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Integration of Virtual Prototyping and Building Information Modeling to Optimize the Construction Site Planning and Management

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Abstract

Objectives: To study the possibility of using Building Information Modeling (BIM) to improve the efficiency of site planning and management spaces within the buildings. **Method:** In order to achieve this study, the literature and previous research in the field has been consulted, as well as the collection of data by interviewing a group of engineers through collection of documents and maps of the project and taking realistic picture of the buildings. **Findings:** By analyzing case study and finding real area data by using BIM technology and comparing it with the international standards for space management on campus, there was a significant difference. And it was found that there is no international standard used in the design of these spaces and it is not suitable for student and staff and teaching staff. The researcher recommends the use of BIM technology in the early stage of the project to reduce the design error in space management and the efficiency of this technology and it's easy to obtaining information and data. Although there are obstacles to the use of BIM practices due to the reasons for the scarcity of qualified personal in this field, in the near future there will be the usage of large scale BIM system in the construction industry. **Applications:** BIM technology is one of the most important technologies in the construction industry and it increases the performance during project life cycle. As a result of the development of the construction industry, such technology has to be used, increasing design efficiency and improving construction work while providing more time and cost

Keywords: Building Information Modeling (BIM), Site Planning, Space Management

1. Introduction

Numerous studies as of late are attempting to execute the utilization of Building Information Modeling (BIM) with a specific end goal to pick up benefits in various view points of the development procedure including the administration of the development site and the utilization of models nearby. From a site configuration perspective, two fundamental viewpoints are underlined by global looks into: 4D planning, Safety or both together. 4D booking research began quite a long while back with 3D CAD frameworks actualized with time so as to envision the works advance. With the improvement of BIM the exploration on 4D planning clearly preceded onward this framework since the opportunity to embed "schedule", robotizing[1]. BIM is so different from the traditional CAD method in building design[2]. Through the use of BIM

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approach by project participation, it is easy to exchange the information of project.

The BIM model can save the energy performance data such as power consumption, temperature, CO_2 emissions, occupancy and humidity, Site planning, green technology application, and many others. The important benefit of BIM model were seen through the lower cost of construction project by making building planning, design, construction, and Maintenance more efficient and deliver better value of project[3].

2. BIM Programming

There are arrangements of organizations that are considered as an engineer for BIM programming and these products are shifted to play out different purposes. In[4] calls attention to that the major BIM Programming delivered via Autodesk, Graph iSOFT, and Bentley. BIM programming can be arranged into numerous gatherings, for example:

1. Software for compositional outline.
2. Software for auxiliary outline.
3. Software identified with supportability.
4. Software for mechanical, electrical, plumping (MEP) outline.
5. Software for estimations, reproduction, investigation and discovery of contentions.
6. Software to oversee offices.

3. BIM Measurements

There are a few ideas, terms and applications created over the BIM, including what is known as the BIM measurements (3D, 4D, 5D, 6D, and 7D) as the BIM does not manage a 2D or 3D framework just, but instead surpasses it for different measurements. Each measurement includes certain reasons inside the development venture. Figure 1 demonstrates the measurements of the BIM and its substance.

- 3D measurement: This measurement is for perception where it enables to partners to see the working in a virtual domain before it is really manufactured and furthermore enables them to see refreshes for this Representation along the life of building[5-7].
- 4D measurement: This measurement is worried about adding the booking to the past measurement (3D). Through this measurement, the partners have the capacity to picture and concentrate the advance of the working exercises amid the allocated course of events[8].
- 5D measurement: This measurement is worried about adding the cost to the past measurement (4D). Through this measurement, partners can assess both time and cost for everything in the venture[8-10].
- 6D measurement: This measurement is worried about adding the supportability to the past measurement (5D). Through this measurement, partners can acquire exact and finish vitality estimations[7].
- 7D measurement: This measurement is worried about adding the office administration to the past measurement (6D). Through this measurement, partners can oversee resources ideally through undertaking stages[11].

