

# Selection of Final Year Project for Best Project Award using Analytical Hierarchy Process

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## ABSTRACT

The final year students of engineering colleges must complete a project for their course requirements. There are several streams in engineering. In each stream, there are many topics for the students to do their projects. These projects are done as a team and not individually. Each year the best project award is given in each branch to encourage the students for their effort in the project. This award is a recognition given during their lifetime for their work. These awards are also given to motivate junior students to perform better in their future projects.

There are many ways to select a project among different projects for the best project award. The drawback of these methods is that they choose a project based on one criteria only. They may be biased also. They may show favoritism to some students. Sometimes they may be based on the most expensive project. This paper is based on the project done by the Mechanical branch students. In mechanical engineering, the projects may be based on in-house fabrication or sometimes industrial oriented. Sometimes they may be experimental themed also. There are many subjects in which the projects could be carried out. The university appoints examiners to review the project. These examiners may have expertise in few fields only. In that case, there is a dilemma in selecting the project for the best project award. In these kinds of scenarios, the multi-criteria decision-making techniques come into play.

Whenever there is a dilemma, one can opt for multi-criteria decision-making techniques for clearing it. Analytical Hierarchy Process (AHP) is one such technique for which has been adopted for this scenario.

## Keywords

Multi-criteria, Analytical Hierarchy Process, Selection, Award

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## Introduction

Every engineering student has to do a project in his final semester. For undergraduate students they have to do the project as a team. Mechanical engineering students have to do a fabrication-oriented project. They have to do a presentation and submit a report as a part of their course work. They may do their project based on different topics like design engineering, thermal engineering, manufacturing engineering, or industrial engineering.

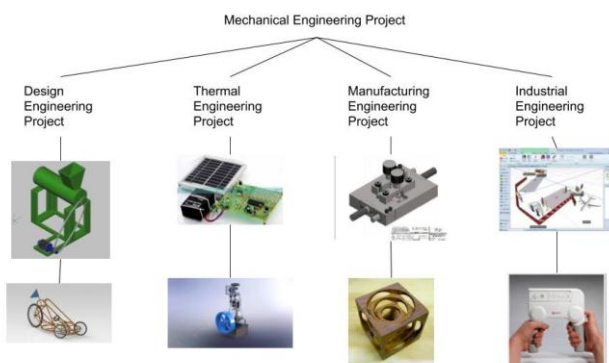


Fig 1: Mechanical Engineering Project Divisions.

Based on their fabricated project, presentation, and report, they will be evaluated. To motivate the students, the best project award is given at the end of every project. This is to motivate the students to do their best and to give healthy competition. The project can be done as a fabrication-oriented project or an experimental work or as an industrial project. For fabrication-oriented work, the students have to come up with an idea, and then they have to come up with computer-aided design (CAD) models after calculating the formulas. They have to analyze the structures and finally fabricate the model. These types of project works often get the best project award. The next type of project is the experimental one in which the students have to do the work experimentally and come up with a new finding. These types of projects usually are presented in conferences and end up with a journal publication. The last type of project work is the industrial oriented one in which the project can be a process-oriented one in which the students have to improve the process, be it quality or improving production. The next method is the design-oriented one in which the students design a product for improving a process. This involves fabrication.

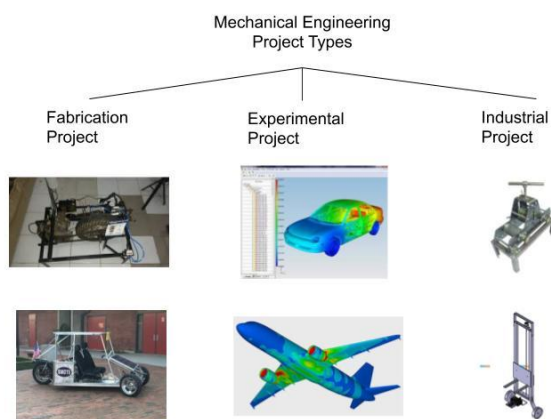


Fig 2: Project Types

The Professors in the Mechanical Engineering department thoroughly examine the projects of the students. After intensive grilling of the students, whether they have purchased the project or done by themselves, they are awarded the marks. During the semester, the project is reviewed four times. During the zeroth review, the students have to come up with the research area in which they are doing the project. During the first review, the students have to come up with the title of the project and the literature review. During the second review, they have to come up with the calculations and drawings. During the final review, they have to show the final work and report.

