

The Significance Of Modelling Software In Relevance To Architecture Academics

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Abstract

How to most effectively utilize emerging parametric design technology so as to get the better output from the design process. Students getting exposure to the new technology may get an opportunity bring something different from the design briefs. This paper will introduce substituting applications of tools for design development such as 3d modeling for students, which can potentially support to analyze and find solutions. Parametric teaching methodology is getting adapted all over the world, then why not India? The paper consists of three bodies of work that inform this study. First, a survey taken from students restricted to the tools and the methodology uses for designing. Secondly, a detailed technical background study will be done for the tools. Thirdly, by choosing random academic design assignment, the execution will be done within restrictions of tools that are kangaroo, ladybug, karamba and heliotrope. The results will be judged on the basis of accuracy, flexibility, optimization, and analysis of the project. To state, how using parametric tools can help students to come up with the better output in modeling.

The goal of using a new approach to design problem is to enable the border group of students to take full advantage of the benefits offered by parametric design tools, implement precise design processes that lead to better designs.

Keywords— Parametric software, academics, conventional design software, rhino-grasshopper, auto cad, sketch up

I. INTRODUCTION

1.1 – Background

What impact do technological advancements and tools have on architecture education? In the 1920s, we saw a paradigm shift in the role of the architect. 'In the future, digital tools will get closer to our human bodies, allowing us to access and use digital information more conveniently in our daily lives,' says architect and designer SoomeenHahm. Willim Gibson, an American

writer, created the phrase "Digital Architecture." Complicated calculations that delimit architects and allow a varied range of complex forms to be constructed with remarkable ease utilizing computer algorithms are possible with digital architecture. Digital architecture is responsive, scalable, and agile. It eliminates legacy costs and complexity. It also serves as a platform for the quick deployment of innovative, customer-centric services.

1.2 –Differentiation between traditional and digital architecture

Table no. 1

No.	Title	TRADITIONAL ARCHITECTURE	DIGITAL ARCHITECTURE
1	Applications	Disadvantage – • Reusability is limited. • Expensive to change • A high level of apprehension	Advantages – • Can be modified individually • Is less expensive to reconfigure • Can be installed quickly
2	Data	Disadvantage – • Proliferation • High level of difficulty in enforcing quality standards • Limits the capacity to analyses data.	Advantages – • Compiles a large amount of data • Data of higher quality Advanced analytics will be built on a stronger foundation.
3	Technology	Disadvantages – • Server-dependent, making it difficult to add new components or adjust.	Advantages – • Scalable • Can be quickly deployed

1.3 – Introduction to NURBS geometry

Rhino was created in 1990 by Robert McNeel as a complement to Autodesk CADD, beginning with a lunch of rhinoceros. It was stable released in 1998, with the first version known as Rhino Version 1. AG required assistance in integrating AGLib and NURBS geometry into CAD. After creating a prototype on CAD, Robert McNeel and AG decided to create NURBS modeling software.

The distinction is that Rhino 3D is a NURBS-style package, whereas SketchUp is a polygon-based (also known as mesh-based) application. To explain the differences between a NURBS-based design package and a mesh modeler, compare Adobe Illustrator to Adobe Photoshop. As shown in the (fig no. 1).

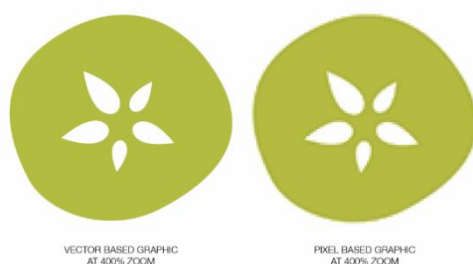


Figure no. 1

NURBS packages have the advantage of acting similarly to vector-based drawing applications like Adobe Illustrator. That is, it can be scaled to any size without losing resolution, whereas

SketchUp and other polygon-based applications are more akin to pixel-based software like Adobe Photoshop. As a result, companies in the aerospace, automotive, architectural, and product design industries rely on NURBS surfacing tools to better capture design intent before moving on to manufacturing. The difference between NURBS surfaces and mesh surfaces can be seen as below in the (fig no.2).

