference documents, drawing documents, document management, document control, document traceability, communication document, event history document, store approved documents, upload documents, organize documents, documentation, accessibility of documents and duplicate documents.
Manage	269	193	Cloud-based management, better time management, better drawing control management, documentary management and workflow, construction management, document register management, project management, management features, process manage and manage plans.
Construct	251	170	Construction document, construction work, construction jobs, construction management, construction process, construction software, type of construction, pre-construction, construction manager and constructive reviews from the subcontractor.
Custom	223	158	Customer service, customization and customize, allow more customization, tool needs to be customizable without Admin rights, customer services are very accommodating and Customer support
Feature	216	166	Workflow feature, collaborate & calculation feature, navigate feature, meeting minutes feature, subcontractor features, features in computing estimation, features easy to learn, tracking features, reporting features, edit features, scheduling features and sync features.
Inform	183	139	Information, informed, transfer information, project information, organize information, relevant information, sharing information, building information, informative training, consolidate information, store information, filtering and sorting information, customize information and real-time information.
Product	181	137	Overall product, similar & great product, productivity, resultant & software product, tracking productivity, constantly improving product, Recommendations with this product, Great for our production team, product training, using a product, product data and product knowledge.

Word	Total occurrence	Document occurrence	Associated concepts
Field	161	116	Magnificent Field, Field Reports, construction field, Field Employees, field superintendents, office-field-client, field workers have instant access, schedule in the field, reduce field mistakes. a field on the dashboard and smartest field tracking program.
System	159	106	Project Management System, great & different systems, document management system, time clock system, PO system, everything in one system, project delivery system and Strong Accounting System.
Easy use	158	143	Ease to use, easy to access, Easy to use great Customer Service, get up and running right away, but complete, estimating and budgeting option, presentable to clients and Excellent and easy to use Customer support.
Access	152	119	Access current drawings, access from any device, internet access, access from anywhere, easily accessible, 1 cloud base and Document access.
Process	151	106	Project management process, dispute resolution process, construction process, closeout process, learn the process, Constant learning process, guide me through the process, process solution and Integrated processes
Company	148	111	Benefits of the entire Company, different company, individual company needs, contraction company, culture of our company, find a company, construction management company and Benefits the entire Company
Client	147	102	Client Management, Client oriented, Client view, Client login, Client keep track, first meeting with clients, clients and trade contractors, Great experience for our clients and client under a professional service.
Support	142	117	Customer support, support team, Good Support, Support service is first rate, Support is exceptional, Support staff, Support Portal, over the top support, support needs better follow up and support staff is great.
Change	136	109	Change Events, Change Orders, what has changed, contract change orders is a drag, change events, especially proposed change notices, changing features, budget changes and the change order process.
Program	133	100	Maintenance Software Program, Great program, expectations of programs are great, Program Management, Review Programs, multi-year & large capital programs and Smartest Field Tracking Program.
Track	131	112	Tracking of all documents and communication, tracking individually, monitoring permits is also tracked accurately, Smartest Field Tracking Program and Ease of tracking documents.
Function	123	103	Companies functionalities, Functionality has some kinks, earlier functionality and collaboration, minor functions, site functions are easy to use, functionality of drawing module and functionality of the system.
Update	118	96	Updates on regular basis, updated contract documents, updates to the GUI and functions, easily update a schedule, Real time field / office updates and update multiple files.
Report	116	83	Customization of reports, report on daily activities, success in generating reports, Comprehensive reports, reporting to extract the data and ability to create reports.
Allow	115	91	Allows engineers, allows quick assessment, allows us to track, allows for seamless communication, allow more customization, allow to easily learn, allow all levels of production and allows seamless integration.
Community	114	100	Joining a community, knowledge base articles in the Community and e-Builder Community function.
Learn	111	94	Learning, easy to learn & use, learning curve, learn the software, watch & learn, much to learn, learn it correctly and invest time to learn system.
Organ	111	89	Project organized, organize my construction project, organize information, organizational tool for project management, keep things organized and Information is organized in a clear manner.
Upload	103	71	Uploading drawings and updating the daily log, easy to upload, drawing revisions can be uploaded, the process of uploading or downloading files and uploads estimate to QuickBooks.
Friendly	102	94	User friendly, make it more user friendly, friendly support, very user friendly, actually very friendly and easy to download and user friendly.