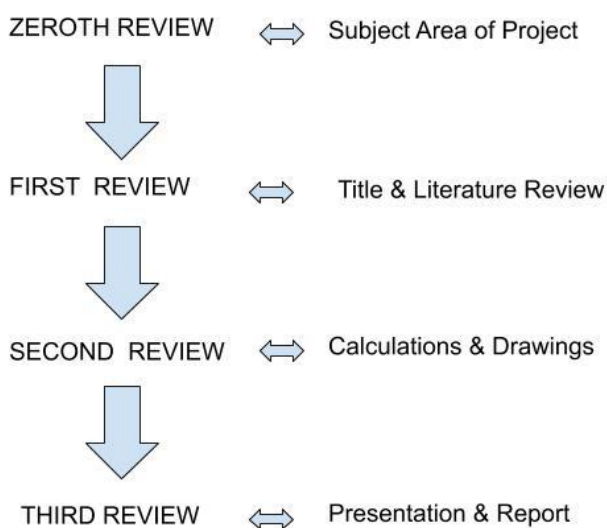


Fig 3: Reviews

Based on the above four reviews, the internal marks are awarded to each project batch. Then there is an end semester review in which the external marks are awarded. Based on the total marks awarded, the students are awarded the best project award. If they are categorized, the project can be of three types: low-quality projects, medium quality projects, and top quality projects.



Fig 4: Quality of Projects

The Professors out of the top-quality projects have to award only one project the best project award. This is a difficult decision as the professors have expertise only in one area. They find it very difficult to judge the projects in other areas. There are many criteria in which to judge the project. Sometimes one criterion alone may be considered for the best project award. Therefore, it becomes necessary that a scientific method is applied to select the project for the best project award. Hence we use multi-criteria decision-making techniques for the selection of the best project.

There are many techniques for multi-criteria decision making. Among them, the best and the most widely used technique is the Analytical Hierarchy Process (AHP) technique. In this technique, the analysis is done hierarchically. Each criterion is given a weight, and the weights are multiplied with the ranking, and finally, we get the output. Whichever project has the highest rating, that project is selected as the best project.

### Literature Review

There are no papers related to student best project awards. Only related papers. (Patil, et al., 2012) have come up with a fuzzy logic technique for the best student award. (Aydin, et al., 2012) have used a fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate firms applying for European Quality Award. (Aydm & Kahraman, 2019) have used the fuzzy Analytical Hierarchy Process (AHP) to evaluate firms applying for the European Quality Award. (Badri & Abdulla, 2004) have come up with the AHP method for the evaluation of faculty members for various awards. ( Colson, 2000) has come up with a group decision technique to assist the jury in giving awards to final year project students. (Kousalya & Reddy, 2011) have come up with a technique for selecting students for all-round excellence award. (Mu, 2016) had applied the multi-criteria decision-making technique for selecting the golden ball award winner in the FIFA World Cup 2014. (Mynit, 2019) have come up with a multi-criteria decision-making technique for the selection of students for all-round excellence award. (S & P, 2016) have come up with a multi-

criteria technique for selection of all-round excellence award. The above shows only related papers on best project selection and none on the best project award selection. (Anand Jayakumar, et al., 2020) have used the Analytical Hierarchy process for selection of candidates for the chairman post for a student chapter. (Anand Jayakumar & Krishnaraj, 2015) (Anand Jayakumar, et al., 2016) (Anand Jayakumar, et al., 2017) have used LINGO software for decision making.

