AUS | الجامعة الأميركية في الشارقة
American University of Sharjah

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2019 Architectural Engineering Institute (AEI) Conference

BIM as a Pedagogical Tool for Teaching HVAC Systems to Architecture Students

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Professor | Architecture

College of Architecture, Art, And Design

Environmental Control Systems (ECS)

Proposed Sequence of Study
Bachelor of Architecture (BArch)

FIRST YEAR (30 credits)			
Term	**Course #**	**Course Title**	**Credit**
Fall	DES 111	Descriptive Drawing I	3
	DES 121	Introduction to Architecture, Art and Design History	3
	DES 131	Design Foundations I	3
	MTH 111 or MTH 103	Mathematics for Architects or Calculus I	3
	WRI 101	Academic Writing I	3
		Total	**15**
Spring	DES 112	Descriptive Drawing II	3
	DES 122	Modern Developments in Architecture, Art and Design	3
	DES 132	Design Foundations II	3
	WRI 102	Academic Writing II	3
	GER-Core	History and Culture of the Arab World	3
		Total	**15**

SECOND YEAR (36 credits)			
Term	**Course #**	**Course Title**	**Credit**
Fall	ARC 201	Architectural Design Studio I	6
	ARC 271	Introduction to Landscape	3
	ARC 281	Architectural Principles	3

FOURTH YEAR (30 credits)			
Term	**Course #**	**Course Title**	**Credit**
Fall	ARC 401-01	Architectural Design Studio V	6
	ARC 421	Architectural Theory	3
	ARC 451	Environmental Control Systems	3
	GER-Core	Arts and Literature	3
		Total	**15**
Spring	ARC 402	Architectural Design Studio VI	6
	ARC 463	Professional Practice	3
	GER-SCI	Natural Sciences	3
	FRE	Free Elective	3
		Total	**15**

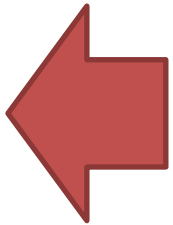
FIFTH YEAR (30 credits)			
Term	**Course #**	**Course Title**	**Credit**
Fall	ARC 501	Architectural Design Studio VII	6
	ARC 581	Critical Practice and Contemporary Discourse	3
	ARC 591 or FRE	Directed Architectural Design Research or Free Elective	3
	GER-Core	Human Interaction and Behavior	3
		Total	**15**

Typical Subjects in an ECS Course

- HVAC Systems 
- Water Supply and Drainage Systems.
- Fire Protection Systems.
- Electric Systems.
- Mechanical Vertical Transportation Systems.
- Others.

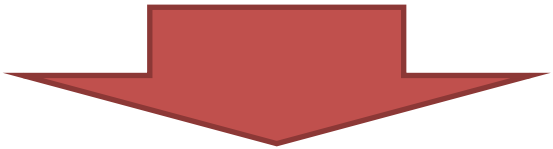
Objectives of Learning HVAC (for Arch Students)

1. Recognize the **terminology** used in these systems.
2. Understand - to a reasonable extent - the **design concerns** of an HVAC engineer.
3. Recognize the **impact** of the HVAC system components on the building architecture.
4. Recognize the potential of using the HVAC components as **architectural elements**.



Difficulties to Teach the Subject (to Arch Students)

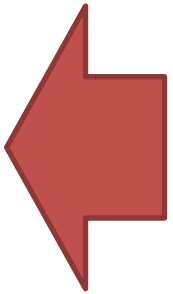
- Students' recognition of the **importance** of the subject to their professional career.
- The components of a typical central HVAC system are **commonly hidden** in a building.



- The difficulty to make architecture students **like the subject**.

Tools that Help Students' Learning

- *Lectures* that are **enriched** with photos and videos.
- *Field trips* allow students to closely **see and touch** the different components.
- *Class exercises* to discuss the **logic** for integrating the HVAC system components with the architecture design.