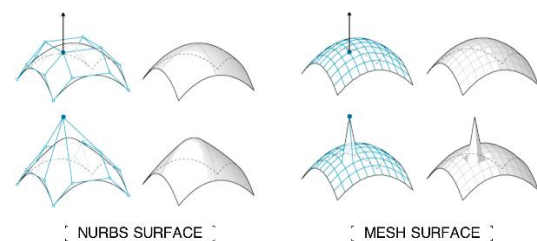


Figure no. 2

Rhinoceros was released in 1998, and Sketch was released in 2000 as a 3D modeling software. In an attempt to consider digital tools and techniques as part of architectural education, a course was proposed for the first time in the department of architecture at Birzeit University in Palestine as an initiative to introduce students to the innovative processes used in architecture design and fabrication processes.

After Rhino 3D became popular in the market, the style of architecture in the 2000s changed dramatically. Many fluid and free designs began to appear around the world, and they all had one thing in common: Rhinoceros 3D made them possible.

II. AIM AND OBJECTIVE

The aim of this research is to promote the rhino+grasshopper3d modeling tools in learning process which can be beneficial for students of architecture from 1st to 5th year in academic projects.

The objectives are-

1. Promote architectural design education by using tools to the different scale, quality, innovation, feasibility of design.
2. Demonstrating effectiveness of parametric software at student working level of B.Arch. (5 years)

III. RESEARCH GAP

There is no any particular academic study for students of architecture, advocating 3d modeling software i.e., rhino as design development.

IV. SCOPE

The research is going to get perform within the sample of architecture students from 1st to 5th year. on the basis of primary data collection i.e., by the questionnaire.

Restricting uses of tools to only kangaroo, ladybug, karamba and heliotrope which stands for form finding, environmental analysis, structural analysis and responsive design to solar respectively.

V. METHODOLOGICAL APPROACH

The goal of using a new tool for design problems is to enable a border group of students to fully utilize the benefits of parametric design, implementing precise design processes that result in better designs.

5.1 Theoretical Approach-

5.1.1 Briefing what is parametric architecture.

Parametric design is an algorithmic thinking-based process that allows the expression of parameters and rules that define, encode, and clarify the relationship between design intent and design response. The relationship between elements is used to manipulate and inform the design of complex geometries and structures in parametric design.

Parametric architecture's history -

Antonio Gaudi's upside-down church models were among the first examples of parametric

design (fig no.3). He created a model of strings weighted down with birdshot to create complex vaulted ceilings and arches in his design for the Church of Colonia Güell. He could change the shape of each arch by adjusting the position of the weights or the length of the strings.



Figure no. 3

5.1.2 What exactly are parametric analysis and optimization?

A parametric analysis, also known as a sensitivity analysis, is the investigation into the impact of various geometric or physical parameters, or both, on the solution of a problem. Parametric analysis is a useful tool for design exploration, for example, to investigate the effect of air gap length on magnetic force in a contactor.

Optimization, on the other hand, seeks to find the best solution or the best compromise between competing parameters. Unlike parametric analysis, which requires an initial design for examination, optimization provides engineers with a blank slate to explore the design space and create optimal designs based on the user's constraints. Optimization software is based on either deterministic or probabilistic algorithms. The terms metric analysis and optimization are interchangeable.

5.1.3 What is rhino + grasshopper, and what are the advantages of using it?

You can use Grasshopper to reference Rhino geometry objects (points, curves, surfaces, and so on), create geometry, or bake Grasshopper geometry back into Rhino.

Here are a few reasons why I believe Grasshopper could help your architecture design process by making it easier, faster, and less repetitive.

