Implementation of Building Information Modelling (BIM) Revit to meet the needs of the construction industry

F N Aryanti*, R R T Busono and S Siswoyo
Department of Architectural Engineering Education, Universitas Pendidikan Indonesia, Dr. Setiabudhi No. 207, Kota Bandung, Indonesia

*haryanthiferanur@gmail.com

Abstract. This research aims to know the students’ Revit operating ability on beginner level competency in extracurricular activities, in order to fulfill the needs of the Indonesia construction industry. This research was conducted by 30-second grade students of DPIB Vocational High School 2 Garut. The research method was class action research, conducted in three cycles. In the first cycle, the percentage of students learning achievement in mastering Revit was only reached Architecture 85%, Annotate 57%, and View 43%. In second cycle, students achievement increased to Architecture 90%, Structure 79%, Annotate 58%, Massing & Site 88%, and View 43%. While in the third cycle, the percentage significantly increased to Architecture 90%, Structure 82%, Annotate 87%, Masing & Site 88%, and View 86%. The average score of Revit mastery in the first cycle reached 60 (not competent category). In the second cycle, the result of Revit's average scores increased to 77 (competent quite category). And in the third cycle, the average score significantly increases to 88 (included competent category). The conclusion of this research showed the Revit implementation on beginner level competency in Vocational High School 2 Garut had fulfilled the needs of the Indonesia construction industry.

1. Introduction
SMK is a Vocational High School or vocational education that holds an important role in preparing the labor force to fulfill the needs business world or industry world that will adapt to the advances of science and technology. To fulfill the needs business world or industry world requires good competencies of skill, whether soft skill and hard skill. Especially for a graduate vocational high school in modeling design and building information department (DPIB), that graduates will work as a drafter be required to master many different types of architectural application or civil application, as AutoCAD, SketchUp, Photoshop, Revit, Lumion, and other application.

Technology developments in the construction industry causing a change in the industrial companies in Indonesian. In the construction industry, the design process a building, most have used Building Information Modeling (BIM). BIM is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure [1]. In construction work, BIM has many benefits, as if BIM helps project stakeholders to visualize what is to be built in a simulated environment to identify any potential design, construction or operational issues (NBIMS, 2019). The application of BIM in Indonesia is still low, the use rate of BIM just reached 38% of 88 respondents were professional practitioners and academics [2]. In order to minimize that, according to Direktur Jenderal Bina...
Konstruksi Kementrian PUPR Syarif Burhanuddin required collective collaboration with stakeholders (Indonesia BIM Forum).

Therefore, at the SMK 2 Garut, held extracurricular activities to support learning and to prepare students to participate in the Student Competency Sheet (LKS). The material learning for extracurricular activities learned in SMK 2 Garut is AutoCAD and SketchUp, while in the construction industry the BIM software is being required. This is due to the lack of human resources at SMK 2 Garut who can teach the BIM software. Based on the description above, to be able to meet the needs of the construction industry, implemented BIM software, namely the Revit application in extracurricular activities at SMKN 2 Garut.

2. Methods
This research is a classroom action research method. The research design uses a spiral model by Kemmis and Mc Tanggart [3].

The sample used was 30 students of class XI DPIB SMKN 2 Garut. Data collection techniques used were interviews, observation of teacher activity, observation of student activity, observation of student learning outcomes, Revit mastery tests of students, documentation of student work.

Data analysis techniques in this study used descriptive qualitative and quantitative analysis. Where descriptive used is to calculate the percentage of student activity, teacher activity, and student learning outcomes from descriptive qualitative observation sheets. The analysis used is scoring the percentage of use of the Revit feature, and n-gain for increasing student learning outcomes.

3. Results and discussion

The percentage of students mastery of the Revit feature (Source: Personal Analysis, 2019).
3.1. **Architecture features**

In cycles I, the material taught about the Architecture Revit features are Grid, Column, Wall, Floor, Door, Window, Ceiling, Circulation (Stairs), and Roof. This feature is used to draw floor plans 1 and floor plans 2. The average percentage of the first cycle has reached 85% with a competent category meaning students have mastered Architecture features, namely: Grid, Column, Wall, Floor, Door, Window, Ceiling, Circulation (Stairs), and Roof. However, in the first cycle of this Architecture feature, there were still 14 students who had not yet met the KKM, because students had not entered parametric data in the modeling of building elements.