Project: The total occurrence of this word is 543 and document occurrence is 321. Most of the time users mention ‘project’ to indicate the tools as ‘project management tool’ or ‘construction project management tool’ and/or indicate the project size and type that have been managed through the tools. For example, Case 799 indicated

“worked on a number of large complex projects using the tool and it was very useful, all drawings in one place and you can see previous versions of the same drawing and how it has progressed.” According to Case 12 “A must-have software for medium to large scale projects best for traceability and sharing of large files.” The above example indicated that users expressed their positive perceptions of the tools based on how they helped them to manage different types and sizes of tools along with the different features, aspects, levels and management issues of the projects. Communication aspect of tools have been mentioned also viz Case 65: “The software allows Project Management teams to efficiently and effectively communicate project details or issues, collaborate on solutions to issues, and have access to any project details at any time there is an internet connection”. Moreover, project financial tracking, accessibility of project information, project stakeholders, and ease of managing a project also mentioned to indicate positive sentiment.

Great: Great term total occurrence is 414 and document occurrence is 255. This term mainly associated to indicate how positivity of the reviewers regarding tools. Great also used to highlight some features of tools that users liked most such as user-friendliness, collaboration, streamline communication, workflow, etc features indicated as great. For instance, case 45 mentioned “It’s a really great program and I would not be able to work remotely without it. You can access the job details anywhere. You can update items on the go. And it is relatively easy to use.” On the other hand case, 99 indicated “...great for keeping track of communications, tasks, RFIs, etc., maintaining a directory, storing documents and drawings”. Moreover, case 102, mentioned the positive aspect of tools as a “great support network”, and case 233 as a “Great application to impress your clients....and Great for organizing tight schedules by the weeks.”

Software: This term’s total occurrence is 409 and document occurrence is 255. Associated words included ‘estimation’, ‘learning’ and ‘integration’. Case 7 indicated that: “It is hard to break the traditional methods (i.e., e-mail and project folders on the hard drive), especially for those that don’t like learning new software,” and in so doing emphasized the learning aspect of tools. Case 8 explained the features of tool that they like viz: “estimate in the software, which then translates to a completed Specs/Selections sheet for the customers.” In brief the software word association indicated the tools features, users’ perception of tools and different integration of tools. Such as Case 112 i.e. “software useful to track and documents all kinds of items to ensure proper work is done.”

Document: This term’s total occurrence is 333 and document occurrence is 182. The word ‘document’ word is associated with terms such as ‘contract documents’, ‘reference documents’, ‘drawing documents’, ‘document management’, ‘document control’ and ‘document traceability’. The word document is frequently mentioned as users talked about the tools document management features, how the tools deal with different sort of documents and their experiences of documents and tools. For example, Case 90 indicated the positive aspect of tools by mentioning the: “Best tool for the job site for having contract documents handy”, case 21 indicated the searchability and document transmission features is the positive aspect of tools. Another case 23 indicated the “fully complies with internal needs and also allows the organization to be up-to-date with ISO 30300 and the best practices in the documentary field.” Tracking features of documents and monitoring of emails is vital. Document register, request for information (RFI), was mentioned by case 805. In brief, document management, document control, document tracking, document associated tasks are vital for the users and the tools effectiveness is judged by its overall document management aspect.

Manage: This term’s total occurrence is 269 and document occurrence is 193. Content analysis reveal that the word ‘manage’ words is used in association with terms such as ‘cloud-based management’, ‘a user-friendly file management system’, ‘better time management’, ‘better drawing control management’, ‘documentary management’ and ‘workflow and correspondence management’. According to the way the ‘manage’ word frequently appeared it indicated that users’ perceptions of tools capability to manage the project aspect and the overall management issues are vital. For example, Case 120 mentioned that “Client Management via the tools removes the ‘grey area’ often used by clients to negotiate free services.” Another Case 4 indicated the file management system to explain the positive aspect of tools such as “It is a very user-friendly file management system that helps us/our Client keep track of all the pertinent file and drawing document on a project by project (task by task).” Conversely, Case 766 indicated “being able to manage a project on one platform that is web-based allowing for remote access”, incorporated the accessibility of tools and how they manage projects.

