Content validity of governing in Building Information Modelling (BIM) implementation assessment instrument

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Abstract. BIM governance assessment instrument is a process of analysing the importance in developing BIM governance solution to tackle the existing problems during team collaboration in BIM-based projects. Despite the deployment of integrative technologies in construction industry particularly BIM, it is still insufficient compare to other sectors. Several studies have been established the requirements of BIM implementation concerning all technical and non-technical BIM adoption issues. However, the data are regarded as inadequate to develop a BIM governance framework. Hence, the objective of the paper is to evaluate the content validity of the BIM governance instrument prior to the main data collection. Two methods were employed in the form of literature review and questionnaire survey. Based on the literature review, 273 items with six main constructs are suggested to be incorporated in the BIM governance instrument. The Content Validity Ratio (CVR) scores revealed that 202 out of 273 items are considered as the utmost critical by the content experts. The findings for Item Level Content Validity Index (I-CVI) and Modified Kappa Coefficient however revealed that 257 items in BIM governance instrument are appropriate and excellent. The instrument is highly reliable for future strategies and the development of BIM projects in Malaysia.

1. Introduction
Building Information Modeling (BIM) has been used widely by designers, contractors, and suppliers to reduce the demand (time, cost, and quality) in construction projects and achieve detail design that would be possible without 3D-digital design and fabrication [1]. Public and private clients now are requiring BIM and it has been widely adopted for complex projects. According to the study by Stanford University’s Center for Integrated Facility Engineering report that, BIM will continue rise in the future. BIM generally encompasses a series of technology appliances that transforming design and construction. Several aspects of BIM definitions deserve discussion. However, the most common understandable definition of BIM is from the National Institution of Building Services (NIBS) [2] as follows:

‘A Building Information Model, or BIM, utilizes cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, and is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility’.
Model (models) is a central information resources that drive for a communication and interdependence, thus leads to building information models are the platforms of collaboration practices [1]. BIM offers stakeholder collaboration to every project lifecycle to insert, extract, update, or modify the information during the BIM process [3]. It is clear from previous research that BIM prioritises collaboration as the heart of the construction process [4]. Hence, it can be concluded that BIM provides the opportunity for collaboration. This will enable the project stakeholders to work from a fragmented working process to the seamless flow of structured process.

2. Problem statement
BIM governance has not previously been investigated in construction projects in details [5]. Previous studies [6–9] had focus on ICT governance efforts and framework; however it is not developed to meet the construction industry needs and requirements [10,11]. With regards to the issues above, it is pertinent to define definitions of BIM governance to better understanding on the subject matter. Data governance is define as ‘the collection of decision rights, process, standards, policies, and technologies required to manage, maintain, and exploit information as an enterprise resources.’ [12]. Meanwhile, BIM governance also is define as ‘the process of establishing a project information management policy across lifecycle and supply chain underpinned by a building information model taking into account stakeholders’ rights and responsibility for project’s data and information’ [13]. Given the above, in the context of this research, BIM governance could be defined as a process of establishing a project information policy through the collection of technical and non-technical elements taking into consideration of stakeholders’ rights and responsibility for project's data and information.

Past studies [14–17] have investigated technical and non-technical issues of BIM adoption. The technical BIM adoption issues could be divided into five (5) namely; lack of training; inadequate business process; lack of compatibility and reliability; resistance of change; and lack of data integrity/user authentication [14–17]. While, the non-technical BIM adoption measures could be divided into three (3) namely; people related, organisational cultural values/beliefs and process [14–17]. Nevertheless, the previous research failed to address many important instruments such as legal, contractual and information ownership; governance control; project & client attributes; and market structures which are very crucial from the technical and non-technical perspectives. Due to the lack of these instruments, the data are regarded as inadequate to develop a BIM governance framework. Hence, the study aims to fill the gap by identifying additional crucial constructs for a BIM governance framework. The framework comprises of six (6) important constructs namely: project attributes in BIM-based projects; client attributes in BIM-based projects; client demand in BIM-based projects; governing success measure of BIM-based projects; governance and control of BIM-based projects and market-structure. The objective of the paper is to develop and evaluate the content validity of BIM governance assessment using Content Validity Ratio (CVR), Content Validity Index (CVI) and modified Kappa coefficient for the six constructs. The purpose of assessment is act as input factors (initial step) prior to the main data collection to form a conclusive BIM governance framework.

