Dissertation on

An Optimized Model Using AHP-VIKOR in the Web-Service Based E-Learning

Thesis submitted towards partial fulfilment of the requirements for the degree of

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Submitted by
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CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactory to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

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DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his **Master of Technology in IT (Courseware Engineering)** studies.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by this rule and conduct, I have fully cited and referenced all materials and results that are not original to this work.

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With regards,

Date:

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Contents

List of Figures

List of Tables

Chapter 1

Executive Summary

E-learning is experiencing a surge in **Information and Communication Technologies (ICT)**. As a result, web-based e-Learning systems are being groomed for growth, even though poor content and design difficulties prohibit this. To optimize its utilization, elements such as content and design must be considered.

Multiple-criteria decision-making (MCDM) or **multiple-criteria decision analysis (MCDA)** approaches were used to identify and prioritize elements for improving the quality of e-learning systems.

In that analysis for obtaining the best result **Analytical hierarchical process (AHP)** was used and **Fuzzy AHP** and **TOPSIS** technique was kept for future exploration. However, **fuzzy AHP** and **TOPSIS** will not share the most wanted result, there is another approach called **VIKOR** which is productive for this process but shares less advantage.

Combining **AHP** and **VIKOR**,a derived method is proposed which is **AHP-VIKOR**. This is excellent for achieving the most desired result for optimization in this case. There were significant improvements in the model due to this approach.

An extensive literature review revealed the most effective components and a survey was conducted based on those most important elements to create an ideal Web-based e-Learning system. The observed and emphasized criteria were classified into four parts. Among these four factors, the **content** was identified as the most salient factor, whereas **organization** was found to be the frivolous factor.

Structural Equation Modeling (SEM) was used to create a positive optimized Web-based E-Learning system. As a learning methodology, the **Successive Approximation Model (SAM)** should be adapted over the **ADDIE model**.

During this study, **Multiple-criteria decision-making(MCDM)** methods like **AHP,VIKOR** and **AHP-VIKOR** were studied for decision making to provide optimised solution.

Based on the certain methods the procedures were calculated using **Relative Importance of Different Attributes, Normalized Pairwise Comparison matrix, Weighted Sum value, Criteria Weights, Consistency Index, Relative Closeness to ideal solution** and other attributes as well.

Chapter 2

Introduction

2.1 Overview

Quality is a driving factor in every competitive expanding sector, thus a new model to maintain quality may be devised to increase production, deflation and revenue increment. There are three different categories of characteristics. Fundamental quality, performance quality and excitement quality[24] are three of these and sustaining them can benefit the E-Learning platform's optimum implementation.

2.2 Problem Statement

E-learning often gets affected by different issues. **Factors that are responsible for obtaining the optimization are not being considered properly.** The infrastructure lacks **inadequate** and **substandard** content causing issues in the standard of study. Course design challenges are critical issues that may or may not be suitable for learners. Imbalance in priority factors that are rudimentary showcases an inefficient **E-Learning model**. To solve most of these issues in precedence the model is to be designed. This model will use **techniques** to eradicate what is there and also the factors that may cause issues in near future. With the great enhancement, the learners will also be able to avail themselves the most from E-learning.

2.3 Objectives

The objectives of this thesis paper is **to reduce the ineffectiveness of certain methodology**. There are lots of constraints while using E-learning or while teaching in e-learning. **Learners** and **instructors** both come across multiple obstacles. There are many physical issues like *internet availability, technological awareness* and other factors as well.

By identifying and reducing its constraints improvement can be done. Still, unfortunately, many of the factors can't be dealt with due to **financial** and **other sensitive reasons** but the factors that can be manipulated to enhance the quality can be identified and get prioritized using **ranking methods** to diminish the inefficiency.

2.4 Motivation

E-learning is experiencing a surge in **Information and Communication Technologies (ICT)**[37]. Earlier in 2.3 of the thesis, the objectives are shared where it is discussed that there is a scope of improvement which motivates to improve the efficiency. The usage of **E-Learning** is so high that improvement on that can bring immense change in education and can help the future generation.

Besides, the used AHP[27] can be improved using the other approaches to improve the efficiency. Using them the identification of factors can be done and can be used accordingly to design a more powerful E-Learning model.

The potential of **Multiple-criteria decision-making (MCDM)**[41] methods, alternate modelling system like **Structural Equation Model(SEM)**[8] to create a positive optimized **Web-based E-Learning system**[3] are the driving forces behind this research paper.