Construct: The total occurrence of construct term is 251 and document occurrence is 170. Construct term often mentioned to indicate construction collaboration tools, construction management software, construction type, construction project, and construction process and construction document, and so on. For instance, case 39

mentioned positive aspects of tools as “Best construction project management tool, ease of use, customer support, all field tools, financial tools, project management tools, closeout tools etc.” Another case 68 said about tools “...helping me to organize my construction project by providing subcontractors a platform for consolidated document review.” In short, construct terms often used to indicate projects, tools, processes and so on.

Custom: Total occurrence of ‘custom’ is 223 and document occurrence is 158. The word custom is further associated with such as ‘customer service’, ‘customization’ and ‘customize’. Users frequently utilize this word to discuss the customer service facilities provided by the tools followed by the customization capabilities of different tools. Examples include Case 66 who indicated that: “the customer service by far is the BEST I've ever encountered anywhere. They ALWAYS get you an answer in such a timely manner and are so polite, friendly and willing to go the extra mile.” Case 422 indicated that: “so the Customer support is a big help to assist the users of the functionality, custom builder, flexibility in customization, connect with customers.” Another reviewer mentioned: “The ability to bring everything together into one file from communication with trades/suppliers/Customers to filing contracts/change orders/financial matters. Business Intelligence (BI) reporting provides more options for customized reporting.” So, customization features are vital for users and not all tools provide the features.

Feature: The ‘feature’ word total occurrence is 216 and document occurrence is 166 and was associated with features such as ‘workflow features’. According to case 213 “The snapshot feature allows me to send changes to foremen in the field when I receive it.” Other features that users discussed included: “The features I like most about this application are the ability to sync to other users.”, “tracking features”, “Time tracking features”, “good features in computing estimation” and “document management features.” Moreover, “The punch list feature” is incredibly convenient according to Case 321. Another Case mentioned that “constantly growing and adding new features, multiple functions” was desirable. These indicated the features of collaboration tools are vital for the users and the overarching positive aspect of tools were their features that satisfied the users’ needs.

4.4 Content Analysis of Negative Dataset

After sentiment analysis, the negative and positive data set was investigated by text mining approach and the frequency of total word and document occurrence of word have been created. In the negative data set list word like ‘great’, ‘builder’ and ‘construct’ were omitted as they do not exhibit any meaningful result. Although a total of 81 frequently appearing words were noted, only words had more than 40 total occurrences and were selected for content analysis. Findings of the top six frequently appearing words are now discussed in detail.

TABLE 3: Major studies related to collaboration tools.

Word	Total occurrence	Document occurrence	Associated concepts
Project	251	137	Project management, large-size projects, project documents, project manager, manage an entire project and tracking project.
Document	191	98	Document tracking, edit documents, poor documentation, critical construction documents, companies documentation, project documents, field documentation side and document control manager.
Software	151	112	Project management software, powerful software, accounting software, software is expensive, easy to use software, improving the software and software was more user friendly
Manage	109	73	Management software, construction management, project management, monitoring and properly manage, manage an entire project, how we managed our business, document management and manage appointments.
Report	99	60	Custom report tool, customization reports, put a daily report together, inspection reports, reports to be exported, ability to utilize BI for reporting, many types of reports, project reportment field and setting up reports.
Feature	77	56	Features are difficult to learn, features not working, features they promise some features require internet connection, feature that adds material to overall cost, some additional features, report features and few features that it doesn't have.
Access	70	54	Database accessible, allows access to important information, peak hours can limit access, no internet....no access, easily accessible tools that are used daily, has access to every document at any time, have access to all project documents, access from different software and easy access to projects information.
Process	68	40	Slow the process down, process need work, streamlining process, selection process, construction process, process integration, billing process, business process, can be slow to response and process and not a smooth process.

