



## **INFORMATION MANAGEMENT RESEARCH IN THE CONSTRUCTION INDUSTRY FROM 2011 TO 2016**

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**Abstract:** This paper examines information management (IM) research in the construction industry (CI) for the period 2011 to 2016 inclusive to identify research focus. The scope of this study targets all phases of a project and is based on the construction industry in North America. A structured process is used to select and analyse 168 articles from literature. The articles are analysed in the context of a spreadsheet matrix framework based on: (i) Articles bibliographic attributes (year and country); (ii) Industry perspectives (industry, organization, project, library, and personal); (iii) PMBOK process groups (initiating, planning, executing, controlling and monitoring, and closing); (iv) Functional IM Model perspectives (IM process, IM input and output, IM resources and IM constraints); and (v) Performance assessment methodologies (management, content, and infrastructure). The results indicate six emerging sub-themes and IM research focus from a construction project perspective, specifically in the project management-executing phase. There is focus on improving information access and dissemination, information value, Information as a Resource, ICT integration, and reducing IM complexity. There is little focus on assessing ICT (infrastructure), IM (management), and Information (Content). This paper identified research focus, emerging areas of interest, and areas that may require further research, which could be useful to IM researchers and managers of information.

### **1 Introduction**

The construction industry (CI) can be characterised as a complex and highly specialised industry that operates on information. This complexity and specialization demands the proper management of information at the project and organizational levels to avoid issues relating to: poor quality of information, untimely communication and exchange of information, loss of information, completeness of information, evaluating the value of stored information, access to relevant information, and flexibility of information systems to meet user information needs. Construction IM researchers, such as, Titus and Brochner 2005; Hicks et al. 2006; Forcada et al. 2007; Tang et al. 2008; Karim, and Hussein 2008; Chassiakos and Sakellariopoulos 2008; and Sheriff, et al. 2012, have identified and proposed solutions to resolve many of these issues. This indicates that effective information management (IM) is essential for the success of engineering and construction projects and organizations. Given the challenging nature of IM in the CI, an important first step is to understand construction IM literature, to identify emerging areas of interest and areas that may require further research. The literature reviews and literature analysis of construction IM literature tend to concentrate on a single aspect of IM, for example, information technology, information systems, or BIM. As a result, literature reviews and analysis do not provide an extensive classification of IM research in the CI, because of the lack of collective consideration for key IM perspectives such as, people resources, ICT resources, practice resources, IM processes, IM objectives, IM inputs and outputs, and IM constraints. Further, no extensive classification or analysis of IM literature for the CI was found for the study period in North America.

The objective of this paper is to classify the current state of IM research in CI for North America from 2011 to 2016 inclusive (2017 was not a complete year at the time of this study). The classification is achieved by comparing articles with a primary focus on IM to categorizations developed from (i) Bibliographic attributes from the articles (publication year, first author's country); (ii) Detlor's (2010) perspectives of IM (organizational, library and personal), which was modified based on literature analysis to include the industry and project perspectives; (iii) PMI's PMBOK process groups (initiating, planning, executing, controlling and monitoring, and closing) (PMI, 2013); (iv) Aziz et al. (2016) Functional IM Model (IM process, IM input and output, IM resources and IM constraints), which was developed based on the IDEF0 model (Presley and Liles 1995) and the construction conceptual assessment model (Fayek et al. 2008); and (v) Pickard's (2007) performance assessment methodologies (qualitative and quantitative), which were applied to IM attributes assessment (management, content, and infrastructure) based on literature analysis. This paper is limited to electronic journal articles published in English language journals and include technical articles, research articles, literature review articles and case studies. The contribution of this paper is the classification of the state of IM research in the CI for North America, which provides insight into IM areas that may require further research.

## 2 Methodology

The research methodology in Figure 1 shows the process used to identify and analyze the IM literature. The categorizations used to develop the matrix are shown with the authors, and the section in which they appear in this paper. The bibliographic attributes (year of publication and first author' country) embedded in each article are extracted directly from the article.