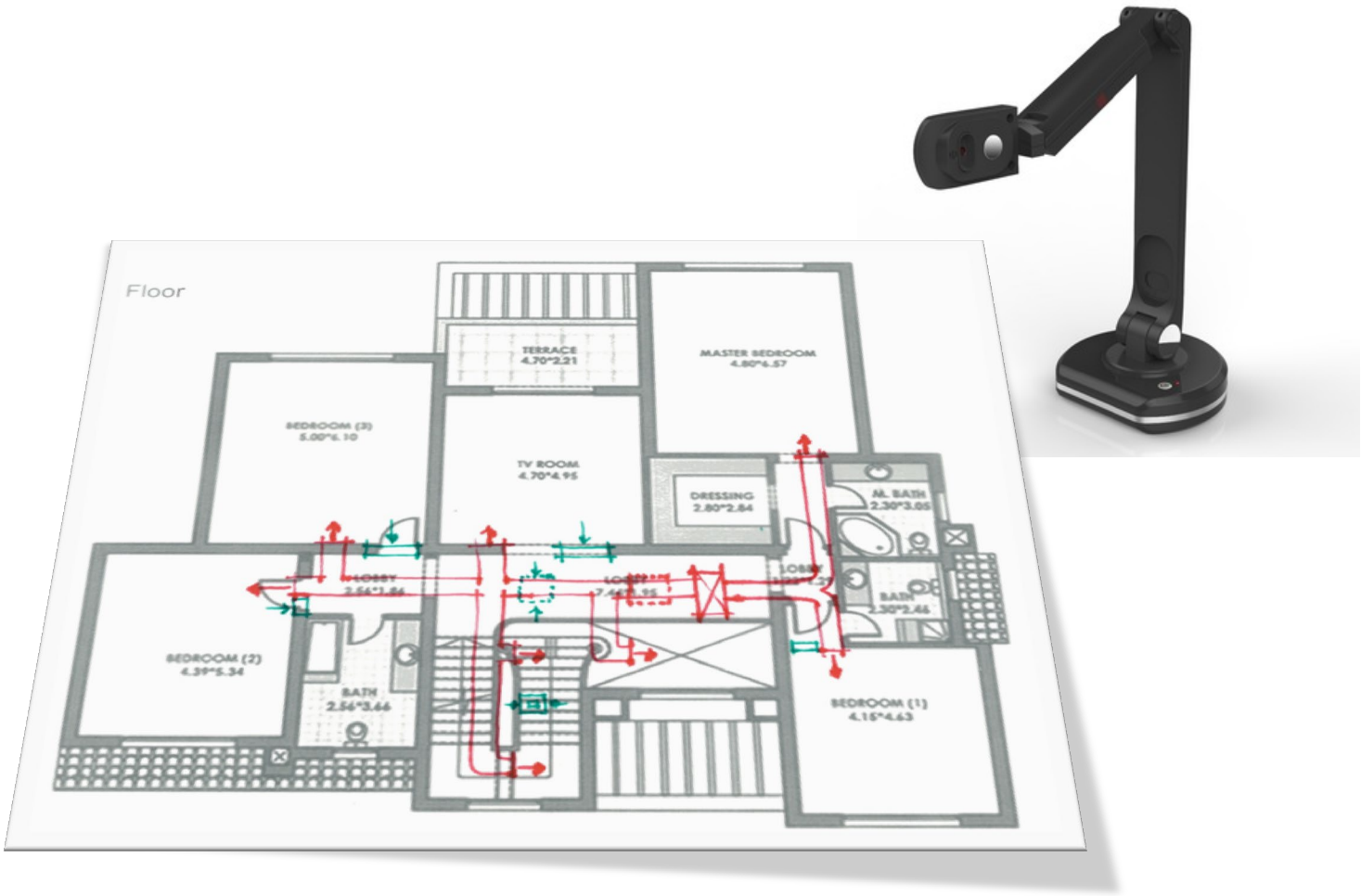


Example of a Class Exercise

- Determine the type, location, and distribution elements for a central HVAC in the shown villa.
- In particular, you need to define the following:
  - Air system vs. Water system. Hence, the type of needed equipment
  - Location of the FCUs (if needed)
  - Location of the pipes/ducts (as needed)
  - Location of the supply and return diffusers / registrars / grills.
- Make sure to make appropriate decisions so you do not have ducts or other components interrupting the architecture design of the spaces (unless on purpose)