- **AUTOMATE THINGS** - Consider drawing 1000 perpendicular lines to a given line at a given distance. Let us refer to this distance as X. You're not going to do this with a pencil and a ruler, are you? Assuming you don't use a parametric tool like Grasshopper, you'd get a CAD tool and draw one perpendicular line, then copy it 999 times one by one. In the best-case scenario, the matrix function can be used to repeat the action 999 times.

- **ENCAPSULATE REGULAR TASKS** - Grasshopper allows you to create your own modules to perform a specific task. Each module functions as a function, taking inputs as variables and returning solutions or results as outputs. In the previous example, the inputs are the number of perpendiculars (X) and the line into which they will be drawn. The perpendicular lines are the outputs of the module.




- **ITERATE. VERY FAST.** - So, for example, you could complete a design in CAD in an hour. Depending on the complexity of the design, you may be able to complete a parametric model of the same design in the same amount of time, or in less.

So, how does the parametric model help? Because, once you have the model, it will most likely take you less than a minute to change your variables to generate different possibilities, whereas in CAD, you would have to spend an hour for each new iteration you want to test.

5.2 Plugins – The plug ins mentioned down below are shortlisted by the response on the survey taken. Were, two of them that are Heliotrope and Kangaroo will be experiment for the research.

Table no. 2

Ladybug	Ladybug imports Energy Plus Weather (.EPW) files into Grasshopper and Dynamo. It
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	offers a range of 2D and 3D interactive climate graphics to aid decision-making during the early stages of design. Ladybug also aids in the evaluation of preliminary design options via solar radiation studies, view analyses, sunlight-hours modelling, and other methods. Integration with visual programming environments enables real-time feedback on design changes and a high level of customization.
Heliotrope 	Heliotrope is a Grasshopper plug-in that allows you to manipulate solar geometry. The tool computes solar position vectors at specific dates and times and provides a variety of components for parametrically manipulating those dates and times. It can be used to create solar-aware designs, align geometry, position rendering lights, and analyse incident sun on structures.
Kangaroo 	Kangaroo is a Grasshopper-based Live Physics engine that allows for interactive simulation, optimization, and form-finding. It is made up of a solver library and a collection of Grasshopper components.

VI. EXPERIMENTAL APPROACH

6.1 We approach a considerable number of students to find out about their knowledge about parametric design and how they have used it. A total of 40 students were taken into consideration.

Question 1 – Current year of study?

Table no. 3

2 nd year	3 rd year	4 th year	5 th year
10 students	5 students	20 students	45 students

Question 2 - Do you know what is Parametric Architecture?

Table no. 4

Yes	No
50 % students	50 % students

Question 3 - Have you used the software mentioned below?

Table no. 5

Rhino + grasshopper	Blender	AutoCAD	Sketchup	Revit
35 %	17.5 %	95 %	92.5 %	35 %

Question 4 - Which software do you use for 3D Modelling?

Table no. 6

Revit	Sketchup	Rhino + Grasshopper	AutoCAD 3D, Maya
20 %	97.5 %	12.5 %	2.5 %

Question 5 - Can you easily do changes in the current software you are using for 3D?

Table no. 7

Yes	No
67.5 % students	32.5 % students

Question 6 - Have you ever used any software for site analysis?

Table no. 8

Yes	No
80 % students	20 students

Question 7 - Have you ever done the structural analysis of your project?

Table no. 9

Yes	No
82.5 % students	17.5 % students

Question 8 - Have you ever tested your project with respect to the site after the project completion?

Table no. 10

Yes	No
80 % students	20 students

Question 9 - How do you do your project data analysis?

Table no. 11

Manually	Computerised
77.5 % students	22.5 % Students

6.2 From these 40 students afterwards 1 student was selected to represent students using parametric way. This student was asked specific questions -

Question - How did you come to know about Parametric architecture?

Answer - Came to know via certain firms like Zaha Hadid and Indian firms like Rat lab.

Question - Which tools in parametric architecture you know about?

Answer – mostly I used kangaroo and lady bug.

Question - After using these tools have, they benefitted from it?

