ANALYSIS OF MODELING APPROACH THROUGH BIM LOG FILES
To promote further BIM collaboration by different individual users

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1.   Introduction

It is a worldwide problem that the productivity in architecture, engineering, and construction (AEC) field has remained non-growing over a couple of decades. The industry is still unsuccessful to migrate its information flow into the digital process, which is mainly due to the joint losses happen between the different disciplines and multiple individuals who work on the separated information environment. Therefore, unifying every project information into one place is expected to improve the integrity and interoperability of information, subsequently eliminate the loss in communication, and ultimately to raise the productivity.

Building Information Modeling (BIM) is the platform that aims to centralize the project information in the form of geometry and attribute. Adopting BIM as a common language of the project benefits the stakeholders with the ease of access, change management, and creating a project database. Hence, it is vital in leveraging BIM in a better way that the chief practitioners in project work on the same selected project platform, beyond their traits or preferences.

It is a massive transformation of the industry to alter the long-established conventional workflow into the BIM-based one. The industry often allocates the human resource as the key to success in the BIM project. Such wanted practitioners as the project BIM enablers are too expected to have both the full range of architecture literacy and the fluent BIM skill on top of it. This tall order may cause the mismatch between the industrial need and the appropriate BIM talent. Moreover, leaving BIM related issues to the specialists does not contribute to achieving the original concept that to use the common platform by all the project players.

The ideal situation is to tailor the use of BIM as per the individual user's characteristics and circumstances. The local BIM standard, project BIM objectives, personal architecture, BIM skill, and the modeling strategy; these all can affect the BIM activities. It may accordingly determine the performance and efficiency in BIM.

Having metrics to investigate such mixed conditions has been difficult, mainly because project BIM models are not directly comparable. To overcome the situation, several types of recent research instead subjected BIM log file, which is the record of users' activities during the software workshop. This research carries out the cross-user comparison of BIM log files recorded through the experimental modeling session by the BIM starters so that the data will show the diverse BIM activities with minimizing the influence from project level and organization level. Business intelligence (BI) software then applied to discover and visualize the user traits observed.

The research objective is to identify the points that affect the effectiveness in BIM modeling process, to promote the further collaborative use of BIM.

2.   Related Studies

Yamohammadi et al (2016) first subjected BIM log files to extract the sequential pattern from skilled BIM architects, to find the habit common in high-performance users. Next, they investigated the pattern in command history further to measure the performance for modeling decisions to analyze further data such as modeling time and modification per objects (2018). Ten Master of Architect university students contributed to produce the model output under the same conditions.

Zhang et al (2018) also analyze log files to find the productive sequential patterns, and to discover the social network connection among BIM users belong to the same design organization (2018).

The previous research contributed to prove that analyzing BIM log file is a practical approach to review and analyze the user activity in the software. Papers mentioned above, however, based on the operation by the skilled BIM users from the productivity point of view. This study commences from providing the BIM training program to BIM beginners, to normalize the background of modeling condition further.

3.   Methodology
3.1. RESEARCH OVERVIEW

This research subjects the log file of Autodesk Revit, the most adopted BIM authoring software worldwide. Revit records the user activity to a file called journal, which contains the history of selected commands, mouse movements, the parameters and

configurations loaded for the software session, and the like. Figure 1 shows a part of the journal file.

```
Jrn.Key    0 , "VK_F3" , 0
' 0:< Candidates (curIdx = -1):
'E 08-Aug-2017 15:33:34.581:   0:<
Jrn.MouseMove   0 ,    562 ,    456
'E 08-Aug-2017 15:33:34.581:   0:<
Jrn.Command "KeyboardShortcut" , "部屋にタグを付ける , ID_OBJECTS_ROOM_TAG"
' 0:< Unnecessary nesting:ArrowUI_4:-1:ID_OBJECTS_ROOM_TAG :N++EB(NB) ;
' 0:< Unnecessary nesting:RoomUI_1:-1:String_RoomAreaPlan_RoomTag :N++EB(NB) ;
' 0:< Containing transaction RoomUI_1,-1, contained transaction RoomUI_2,-1, BUTO C++EB
' 0:< <<Begin build CT>>
```