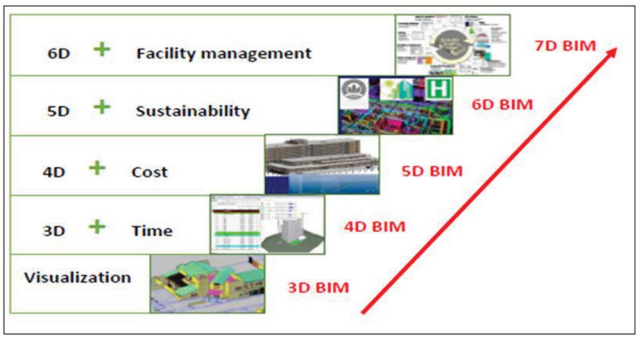


Figure 1. BIM dimensions (researcher).

4. Research Methodology

4.1 Theoretical Approach

- It will be focused on the theoretical analysis of scientific literature. It will start from the general concept of BIM as a new collaborative process, and then will continue with its analysis as an "n-D" tool.
- General concept of Building Information Modeling as a tool and process to manage information in different area of the site planning.

4.2 Experimental Analysis

- General site planning vs. BIM site planning comparison. This quantitative analysis for a case study

of already existing project, based on the automatic process of extracting information from BIM models.

- Case study was modeled by Revit software according to BIM to calculate their actual area and compared with the international standard.

5. Case study Medicine Collage

Medicine collage is one of the important collage in diyala university campus in Iraq it consist of Six main building (deanship, library and four factual department). Local company was implemented this project. The type of contract is unit price contract and it was built in (2002). This collage has 422 students for the year of (2017-2018) for different department (Figure 2).

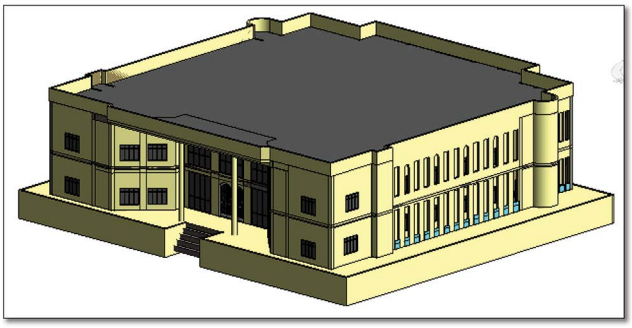


Figure 2. Deanship of medicine collage.

6. Experimental Work

Part I: division of internal spaces of buildings

The ground floor and first floor of internal spaces of deanship and factual department for case study should be divided into (office room, lecture hall, laboratory and service room) and the library should be divided into (library, Lecture hall, book store, office room) this process is done by using architectural tab and room panel are shown in the Figure 3.

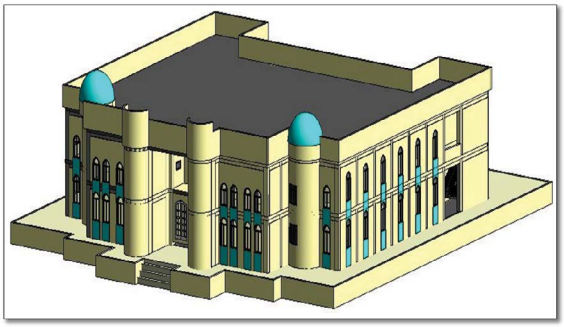


Figure 3. Library of medicine collage.

Part II: rooms schedule

Schedule is created for all building floors to determine their area. From "view" menu choose "schedule" Then chose room from "filter list" as shown in the Figure 4.

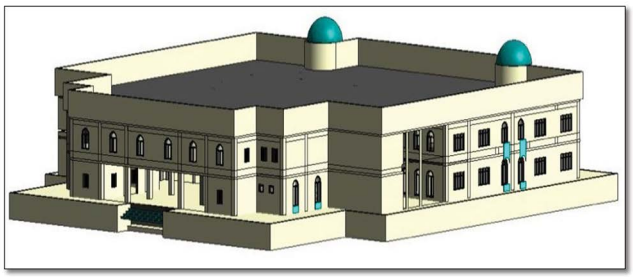


Figure 4. Factual departments of medicine collage.

Chose the flowing parameter (number, name, area, level) (Figure 5).