3. Methodology
The methodology used for this research is based on quantitative research technique through predetermined questionnaire of content validity distributed to panels of content experts. Accordingly, this study was undertaking an analysis of the BIM governance instruments that facilitate the successful of BIM implementation. The purpose of the evaluation was to determine the content validity of the BIM governance instrument. The following provides an overview and analysis of the main findings of this research. The findings of the questionnaire survey were evaluated through Content Validity Ratio (CVR), Content Validity Index (CVI) and Modified Kappa Coefficient (K*) which are discussed in turn.
3.1. Literature Review
The first method is through literature review of four existing BIM governance assessment instruments [1,5,18,19] in order to identify critical components in BIM governance and the impact of governance on BIM. The purpose of literature review is to develop BIM governance instrument in the form of questionnaire (i.e., CVR - 3-point scale; and CVI - 4-point scale).

3.2. Questionnaire survey.

3.2.1. Classification of respondents. A minimum of five (5) experts is recommended to have ample control over the chance agreement on the content validity [20–22]. In addition, the maximum numbers of experts have not yet to be determined nonetheless it is unlikely that more than ten experts were not recommended for this assessment. Thus, eight (8) respondents have been selected as content experts for the purpose of this research since the recent study received by six (6) content experts in construction management research [23]. Hence, it could be inferred that the numbers of experts involved in the research are acceptable. Table 1 provides information on the eight (8) respondents that were selected as content experts. Based on the designation, professional background and experience of the respondents in construction industry and BIM, it is reasonable to deduce that the respondents have sound knowledge and prominent on BIM-based projects particularly related to the client governing BIM instrument items.

Table 1. Sample and respondents of the content validity.

| No | Respondents                  | Research-based                        | Industry / Academia | Experience in Industry (years) | Experience in BIM (years) |
|----|------------------------------|---------------------------------------|---------------------|-------------------------------|--------------------------|
| 1  | Senior Manager               | Building Information Modelling (BIM)  | Industry (Public Sector) | 24                           | 7                        |
| 2  | Ass. Vice President         | Involving in BIM-based projects       | Industry (Public Sector) | 12                           | 8                        |
| 3  | Head of Development         | Involving in BIM-based projects       | Industry (Private Sector) | 22                           | 6                        |
| 4  | Principal Ass. Director (Civil) | Involving in BIM-based projects | Industry (Public Sector) | 29                           | 8                        |
| 5  | Principal Ass. Director (Arch.) | Involving in BIM-based projects | Industry (Public Sector) | 27                           | 7                        |
| 6  | Assoc. Prof (researcher)    | Building Information Modelling (BIM)  | Academia             | 16                           | 6                        |
| 7  | Assoc. Prof (researcher)    | Building Information Modelling (BIM)  | Academia             | 14                           | 3                        |
| 8  | Assoc. Prof (researcher)    | Building Information Modelling (BIM)  | Academia             | 23                           | 5                        |

3.2.2. Content Validity Ratio (CVR). Content validity is a degree of measuring instruments to which the content of the items adequately represents the universe of all relevant items under study [24]. The content validity could be employed by means of judgmental method and panel evaluation with CVR. The CVR method represents as proportional level of experts' agreement in rating an item as essential [25]. In addition, a 3-point scale was recommended to rate each item; (1) not necessary; (2) useful but not essential; and (3) essential [25]. In order to evaluate the item as very important, the value of CVR will be compared to CVR critical table that has been revised by Ayre and Scally [26].
**Content Validity Ratio (CVR)**

\[
\text{Content Validity Ratio (CVR)} = \frac{\text{ne} - (\frac{N}{2})}{(\frac{N}{2})} \quad [25]
\]

where,

- \text{ne}: number of expert’s panel members indicating an item ‘essential’
- \text{N}: number of expert’s panel members

3.2.3. **Content Validity Index (CVI)**. In contrast, another approach is the CVI instruments proposed by Lynn [20] and, Polit and Beck [27] which can be used to rate each instrument item in terms of its relevancy to the construct on a 4-point scale; (1) irrelevant; (2) somewhat relevant; (3) relevant; and (4) extremely relevant. The CVI is CVR mean for all retained items. Polit and Beck [28] asserts that there are two quantitative approaches for estimating CVI: Item Level Content Validity Index (I-CVIs); and Scale Level Content Validity Index (S-CVIs). CVI for relevancy of each item (item levels (I-CVIs)) are computed as the number of experts giving a rating 3 or 4 to the relevancy of each item, divided by the total number of experts [27,29]. Compared with I-CVIs, S-CVIs are the proportion of total items on an instrument that achieve a rating 3 or 4 by the content experts [30].