2.5 Organization of Thesis

This thesis depicts the approaches that will bring the most from the E-learning platform. The issues, already proposed methods and alternative solutions are discussed. Besides that, in this thesis, the approaches are shared that enhance the quality and improve other aspects.

The structure of the thesis is as follows:

Chapter 2 presents *background information and core concepts* related to the **Multiple-criteria decision-making (MCDM) methods** and other predefined approaches for improving E-learning.

Chapter 3 depicts *different Multiple-criteria decision-making (MCDM) approaches* in detail and proposed approaches that will add more efficacy to E-learning than predefined methods. This chapter will share the idle structure model of e-learning with high coherence.

Chapter 4 describes *methodologies and calculations* with steps. The result will be provided here.

Chapter 5 delineates the *comparative analysis* associated with the research. It will showcase the comparison of efficiency between traditional and proposed algorithms.

Chapter 6 presents the *conclusion* based on research findings generated.

Upcoming chapters will focus on the topics as per shared in section 2.5. The conclusion will be drawn based on **Comparative analysis** which will be deducted from the **Experimentation and Results Section**.

Literature Survey will be about the concepts and references of previous work done so far about this topic or related algorithms.

In the **Proposed Approach section** overall ideal E-learning model will be proposed with *various Methodologies* and implementation will be done based on that using the data set that will be added using the literature survey.

In the next chapter **Literature survey** will be discussed in details.

Chapter 3

Literature Survey

In this chapter, there will be two parts. In the first part, the reviewer will be introduced to the basic terminology and concepts that will be used throughout the work and in the second half, the related works done till now will be discussed.

Preliminaries

This chapter provides all the required concepts that are required for going through this thesis. The theoretical background behind this study is provided here. To understand the concept of **Multiple-criteria decision-making (MCDM)** methods that are used to make decisions while identifying the factors related to this E-learning model.

In this chapter, the discussion starts with the essential concept of statistical concepts, model variations and decision-making methods in details.

3.1 Statistical Measures

Statistical measures are a form of descriptive analytic approach that is used to summarise the properties of a data collection. This data collection can indicate either the entire population or a subset of it. Statistical measurements are divided into two types: measures of central tendency and measures of spread.

3.1.1 Mean

The Sample mean is the average of the sample proportion. It is calculated by dividing the sum of all the outcomes of the sample by the total number of events of the sample population. It is represented by $\bar{X}$. Let there be a sample of n elements,$(X_1, X_2, X_3, ..., X_n)$ in a same population. Then mean can be defined as:

$$\bar{X} = \frac{1}{n}(X_1 + X_2 + X_3 + ... + X_n) \tag{3.1}$$

The mean is indeed significant since it incorporates values out of each observation in a data set.

3.1.2 Standard Deviation

The standard deviation is a representation of the variation of values within a population's data set. It measures how to spread out the members is from its weighted average.

A low standard deviation means the data points are towards the set's average, whereas a high standard deviation means the data sets are dispersed out over a wider range of values.

It is represented by μ.

$$E(\bar{X}) = \frac{1}{n}\left(E(X_1) + E(X_2) + E(X_3) + ... + E(X_n)\right) = \mu \tag{3.2}$$

The standard deviation of any observed value is a measure of how much it deviates from the normal.

The standard deviation is often used to quantify consistent data rather than categorical data, along with the mean. Furthermore, like the mean, the standard deviation is frequently mainly utilized when the continuous data is not significantly skewed or contains outliers.

3.1.3 Normalization

Normalization is a data-shifting and re-sampling technique in which data points are shifted and trimmed till they're inside the 0 to 1 range. It's also referred to as the min-max scaling. The formula for calculating the normalized score is :

$$X_{normalized} = \frac{(X - X_{min})}{(X_{max} - X_{min})} \tag{3.3}$$

The maximal and minimal values of the attribute are denoted by $X_max and X_{min}$, respectively.

- If $X = X_{min}$; then $X_{normalized} = 0$ since the value of $(X - X_{min})$ will become $(X_{min} - X_{min})$ which is 0.
- If $X = X_{max}$; then $X_{normalized} = 1$ since both numerator and denominator is same and nullifies each other.

In the next section 3.2 the discussion will be about Multiple-criteria decision-making method or MCDM in brief.

3.2 Multiple-criteria decision-making method (MCDM)

Multi-Criteria Decision Analysis (MCDA), also known as **Multi-Criteria Decision-Making (MCDM)**, is a *decision-making technique that involves weighing numerous factors (or outcomes) in order to rank or make a decision variants.*

The MCDA techniques[10] provide a platform for evaluating criteria and contain features like criteria that can be an attribute or geographical data, conflicting criteria, as well as the similarities and differences between each criterion, each criterion can be measured in a separate unit. It provides a flexible design with a weight calculation structure that is entirely adaptable.