Answer - Benefitted from kangaroo for quick and easy simulations. Lady bug helped in analysing the site. Using these benefitted me in using components I could not in Grasshopper

Question - Where have they used these tools and in which projects?

Answer - Used in workshops in skyscrapers and parametric pavilions in 2nd year project.

Question - talk about your experience with rhino compared to auto cad and SketchUp?

Answer - They are Advanced interface, more quickly accessible than AutoCAD and SketchUp. Once used, AutoCAD and SketchUp were comparatively easy to start without getting any in depth knowledge about them.

6.3 Selection of academical projects –
 3rd year – architectural design – business center
 SEM VII – YEAR 2021

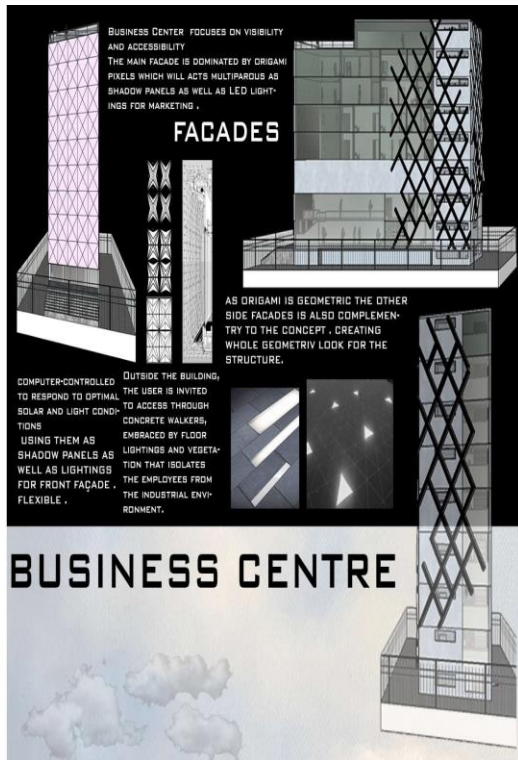


Figure no. 4

6.4 Selection of tasks –
6.4.1 Form making

which one of small unit of the solar controlled façade.

Name of plug in – kangaroo (it is a form making plug in in grasshopper)



Figure no. 5

This is origami shape which has been taken into consideration while performing it into grasshopper

Script –

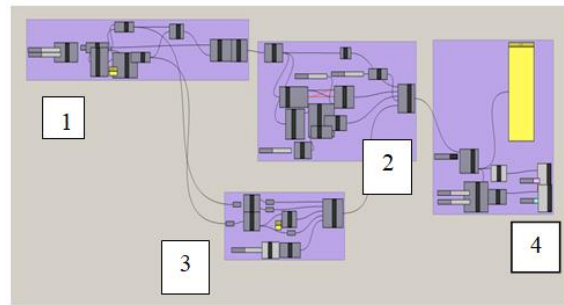


Figure no. 6

Full script of kangaroo for the form finding. Which has been written in java language. Starting with deconstructing the form into the pieces and decoding the full script into 4 parts as below down.

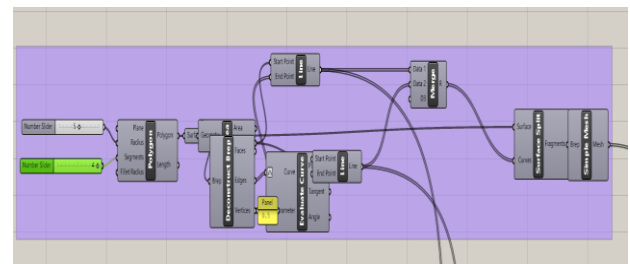


Figure no. 7

Detailed script of [1]- which is about making the basic shape i.e. the square.