Figure 1. Quotation from the journal file

The author first organized a two-day Revit workshop for university architecture students, who are in principle new to the software. Participants took the Revit start-up training program during the first day, to become familiar with the necessary software operation. On the second day, they underwent a 5-hour experimental modeling session in which the participants complete a middle-scale commercial building project. The drawings were provided in 2D CAD format to import to BIM. A tutor available during the exercise answered the technical modeling question but did not advise the modeling process.

The analysis subjected the journal files collected through this exercise. The preparing process extracted the sequence of executed commands with their timestamps per users. Multiple filtrations applied to highlight the underlying patterns of software activity by the Business Intelligence (BI) software. Finally, the discussion is made upon the obtained result.

3.2. DATA COLLECTION
Seven users attended the software workshop. All participants except one (User D) had not used Revit before. They are from architecture design course; six students are from the graduate school, the other was undergraduate (User G). User B did not attend the training program on the first day; he alternatively watched the recorded videos to supplement the software skill. The participants submitted both BIM model and recorded log files at the end of the modeling session.

3.3. DATA PRE-PROCESSING
The author created a Python script to parse the text in collected log files. The code summarizes the journal files into only the executed command IDs and associated timestamps in comma-separated values (CSV) format. After this process, he obtained 5,990 commands from all users through this process. Table 1 shows the details of data and some statistical highlights.

3.4. DATA EXPLORATION
179 types of commands are used in total, but most of them appear only a few times in the whole session. Thus there needs to compile the command types into the limited number of categories to clarify the hidden pattern.

BI software is a type of application that aims for rapid and intuitive data retrieval, analysis, transformation, and report. Tableau, a widely adopted BI solution in the industry, enables to test many different data filters and groupings to discover the critical command pattern with the graphical outputs for the comparison purpose. At last, commands that relate to adding new elements to the model showed prominent difference among participants. These are shortlisted and grouped by categories, such as to make a wall, column, or stair. The rest commands settled into one category, which is insightful to visualize the activeness of users. Finally, the data transformed into the Gantt chart along the timeline.

4. Analysis
Figure 2 is the overview of the BIM submitted models. There is a certain range in modeling progress and design interpretation, for instance, type of balustrade, door height, or mullion layout in exterior curtain walls. Overall, they accomplished the baseline of required modeling quality.
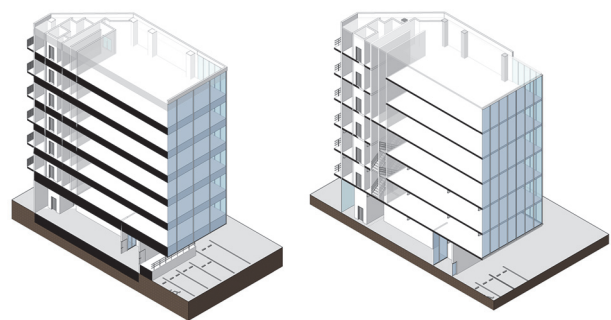

Figure 2. Submitted models, by User C (left) and User G (right)

Figure 3 is the chart for the result of the process 3.2 through 3.5. The horizontal axes are for the time stamp during the modeling session from 12 pm to 5 pm. The vertical axes correspond to the executed commands per category. Commands to make new component belong to respective categories from number one to eight. Additionally, the commands related to model copy and paste, which also contribute model making by the duplication, forms one group at number nine. The rest commands are all categorized in number ten as Others, except one command named "ID_CANCEL_EDITOR" that appears every time a user presses escape key. Category number ten shows if the user was active in Revit at the relevant point of time. The long intervals in category ten offer to the time when the user was off the seat.

Some users did not execute specific modeling commands. User A, B, C, and D, for example, did not address the ceiling modeling

during the session. User C represented the ceiling together with the next floor, the models from the rest did not represent the ceiling. Similarly, some realized that the beams are necessary, which also only appear in the section drawing.