3.2.4. **Modified Kappa Coefficient (K*)**. Despite CVI is extensively used to estimate content validity by researchers; this index does not consider the possibility of inflated values because of the chance agreement. Therefore, CVI and K* could provide quantifiable methods for evaluating the level of agreement between content experts [29,31]. To calculate the K*, the formula \( P_c \) was first calculated and by using the I-CVI, finally Kappa was computed by entering the values of \( P_c \) using the formula given below.

\[
\text{Probability of chance agreement (Pc)} = \frac{(N!)}{(A!(N-A)!)} \times 0.5^N \quad [29]
\]

\[
\text{Modified Kappa Coefficient (K*)} = \frac{(1-CVI-Pc)}{(1/Pc)} \quad [29]
\]

where,

- \text{N}: number of expert’s panel members
- \text{A}: number of expert’s panel members indicating an item ‘relevant’

4. **Findings and discussion**

The key findings from the questionnaire survey were presented in terms of analysis of Content Validity Ratio (CVR), Content Validity Index (CVI), and Modified Kappa Coefficient (K*).

4.1. **Analysis of the Content Validity**

Table 2 presents the components of each construct (i.e., project attributes in BIM-based projects; client attributes in BIM-based projects; client demand in BIM-based projects; governing success measure of BIM-based projects; governance and control of BIM-based projects and market-structure) along with number of items. The BIM governance instrument comprises of 273 items with six (6) constructs (i.e., project attributes in BIM-based projects - 41 items; client attributes in BIM-based projects - 31 items; client demand in BIM-based projects - 57 items; governing success measure of BIM-based projects - 64 items; governance and control of BIM-based projects - 40 items and market-structure - 40 items) which have been extracted from the existing assessment instruments mentioned earlier.

Hence, it could be deduced that the developed items from literature search act as input factors for further main data collection through questionnaire of BIM governance instrument by various content experts.
Table 2. Components of BIM governance instruments.

| No | Constructs                                | Items                                      | No. of Sub-items |
|----|-------------------------------------------|--------------------------------------------|------------------|
| 1  | Project Attributes in BIM-based Projects  | Project feasibility                        | 6                |
|    |                                           | Project definition and formulation         | 4                |
|    |                                           | Project duration                           | 6                |
|    |                                           | Project objective                          | 4                |
|    |                                           | Project location                           | 8                |
|    |                                           | Size of the project                        | 7                |
|    |                                           | Type of the project                        | 6                |
| 2  | Client Attributes in BIM-based Projects   | Client organisation structure              | 5                |
|    |                                           | Client’s duty                              | 9                |
|    |                                           | Client’s attitude                          | 4                |
|    |                                           | Client’s financial stability               | 3                |
|    |                                           | Client’s size                              | 4                |
|    |                                           | Past experience of client                  | 6                |
| 3  | Client Demand in BIM-based Projects       | Time                                       | 8                |
|    |                                           | Cost                                       | 12               |
|    |                                           | Quality (functionality, comfort, impact)   | 37               |
| 4  | Governing Success Measure BIM-based Projects | Governance factors                       | 4                |
|    |                                           | Functional requirements                    | 17               |
|    |                                           | Characteristics of BIM-based projects      |                  |
|    |                                           | • Process and system                       | 3                |
|    |                                           | • People                                   | 5                |
|    |                                           | • Technology                               | 6                |
|    |                                           | • Structure                                | 5                |
|    |                                           | Success measure of BIM-based projects      |                  |
|    |                                           | • Socio-organisational                     | 6                |
|    |                                           | • Legal                                    | 6                |
|    |                                           | • Technical                                | 6                |
|    |                                           | • Financial                                | 6                |
| 5  | Governance and Control of BIM-based Projects | Organisational structure                  |                  |
|    |                                           | • Top management (strategic)               | 9                |
|    |                                           | • Middle management (tactical)             | 5                |
|    |                                           | • Operational management (staff)           | 3                |
|    |                                           | Organisational transformation             |                  |
|    |                                           | • Vision and sponsorship                   | 7                |
|    |                                           | • Driven leadership                        | 9                |
|    |                                           | • Incremental integrated change (s)        | 7                |
| 6  | Market-structure                          | Objective, project stages and milestones    | 5                |
|    |                                           | Champions and drivers                      | 5                |
|    |                                           | Regulatory framework                       | 5                |
|    |                                           | Noteworthy publications (R&D)              | 5                |
|    |                                           | Learning and education                     | 5                |
|    |                                           | Measurements and benchmarks                | 5                |
|    |                                           | Standardised parts and deliverables        | 5                |
|    |                                           | Technology infrastructure                  | 5                |
|    |                                           | TOTAL                                      | 273              |
4.2. Content Validity Ratio (CVR)
Table 3 shows 202 out of 273 items have been addressed by the content experts as utmost critical item: project attributes in BIM-based projects - 26 items; client attributes in BIM-based projects - 21 items; client demand in BIM-based projects - 51 items; governing success measure of BIM-based projects - 34 items; governance and control of BIM-based projects - 37 items and market-structure - 33 items. Based on [26], CVR critical table, the item score CVR=1.00 for eight number of experts (N = 8) will be classified as critical.