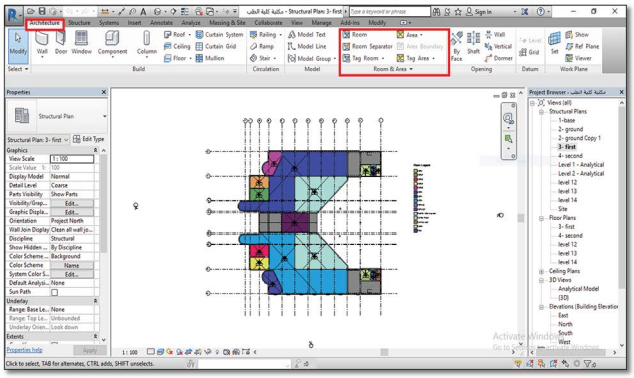


Figure 5. The division of internal spaces of buildings.

After created the room schedule the table was generated which contain the (number, name, area) of each room and space inside the buildings and contain the level of each room located in any floor for all buildings. The method of adding "parameter" based on the "parameter" availability in Rivet software (Figure 6 and 7).

7. Case Study Room Schedule

The researcher made room schedule for ground and first floor for all buildings. Then calculate actual value of area from Rivet software and comprising it by standard value of area to find the difference between them and to give the recommendations (Figure 8-10).

According to the code used in design the lecture hall and laboratories the area of students is about 86% from the total area of lecture hall and the area of each student is about 1.9 m2in lecture hall and 4m2in laboratories[12].

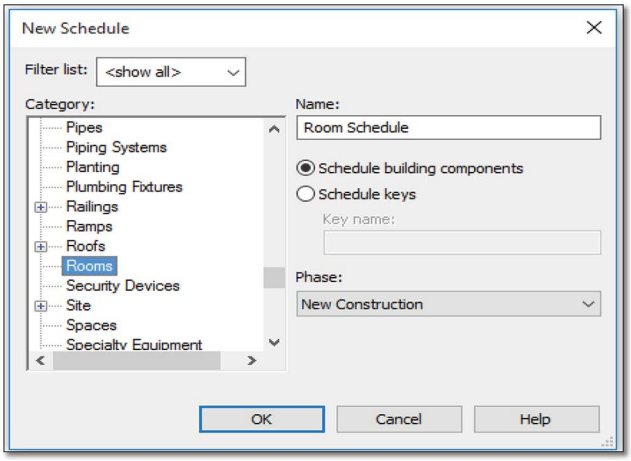


Figure 6. Process of doing room schedule.

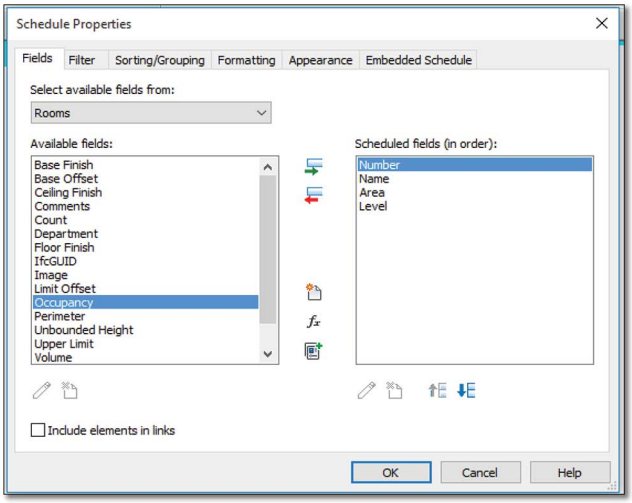


Figure 7. Process of adding parameters.

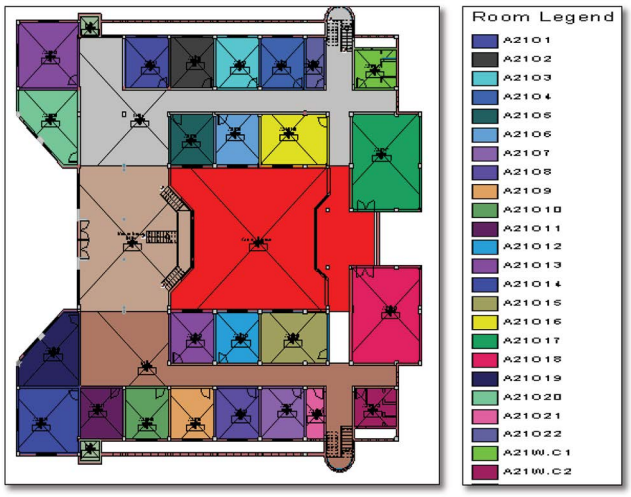


Figure 8. Actual value of internal spaces of ground floor.

