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Teaching Decision Making Method in Engineering Exploration Course – An Experience

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Abstract: This paper presents the experience of teaching decision making method in Engineering Exploration course. This course is offered to the freshman engineering students of all engineering disciplines. The motivation of including this topic in the curriculum of the course Engineering Exploration is to make the students have hands – on experience in using the decision making method as and when required. In order to obtain a best solution for a given problem knowing and applying decision making process is very important. The decision making method is taught using an activity to the students. Later, an assessment is conducted on applying the learning from the previous activity on decision making. The parameters of assessment focused in this activity are selection of criteria, design features and prioritization. The outcome of the assessment activity clearly shows a good attainment of the two parameters i.e., selection of criteria and prioritization. The other parameter which is design features needs improvement.

Keywords: decision making, engineering exploration, design criteria, prioritization

1) Introduction

Engineering is a decision making process. Engineers come up with alternative solutions and then make decisions, decision with respect to the scope of the problem (broadening or narrowing the scope) and solution feasibility. They also decide as to when the teams will meet and how the decisions will be taken. The decision making ability for an engineer is a critical skill. Most of the groups working on a project spend very less time on the decision making process, even if the decision making is very crucial and important [1]. As the time spent on the decision making process is less, this indicates the students' decision making process outcome is ineffective and inefficient. It is also noticed that an individual from a team makes a decision in many cases which is seen in students at different stages of their education levels like high school or even a freshman engineering students' team [2].

A freshman level course titled 'Engineering Exploration' is a mandate for all the students in KLE Technological University, Hubballi, India. Students in this course are provided with hands – on learning experience, wherein the students undergo activities with increasing complexity one after the other and students keep on building upon their prior knowledge as the activities provide an increased depth in understanding the concepts. With repeated challenges through activities in this course students engage themselves in finding solutions to a couple of real – world problems which in turn adds confidence in them. The curriculum of this course strongly promotes active learning, collaborative learning, peer learning, self – assessment, etc, with a focus on learning by doing. This course also demands a course project submission which includes creating project timelines, gathering information, synthesizing information, applying strategies to come up with solutions for the problem statement and many others. All these stages give an opportunity to the students to make use and practice decision making.

In the second cycle of this course delivery, few changes were made in one of the module (Engineering Analysis) to improve the student approaches in decision making process. For example, the new addition in the curriculum included a section which focused on using a decision matrix and its practice which helped students evaluate alternative solutions and group discussions were encouraged in the decision making process. An attempt was made by the instructors to assess the learning of the students in decision making process. In order to check the effectiveness of this newly introduced topic in the curriculum with respect to students learning data has been collected.

2) Background

Decision matrix method (developed by Stuart Pugh in 1996) is an approach used for selection of concept alternatives. This method helps in systematically identifying the information and analyzing the relationship of these set of information. This method is helpful when there are many factors to be considered and their relative importance is to be assessed. Decision matrix method is used for the selection of alternatives by using scoring matrix. This method is used in different activities like planning, selection of goals and features of products, etc.

The first step is formation of evaluation teams. The team then chooses a list of design criteria for their product and then evaluates all the alternatives with the chosen criteria. This evaluation can be done by using different approaches like brainstorming, team discussions, etc. This process needs refinement and is will reach an acceptable state after certain iterations. The team chooses a facilitator to poll the entire team for their opinion of the relative importance of one criterion over another. These priority values are now normalized and the team arranges the normalized criteria values from largest to the smallest. Using a 0–5 scale (0 meaning that the design concept does not meet the criterion at all), the team ranked each alternative design concept according to how well they felt the concept could satisfy each of the design criteria they identified. Finally, a decision matrix was created and the design alternative with the highest score will be chosen as the best design.

A decision making process can be divided into the steps shown in Fig 1. In step 1, the main goal is to mention the issue in a concise, clear and unambiguous form with all the desired and necessary conditions. In step 2, the requirements are to be determined; requirements are the conditions that any solution to a particular problem to be acceptable must meet. In step 3, goals are to be established i.e., the objectives to be achieved. In step 4, the different feasible design alternatives for the product have to be found. Criteria pertaining to the design alternatives chosen are to be listed in step 5. After listing the criteria, a decision tool must be chosen as per step 6. In this study the teams are working using manual calculations. In step 7, the criteria are compared among themselves and priority is assigned and then each alternative is compared against all the criteria. Last step is to validate the solution and confirm that it is in line with the stated problem.