**Table 1:** Authors and their techniques

Authors	Technique
(Patil, et al., 2012)	Fuzzy Logic
(Aydin, et al., 2012)	Fuzzy TOPSIS
(Aydin & Kahraman, 2019)	Fuzzy AHP
(Badri & Abdulla, 2004)	AHP
( Colson, 2000)	ARGOS
(Kousalya & Reddy, 2011)	Fuzzy AHP & TOPSIS
(Mu, 2016)	AHP
(Mynit, 2019)	AHP
(S & P, 2016)	TOPSIS
(Anand Jayakumar, et al., 2020)	AHP

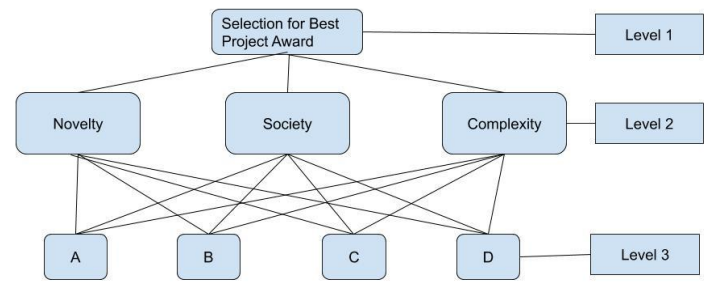
**Table 2:** Authors and their problems

Author	Problem
(Patil, et al., 2012)	Best Student Award
(Aydin, et al., 2012)	European Quality Award
(Aydin & Kahraman, 2019)	Malcom Baldrige National Quality Award
(Badri & Abdulla, 2004)	Faculty Performance
( Colson, 2000)	Best Student Project Award
(Kousalya & Reddy, 2011)	All Round Excellence Award
(Mu, 2016)	FIFA 2014 Golden Ball
(Mynit, 2019)	All Round Excellence Award
(S & P, 2016)	All Round Excellence Award
(Anand Jayakumar, et al., 2020)	Student Selection

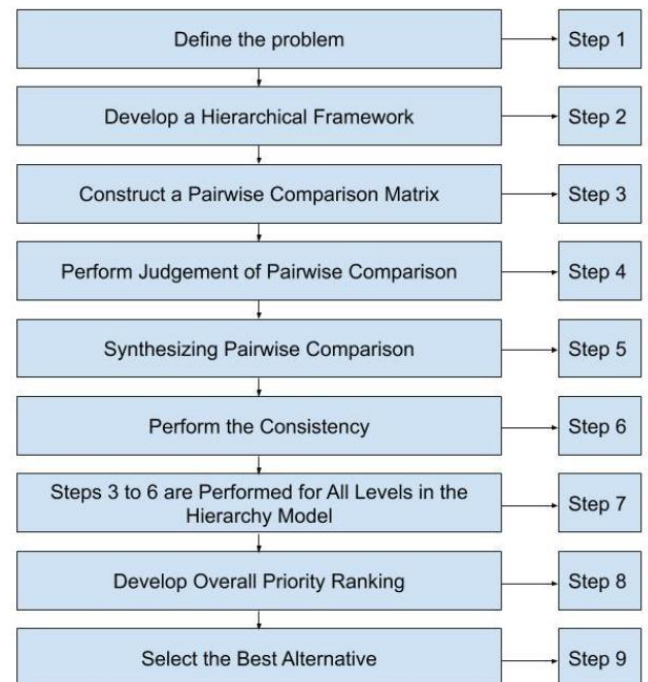
### Methodology

This case study was conducted at Sri Ramakrishna Institute of Technology, Coimbatore. Four projects were considered for the best project ward analysis. The criteria considered for the best project award are as follows:

1. Novelty
2. Society
3. Complexity



**Fig 5:** Criteria for award



**Fig 6:** AHP Steps

The AHP method was decided because it is the best method and the easiest method of all. The faculty member and Head of the department in charge of selecting the best project were consulted. Two Questionnaires were circulated among them. The data regarding the comparison of criteria and alternatives were given. The AHP methodology is shown in figure 6. The criteria followed for the award is shown in figure 5. Table 3 shows the scale for pairwise comparisons. Table 4 is the Questionnaire for constructing the framework. Table 5 is the Questionnaire for the analysis of criteria. The data was collected. The top four projects were compared along the following lines:

1. Novelty
2. Society
3. Complexity

The four projects are as follows

- A – "Design and fabrication of all terrain fire prevention bot."
- B – "Modernization of automotive air conditioning system using Arduino."
- C – "Design and fabrication of double pass solar heater."
- D – "Glazed photovoltaic thermal system."