In cycle II students' mastery of the Architecture Revit feature increased by 0.33 with the category of moderate improvement. The average percentage of cycle II reaches 90% with a competent category meaning that in cycle II students have mastered the Architecture features namely: Grid, Column, Wall, Floor, Door, Window, Ceiling, Circulation (Stairs), and Roof. And in this second cycle, there is only 1 student who has not yet met the KKM.

In cycle III students' mastery of the Architecture Revit feature did not increase significantly and the average percentage was the same as cycle II by 90%. This is because in cycle II all toolbar / Architecture features are: Grid, Column, Wall, Floor, Door, Window, Ceiling, Circulation (Stairs), and Roof students have entered all parametric data correctly and all students have met the KKM specified namely 86. And the only increase in the Architecture Revit feature is Ceiling, Floor, Railing, and Stair by 0.06 so that in the second cycle there was no significant increase.

3.2. **Structure features**

In the first cycle, the material about the Structure Revit features was Structure (Beams, Ringbalk, Sloof, Roof Frame, and Foundation). Because this feature is used to draw pieces. In the first cycle focused on making floor plans first.

In cycle II the average percentage of students' mastery of the Structure Revit features, namely: Structure (Beams, Ringbalk, Sloof, Roof Frame, and Foundation) increased by 0.79 with the category of height increase. And the average percentage has only reached 79% with the category of competent enough, meaning that in cycle II students have mastered the Structure Revit features, namely: Structure (Beams, Ringbalk, Sloof, Roof Frame), and Foundation. Although experiencing a high increase, students have not met the KKM that has been set at 86. Because students have not included building/family elements in their work drawings. In cycle III students' mastery of the Structure Revit features, namely: Structure (Beams, Ringbalk, Sloof, Roof Truss), and Foundation increased by 0.14 with a low category. The average percentage is 82% with the category of quite competent. And there are only 3 students who have met the KKM.

3.3. **Annotate feature**

In cycle, I, the material taught about Annotate Revit features are Dimension, Text, and Tag. This feature is used to provide information on floor plans, looks, and pieces. The average percentage just achieved in the first cycle is 57% with the category of not yet competent meaning students have not mastered the Annotate Revit features, namely: Dimension, Text, and Tags. This is because in the first cycle which was only given information only on the floor plan worksheets 1 and 2 floors only. And in the first cycle, there were no students who fulfilled the KKM value because students did not give complete information on the work plan.

In cycle II students' mastery of the Annotate Revit features, namely: Dimension, Text, and Tags experienced a not so significant increase of 0.02 with a low increase category. The average percentage of the second cycle has only reached 58% with the category of not competent meaning that in the second cycle students have not mastered the Annotate Revit features, namely: Dimension, Text, and Tags. This is because, in cycle II, students are more focused on the work of making structures, beams, ringbalk, and roof on Houses. And in cycle II there are no students who meet the KKM.

In cycle III, students' mastery of Annotate Revit features, namely: Dimension, Text, and Tag, there was a very significant increase of 0.69 with the category of height increase and the average percentage,
namely in cycle III of 82% with the category quite competent. This means that students have mastered the Annotate Revit features, namely: Dimension, Text, and Tag. But there are still 10 students who have not reached the KKM, the remaining 30 students have reached the KKM value. Although students have achieved the KKM value and students have given information on each worksheet that is a floor plan, looks, and pieces. But it is not in accordance with the fully integrated BIM principle (system keynote editing, material keynote, elements, etc.).

### 3.4. Massing and site features

In cycle, I, the material taught about the Massing & Site features are Site Component. This feature is used to add trees to the worksheet. However, at the time of the first cycle, due to a problem, there was no Family Revit on each student's computer. This causes in the first cycle students have not mastered the Massing & Site features.