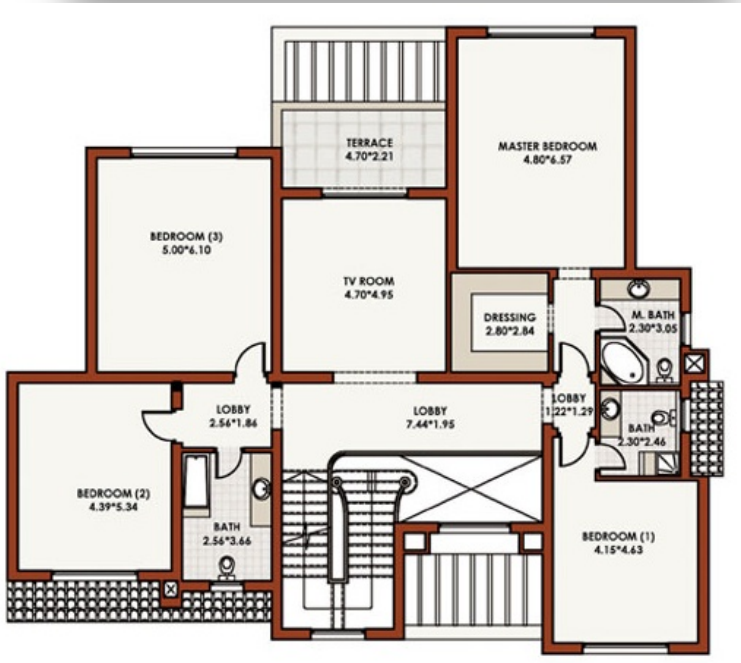
Stages of Class Exercises

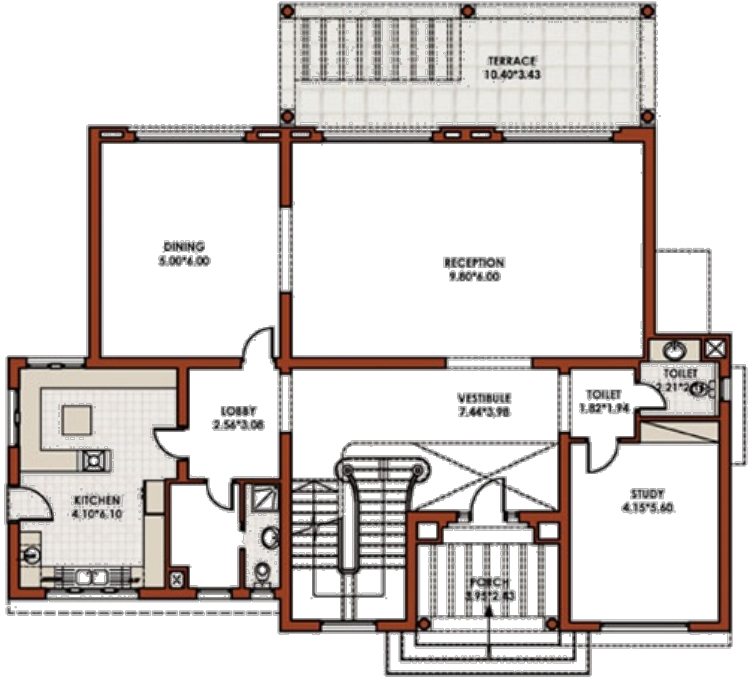
- Two Stages:
  - Demonstration by the instructor.
  - Students do it themselves for a different case.


Floor
TERRACE
4.70*2.21
MASTER BEDROOM
4.80*4.57
BEDROOM (3)
5.00*4.10
TV ROOM
4.70*4.95
DRESSING
2.80*2.84
BEDROOM (2)
4.39*5.34
BATH
2.56*3.46
BEDROOM (1)
4.15*4.63

Common Learning Challenges

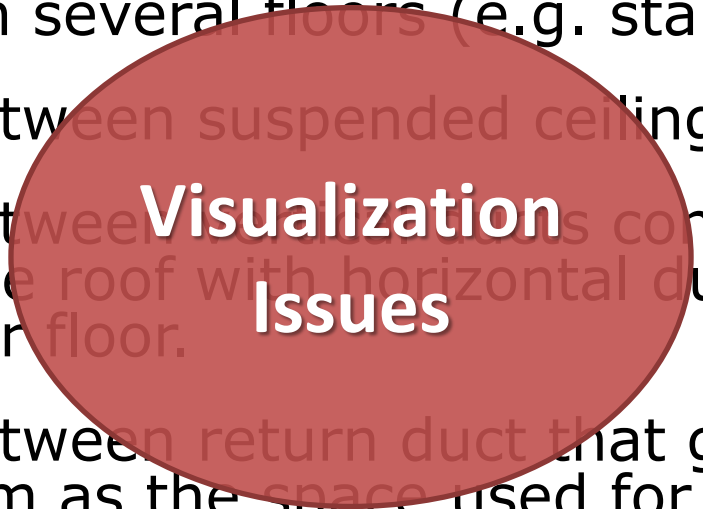
- Relationship between HVAC components and elements that go through several floors (e.g. stairs).
- Relationship between suspended ceilings and ducts.
- Relationship between vertical ducts connecting HVAC machines on the roof with horizontal ducts in the plenum of lower floor.
- Relationship between return duct that goes to the roof, the plenum as the space used for return air, and the walls that cut that plenum.

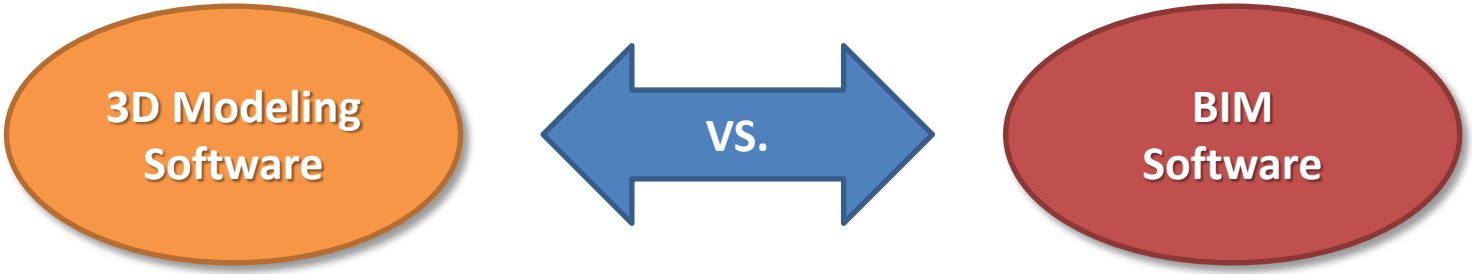

TERRACE
4.70*2.21
MASTER BEDROOM
4.80*6.57
BEDROOM (3)
5.00*6.10
TV ROOM
4.70*4.95
DRESSING
2.80*2.84
M. BATH
2.30*3.05
LOBBY
2.54*1.86
LOBBY
7.44*1.95
LOBBY
1.22*1.29
BATH
2.30*2.46
BEDROOM (2)
4.39*5.34
BATH
2.56*3.66
BEDROOM (1)
4.15*4.63


TERRACE
10.40*3.43
DINING
5.00*6.00
RECEPTION
9.80*6.00
LOBBY
2.56*3.08
VESTIBULE
7.44*3.98
TOILET
1.82*1.94
TOILET
KITCHEN
4.10*6.10
STUDY
4.15*5.60
PORCH

Common Learning Challenges

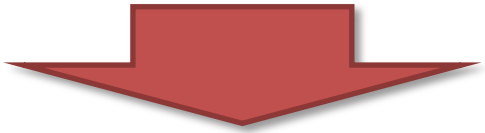
- Relationship between HVAC components and elements that go through several floors (e.g. stairs).
- Relationship between suspended ceilings and ducts.
- Relationship between components connecting HVAC machines on the roof with horizontal ducts in the plenum of lower floor.
- Relationship between return duct that goes to the roof, the plenum as the space used for return air, and the walls that cut that plenum.