Each project has a three-member team.

Figure 5 shows the criteria for the award. Each criteria novelty, society, and complexity, are compared among themselves for the ranking and weightage. Novelty criteria is compared among the four projects A, B, C, and D. Society criteria is compared among the four projects A, B, C, and D. Complexity criteria is compared among the four projects A, B, C, and D. The four projects A, B, C, and D are ranked by comparing them among each other.

Figure 6 shows the AHP steps. The initial step is to define the problem ie, the selection of the best project for the award. The second step is to develop the hierarchical framework. This is shown in figure 5. Next, we have to develop a pairwise comparison matrix. Here the pairwise comparison matrix four in number. The first one is the comparison of novelty, society, and complexity criteria. The second matrix is the comparison of the projects for novelty criteria. The third matrix is the comparison of the projects for the social criteria. The fourth matrix is the comparison of the projects for the complexity criteria. The next step is to perform judgment of the pairwise comparison. The first judgment set is among the novelty, society, and complexity criteria. The second judgment set is among the projects for the novelty criteria. The third judgment set is among the projects for the social criteria. The fourth judgment set is among the projects for the complexity criteria. The next step is to synthesize the judgments for the four matrices. The next step is to perform a consistency check. The consistency check is done so that there is no mistake while making the pairwise comparisons. The consistency check is done for all the four matrices. The last step is to develop the overall priority ranking and selection of the best alternative.

Table 3 shows the scale for the pairwise comparisons. This is important when we compare the elements. We want to know which is of equal importance and which is extreme importance. The inverse value means they are of least importance. For example, 1 means equal importance. Five means of vital importance. 9 means extreme importance. 2,4,6 and 8 means intermediate values. The inverse value 1/5 means the strong least importance. 1/9 means extreme least importance.

**Table 3:** Scale for pairwise comparisons

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two elements contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one element over another
5	Strong Importance	Experience and judgment strongly favor one element over another
7	Very Strong Importance	One element is favored strongly over another, and its dominance is demonstrated in practice
9	Extreme Importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express		

intermediate values.

Table 4 shows the excerpts from the Questionnaire for constructing the framework. The Questionnaire contains questions like what are the projects competing for the best project award. What are the criteria involved in comparing the projects?

**Table 4:** Excerpts from the Questionnaire for constructing a framework

Questionnaire	
Kindly respond to the following questions	
1	What are the projects contesting for the best project award?
2	What are the criteria for analyzing the projects?

Table 5 shows the Questionnaire for the analysis of the criteria. How does novelty criteria compare to society criteria? How does society criteria compare to complexity criteria? How does complexity criteria compare to novelty criteria?

**Table 5:** Excerpts from the Questionnaire for analysis of criteria

Questionnaire	
Kindly respond to the following questions	
1	How critical is novelty criteria over society criteria? 1/9 1/7 1/5 1/3 1 3 5 7 9
2	How critical is society's criteria over complexity? 1/9 1/7 1/5 1/3 1 3 5 7 9
3	How vital is complexity over novelty? 1/9 1/7 1/5 1/3 1 3 5 7 9

Table 6: shows the comparison of the novelty, society, and complexity criteria. For example, while comparing novelty criteria with novelty criteria, it shows that it is of equal importance. While comparing novelty criteria with society criteria, it shows that it is 1/7 times the least important. While comparing novelty criteria with the complexity, it shows that it is 1/9 times of least importance. While comparing the social criteria with the novelty criteria shows that it is seven times more important than the novelty criteria. When comparing society criteria among itself, it shows that it is of equal importance. When comparing society criteria with the complexity, it shows that it is 1/3 times of least importance. When comparing the complexity criteria with novelty, it shows that it is nine times more important. When comparing the complexity with the social criteria, it shows that it is three times more important. When comparing the complexity criteria with itself, it shows that it is of equal importance.