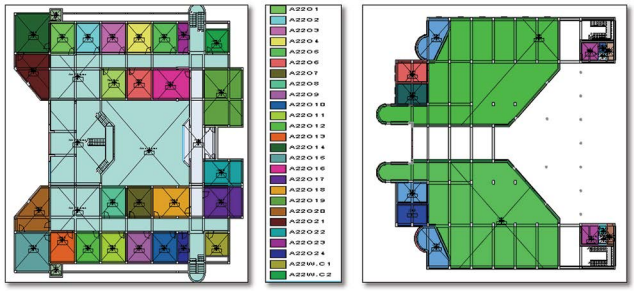


Figure 9. Actual value of internal spaces of first.

Figure 10. Actual value of internal spaces of ground floor.

According to the code used in the room area for teaching staff is about 22m2 for professor and 20m2 for assistant and 15m2 for lecture[12].

According to the code used the room area for staff allocation is about 18m2 for two staff and 12m2 for one staff and (24-30) m2 for manager[12].

The number of student according to standard is calculated by the flowing formula:

$$Y = (86\% AA / 1.9) \ldots\ldots \text{for student in lecture hall} \quad (1)$$

$$Y = (AA / 4) \ldots\ldots \text{for student in laboratories} \quad (2)$$

$$E = X - Y \quad (3)$$

Where:

Y = the number of students according to standard.

AA = actual value of area.

AS =standard value of area.

X = the number of students in real.

E = the difference in the numbers of students.

Q = Meet the requirements of standard.

8. Project I (Medicine Collage)

This project contain (22) room for staff allocation in the ground floor and (24) room in the first floor (Figure 11).

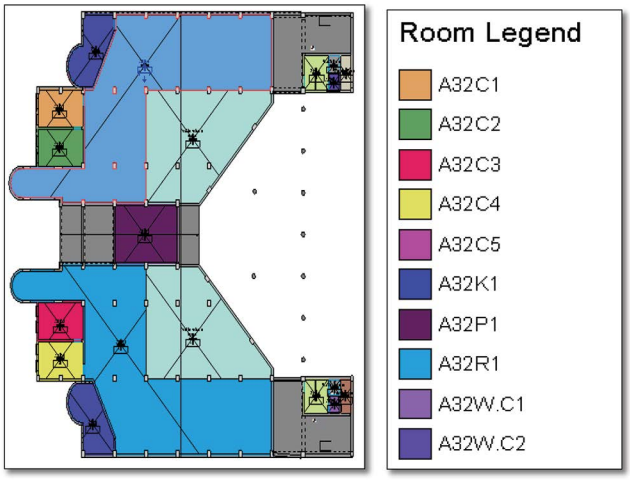


Figure 11. Actual value of internal spaces of ground floor

Table 1 presents the actual value of area for ground floor (project I) is meet the standard requirements except the two room (A21O21, A21O22) are not meet the standard requirement because is don't enough for one staff and need (2) m2.

Table 2 presents the actual value of area for first floor (project I) is meet the standard requirements except the two room (A22O23, A22O24) are not meet the standard requirement because is don't enough for one staff and need (2) m2.