It is reasonable that the modeling started from either wall or column, then the floor. The opening, beam or plumbing do not appear earlier than those components, because they need other geometry as a host of model placement; doors, for example, cannot exist in models without being hosted by a wall.

The prominent difference is observed in the commencement of model making. User D, E, and G started making walls immediately, whereas the other took 40 to 50 minutes before that. In any case, a short span sequence of command repeat appears once they start creating one category of the element.

The short, frequent intervals in 10_OTHERS can be found in User A, B, C, and F: it shows their pauses in modeling operation. The modeling commands are also fewer in such blank time.

Also, there are certain periods when no modeling category selected, whereas the other commands are in motion. Such term is observed in every user, especially typical in User A, C, and E.

5. Discussion

All users successfully imported the building CAD drawing into Revit. It was essential not only to standardize the output but also to offer the elements to be created next. Given the modeling process was ideal, a user can straightforwardly trace every element displayed in the provided drawing. However, every user had hiatuses when no modeling operation happened. There was a tendency that the users who started erecting wall and column earlier had fewer intervals than others.

There are two potential reasons for these suspensions in modeling operation. One is that a user had a technical problem to proceed. Some user may immediately ask the tutor to resolve the issue. However, a longer suspension will occur when users attempt to solve by trial-and-error basis. It can be a chief reason for the blank in modeling categories.

The other reason is that a user is yet to decide the element to model. BIM software requires users to select the modeling command which precisely relevant to the element category. Unlike the 3D modeling software, BIM software does not allow to create the generic geometry first and set its category afterward. Therefore, the elements expressed in drawings need to be explicitly ordered by the modelers, so that they have no hesitation in choosing the right command. The users who chose wall command earlier, or who had fewer intervals, were eventually successful in modeling strategy with breaking down the modeling steps.

6. Limitation of the research

This study is a preliminary of the phased research. The authors aim to collect more data from the broader range of practitioners. The goal of the subsequent research is to discover further implicit patterns underlying in the actual architectural projects, to contribute further BIM implementation to organizations.

7. Conclusions

The research revealed the variety of modeling progress by the same level BIM users. From the observed intervals in modeling commands, it is thought to have occurred due to either the technical difficulty or the modeling strategy that BIM software requires to structure the elements. Besides the technical support, it is vital for the users to have the consolidated modeling steps when they initiate the model in BIM. It will also be a reason why many architects preferred to use the non-BIM 3D application in the concept design phase when designers explore forms without considering the element categorization.

Simultaneously, this research discovered that the extracted information from the BIM log files reflects the trait of BIM users, which is highly challenging to find only from the output. The existence of log file has a potential to improve and enhance the collaborative project process over BIM as a common platform.

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| User | Number of Commands, Total | | | By Command Property | | | | | | Remarks |
	Used	Effective*	In Type	ANNOTATIONS	EDIT	FAMILY	FILE	OBJECTS	VIEW	
A	651	600	56	12	126	3	10	177	29	
B	684	611	58	1	258	2	10	105	76	Video Training
C	662	653	65	3	182	4	93	106	29	
D	1,403	765	84	46	185	2	37	141	8	Revit Skilled
E	669	619	61	2	154	2	6	97	3	
F	635	431	63	4	87	6	7	102	12	
G	1,286	1,005	84	15	239	6	25	280	69	Undergraduate

* The number of effective commands excludes the command "ID_CANCEL_EDITOR"
Chief actions in command categories:
ANNOTATIONS: to add text annotations, dimentions
EDIT: to cut, copy or paste elements, including undo
FAMILY: to load and place families (reusable model component)
FILE: to open or save a Revit file
OBJECTS: to add new model elements, such as walls, columns, floors or ceilings
VIEW: to create a 2D or 3D view of model, or to switch the model window between 2D and 3D