3D Modeling Software
VS.
BIM Software

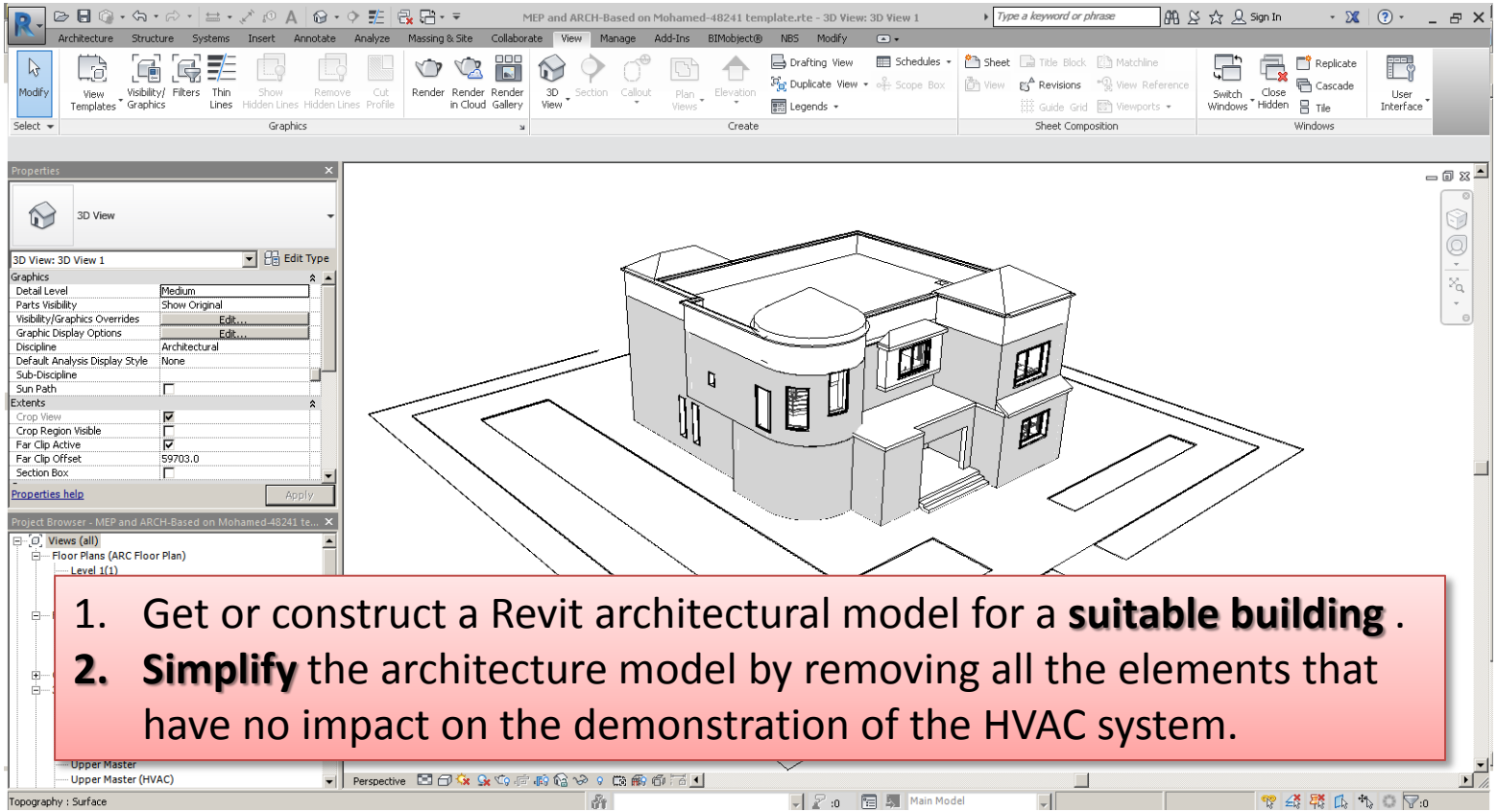
Challenges of Using BIM

- The non-familiarity of many students with the tool.
- The limited time available in a lecture.