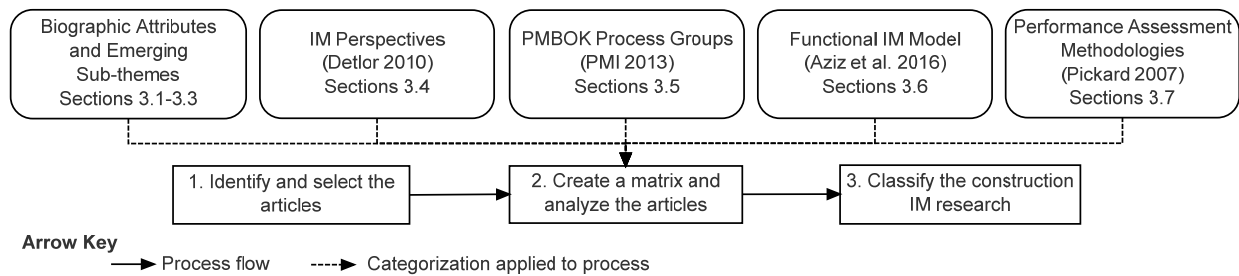


Figure 1: Research Methodology

The structured process used to select the journals and articles on IM in the CI for the period 2011 to 2016 inclusive for Figure 1; Step 1 is presented in Figure 2.