3) Methodology

The course 'Engineering Exploration' is a mandate course offered at first and second semester for undergraduate students. This course is a lab course with two sessions per week each of three hours. Engineering Exploration course aims at enhancing students learning by doing and hence the entire course is designed to have activities which are active and collaborative. Engineering Analysis is one module out of the various modules in this course and decision making method is introduced in this module. In the four years of engineering at KLE Technological University a student undergoes the experience of various assignments and projects. All these tasks at some point or the other require decision making and hence this topic was introduced in this freshman course. A team of instructors designed this module and the content was reviewed by 14 instructors who handle this course.

Participants

The samples considered for this study are taken from past two semesters of the students from the Engineering Exploration course. This course in one semester was offered to 8 divisions with 70 participants in each division and four instructors per class. The session of this course is of 3 hours and the students learn and apply their learning in the class through different activities to meet the objectives set.

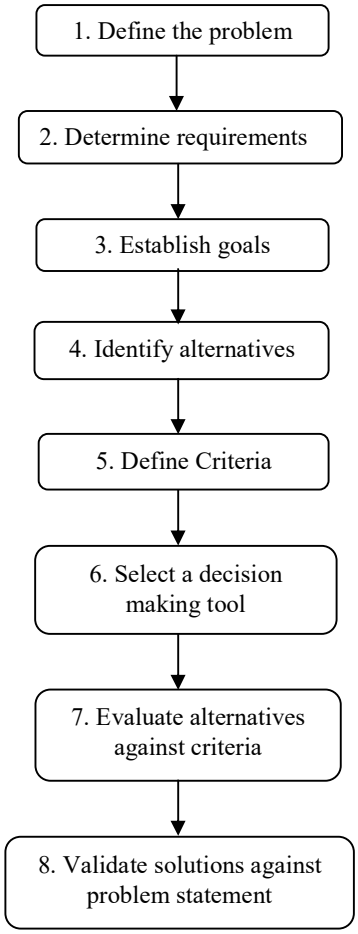


Fig 1. Steps of Decision making Process

An example was explained to all the students which included the various steps of the decision making process in detail. Post this example the students were given an assessment activity wherein the students had to apply the learning from this example taught and come up with a detailed solution to the given problem. The problem given to the students demanded them to strictly follow all the steps of the decision making process to come up with the best solution. The students were also asked to give suitable justifications at all the stages of the process.

4) Implementation and Results

Each division on an average had 17 teams which underwent this assessment activity. The example that was first taught the students is described below;

A team is comprised of four students. They are designing a scooter for children. The team followed the engineering analysis process, and now wishes to evaluate their best design alternatives. The team has three alternatives for their scooter design as shown in table 1.

Table 1: Three alternatives for scooter design

Design	Features
Play – It – Safe Scooter	This scooter has an extra set of brakes, wider tires for extra balance, and detachable scooter training wheels.
Stylish Scooter	This scooter glows in the dark and has blinking lights powered by the motion of the wheels!
Teeny-Tiny Scooter	This scooter is constructed of thin metal materials and can fold up to fit inside a small backpack.

The team came up with the following four design criteria: Safety, Ease of use, Appearance and Cost to produce. The team then compared each criterion with one another and came up with an interaction matrix as shown in table 2. The team chooses a facilitator to poll the entire team for their opinion of the relative importance of one criterion over another.

Table 2. Interaction Matrix

Criteria	Safety	Appearance	Ease of use	Cost of production
Safety	-	4	4	4
Appearance	0	-	1	2
Ease of use	0	3	-	3
Cost of production	0	2	1	-

All team members ranked safety over appearance, ease of use, and cost of production. One team member ranked appearance over ease of use. Two team members ranked appearance over cost of production. Three team members ranked ease of use over cost of production. The team then normalized the priority values and this is shown in table 3.

The team ordered the normalized criteria values from largest to smallest and wrote these values in the decision matrix as shown in table 4. Using a 0–5 scale (0 meaning that the design concept does not meet the criterion at all), the team ranked each alternative design concept according to how well they felt the concept could satisfy each of the design criteria they identified. From table 4 it can be seen that the total for design alternative – 1 is high and hence it is selected.