**Table 6:** Pairwise comparison of criteria

	Novelty	Society	Complexity
Novelty	1	1/7	1/9
Society	7	1	1/3
Complexity	9	3	1

Table 7 shows the pairwise comparison for the alternatives. For example, in 7(a) is the pairwise comparison matrix among the novelty criteria. Here Project A is of equal importance with itself. Project A is of 1/3 times essential

when compared to project B. Project A is five times more important than project C. Project A is three times more important than project D. Project B is three times more important than project A. Project B is of equal importance when compared among itself. Project B is seven times more important than project C. Project B is five times more important than project D. Project C is 1/5 times less critical than project A. Project C is 1/7 times less critical than project B. Project C is of equal importance when compared among itself. Project D is 1/3 times less critical than project A. Project D is 1/5 times less critical than project B. Project D is three times more important than project C. Project D is of equal importance when compared to itself.

Similarly, the remaining pairwise comparison matrices under society criteria and complexity criteria.

**Table 7:** Pairwise comparison matrix for alternatives

7(a) Pairwise comparison matrix under novelty criteria				
	A	B	C	D
A	1	1/3	5	3
B	3	1	7	5
C	1/5	1/7	1	1/3
D	1/3	1/5	3	1
7 (b) Pairwise comparison matrix under society criteria				

	A	B	C	D
A	1	1/3	5	3
B	3	1	7	5
C	1/5	1/7	1	1/3
D	1/3	1/5	3	1
7(c) Pairwise comparison matrix under complexity criteria				
	A	B	C	D
A	1	5	1/3	3
B	1/5	1	1/7	1/5
C	3	7	1	5
D	1/3	5	1/5	1

Table 8 shows the commotion along the rows. For example, in Table 8 (a), when we add 1, 7, and 9, we get 17. When we add 0.1429, 1, and 3, we get 4.1429. When we add 0.1111, 0.3333, and 1, we get 1.4444. similarly, for Table 8 (b) for the novelty criteria, Table 8 (c) for society criteria, and Table 8 (d) for complexity criteria.

**Table 8:** Summation along rows

8 (a) Row sums for the main criteria				
	Novelty	Society	Complexity	
Novelty	1.0000	0.1429	0.1111	
Society	7.0000	1.0000	0.3333	
Complexity	9.0000	3.0000	1.0000	
	17.0000	4.1429	1.4444	
8(b) Row sums for novelty criteria				
	A	B	C	D
A	1.0000	0.3333	5.0000	3.0000
B	3.0000	1.0000	7.0000	5.0000
C	0.2000	0.1429	1.0000	0.3333
D	0.3333	0.2000	3.0000	1.0000
	4.5333	1.6762	16.0000	9.3333
8 (c) Row sums for society criteria				
	A	B	C	D
A	1.0000	0.3333	5.0000	3.0000
B	3.0000	1.0000	7.0000	5.0000
C	0.2000	0.1429	1.0000	0.3333
D	0.3333	0.2000	3.0000	1.0000
	4.5333	1.6762	16.0000	9.3333
8 (d) Row sums for complexity criteria				
	A	B	C	D
A	1.0000	5.0000	0.3333	3.0000
B	0.2000	1.0000	0.1429	0.3333

C	3.0000	7.0000	1.0000	5.0000
D	0.3333	3.0000	0.2000	1.0000
	4.5333	16.0000	1.6762	9.3333

Table 9 shows the normalization of the matrices. When we divide each element in the first column by 17, we get 0.0588, 0.4118, and 0.5294. When we add all of them, we get unity. When we divide each element in the second

column by 4.1429, we get 0.0345, 0.2414, and 0.7241. When we add all of them, we get unity. When we divide each element in the third column by 1.4444, we get 0.0769, 0.2308, and 0.6923. When we add all of them, we get unity. In Table 9 (a), 9(b), and 9(c) similar procedure is repeated.