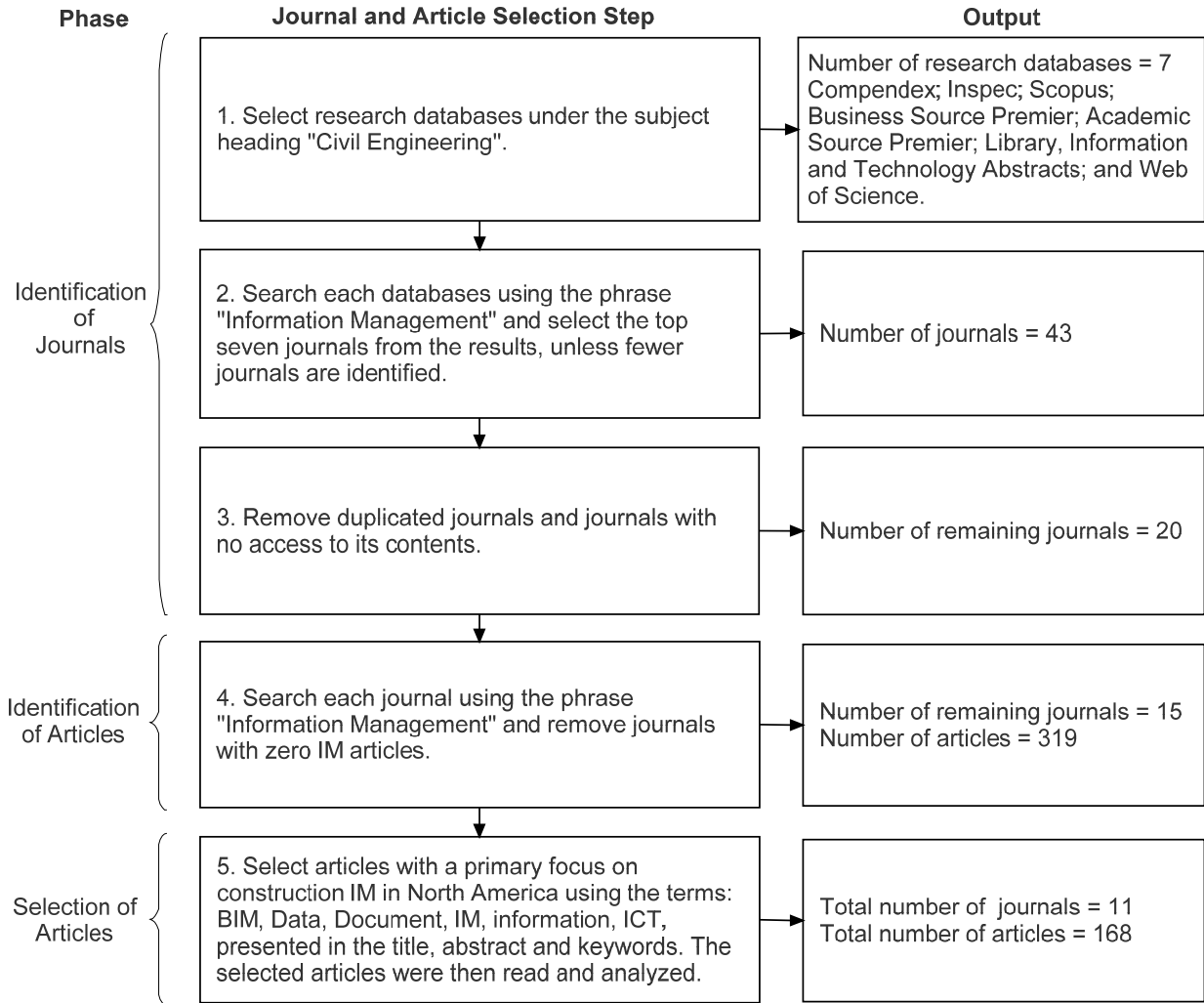


Figure 2: Journal and Article Selection Process

To analyze the literature, the definition provided by the respective author(s) for each categorization identified in Figure 1 and the key terms provided in the articles' title, abstract, and keywords was compared to the articles during the reading and analysis process to determine the primary area of IM focus; some subjectivity is inherent in this process. The "number of articles" is the unit of measurement in this paper, which allowed each article to be counted once for each area of focus; articles that focus on two or more areas are placed in a group called multiple areas. The articles that are not a focus on an IM area are not shown in the results. The percentage value shown in the results section are rounded-up to the nearest whole number.

### 3 Results and Discussion

The results from the analysis of the 168 articles are presented and discussed in sections 3.1 to 3.7, which highlights the areas of IM focus in the CI.

#### 3.1 Number of Journals and Articles

The number of journals and articles obtained from Figure 2, Step 5 are presented in Table 1. The analysis indicate focus on information as a resource, data management, and information and communication technologies.

Table 1: Total Number of Journals and Articles

Journals	Number of Articles
Automation in Construction	50
Journal of Computing in Civil Engineering	33
Advanced Engineering Informatics	27
Journal of Management in Engineering	15
Journal of Construction Engineering and Management	14
Construction Innovation	9
Journal of Information Technology in Construction	8
Engineering, Construction and Architectural Management	4
Journal of Professional Issues in Engineering Education and Practice	4
Canadian Journal of Civil Engineering	3
International Journal of Project Management	1
Journal Count = 11	Article Count = 168

### 3.2 Publications by Year

Figure 3, presents the number of articles published per year from 2011 to 2016 inclusive with a primary focus on IM. Of the 168 articles, 141 articles (84%) focus on IM in the U.S.A and 27 articles (16%) focus on IM in Canada. A 4-year moving-average trend (not shown) indicates a consistent focus on IM in the CI. A 4-year moving-average trend was selected to reduce the number of fluctuations in the trend line and make it easier to interpret the result. The increase in 2013 is due to the focus on BIM.