Table 3. Normalized Priority Values

Criteria	Safety	Appearance	Ease of use	Cost of production	Row total	Normalized Value
Safety	-	4	4	4	12	12/24 = 0.5
Appearance	0	-	1	2	03	3/24 = 0.125
Ease of use	0	3	-	3	06	6/24 = 0.25
Cost of production	0	2	1	-	03	3/24 = 0.125
Column Total					24	1.00

Table 4. Decision Matrix

Criteria	Normal Priority Value	Design Alternative – 1 Play – It – Safe Scooter		Design Alternative – 2 Stylish Scooter		Design Alternative – 3 Teeny – Tiny Scooter	
Safety	0.5	5	2.5	2	1	3	1.5
Appearance	0.25	4	1	3	0.75	5	1.25
Ease of use	0.125	2	0.25	5	0.625	4	0.5
Cost of production	0.125	2	0.25	2	0.25	5	0.625
Totals			4		2.625		3.875

After this practice activity, an assessment activity was conducted. This activity was a group activity with four members in a group. The problem statement of this activity is as below;

Portable Water Filter:

For many villages in India municipal-corporation water is rarely available, villagers often fetch the water from ponds or lakes. Villagers can make use of water from ponds or wells and then filter it to increase the quality of water for drinking purposes. Also for travellers pure water is not available everywhere to drink, hence designing a portable water filter so that the travellers can use it to filter the water during need and also to carry it wherever they go.

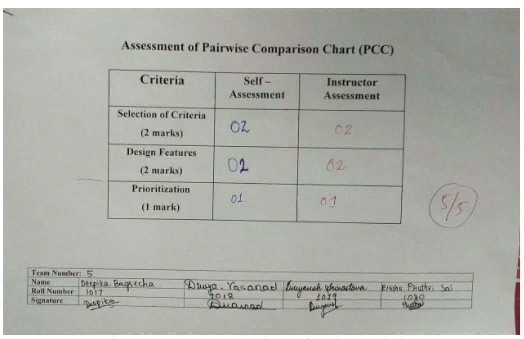
Students were asked to think of some design criteria for portable water filter and also to come up with three alternatives for portable water filter design. They were also asked to construct a decision matrix and hence prioritize the criteria. Provide the suitable justification. To complete this activity the teams were given 30 minutes.

The students were shown with the rubrics for the assessment at the beginning of the activity in order that the students will have a clear idea as to what is expected from them from this activity and they can accordingly start working. Table 5 shows the rubrics that were used for assessment of this activity.

Most of the students were successful in achieving the 'selection of criteria' and 'prioritization' parameter. Few teams were unable to come up with feasible design features. For this activity there is both self assessment and instructor assessment. The self assessment component was done by the team and across all the divisions it was seen that the students have rated their work fairly good. A sample copy of one of the team is shown in Fig 2, Fig 3 and Fig 4 below;

Table 5. Rubrics for Assessment

Criteria	Excellent (2 marks)	Mediocre (1 mark)	Poor (0 mark)
Selection of Criteria (2 marks)	The team has listed four relevant design criteria	The team has listed less than three and more than one relevant design criteria	The team has listed one design criteria
Design Features (2 marks)	The team is able to come up with three feasible design features	The team is able to come up with two feasible design features	The team is able to come up with one feasible design feature
Prioritization (1 mark)	Prioritization is done with suitable justification (1 mark)	Prioritization is incomplete or vague (0 mark)	



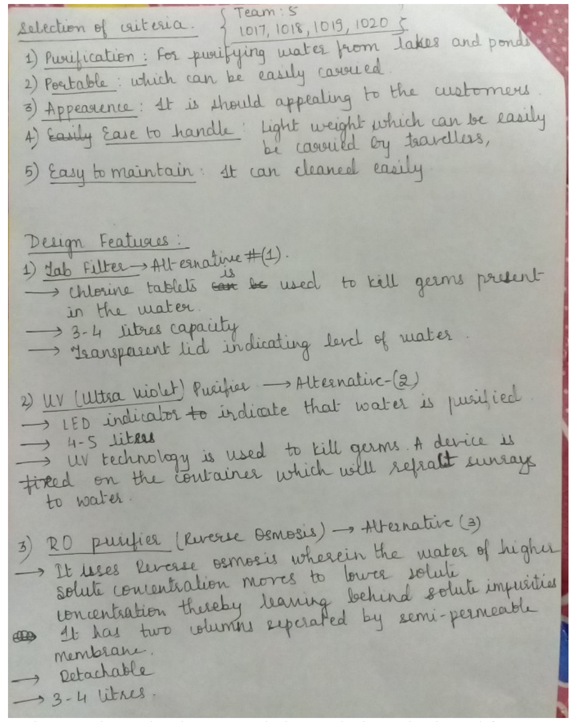
Assessment of Pairwise Comparison Chart (PCC)

Criteria	Self – Assessment	Instructor Assessment
Selection of Criteria (2 marks)	02	02
Design Features (2 marks)	02	02
Prioritization (1 mark)	01	01

5/5

Team Number: 5				
Name	Deepika. Bagrecha	Divya. Yasanad	Divyansh Srivastava	Erram Pruthvi Sai
Roll Number	1017	1018	1019	1020
Signature	Deepika	Divyasad	Divyansh	Pruthvi