**Table 9:** Normalization of matrices

	Novelty	Society	Complexity	
Novelty	0.0588	0.0345	0.0769	
Society	0.4118	0.2414	0.2308	
Complexity	0.5294	0.7241	0.6923	
	1.0000	1.0000	1.0000	
9 (a) Pairwise comparison matrix under novelty criteria				
	A	B	C	D
A	0.2206	0.1989	0.3125	0.3214
B	0.6618	0.5966	0.4375	0.5357
C	0.0441	0.0852	0.0625	0.0357
D	0.0735	0.1193	0.1875	0.1071
	1.0000	1.0000	1.0000	1.0000
9 (b) Pairwise comparison matrix under society criteria				
	A	B	C	D
A	0.2206	0.1989	0.3125	0.3214
B	0.6618	0.5966	0.4375	0.5357
C	0.0441	0.0852	0.0625	0.0357
D	0.0735	0.1193	0.1875	0.1071
	1.0000	1.0000	1.0000	1.0000
9(c) Pairwise comparison matrix under complexity criteria				
	A	B	C	D
A	0.2206	0.3125	0.1988	0.3214
B	0.0441	0.0625	0.0853	0.0357
C	0.6618	0.4375	0.5966	0.5357
D	0.0735	0.1875	0.1193	0.1071
	1.0000	1.0000	1.0000	1.0000

Table 10 shows the average of the rows of the matrices. For example, in Table 9, when we find the average of 0.0588, 0.0345, and 0.0769, it is found to be 0.0567, as shown in Table 10 (a) for novelty criteria. When we find the average for 0.4118, 0.2414, and 0.2308, it is found to be 0.2946 for the social criteria. When we find the average for 0.5294, 0.7241, and 0.6923, it is found to be 0.6486 for the complexity criteria. The same procedures is repeated for Tables 10 (b), 10 (c), and 10 (d). Average of the rows of the novelty criteria, society criteria, and complexity criteria are found out.

**Table 10:** Average of Rows of Matrices

10 (a) Average of rows of main criteria	
Novelty	0.0567
Society	0.2946
Complexity	0.6486

10 (b) Average of rows of novelty criteria	
A	0.2633
B	0.5579
C	0.0569
D	0.1219
10 (c) Average of rows of society criteria	
A	0.2633
B	0.5579
C	0.0569
D	0.1219
10 (d) Average of rows of complexity criteria	
A	0.2633
B	0.0569
C	0.5579

D	0.1219
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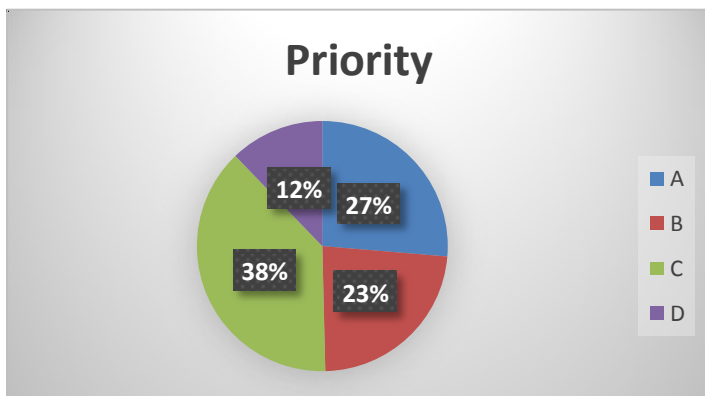
Table 11 shows the overall priority ranking. It is calculated by multiplying the weightage of the novelty criteria with the project A novelty row average and summing with weightage of the society criteria with the project A society row average and summing with the weightage of the complexity criteria with the project A complexity row average we get 0.263274 for project A. Similarly for project B, project C and project D. We find that project B has a priority ranking of 0.232896. Project C has a priority ranking of 0.381843, and Project D has a priority ranking of 0.121888. We find that that highest priority is for project C with 0.381843. This shows that project C is the winner of the award.

**Table 11: Overall Priority Ranking**

Project	Priority Ranking	Rank
A	0.263274	II
B	0.232896	III
C	0.381843	I
D	0.121888	IV

### Result and Discussion

From Table 11, we get the overall priority ranking. This is shown in figure 7. This shows that project C is the clear winner.