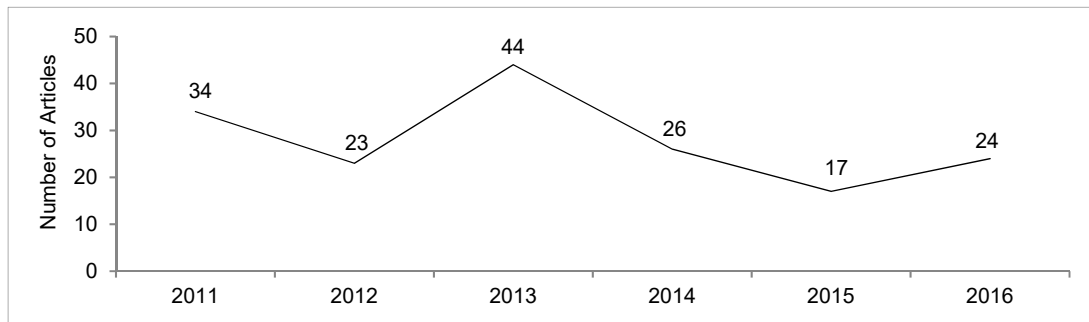


Figure 3: Articles Publication by Year

### 3.3 Emerging Sub-theme

The 168 articles are classified into six emerging sub-themes and presented in Figure 4. The sub-themes were developed based on the terms used to select articles in Figure 2, Step 5. The sub-themes include: (i) *Building Information Modelling (BIM)*, 30 articles (30%) indicate a focus on BIM process integration into construction project information systems (IS) to improve the visualization and sharing of information; (ii) *Data Management*, 22 articles (13%) indicate a focus on automated project data and information collection; (iii) *Document Management*, 10 articles (6%) indicate a focus on project information retrieval; (iv) *Information and Communication Technology (ICT)*, 45 articles (27%) indicate a focus on the use of mobile and collaborative-based technologies to enhance the communication, and exchange of information among project participants; (v) *Information as a resource*, 27 articles (16%) indicate a focus on information retrieval and the integration of information from various sources to improve information value; and (vi) *Information Management (IM)*, 14 articles (8%) indicate a focus on information accessibility and relevance to improve project communication. An overall analysis of the sub-themes indicates that the state of IM research in the CI is trending towards enhancing project IM activities to improve information visualization and value.

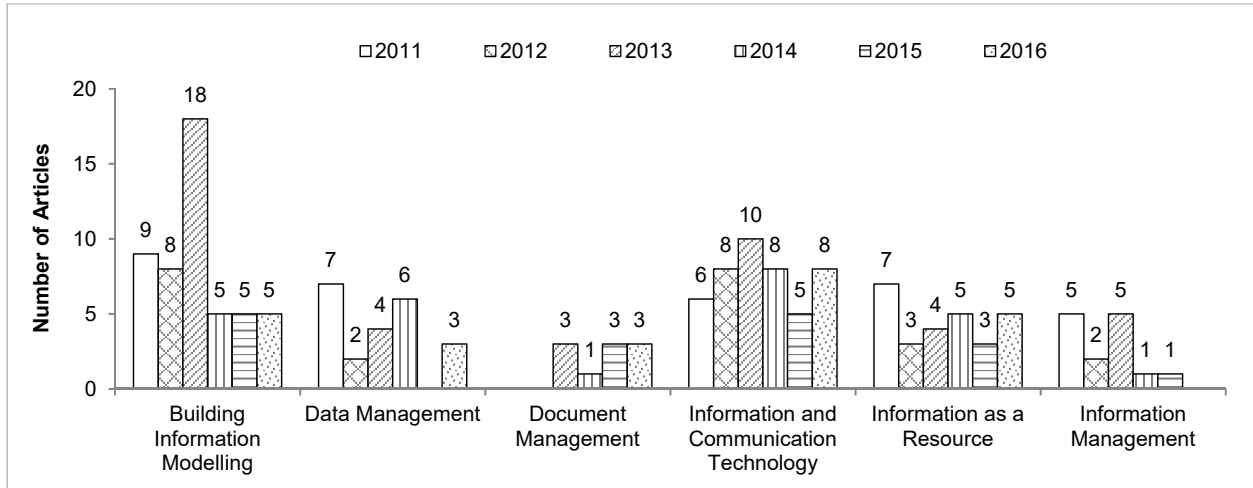


Figure 4: Emerging Sub-Themes

### 3.4 Information Management Perspectives

The 168 articles are classified into the four IM perspective and presented in Figure 5. The perspectives include: (i) *Industry perspective*, 19 articles (11%) focus on improving IM standards for the CI; (ii) *Organization perspective*, 9 articles (6%) focus on improving IM processes in construction organizations; (iii) *Project perspective*, 135 articles (80%) focus on improving project information classification and navigation; and (iv) *Individual perspective*, 5 articles (3%) focus on improving information workers IM behaviour. The *Library perspective* did not yield any article. An overall analysis of the IM perspectives indicates a focus on reducing errors due to incorrect information, providing the right information for decisions, and improving the value of stored information.