Table 1. Actual and standard value of area of ground floor

No.	Name	Level	AA (m2)	AS (m2)	Q
1.	A2101	Ground Floor	22	18	v
2.	A2102	Ground Floor	22	18	v
3.	A2103	Ground Floor	22	18	v
4.	A2104	Ground Floor	22	18	v
5.	A2105	Ground Floor	22	18	v
6.	A2106	Ground Floor	22	18	v
7.	A2107	Ground Floor	22	18	v
8.	A2108	Ground Floor	22	18	v
9.	A2109	Ground Floor	22	18	v
10.	A21010	Ground Floor	22	18	v
11.	A21011	Ground Floor	22	18	v
12.	A21012	Ground Floor	22	18	v
13.	A21013	Ground Floor	39	24-30	v
14.	A21014	Ground Floor	39	24-30	v
15.	A21015	Ground Floor	34	18	v
16.	A21016	Ground Floor	34	18	v
17.	A21017	Ground Floor	65	30	v
18.	A21018	Ground Floor	65	30	v
19.	A21019	Ground Floor	33	18	v
20.	A21020	Ground Floor	33	18	v
21.	A21021	Ground Floor	10	12	x
22.	A21022	Ground Floor	10	12	x
23.	A21W.C1	Ground Floor	16	/	/
24.	A21W.C2	Ground Floor	16	/	/

Table 2. Actual and standard value of area of first floor

No.	Name	Level	AA (m2)	AS (m2)	Q
1.	A2101	First Floor	22	18	v
2.	A2102	First Floor	22	18	v
3.	A2103	First Floor	22	18	v
4.	A2104	First Floor	22	18	v
5.	A2105	First Floor	22	18	v
6.	A2106	First Floor	22	18	v
7.	A2107	First Floor	22	18	v
8.	A2108	First Floor	22	18	v
9.	A2109	First Floor	22	18	v
10.	A21010	First Floor	22	18	v
11.	A21011	First Floor	22	18	v
12.	A21012	First Floor	22	18	v
13.	A21013	First Floor	22	18	v
14.	A21014	First Floor	39	24-30	v
15.	A21015	First Floor	39	24-30	v
16.	A21016	First Floor	34	18	v
17.	A21017	First Floor	34	18	v
18.	A21018	First Floor	34	18	v

19.	A21019	First Floor	65	/	v
20.	A21020	First Floor	33	18	v
21.	A21021	First Floor	33	18	v
22.	A21022	First Floor	30	18	v
23.	A21023	First Floor	10	12	x
24.	A21024	First Floor	10	12	x
25.	A21W.C1	First Floor	16	/	/
26.	A21W.C2	First Floor	16	/	/

9. Project II (Medicine Collage)

This project divided for four parties (library, Lecture hall, book store, office room). The ground floor contains two book stores their area about (27m2) and two free unit their area about (21m2) the area of library and lecture hall is about (405m2) Figure 12-15.

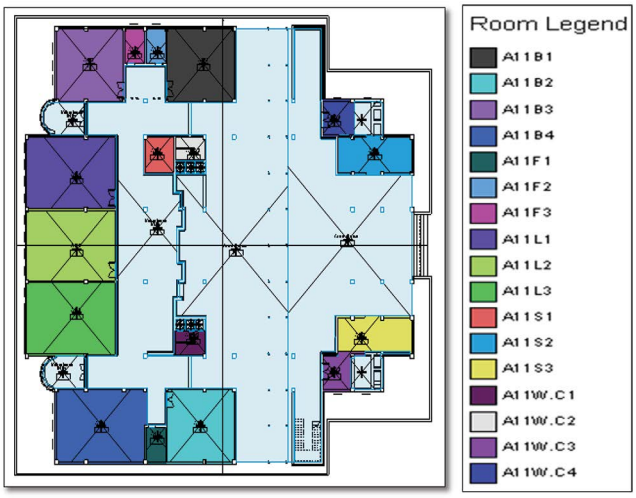


Figure 12. Actual value of internal spaces of ground floor.