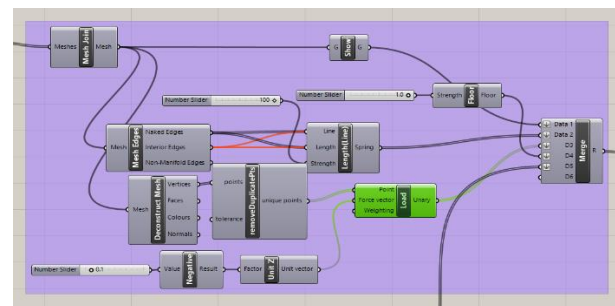


Figure no. 8

Detailed script for [2] which is for creating mesh, faces, vertices for the shape. which also includes the controller which can easily do changes in the shape and its characteristics.

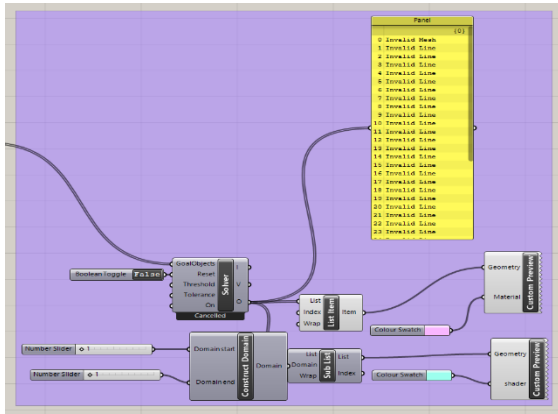


Figure no. 9

Detailed script for [3] this part of the script contains the material, construction domain.

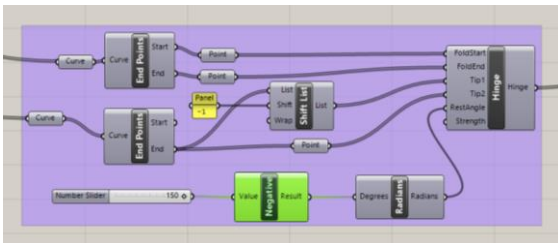


Figure no. 10

Detailed script for [4] the last part contains the controller which can show how the form is going to get perform at different values.

Output –

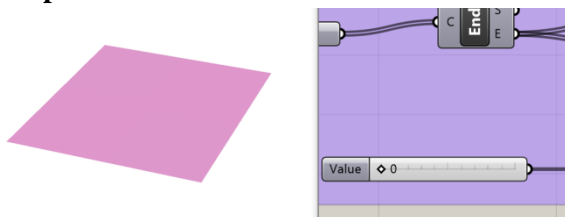


Figure no. 11

Output at value 0, which is flat form on the surface.

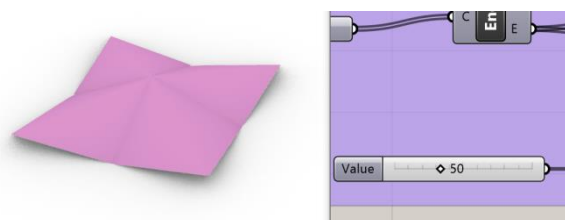


Figure no. 12

Output at value 50, shows the folding at the given value.

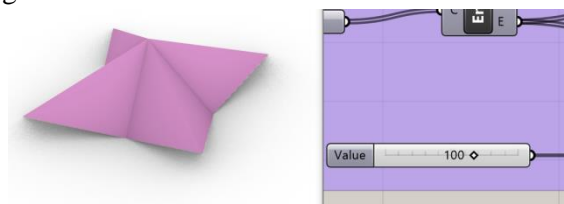


Figure no. 13

Output at value 100, shows avg folding of the object.

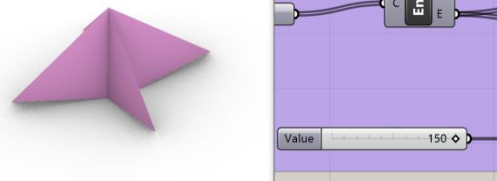


Figure no. 14

Output at value 150, shows the maximum folding of the object.

Results 1 -

Table no. 12

Accuracy	Could exactly know at what value how much folding will happen.
Flexibility	Script provided that flexibility to do changes in the form and shape.
Optimization	Accurate setting of parameters led to ideal end form as expected.