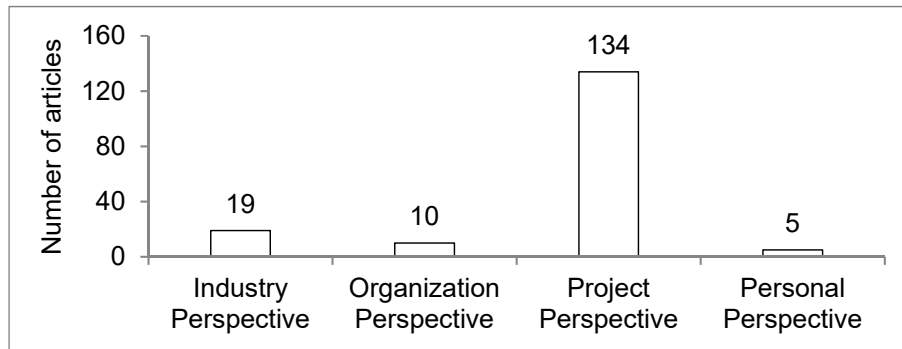


Figure 5: IM Perspectives

### 3.5 PMBOK Process Groups

The analysis indicates that of the 168 articles: 135 articles (80%) are a focus on the PMBOK process groups, as presented in Figure 6. Focus is on ICT interoperability and scalability to improve the executing phase of construction project management. An overall analysis of the process groups indicates a focus on reducing delays due to information overload and improving the classification of project information to reduce inefficiencies.

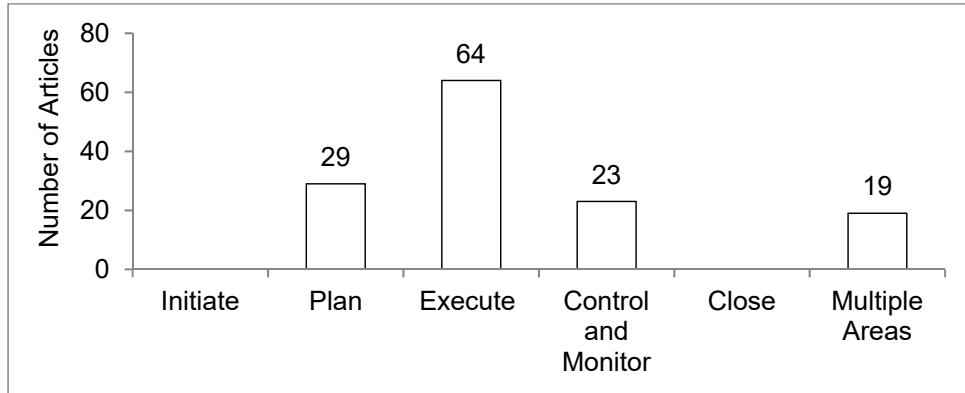


Figure 6: PMBOK Process Group

### 3.6 Functional IM Model

The model in Figure 7 provides five IM perspectives (IM Process, IM Inputs and IM Outputs, IM Resources, and IM Constraints). The results for each perspective are provided under their respective sub-headings in this section.

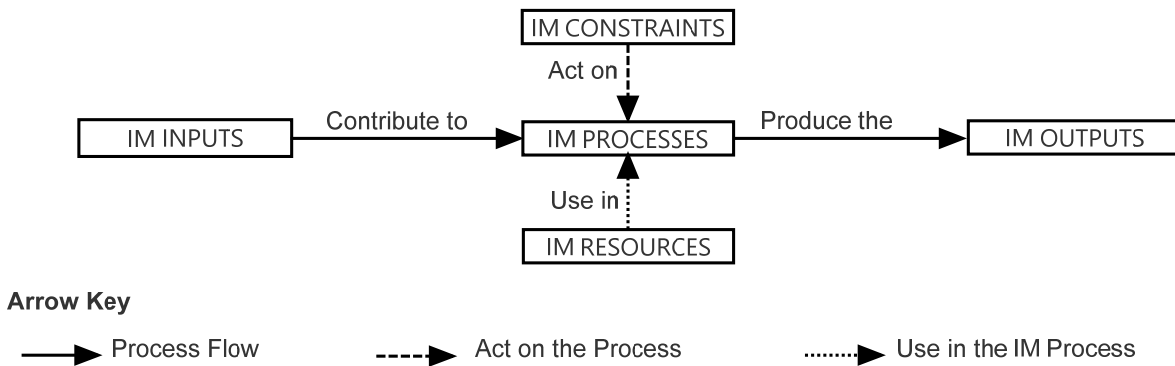


Figure 7: Summary of the Functional IM Model

*IM Process:* Of the 168 articles, 109 articles (65%) are a focus, as presented in Figure 8. The six activities in the IM process are used to transform the IM input to IM output and were identified by Choo (2008). Focus is on the access and dissemination of project information.