Table 3. CVR critical items in BIM governance instrument.

| Construct No | Items                                           | No. of Sub-items |
|--------------|-------------------------------------------------|------------------|
| 1            | Project Attributes in BIM-based Projects         | 26               |
| 2            | Client Attributes in BIM-based Projects          | 21               |
| 3            | Client Demand in BIM-based Projects              | 51               |
| 4            | Governing Success Measure of BIM-based Projects  | 34               |
| 5            | Governance and Control of BIM-based Project      | 37               |
| 6            | Market-structure                                | 33               |
| TOTAL        |                                                 | 202              |

To recapitulate, these 202 items have been asserted by all the respondents as critical to be incorporated in the BIM governance instrument. However, the remaining 71 items will be retained for further CVI and K* testing.

4.3. Content Validity Index (CVI) and Modified Kappa Coefficient (K*)
Table 4 shows the evaluation criteria for I-CVI [32] and K* [33,34]. Based on the I-CVI scores, 273 items ranged from 0.875 to 1.000 are classified as appropriate to be incorporated in the BIM governance instrument. Four (4) items (PAB04, GCP01, GCP04, and GCT06) items ranged from 0.70 to 0.79 and needs a further revision. However, the value of remaining twelve (12) items (PAC04, PAD04, PAF02, CAF03, CDQ02, CDQ03, GBB05, GBB10, GCS05, GOT06, GOI06, and GOI07) are below than 0.700. Hence, it is reasonable to infer that the remaining twelve (12) items should be eliminated from the BIM governance instrument.

Table 4. Evaluation criteria for I-CVI and K*.

| I-CVI classification | No. of items | Score        | Modified Kappa Coefficient (K*) | No. of items | Score |
|----------------------|--------------|--------------|---------------------------------|--------------|-------|
| > 0.79               | 273          | Appropriate  | > 0.74                          | 275          | Excellent |
| 0.70 - 0.79          | 4            | Needs revision | 0.60 - 0.74                  | 4            | Good |
| < 0.70               | 12           | Eliminate    | 0.40 - 0.59                     | -            | Fair |
|                     |              |              | < 0.70                          | 12           | Poor |

Source: Davis [32], Cicchetti and Sparrow [33] and Polit, Beck, and Owen [34]

Apart from determining the elimination of the items using I-CVI, all the items as well have been evaluated based on K* scores [33,34]. The findings revealed that 257 items are excellent, four (4) items are good and the remaining twelve (12) items (PAC04, PAD04, PAF02, CAF03, CDQ02, CDQ03, GBB05, GBB10, GCS05, GOT06, GOI06, and GOI07) is considered poor which is in-line with previous I-CVI findings. Thus, it is recommended that those four (4) items need to be revised further and twelve (12) items should be eliminated. Table 5 shows the revision of item PAB04, GCP01, GCP04, and GCT06 of content validity for BIM governance instrument by means of S-CVI/Ave (before and after revision).
Table 5. Content validity of BIM governance instrument (before & after revision).