In cycle II the students' mastery of the Massing & Site features is: Site Component experienced a significant increase of 0.88 with a high increase category. The average percentage of this second cycle has reached 88% with the category of competence meaning that in the second cycle students are already very familiar with the Massing & Site features, namely: Site Component. And in this second cycle, all students have reached the KKM.

In cycle III students mastery of the Massing & Site features, namely: Site Component did not increase and the average percentage was the same as cycle II of 88%. This is because in cycle II all toolbars /Massing & Site features are: Site Component, students have entered all data in accordance with the requested job sheet and in the previous cycle students have reached KKM.

### 3.5. View feature

In cycle, I, the material taught about the View Revit features are: Create, and Sheet Composition. These features are used to create pieces, view plans, views, pieces, 3D, and also structure plans. And can make title blocks or header images. The average percentage of the first cycle has only reached 42% with the category of not competent meaning students have not mastered the View Revit features, namely: Create, and Sheet Composition. This is because the toolbar / Sheet Composition feature has not been explained in cycle I. And in this cycle I all students have not yet reached the KKM value.

In cycle II students' mastery of the View Revit features, namely: Create, and Sheet Composition increased by 0.02 with a low increase category and an average percentage of 43%. In this second cycle, the same as the first cycle students have not yet reached the KKM value.

In cycle III students' mastery of the View Revit features, namely: Create, and Sheet Composition experienced a rather significant increase of 0.75 with a high increase category. The average percentage of this cycle III has reached 86% with the competent category, meaning that in cycle III the students have mastered the View Revit feature, namely: Create, and Sheet Composition. And in this third cycle, as many as 10 students have not yet reached the KKM score. Because the sheet created does not match the Job sheet and there was an error while making the View piece, Views.

![Figure 3. The 3D level students have achieved (Source: Personal Analysis, 2019).](image-url)
The instrument used to measure students' learning abilities in implementing Revit in order to meet the needs of the construction industry specifically in the application of BIM is to use the Individual Revit Competency Matrix taken from the Autodesk Revit Forum and has been through the face validity expert judgment type validation by Design Lecturer and Teacher Subject; subsequently, be appropriate-considered for assessing student work documentation.

The results of the Revit mastery calculation, students have mastered several indicators on the Individual Revit Competency Matrix, namely Level 3D. Following below are the 3D Level work indicators on the Individual Revit Individual Competency research, namely:

3.5.1. View with indicators that must be achieved by students, namely:
- Make New Plans, Draftings, and 3D Views
- Create and change levels
- Create and modify Collations, Elevations, Sections, and Details.
- Enter and change Sheets and enter Views
- Print Sheets and arrange Sheets

The percentage of achievements that have been achieved by students at the 3D Level has only reached 86, while the value that students must reach the 3D level is 88. This is because in the House 2 Floor assignment students only make plans, views, and pieces are not instructed to make Callouts Details.

3.5.2. Elements and Family with indicators that must be achieved by students, namely:
- Create and change grids
- Edit types, insert and change Walls, Doors, Windows, and Components
- Edit types, insert and change Curtain Wall
- Create and insert
- New Family (from the Library)
- Edit the Family parameter to create a new type

The percentage of achievement that has been achieved by students at the 3D Level, at modeling amounted to 70, while what students must achieve at the 3D level is 85. This is due to the indicator editing the Family parameters to create a new type. Students are not instructed to create new types of Family, students are only instructed to use Family which is already in the library of each computer.

3.5.3. Modeling with indicators that must be achieved by students, namely:
- Edit types, insert and change Roofs, Ceiling, and Floor
- Edit types, insert and change Ramps, Stairs, and Railing

Percentage of achievements that have been achieved by students at Level 3D, on modeling work by 90, the value has exceeded the value that students must achieve at level 3D 84. This is because, in modeling work with each indicator, students have worked on each indicator by entering the parametric data that is correct.