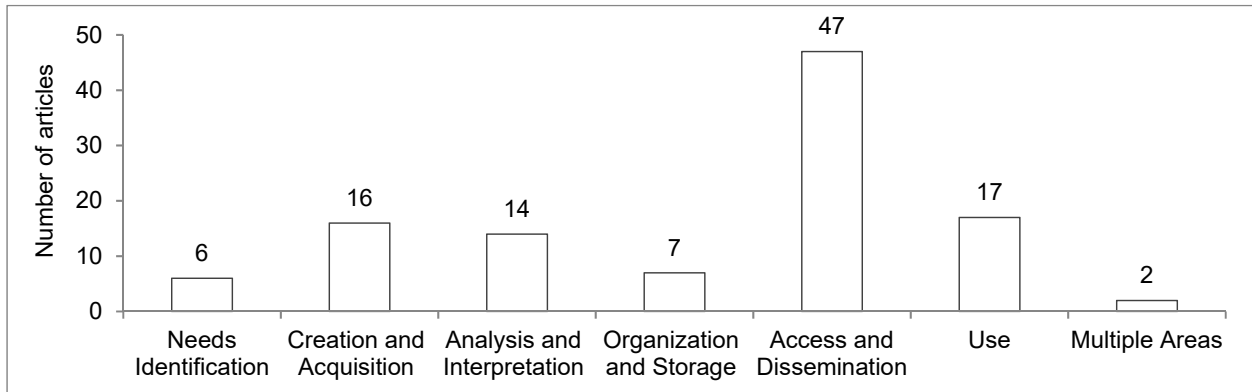


Figure 8: IM Process

*IM Inputs and IM Outputs:* Of the 168 articles, 74 articles (44%) are a focus, as presented in Figure 9. The inputs and outputs are combined and classified as flow, quality, and value of information that contribute to, and produce by the IM process, respectively. Focus is on the value of project information to improve project success.

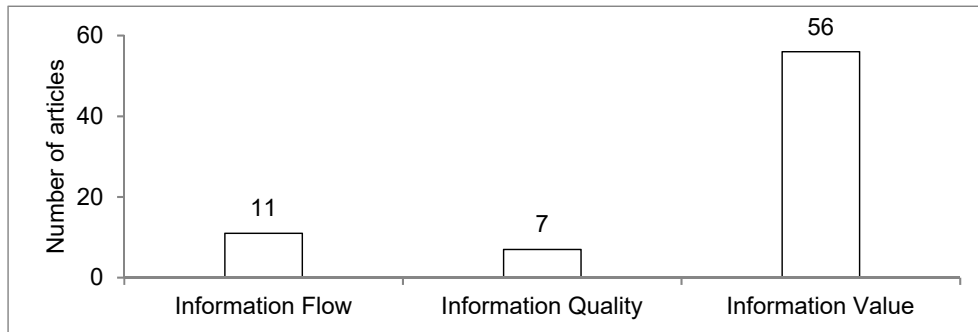


Figure 9: IM Inputs and Outputs

*IM Resources:* The resources used in the IM processes to achieve the IM output are presented in Figure 10. Each resource is compared separately to the 168 articles. The resources include: (i) *People*, Of the 168 articles, 31 articles (18%) focus on information behaviour relating to information gathering and perceived information needs; (ii) *Information as a Resource*, Of the 168 articles, 149 articles (89%) focus on strategic information and document management to improve information value; (iii) *Information and Communication Technologies (ICT) and Information Systems (IS)*, Of the 168 articles, 133 articles (79%) focus on the adoption of new technology to improve the development of information management systems; (iv) *IM Practices*, Of the 168 articles, 139 articles (83%) focus on practices for information communication and exchange to improve information service delivery.