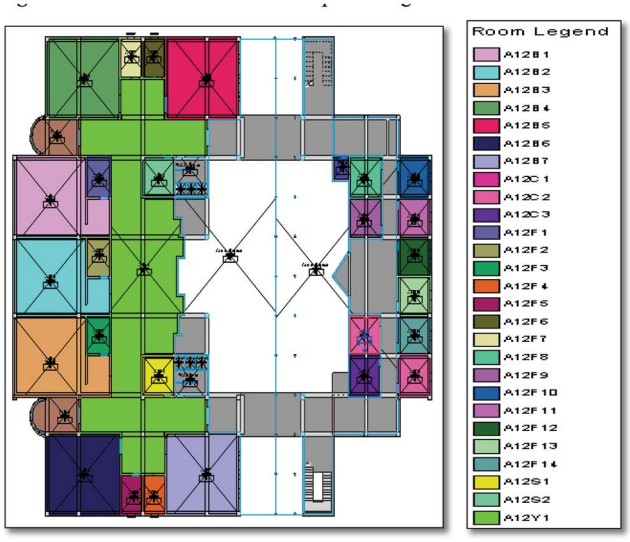
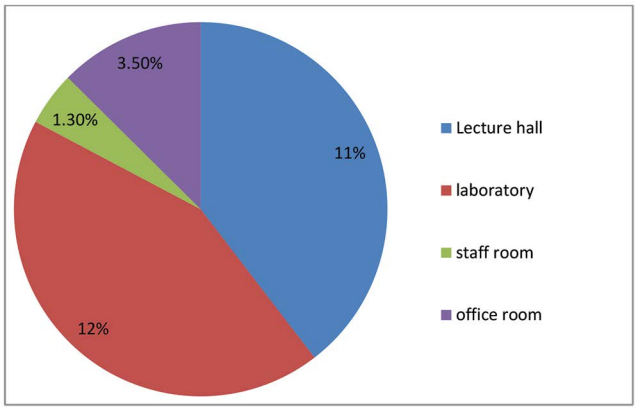


Figure 13. Actual value of internal spaces of first floor.



Figre14. Percentage of building details for ground floor.

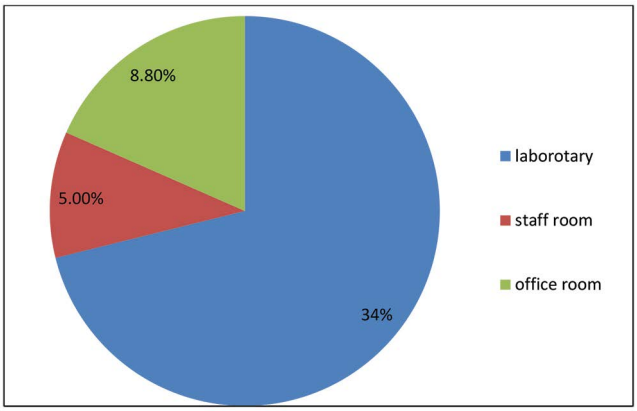


Figure 15. Percentage of building details for first floor.

The first floor contain (5) office room their area about (21m2), library and book store their area about (274m2), computer room their area about (45m2).

10. Project III (Medicine Collage)

This project contain (14) room in the ground floor and (22) room in the first floor.

Table 3 presents a big difference between actual value of area that calculated by Revit software according to BIM and standard value of area in the case of staff room need (10, 3, 8) m2 to meet staff room requirement. And there are a big difference between the number of students in real and the number of students according to standard in the case of lecture hall the difference is about (104,53,24) and in the case of laboratory the difference is about (80,51,51,124) and don't meet the requirement of standard.

The researcher suggests that the development the buildings reallocating spaces according to international

Table 3. Actual and standard value of area of ground floor

No.	Name	Level	AA (m2)
1.	A31I1	Ground Floor	405
2.	A31L1	Ground Floor	405
3.	A31K1	Ground Floor	27
4.	A31K2	Ground Floor	27
5.	A31V1	Ground Floor	21
6.	A31V2	Ground Floor	21
7.	A31W.C1	Ground Floor	14
8.	A31W.C2	Ground Floor	14

standards in order to accommodate the number of existing students and teaching staff or be the number of\ students suitable for existing spaces.

Table 4-6 present a big difference between actual value of area that calculated by Revit software according to BIM and standard value of area. In the case of teaching staff the spaces don't meet teaching staff room requirement and meet standard requirement in the case of office room.