Word	Total occurrence	Document occurrence	Associated concepts
Custom	67	49	Customer support customers, custom build, custom report tool, interaction and customization, customer service, customer-centric, customer interaction and customer portal.
Field	66	47	Project management field use in the field and the office, field documentation, field team, some data fields not available for setting up reports, custom fields. and not certain what fields to fill out.
System	66	42	System overloads, system navigate, overall system, have duplicity in the system, data access can be challenging for a project-based system, difficult to learn the system and reporting system.
Upload	62	40	Re uploaded, ability to upload, documents upload, mass upload product specs, need more flexibility for folders and uploading, only single photo upload and uploaded file difficult to find.
Allow	61	51	Allow to store, more level of users allow different pricing structures, allow mark ability, allow to tack as-built work, allow many users to work together, the workflow does not allow multiple comments per sheets and doesn't allow for flush photography.
Update	56	38	Update construction documents, design updates, complicated to update, updated drawings, regular updates and mobile update.
Inform	54	40	Centralized information, project information, required information, extract some analytical information is not available, crucial to transmit accurate information and not able to access or manipulate all the information via an app.
Function	48	42	New functionalities, drag and drop functionality, project functions and details, difficult to produce a report with functions, crash issue fixed functional but limited ability, too many functions, need to apply similar functions, level of functionality, some functionality is not working, office function.
Search	48	31	Requires searching, search can be frustrating, hard to search for documentation, ease of search, keyword search features, search capabilities difficult, advanced searching engine, no cross-search area and search engine for a document.
Program	46	37	Different apps and programs, program can be unreliable, does not integrate with CAD programs, interfaces with existing construction and accounting programs, automated programs, programs go down and making the program better.
Organ	45	36	Organized, organization has registered expensive, documents from which organization to which organizations, file organize, upload and organize drawings and sheets were organized as they were meant to be.
Product	44	38	Working with Product, utilize a product, product review, productivity, workable product and other products cheaper,
Track	42	38	Document tracking lose track of things, project tracking, there is no backtracking through hundreds of emails, issue in tracking., difficult to track equipment use hours and no way of tracking sub-contractors.

Project: The total occurrence of this word in negative data is 251 and document occurrence is 137. After analyzing the content of the negative data set reviews, it has been found that to mention the tools as a project management software the word has been utilized. Akin to the positive data set, 'project' was discussed along with the negative aspect of the tools that cannot support different aspects of projects. According to Case 104: "Those all come in different file format. The format can be anything from rvt's, .rfa's, .rte's, .dwg's, .dxf's, .xlsx's, and the list goes on including different Adobe and Microsoft file formats. For large scale projects it is inevitable that all these file types get mixed up in a folder or folders. I think 'sorting by file type' would be a valuable addition to this otherwise extremely helpful tool." Case 14 indicated that: "People end up putting the documents related to certain parts of the project in folders, and it is easy to lose track of things."

Software: Total occurrence of this word is 151 and the document occurrence is 112. Reviews mentioned 'software' to discuss tools such as construction project management software, powerful software or only software. Moreover, this word is associated with the bugs, glitches, slowdown of computers, loading and crashing of the software/ tools. Constantly rolling features, functionality, organization and structure were also mentioned. Another problem indicated by Case 106 is: "This software makes easy to non- Revit Users to collaborate on a Project, this is a very heavy software and can make your computer slow. Also, with the high-speed internet today's we need a real-time collaboration type of software."

Document: The 'document' word had a frequency of 191 and 98 document occurrences. The context for using the word document included to indicate 'document tracking', 'reuploaded document', 'accessing project documents', 'streamline and time stamp documents', 'extreme amount of document storage' and 'link RFI'. According to one user: "There is a document format that it cannot produce" thus indicating the document format related issues. Another problem was highlighted as: "people end up putting the documents related to certain parts of the project in folders, overloaded of sites." Reviewers also faced problems while searching for documents through "searching features "of tools. Comments like "It is sometimes hard to navigate through the site and find specific reports or search for documentation." Indicated the searching problems. Case 424 mention "It was challenging to not be allowed to edit folder names and files without permissions for each file as a document control manager." In brief, negative sentiments of tools indicated a variety of difficulties related to the document management features.

Manage: This word had a total occurrence of 109 and document occurrence of 73 and was associated with manage, management, manager word. These words have been mentioned to indicate 'construction management', 'project management', 'budget manage' and 'manage meeting minutes'. While the positive dataset indicated the management aspect of tools, the negative data set indicated that too many people using the site at once sometimes disrupt the management of work. Case 813 mentioned "...This software is not intended for an overall program management software and does not have a means of tracking action items, financial, change management, etc. The biggest hurdle to overcome is that this is not a folder-based structure."