6.4.2 Solar responsive façade building.

Which is at the front side of the building which is used multiway, as sunshades and also as marketing by using LED hoardings.

Name of plug in – heliotrope (which can perform by solar controlled components)

Form - the folding origami form has been taken, which is produced in kangaroo command.

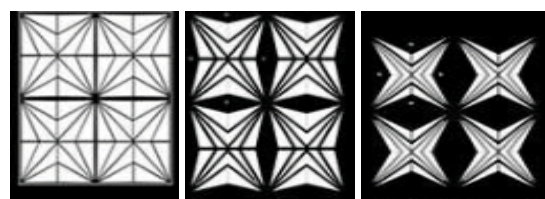


Figure no. 15

Script –

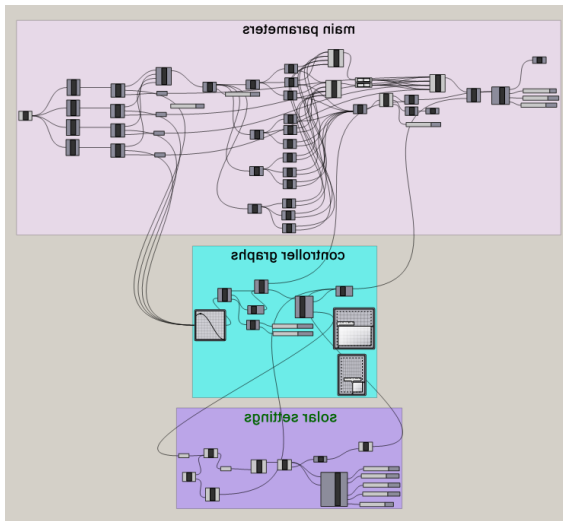


Figure no. 16

Full script of heliotrope for the solar responsive facade. Which includes main parameters, controller graphs and solar settings. By which we can easily see at what angle of the sun, the origami façade is going to react.

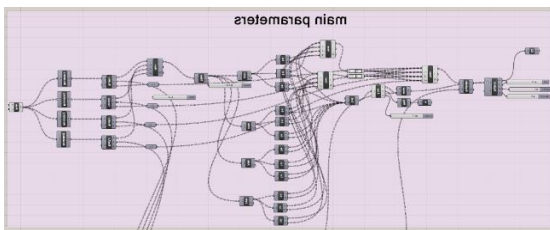


Figure no. 17

Script for setting up parameters, for the shape of the single unit from façade that is square shaped origami which is produced by the plug in Kangaroo.

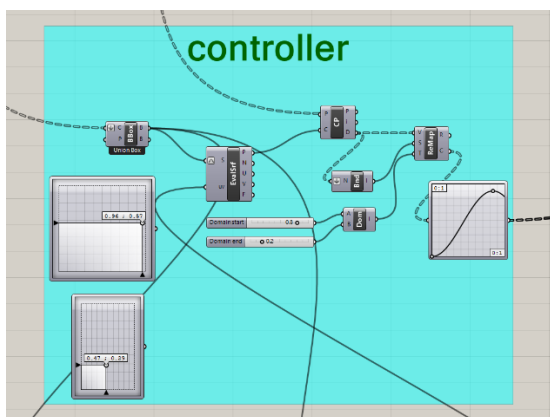


Figure no. 18

Script for controller which can show the output by controlling manually.

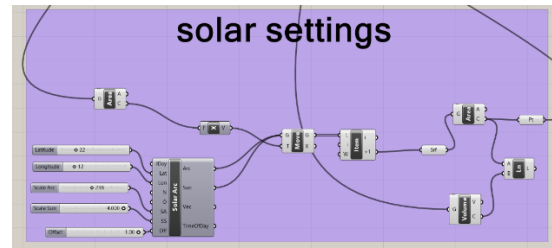


Figure no. 19

Script for solar settings for showing output as the sun changes automatically by putting the exact location (Pune) in the script.