3.5.4. Documentation with indicators that must be achieved by students, namely:
- Create and change Rooms, Room Tags and Room Separation
- Insert and change detailed elements such as Detail Lines, Filled Regions, and Masking Regions
- Enter and change dimensions and text

The percentage of achievements that have been achieved by students at the 3D Level in Documentation is 29, while the value that must be achieved by students at the 3D level is 86. This is because, in the House 2 Floor assignment that students work on, students have not implemented a text system and
drafting lines that are in accordance with the BIM fully integrated with indicators creating and changing rooms, room tags, and room separations, including and changing detailed elements such as detail lines, filled regions, and masking regions in the assignment of 2 story houses.

3.5.5. Collaboration. At this stage, no value is achieved by students, because at the 3D Level collaboration stage in accordance with the Revit KPI there are no indicators to be learned by students. All the achievements that have been achieved by these students, students are said to have reached the beginner level category. From the results of observations of student learning that has reached the beginner level, there are still some problems while the learning process is taking place. For example, Library and Family Revit are not fully installed so that it inhibits the learning process and also the results of worksheets that students have done, related to the addition of notation, floor height, and keynotes that use text systems and drafting lines are not in accordance with the fully integrated BIM (system keynote editing, material keynote, elements, etc.).

It can be seen based on Figure 3, the results of students' mastery of Revit have reached the beginner level / 3D or have reached the predetermined KKM value. This KKM value is a value that must be agreed upon by students on each indicator of the work topic. Although students have reached the beginner level, based on the results of interviews with Mr. Irfan Irwanudin that the mastery of BIM software is needed based on the maturity level, namely 3D, 4D, 5D, 6D, to 7D. And related to the type of BIM job required by the construction industry are the BIM manager, BIM engineer, BIM coordinator, BIM technician, architect, mechanical, electrical, and plumbing (MEP) BIM engineer, BIM project manager, BIM designer, BIM MEP designer, and senior architect [4].

In addition, students can fill positions as CAD / BIM compilers, based on interviews with Mr. Yusuf as a planning expert in Architecture & Engineering Consultant Suriadipraja, uses BIM software in the Indonesian construction world which is more expected in project management or construction management. So it can be denied that the mastery of Revit which has reached the beginner / 3D level has not met the needs of the construction industry in Indonesia. However, if you want to reach the level of project management or 4D-7D, additional time is needed for learning material and it is expected that SMK will apply Teaching Factory (TEFA) with construction industry companies.

4. Conclusion
The conclusions obtained from this study are:

- Student competency needs through the implementation of Revit Building Information Modelling (BIM) in extracurricular activities at SMKN 2 Garut has reached a level in beginners or 3D. However, it has not been able to meet the needs of the application of the BIM in the construction industry.

- Implementation of Building Information Modelling (BIM) Revit on Extracurricular at SMKN 2 on the results of observations of the first cycle 92% of teachers have explained learning well and guided students very well. And in cycle II there was an increase to 94% and in cycle III to 100%, in each cycle, the teacher's activity remained in the excellent category. And besides, in the first cycle student activity by 65% with a good category. And in the second cycle increased by 16% wherein the second cycle to 81% with a good category. And in the third cycle increased by 11% were in the third cycle to 92% with a very good category.

- Implementation of Revit Building Information Modelling (BIM) in Extracurricular in SMKN 2, seen from the results of mastery of Revit application, in cycle I with the material that is explained how to make grids, columns, walls, floors, ceilings, doors, windows, stairs, and roof coverings, the average student gets a score of 60, with the highest value of 64 and the lowest value of 60. And the completeness of learning in this first cycle is 0%, this is because when working on library and family assignments on Revit is not completely installed and causes student assignments that have not been completed because they have not entered parametric data on each element of the building. In the second cycle, there was an increase in the gain score of learning completeness that is equal to 0.43 in the medium category with an average value of
30 students of 77. And mastery learning in this cycle II equal to cycle 1 is 0%, this is due to the work on the Family Roofing Wood assignment cannot be used because of the different versions of Revit that students use. For the highest value in cycle II of 80 and the lowest value of 73. In cycle III there was a significant increase in learning completeness by 100% with an average value of 88. The highest value in cycle III was 90 and the lowest value was 83. In cycle II to III increased by 0.48.

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