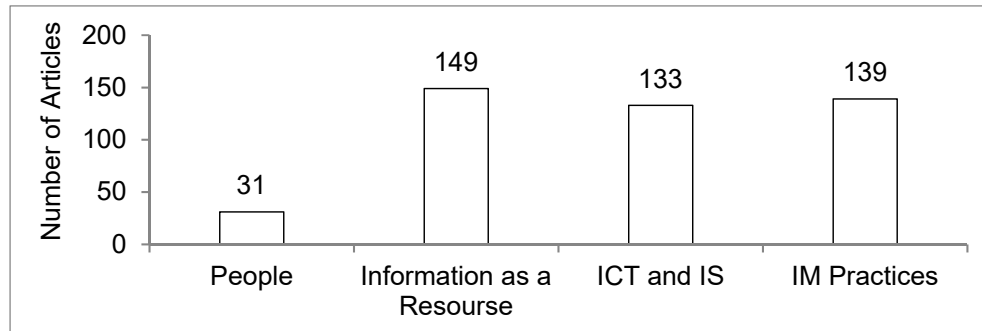


Figure 10: IM Resources

*IM Constraints:* The constraints that act on the IM processes and influence the achievement of the IM output are presented in Figure 11. Each resource is compared separately to the 168 articles. The constraints include: (i) *IM Objectives*, Of the 168 articles, 90 articles (54%) focus on reducing the hindrances to information access and usability; (ii) *Organizational IM Conditions*, Of the 168 articles, 148 articles (88%) focus on reducing complexity in IM and identify hindrances to information system flexibility and IM interdependency.

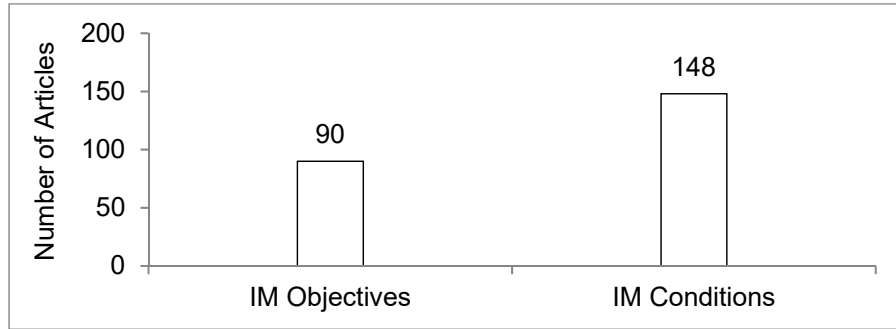


Figure 11: IM Constraints

### 3.7 Performance Assessment Methodologies

The analysis indicates that of the 168 articles: 20 articles (12%) are a focus on performance assessment in IM. Figure 12 presents the classification of the combined qualitative and quantitative research methodologies as: IM assessment (focus on management attributes), Information assessment (focus on content attributes), and ICT assessment (focus on infrastructure attributes).

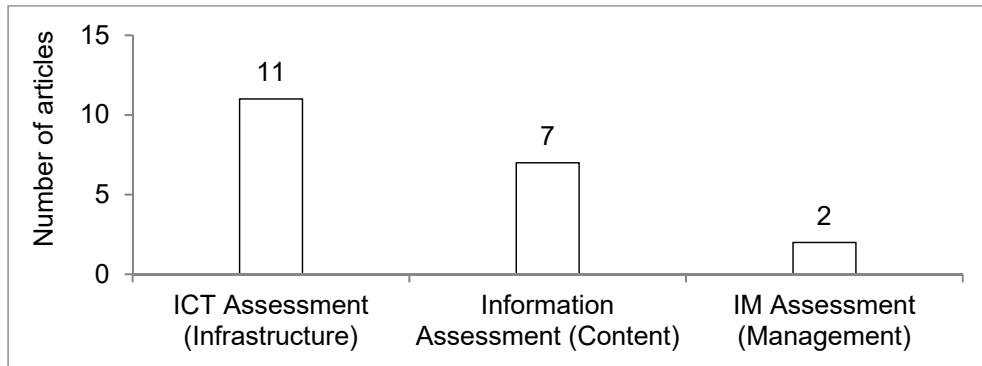


Figure 12: IM Performance Assessment Methodologies

## 4 Summary and Conclusion

This paper provides a classification of IM literature in the CI for the period 2011-2016 inclusive. The scope of this study is limited to North America. A total of 168 articles with a primary focus on IM in the CI were selected, classified, and analysed using a structured methodology. A spreadsheet matrix developed from IM categories identified in the literature is used to analyse the articles and identify the state of IM research in the CI. Figure 13, summarises the coverage of the literature for each categorization.