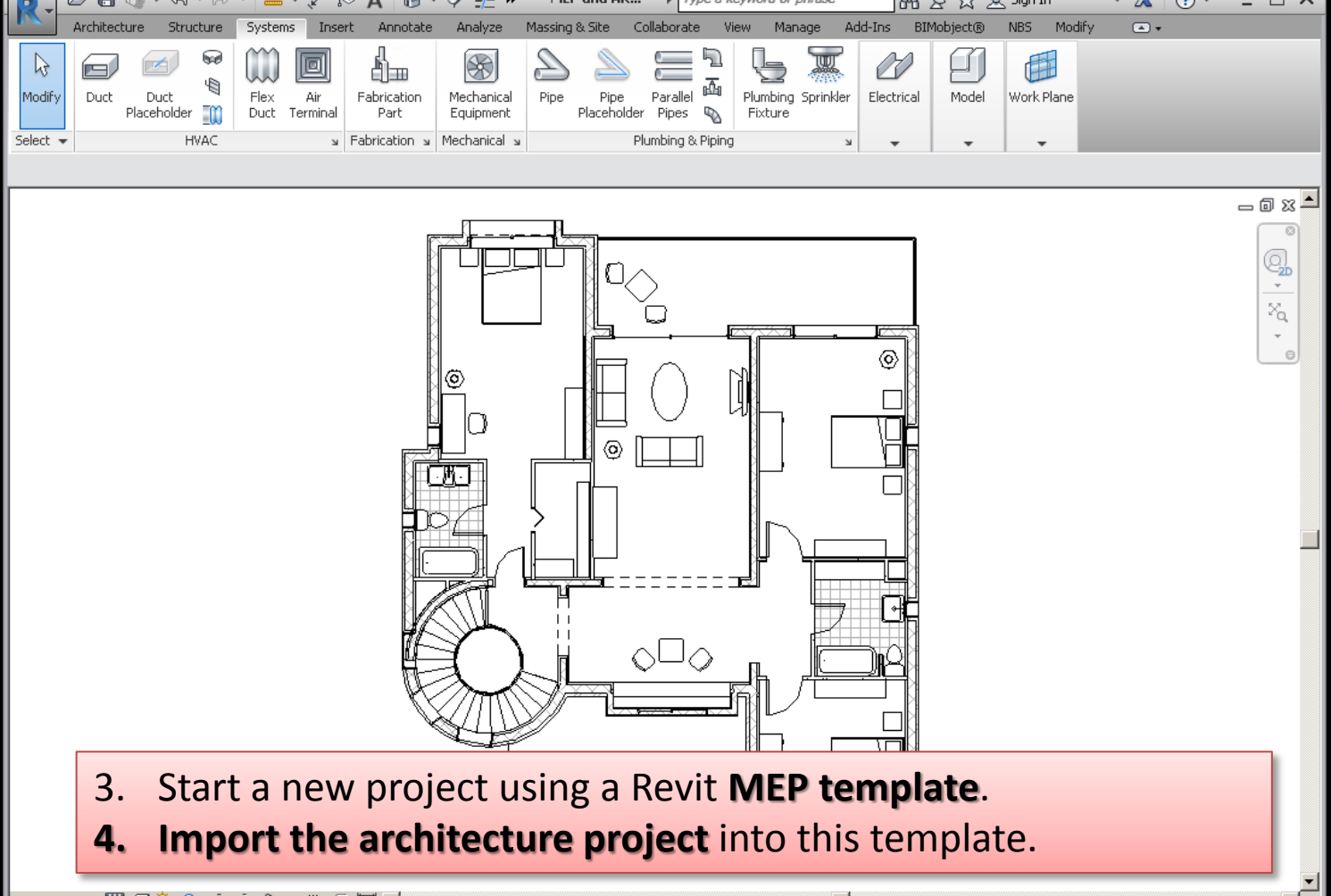


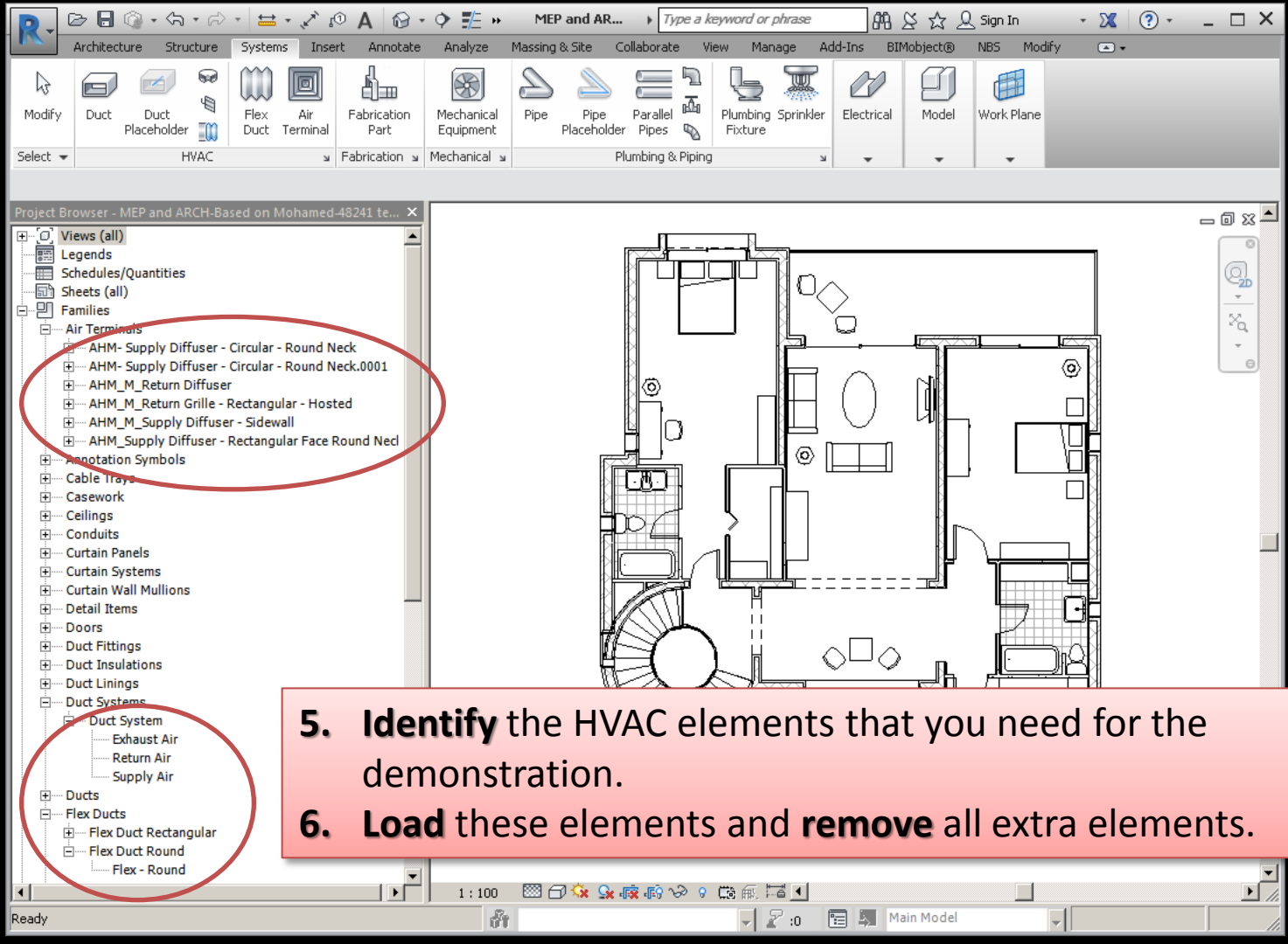
The software needs to be customized for the purpose