Fig 2. Assessment Sheet for the activity



Selection of criteria. { Team: 5 1017, 1018, 1019, 1020 }

1) Purification: For purifying water from lakes and ponds
2) Portable: which can be easily carried
3) Appearence: It is should appealing to the customers.
4) ~~Easily~~ Ease to handle: Light weight which can be easily be carried by travellers,
5) Easy to maintain: It can cleaned easily

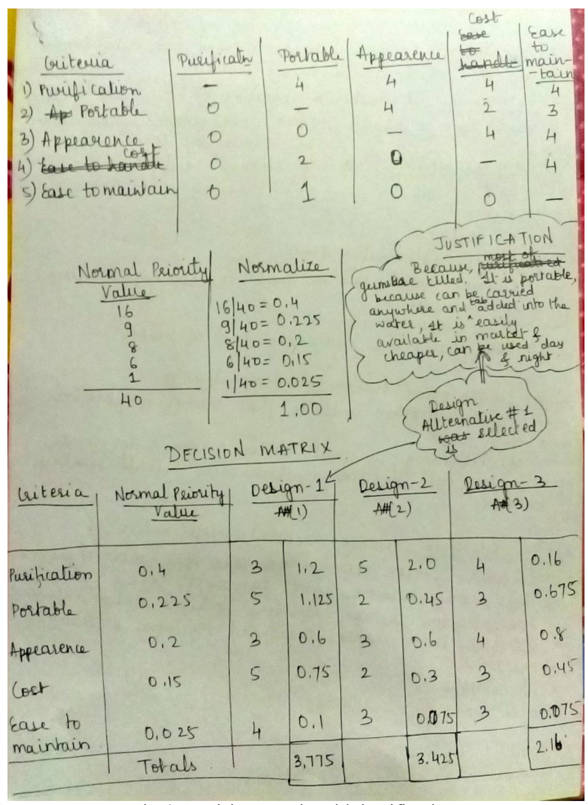
Design Features:

1) Tab Filter → Alternative #(1).
→ chlorine tablets is ~~can be~~ used to kill germs present in the water.
→ 3-4 litres capacity
→ Transparent lid indicating level of water.

2) UV (Ultra violet) Purifier → Alternative-(2)
→ LED indicator to indicate that water is purified
→ 4-5 litres
→ UV technology is used to kill germs. A device is fixed on the container which will refract sunrays to water.

3) RO purifier (Reverse Osmosis) → Alternative (3)
→ It uses Reverse osmosis wherein the water of higher solute concentration moves to lower solute concentration thereby leaving behind solute impurities. It has two columns seperated by semi-permeable membrane.
→ Detachable
→ 3-4 litres.

Fig 3. Write up by the team relating to design criteria and features



Criteria	Purification	Portable	Appearence	Cost	Ease to maintain
1) Purification	—	4	4	4	4
2) Portable	0	—	4	2	3
3) Appearence	0	0	—	4	4
4) Cost	0	2	0	—	4
5) Ease to maintain	0	1	0	0	—

Normal Priority Value	Normalize
16	16/40 = 0.4
9	9/40 = 0.225
8	8/40 = 0.2
6	6/40 = 0.15
1	1/40 = 0.025
40	1.00

JUSTIFICATION: Because, most of germs are killed. It is portable, because can be carried anywhere and tab added into the water, it is easily available in market & cheaper, can be used day & night

Design Alternative #1 is selected

DECISION MATRIX

Criteria	Normal Priority Value	Design-1 A#(1)		Design-2 A#(2)		Design-3 A#(3)	
Purification	0.4	3	1.2	5	2.0	4	0.16
Portable	0.225	5	1.125	2	0.45	3	0.675
Appearence	0.2	3	0.6	3	0.6	4	0.8
Cost	0.15	5	0.75	2	0.3	3	0.45
Ease to maintain	0.025	4	0.1	3	0.075	3	0.075
Totals			3.775		3.425		2.16

Fig 4. Decision Matrix with justification

5) Conclusions

This paper presents the experience of teaching decision making method to freshman engineering students. The

assessment activity conducted gave a good amount of data for analysis pertaining to selection of criteria, design features and prioritization. From the data collected it is found that the students have done fairly well in the two sections i.e., selection of criteria and prioritization. However, there is need for improvement for the parameter design features.

This activity initiated good amount of group discussions amongst the teams and each participant was explaining his view points to the other members of the team. In this process, there was a lot of peer learning happening in all the teams. Students started thinking and this made them come up with different design features and design criteria. They were also able to prioritize the criteria and give the suitable justification for the same. The students also make use of this decision matrix method even during the course project extensively.

Acknowledgement

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