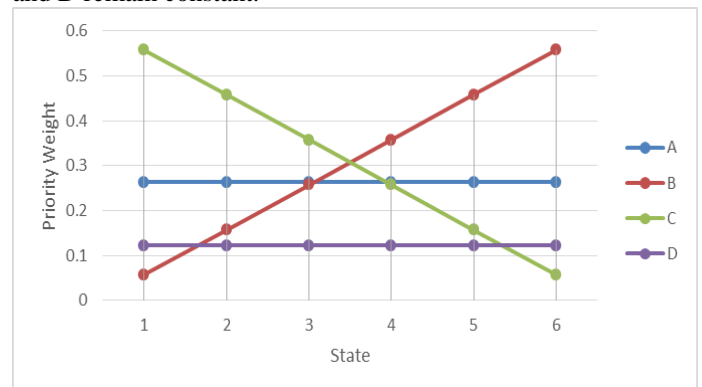
**Figure 7: Priority ranking of the projects.**

Table 12 shows the sensitivity analysis for case 1. Suppose novelty is given a weightage of 1 for state 1 and 0 for complexity and society criteria. State 1 shows the weightage of 0.80 for novelty criteria and 0.10 for complexity and society criteria. State 2 shows the weightage of 0.60 for novelty criteria and 0.20 for complexity and society criteria. State 3 shows the weightage of 0.40 for novelty criteria and 0.30 for society and complexity criteria. State 4 shows the weightage of 0.20 for novelty criteria and 0.40 for society and complexity criteria. State 5 shows a weightage of 0 for novelty criteria and 0.50 for society and complexity criteria.

**Table 12: Sensitivity Analysis Case I**

Society	0	0.10	0.20	0.30	0.40	0.50
Complexity	0	0.10	0.20	0.30	0.40	0.50
Novelty	1	0.80	0.60	0.40	0.20	0
State	0	1	2	3	4	5

Figure 8 shows that project B increases as we proceed from state 0 to state 5, and project C decreases. Both project A and D remain constant.



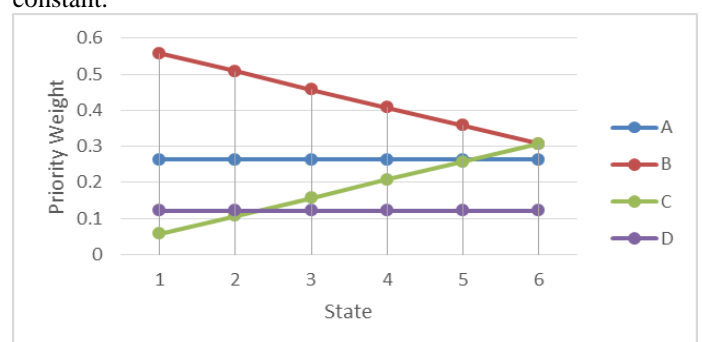
**Fig 8: Sensitivity Analysis Case 1**

Table 13 shows the sensitivity analysis for case 2. Suppose society is given a weightage of 1 for state 1 and 0 for novelty and complexity criteria. State 1 shows the weightage of 0.80 for society criteria and 0.10 for novelty and complexity criteria. State 2 shows the weightage of 0.60 for society criteria and 0.20 for novelty and complexity criteria. State 3 shows the weightage of 0.40 for society criteria and 0.30 for complexity and novelty criteria. State 4 shows the weightage of 0.20 for society criteria and 0.40 for complexity and novelty criteria. State 5 shows a weightage of 0 for society criteria and 0.50 for complexity and novelty criteria.

**Table 13: Sensitivity Analysis Case 2**

Complexity	0	0.10	0.20	0.30	0.40	0.50
Novelty	0	0.10	0.20	0.30	0.40	0.50
Society	1	0.80	0.60	0.40	0.20	0
State	0	1	2	3	4	5

Figure 9 shows that project B decreases and project C increases as we proceed from state 0 to state 5. Both project A and project D remain constant.