Software (Revit) Customization

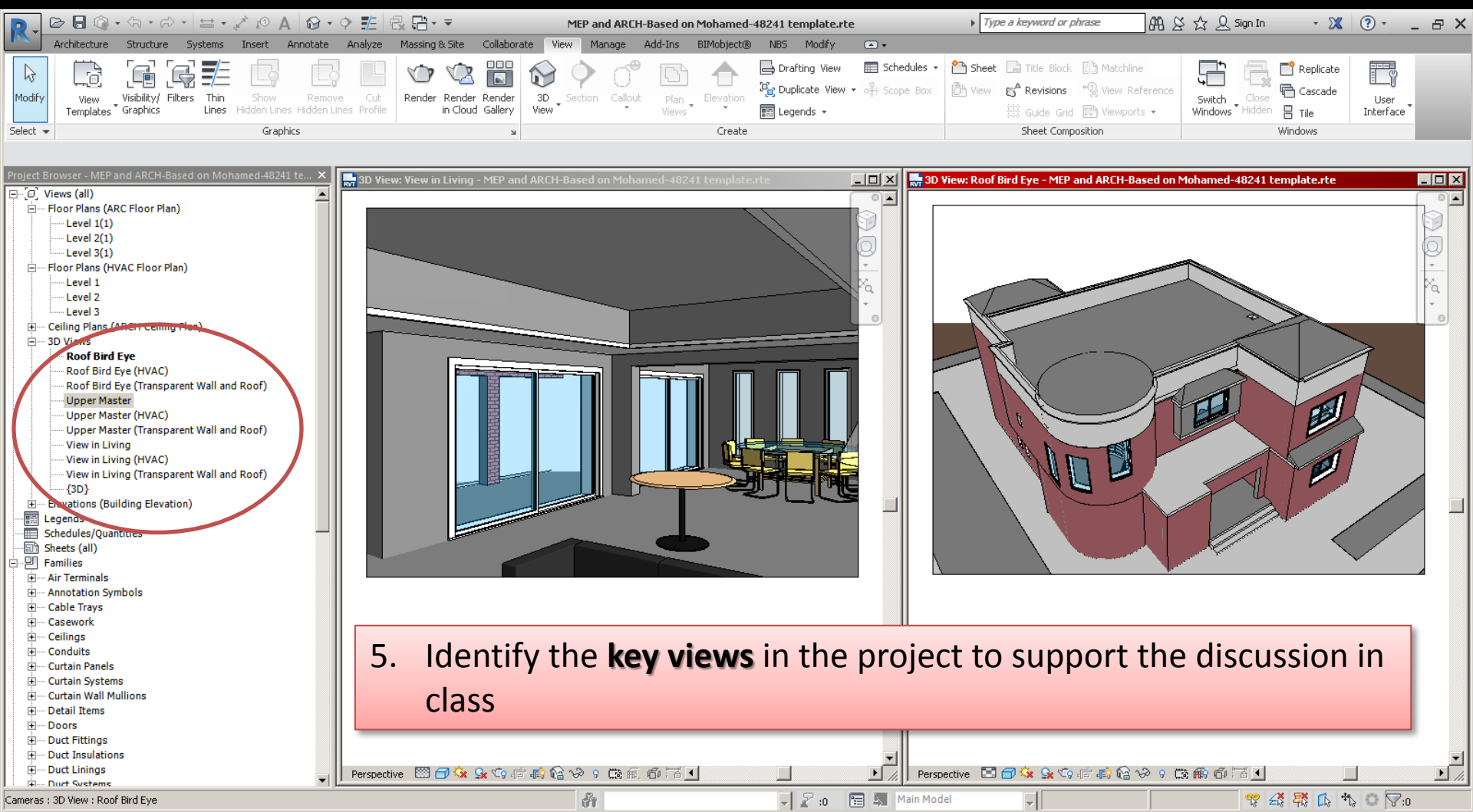


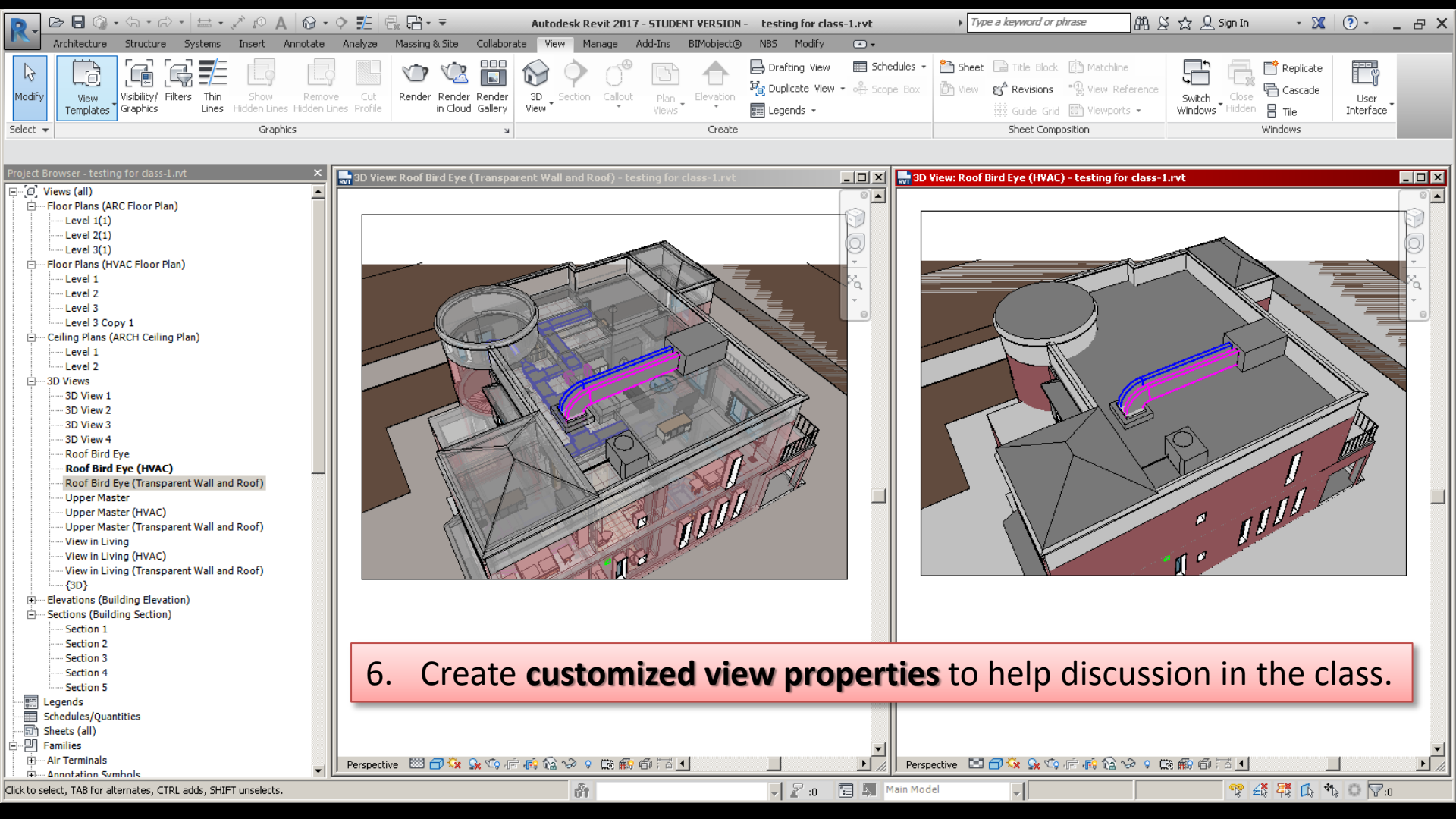
1. Get or construct a Revit architectural model for a **suitable building** .
2. **Simplify** the architecture model by removing all the elements that have no impact on the demonstration of the HVAC system.


MEP and AR...
Type a keyword or phrase
Sign In
Architecture
Structure
Systems
Insert
Annotate
Analyze
Massing & Site
Collaborate
View
Manage
Add-Ins
BIMobject®
NBS
Modify
Modify
Duct
Duct Placeholder
Flex Duct
Air Terminal
Fabrication Part
Mechanical Equipment
Pipe
Pipe Placeholder
Parallel Pipes
Plumbing Fixture
Sprinkler
Electrical
Model
Work Plane
Select
HVAC
Fabrication
Mechanical
Plumbing & Piping
3. Start a new project using a Revit **MEP template**.
4. **Import the architecture project** into this template.
1 : 100
Click to select, TAB for alternates, CTRL adds, SHIFT unselects.
Main Model

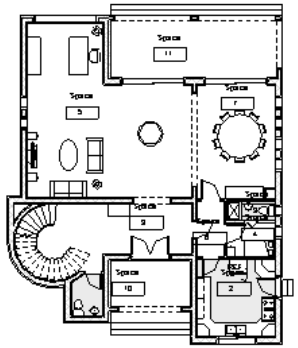


5. **Identify** the HVAC elements that you need for the demonstration.
6. **Load** these elements and **remove** all extra elements.