Output –

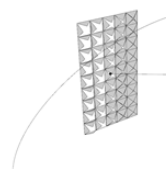


Figure no. 20

Output of the Solar responsive façade at sun with offset 10-degree

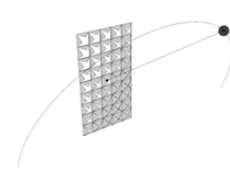


Figure no. 21

Output of the Solar responsive façade at sun with offset 60degree

Results 2 –

Table no. 13

Accuracy	By putting exact location of the site, accurate openings could be seen as results.
Flexibility	Script provided that flexibility to do changes in the form and shape. Also, could easily change the no of rows and columns with one setting without repeating any other process.
Optimization	Accurate setting of parameters led to a perfect solar responsive faced which can show accurate output with provided input.

VII. RESULTS AND DISCUSSION

Technology has the potential to completely alter the design process. Creating a fully detailed virtual model allows designers to test out different options using a single model. Working in this course demonstrated that parametric design tools can significantly reduce the time required to explore the variability in design that they generate and the associations between different aspects of the design.

Three tools were used during the experiment: kangaroo for form finding, heliotrope for climate responsive façade, and ladybug for site analysis. The relationship between the script's configurations and the created forms became clearer during the form-finding process. As a result, it gradually began to connect what was seen on the screen with the related parts of the script that needed to be refined, and thus either changed some of the script's parameters or added new components.

When using heliotrope for a solar responsive origami façade, instant connections could be made because the tool calculates solar position vectors at specific dates and times and provides a variety of components for parametrically manipulating those dates and times. It can be used to create solar-aware designs, align geometry, position rendering lights, and analyses incident sun on structures. Ladybug tools made it easier to understand how building will be performed because it was seen on the screen instantly as scripted on grasshopper. Ladybug also assisted in the evaluation of preliminary design options via solar radiation studies, view analyses, sunlight-hours modeling, and other methods.

VIII. CONCLUSION

By analysing all three results, the conclusion made is-

Table no 14

Accuracy of using tools	Accurate results obtained as given input.
Flexibility while using tools	Script provided that flexibility to do changes in the form and shape.
Optimization	Accurate setting of parameters led to ideal end form as expected.
Time	The initial time of execution is much more than any traditional software, but the afterwards changes are made with on click. this is the great flexibility software provides.

Using tools and making the most of them could help to make the design process more understandable. The use of 3D rhino with grasshopper at a higher efficiency could speed up the design process.

This flexibility is available not only during the form-finding stage, but also during the project's construction. Technological tools and techniques can provide architects and designers with new opportunities. As a result, it must be taken seriously in architectural education. I am convinced that such courses and initiatives can help bridge the gap between architecture education and practice.

The digital era changed the paper-based tradition in architecture and design, and as a result, the nature of design education has changed, with the inclusion of many computer-aided design tools in the design process. Metric design tools based on visual programming languages have recently gained popularity and are now included in many undergraduate education programmers. As a result, the use of these tools has become increasingly influential in the design process.

Students can work on their projects during the form-finding stage while adhering to certain constraints. Because they experienced the use of codes, preparing 3D models compatible with digital fabrication, material-based thinking, and effective time management, the students learned versatile thinking and how to use different tools in combination. These are all critical aspects of the technology that is widely used in modern

architecture. This rapidly developing technology provides many different options to architects, who can use it in accordance with the intended design (such as materials, machinery, and software) and combine selected different tools.

As a result, it is critical that students experience the benefits of using a variety of tools during their education before becoming practicing professional architects.

Technology has the potential to completely alter the design process. Creating a fully detailed virtual model allows designers to test out different options using a single model.

The approach presented here has the advantage of not requiring specific knowledge and skills to produce the design; instead, computer-aided design and manufacturing techniques provide flexibility and ensure feasible production.

It is encouraged that students should learn rhino + grasshopper tools at the academic level. This will be beneficial both at the B.Arch. level and in the architectural practice.

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