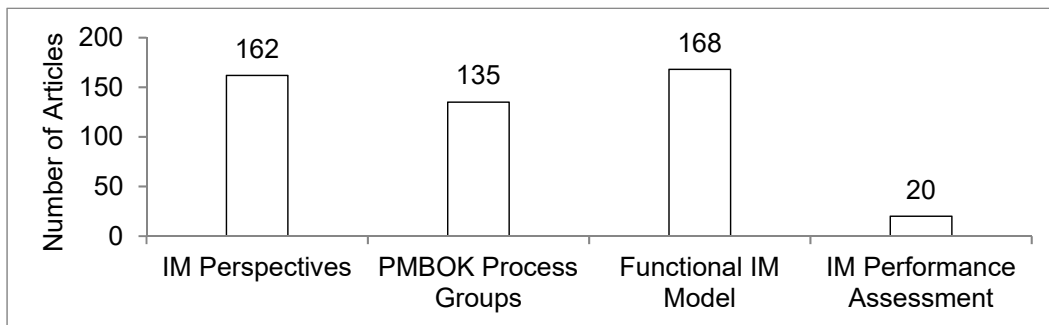


Figure 13: Literature Coverage for each Categorization



The findings can be summarized as follows:

- *Emerging Sub-Themes*: The two most frequent sub-themes are BIM and ICT, while the least frequent is Document Management and IM. There is a decline in BIM focus on IM, although there is an overall increase in BIM publications in the literature. Based on the articles rejected in Figure 2, step 5, a possible explanation for this decline is due to the shift in BIM research focus to improve construction processes that could lead to improved IM.
- *IM Perspectives*: the most frequent focus is on the construction project perspective, while the least frequent focus is on organization and individual perspectives. This is the result of increased testing of mobile and software technologies (e.g. BIM) in engineering and construction projects to improve the ease in finding the required information.
- *PMBOK Process Groups*: The most frequent focus is on the project executing phase, while the least frequent is project initiating and closing phases with no IM study for the analysis period. This is due to the consideration for information gathering and handling during construction.
- *Functional IM Model*: The most frequently studied perspective is the *IM resources*. The focus on each perspective includes:
  - *IM Process*, the most frequent focus is on information access and dissemination, while the least focus is on the identification of information needs, creation and acquisition of information, analysis and interpretation of information, and information use. This is due to the complexity in locating information on an as-need basis.
  - *IM Input and Output*, the most frequent focus is on information value, while the least frequent focus is on the quality of information at project, organization, and industry levels. This is because of focus on information sources and details to produce information of value.
  - *IM Resources*, the most frequent focus is on information as a resource and ICT, while the least frequent focus is on People. This is due to technology integration in information and document management systems to improve information flow and visualization; ultimately producing valuable information that can be considered a project resource.
  - *IM Constraints*, the most frequent focus is on reducing hindrance to project conditions that can negatively affect the IM process, specifically IM complexity, while the least frequent is on IM Objectives, specifically the currency of information used in engineering and construction projects.
- *Performance Assessment Methodologies*: There are few studies on IM performance assessment. The most frequent perspective assessed is ICT (infrastructure for IM) assessment, while the least frequent assessed are IM (management of information) and Information (content of information). There are several proposed benchmarking and maturity models for the evaluation of ICT. However, assessment of information and IM is lacking in literature.

This work has provided an extensive analysis of IM literature in the CI for the study period, and identifies current research focus, emerging areas of interest, and areas that may require further research. The author's assessment indicates an overall trend, which suggests a focus on improving the management of project activities that could influence IM changes in project participants' actions, which will lead to IM improvements in the CI.

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