| Item No. | Before revision | After revision |
|----------|-----------------|----------------|
| PAB04 (Item: Project definition and formulation) | Form of contract (functional grouping of contract; separated or integrated) and the division of responsible and liabilities | Procurement methods (traditional, design and build, two-stage tendering, PPP, private finance initiatives, management contracting, framework agreements, prime contracting) |
| GCP01 (Item: People characteristics) | Clearly defined roles and responsibilities for BIM posts | Clearly defined the new roles and responsibilities of employees for BIM-based projects |
| GCP04 (Item: People characteristics) | Skill employees | BIM designation required a set of skill and attitude to carry the roles and responsibilities that are defined by the organisation |
| GCT06 (Item: Technology characteristics) | Policy | Well-defined ICT policy for BIM |

Table 6 shows the calculation of content validity for BIM governance instrument by means of S-CVI/Ave (before and after modification). Waltz, Strickland, and Lenz [35] and, Polit and Beck [27] recommend S-CVI/Ave score greater than 0.900 for an instrument is considered to have adequate content validity. During early stage, it is suggested that 273 items should be considered for the BIM governance instruments and it is revealed that S-CVI/Ave score is 0.946. Hence, it is implies that BIM governance instruments has adequate content validity. However, based on the previous findings (I-CVI and K*), four (4) items need a revision and remaining twelve (12) items are suggested to be eliminated from the instrument. Thus, after modification (261 items), it is revealed that S-CVI/Ave score is 0.970 which is proved to be more adequate. Hence, it is anticipated that by incorporating those 261 items, the BIM governance instrument is believed to have sufficient content validity.

Table 6. Content validity of BIM governance instrument (before & after modification).

| I-CVI classification | Before modification (273 items) | After modification (261 items) |
|----------------------|-------------------------------|-------------------------------|
|                      | No. of total items | Total score of I-CVI | No. of total items | Total score of I-CVI |
| > 0.79               | 257               | 250.125            | 257               | 250.125            |
| 0.70 - 0.79         | 4                 | 3.000              | 4                 | 3.000              |
| < 0.70              | 12                | 5.125              | < 0.70            | -                  |
| Total               |                        | 258.250            | Total             | 253.125            |
| S-CVI/Ave          | 0.946              | S-CVI/Ave         | 0.970              |

*I-CVI= item-level-CVI; S-CVI/Ave= scale-level-index/Averages

5. Conclusion
The CVR scores revealed that 202 out of 273 items are regarded as the utmost critical by the content experts. These are: project attributes in BIM-based projects - 26 items; client attributes in BIM-based projects - 21 items; client demand in BIM-based projects - 51 items; governing success measure of BIM-based projects - 34 items; governance and control of BIM-based projects - 37 items and market-structure - 33 items. Nevertheless, the remaining 71 items were retained for further I-CVI and K* testing. The findings for I-CVI and K* however revealed that 257 items in BIM governance instrument are appropriate and excellent. Four (4) item is suggested should need a further revision and twelve (12) items are suggested to be eliminated from the instrument. Finally, the total numbers of items selected were 261 after the modification.
Based on the S-CVI/Ave it is revealed that the content validity of the instrument is adequate. As for this reason, it is noteworthy that the BIM governance instrument to be highly regarded for evaluating the BIM governance strategies. The instrument is highly reliable and the items selected are the most appropriate for the construct (i.e., project attributes in BIM-based projects; client attributes in BIM-based projects; client demand in BIM-based projects; governing success measure of BIM-based projects; governance and control of BIM-based projects and market-structure).

The method and approach adopted undoubtedly is a systematic and subjective through two-stage processes. As mentioned before, the first stage dealing with process of instrument development and followed by judgmental method in the form of panel evaluation of the items. It is acknowledged that the process is extensively more accurate approach in criticizing the research instrument.

The research presented in this paper is part of an ongoing Ph.D. research study at the Faculty of Architecture, Planning, and Surveying (FSPU), UiTM Malaysia to develop a framework of client governance in BIM for construction projects in Malaysia. The result of the study will important for future strategies and guidelines for the development of BIM projects in Malaysia.

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