Table 4. Actual and standard value of area of first floor

No.	Name	Level	AA (m2)
1.	A32C1	First Floor	21
2.	A32C2	First Floor	21
3.	A32C3	First Floor	21
4.	A32C4	First Floor	21
5.	A32C5	First Floor	21
6.	A32K1	First Floor	274
7.	A32R1	First Floor	274
8.	A32P1	First Floor	45
9.	A32W.C1	First Floor	14
10.	A32W.C2	First Floor	14

Table 5. Actual and standard value of area of ground floor

c	Name	Level	AA (m2)	AS (m2)	X	Y	E	Q
1.	A11L1	Ground Floor	103	/	150	46	104	x
2.	A11L2	Ground Floor	103	/	99	46	53	x
3.	A11L3	Ground Floor	103	/	70	46	24	x
4.	A11B1	Ground Floor	79	/	99	19	80	x
5.	A11B2	Ground Floor	79	/	70	19	51	x
6.	A11B3	Ground Floor	79	/	70	19	51	x
7.	A11B4	Ground Floor	106	/	150	26	124	x
8.	A11F1	Ground Floor	12	22	/	/	/	x
9.	A11F2	Ground Floor	12	15	/	/	/	x
10.	A11F3	Ground Floor	12	20	/	/	/	x
11.	A11S1	Ground Floor	16	/	/	/	/	x
12.	A11S2	Ground Floor	16	/	/	/	/	x
13.	A11S3	Ground Floor	16	/	/	/	/	x
14.	A11W.C1	Ground Floor	16	/	/	/	/	x
15.	A11W.C2	Ground Floor	16	/	/	/	/	x
16.	A11W.C3	Ground Floor	16	/	/	/	/	x
17.	A11W.C4	Ground Floor	16	/	/	/	/	/

Table 6. Actual and standard value of area of first floor

No.	Name	Level	AA (m2)	AS (m2)	X	Y	E	Q
1.	A12B1	First Floor	88	/	150	22	128	x
2.	A12B2	First Floor	88	/	99	22	77	x
3.	A12B3	First Floor	88	/	70	22	48	x
4.	A12B4	First Floor	79	/	70	19	51	x
5.	A12B5	First Floor	79	/	150	19	131	x
6.	A12B6	First Floor	79	/	99	19	80	x
7.	A12B7	First Floor	79	/	70	19	51	x

8.	A12F1	First Floor	12	15	/	/	3	x
9.	A12F2	First Floor	12	15	/	/	3	x
10.	A12F3	First Floor	12	15	/	/	3	x
11.	A12F4	First Floor	12	15	/	/	3	x
12.	A12F5	First Floor	16	22	/	/	6	x
13.	A12F6	First Floor	16	22	/	/	6	x
14.	A12F7	First Floor	16	22	/	/	6	x
15.	A12F8	First Floor	16	20	/	/	4	x
16.	A12F9	First Floor	16	22	/	/	6	x
17.	A12F10	First Floor	16	22	/	/	6	x
18.	A12F11	First Floor	16	22	/	/	6	x
19.	A12F12	First Floor	16	22	/	/	6	x
20.	A12F13	First Floor	16	22	/	/	6	x
21.	A12F14	First Floor	16	21	/	/	6	x
22.	A12S1	First Floor	16	/	/	/	/	x
23.	A12C1	First Floor	16	12	/	/	/	x
24.	A12C2	First Floor	16	12	/	/	/	x
25.	A12C3	First Floor	16	12	/	/	/	x
26.	A12W.C1	First Floor	16	/	/	/	/	x
27.	A12W.C2	First Floor	16	/	/	/	/	x

And there are a big difference between the number of students in real and the number of students according to standard I n the case of laboratory the difference is about (128,77,48,51,131,80,51) and don't meet the requirement of standard.

The researcher suggests that the development the buildings reallocating spaces according to international standards in order to accommodate the number of existing students and teaching staff or re-study acceptance plans to be the number of students suitable for existing spaces.

11. Conclusions

Depending on the literature review and the case study analysis the following conclusions are made:

1. The BIM technology is working to increase the cooperation between project team and this lead to reducing the conflicts and increasing the efficiency of the project by reducing time and cost.
2. The use of BIM technology in site planning and space management is relatively low.
3. It is easy to obtain space data through the use of the Revit software according to BIM technology and make comparison with international standard.
4. Revit software according to BIM technology is an effective tool that provides the users with a good visualization and documentation when compared to the traditional method.

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