Report: This word had a total occurrence of 99 and total document occurrence of 60. After analyzing the content of negative data set, 'reports' association are related to 'customization', 'custom tools', 'daily report', 'inspection report', 'navigating specific report', 'reporting' and 'dashboarding'. Reviewers specifically mentioned that the word report was associated with phrases such as slow, buggy, not intuitive for tools. One poignant comment indicated problems faced by users viz: "...had some complications on syncing when using tablets in the field, causing a loss of Daily Reports. To access a drawing, you have to completely back out of the field report. It takes 4 steps to get to a specific drawing, and then 5 steps to back to the field report." Tracking and generating report for received and issued drawings and packages is difficult according to one reviewer of tools. Another reviewer mentioned that reports need a lot of work as each report ends up being 100 + pages of checklists.

Feature: This word had a total occurrence 77. Words of associated with the word feature include: 'difficult to learn', 'user friendly features', 'report', 'constantly rolling out features' and 'features exclusive to web app while other features are exclusive to windows or iOS native app'. Reviewers mentioned a desire to see more features such as the ability to create a custom report tool. According to one reviewer, constantly improving features of tools means investment, another reviewer mentioned that report features take time to get used to and to pull out required information. Moreover, requests to include more tutorials to address new features and tools to help implementation was identified together with the observation that constant rolling out of new features resulted in implementation that never ends. Case 104 stated that: "The missing feature of being able to sort file by file type."

Access: This word Total occurrence is 70 and document occurrence is 54. The associated concept for the term "Access" is "no internet no access", "peak hours can limit access", "app does not have same access", "accessible", "access to all project documents", "access all data input" and so on. Content analysis revealed that accessibility-related issues of tools often resulted in negative sentiment. For instance, case 53 mentioned, "seem to have issues from time to time resulting in features not working or the site/app not being accessible."

Process: The total occurrence of process term is 68 and document occurrence is 40. Negative sentiment reviews revealed associated concept with "process " terms are "Slow the process down", "process need work", "streamlining process", "selection process", "construction process", "process integration", "billing process", "business process", "can be slow to response and process", "not a smooth process", and so on.

Associated concepts of process term within negative data set indicated various process-related issues which resulted in difficulties. For example, case 150 indicated "At times, the workflows can slow the process down. You end up waiting on other people to complete their tasks". Furthermore, case 314 mentioned, "Selection process is painstaking; No import option for price catalogs or bidding software". Overall, the frequency of the process term indicates process-related negative sentiment of users.

5. DISCUSSION AND CONCLUSION

The overall sentiment analysis revealed that users incur both positive and negative experiences of collaboration tools. This is an intuitive finding, given the broad range of knowledge and experience within the target population frame. Although existing tools exist in large number, still users are face problems. Overall, the findings indicated that the document management features of tools are significant, and users face issues regarding document findings, searches, and organization and file format aspects. For instance, “Document” word in Table 1 (Total occurrence 333) indicated that tools are judged by their overall document management aspect. However, in Table 2 the same word “Document” is associated with negative sentiment of tools indicating a variety of difficulties related to the document management features. Report features were also observed to be important to users. Issues and problems related to report features were identified and several users discussed the customization of report features. On the other hand, based on “project size” collaboration tools users experience, and tools adoption differs. Apart from these, customer service assistance of tools is an important criterion for users’ satisfaction. Moreover, user-friendliness of tools is also shown to be of significance.

The study investigated the users’ perception of collaboration technology and contributes to the wider body of knowledge in this area. By gaining a deeper and richer appreciation of both the negative and positive perceptions, industry practitioners are better able to implement strategies to maximize collaboration potential in their businesses. In turn, such knowledge could facilitate improvements in productivity performance on site and facilitate better business outcomes. The results present an insight on users’ perceptions regarding collaboration tools. The methodology adopted investigated big data and created a base for further analyzing the dataset. This methodology studied the open source domain data and thus analysis is reproducible. The study also identified the points against which collaboration tools proved satisfactory or unsatisfactory users. The study has limitations, in that it considered only the most frequent terms. Moreover, consideration of other groups of words and different tools may result in broader findings. Thus, wider sample may be considered in a future study to investigate users’ perception in greater detail.

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