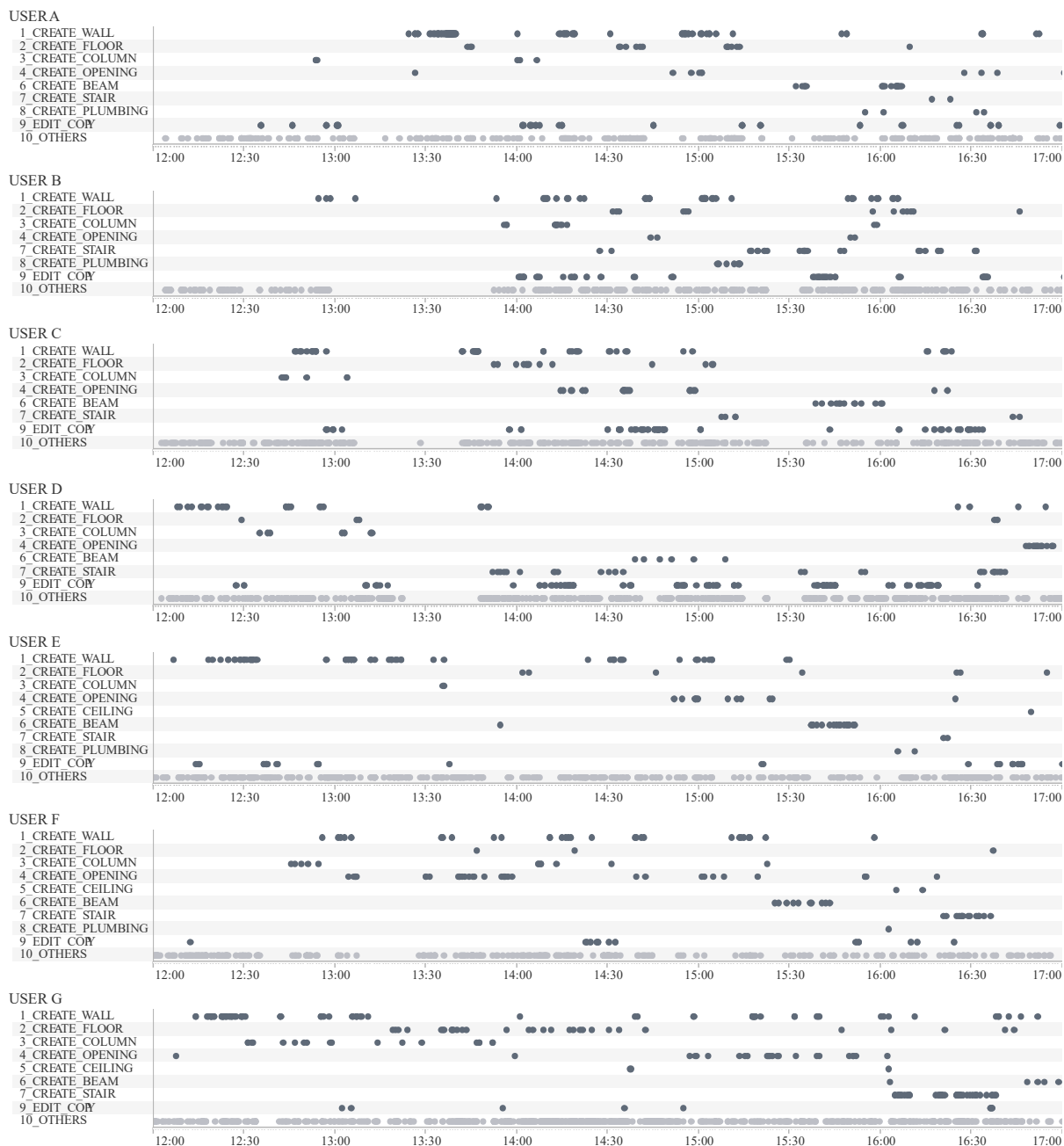Table 1. Statistic information of pre-processed log files

Figure 3. Extracted modeling commands from individual design log files, visualized by BI software