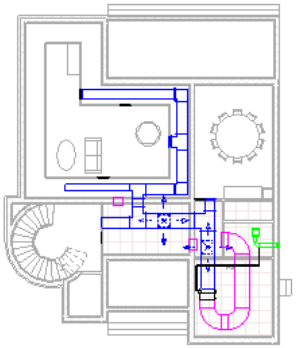

MEP and ARCH-Based on Mohamed-48241 template.rte
Project Browser - MEP and ARCH-Based on Mohamed-48241 te...
Views (all)
Floor Plans (ARC Floor Plan)
Level 1(1)
Level 2(1)
Level 3(1)
Floor Plans (HVAC Floor Plan)
Level 1
Level 2
Level 3
3D Views
Roof Bird Eye
Roof Bird Eye (HVAC)
Roof Bird Eye (Transparent Wall and Roof)
Upper Master
Upper Master (HVAC)
Upper Master (Transparent Wall and Roof)
View in Living
View in Living (HVAC)
View in Living (Transparent Wall and Roof)
{3D}
Legends
Schedules/Quantities
Sheets (all)
Families
Air Terminals
Annotation Symbols
Cable Trays
Casework
Ceilings
Conduits
Curtain Panels
Curtain Systems
Curtain Wall Mullions
Detail Items
Doors
Duct Fittings
Duct Insulations
Duct Linings
3D View: View in Living - MEP and ARCH-Based on Mohamed-48241 template.rte
3D View: Roof Bird Eye - MEP and ARCH-Based on Mohamed-48241 template.rte
Perspective
Perspective
5. Identify the key views in the project to support the discussion in class
Cameras : 3D View : Roof Bird Eye
Main Model


Autodesk Revit 2017 - STUDENT VERSION - testing for class-1.rvt
Project Browser - testing for class-1.rvt
3D View: Roof Bird Eye (Transparent Wall and Roof) - testing for class-1.rvt
3D View: Roof Bird Eye (HVAC) - testing for class-1.rvt
6. Create customized view properties to help discussion in the class.

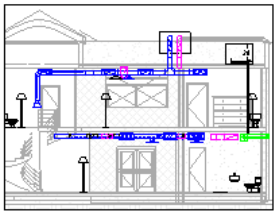
7. Prepare a **sheet** for each point of discussion.



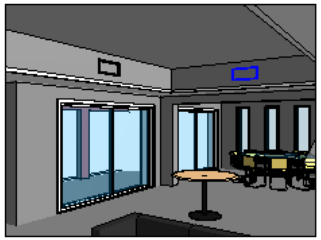
1 Level 1(1)
1 : 100



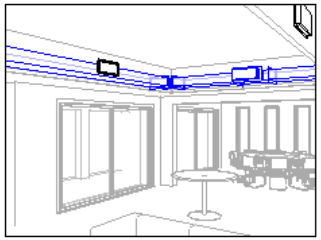
2 Level 1
1 : 100



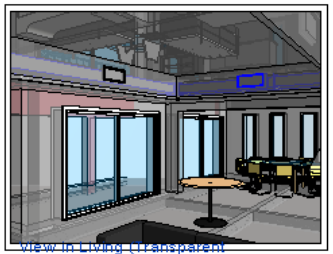
6 Section 1
1 : 100



3 View in Living



4 View in Living (HVAC)



5 View in Living (Transparent Wall and Roof)

Students' Feedback

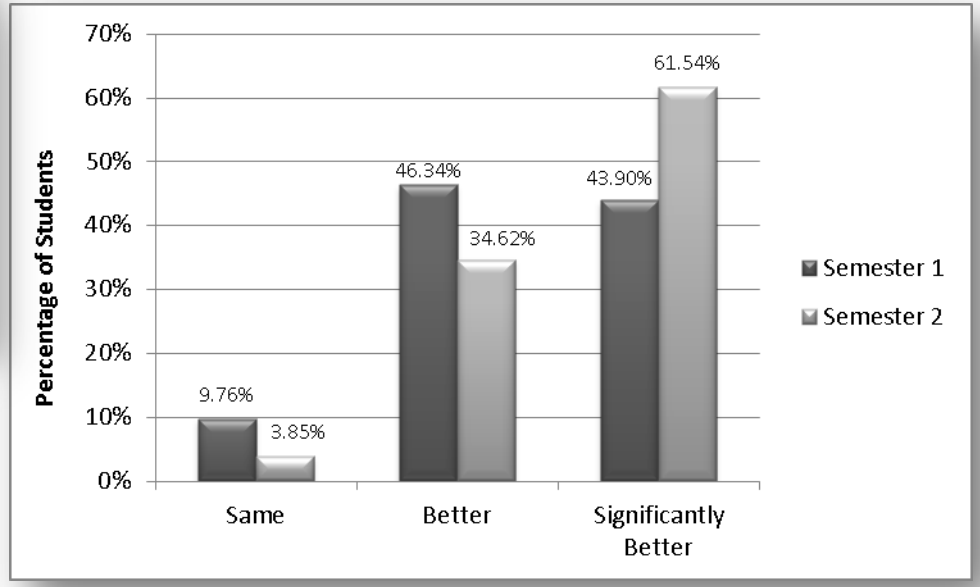
Feedback on using BIM to explain accommodating HVAC systems

The difference in understanding the subject when BIM is used was (Check one):

The same ☐ Better ☐ Significantly Better ☐

Please write any comments here:

- It was helpful to see all the system components in 3D instead of only imagining them, which is much clearer.
- We need to know BIM.
- Using the two approaches together is also useful.



Thank You