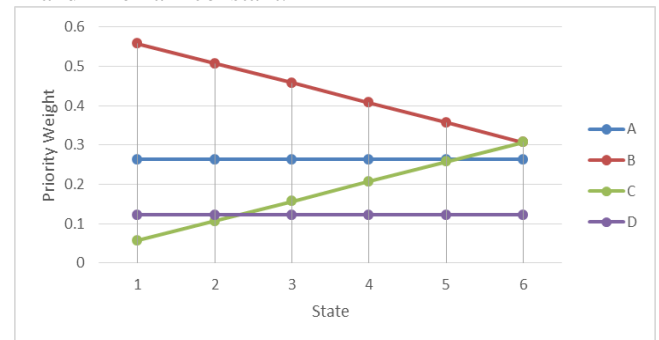
**Fig 9: Sensitivity Analysis Case 2**

Table 14 shows the sensitivity analysis for case 2. Suppose complexity is given a weightage of 1 for state 1 and 0 for novelty and society criteria. State 1 shows the weightage of 0.80 for complexity criteria and 0.10 for novelty and society criteria. State 2 shows the weightage of 0.60 for complexity criteria and 0.20 for novelty and society criteria. State 3 shows the weightage of 0.40 for complexity criteria and 0.30 for society and novelty criteria. State 4 shows the weightage of 0.20 for complexity criteria and 0.40 for society and novelty criteria. State 5 shows a weightage of 0 for complexity criteria and 0.50 for society and novelty criteria.

**Table 14: Sensitivity Analysis Case 3**

Novelty	0	0.10	0.20	0.30	0.40	0.50
Society	0	0.10	0.20	0.30	0.40	0.50
Complexity	1	0.80	0.60	0.40	0.20	0
State	0	1	2	3	4	5

Figure 10 shows that project B decreases and project C increases as we proceed from state 0 to state 5. Both project A and D remain constant.



**Fig 10: Sensitivity Analysis Case 3**

Table 15 shows the consistency check for each of the four matrices. The random index versus the size of the matrix is given in Table 16. The formula for consistency index checking and consistency ratio is given below in the calculations.

**Table 15: Ax**

15 (a) Row sums for the main criteria							
	Novelty	Society	Complexity		x	Ax	
Novelty	1.0000	0.1429	0.1111		0.0556	0.1682	3.0257
Society	7.0000	1.0000	0.3333		0.2424	0.8656	3.5710
Complexity	9.0000	3.0000	1.0000		0.702	1.9296	2.7487
<i>λmax</i>							3.1151
15(b) Row sums for novelty criteria							
	A	B	C	D	x	Ax	
A	1	0.3333	5	3	0.2633	1.0994	4.1756
B	3	1	7	5	0.5579	2.3556	4.2223
C	0.2	0.1429	1	0.3333	0.0569	0.2299	4.0407
D	0.3333	0.2	3	1	0.1219	0.4919	4.0356
<i>λmax</i>							4.1185
15(c) Row sums for society criteria							
	A	B	C	D	x	Ax	
A	1	0.3333	5	3	0.2633	1.0994	4.1756
B	3	1	7	5	0.5579	2.3556	4.2223
C	0.2	0.1429	1	0.3333	0.0569	0.2299	4.0407
D	0.3333	0.2	3	1	0.1219	0.4919	4.0356
<i>λmax</i>							4.1185
15 (d) Row sums for complexity criteria							
	A	B	C	D	x	Ax	
A	1	5	0.3333	3	0.2633	1.0994	4.1756
B	0.2	1	0.1429	0.3333	0.0569	0.2299	4.0407
C	3	7	1	5	0.5579	2.3556	4.2223

D	0.3333	3	0.2	1	0.1219	0.4919	4.0356
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**Table 16** Saaty’s table for random index versus size of matrix

Size of matrix n	1	2	3	4	5	6	7	8	9	10
Random Index	0.00	0.00	0.53	0.88	1.12	1.25	1.34	1.40	1.45	1.48

The consistency index calculations is given below.

Consistency Index (CI) is given by the formula

$$CI = (\lambda_{max} - n)/(n-1)$$

$$CI = (3.1151 - 3)/(3-1) = 0.057561$$

$$CI = (4.1185 - 4)/(4-1) = 0.039512$$

Consistency Ratio (CR) is given by the formula

$$CR = CI/RI$$

$$CR = 0.057561/0.52 = 0.110695$$

$$CR = 0.039512/0.88 = 0.0449$$

n is the size of the matrix.

### Conclusion

The calculations are carried out, and the best project was found out for the award. Project C, which is "Design and fabrication of double pass solar heater," was found out to be the best project. It is proposed out to analyze using other multi-criteria techniques for the award of the best project. The selection of the best project is a tricky business. All the students have to be satisfied. This multi-criteria technique shows that there is no bias when selecting the best project. Other multi-criteria techniques have to be tested to ensure that the results are consistent. Overall it is found out that the students are satisfied.

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