MCDA seeks to *minimize decision-makers' instinct bigotries*, as well as *collective decision-making shortcomings* (e.g., 'group-think'), which practically always plague perceptual strategies. MCDA facilitates choice by establishing the weights and related trade-offs between the criteria concisely in an efficient manner.

There are several MCDAs like **AHP, TOPSIS, VIKOR** etc. These are categorized depending on use cases and procedures. In this thesis paper used algorithms are discussed in a detailed manner.

3.2.1 Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process or **AHP** [40] is *mathematics and psychology-based strategy* for organizing and understanding complicated decisions. It was created in the 1970s by **Thomas L.Saaty** and has subsequently been enhanced.

It consists of three parts: the ultimate aim or problem the reviewer attempting to address, all feasible solutions (referred to as alternatives), and the criteria the reviewer uses to evaluate the alternatives. By defining its criteria and alternative possibilities, and tying those parts to the broader purpose, **AHP** provides a coherent foundation for a needed conclusion.

Its main objective is to aid decision-making in complicated situations where a large number of factors or criteria are taken into account while prioritizing and selecting alternatives or initiatives.

AHP is used for **choice, ranking, prioritization, resource allocation, benchmarking, quality management and conflict resolution**. When there are several choice criteria involved, the choice of one alternative from a given set of alternatives AHP is fruitful. For organizing a list of options from most to least desirable AHP is suitable. Rather than picking a single option or simply ranking them, determining the relative value of members of a collection of choices AHP is convenient.

For allocating resources among a variety of options and comparing one's own organization's processes to those of other best-of-breed businesses AHP is handy. In the case of taking care of the many facets of quality and quality improvement and resolving disagreements between parties that appear to have opposing aims or perspectives, AHP is a reliable approach.

3.2.2 Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS (*Technique for Order of Preference by Similarity to Ideal Solution*)[10] is a **multi-criteria selection analysis approach** established by **Ching-Lai Hwang** and **Yoon** in 1981, with additional refinements by **Yoon** in 1987 and **Hwang, Lai** and **Liu** in 1993.

The **TOPSIS** methodology is often used to tackle decision-making difficulties. This method is based on **a comparison of all the possible solutions to the problem**. It is the concept of a compromise solution. By choosing the best alternative nearest to the positive ideal solution where *positive solution means best attributes and negative solution means worst attributes.* It depends on the **minimum Euclidean distance**, the attributes and the farthest from negative ideal solution.

In this method first Criteria and Alternatives are introduced then **Decision Matrix** is formulated based on that and **Normalized Matrix** is also calculated. Using the **Weighted Normalized Matrix** the finding of Positive and Negative Ideal Solutions are processed and using the closeness coefficient the rankings of the alternatives are done.

TOPSIS is used in **Supply chain management and Logistics, Design, Engineering and Manufacturing Systems**. Besides that, this approach is used in **Business and Marketing Management, Health, Safety and Environment Management, Human Resources Management, Energy Management, Chemical Management, Water Resources Management** etc.

This process came in use mostly in 2019 however the usage of this method is decreasing due to access to alternative better approaches to complete the same task with better optimization.

3.2.3 Vise Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

The **VIKOR**[7] or **Vise Kriterijumska Optimizacija I Kompromisno Resenje** strategy was applied to handle a *discrete decision-making issue with non-commensurable and competing criteria using a multi-attribute decision-making method*. It's also termed as **Compromise Solution and Multi-criteria Optimization.**

In 1990 the term VIKOR was first published publicly from Serbia : **VIseKriterijumska Optimizacija I Kompromisno Resenje**. The idea of this compromise solution was introduced in MCDM by **Po-Lung Yu** in 1973, and by **Milan Zeleny**.

The strategy concentrates on ranking and selecting among a group of options, as well as determining a compromise solution for a problem with competing criteria, which can aid decision-makers in arriving at a final answer. **VIKOR rates the options and chooses the compromise solution that is closest to the ideal**. It presents a multi-criteria ranking index based on a specific 'closeness' measure to the ideal answer **(distance-to-target)**

The **VIKOR** is commonly used[7] to assess and compare the long-term viability of alternative energy plans or renewable energy technologies to provide decision assistance for picking the most viable and appropriate solutions.

To identify the highest 'group utility of the majority'[12] and the smallest 'individual regret of the opponent,' VIKOR uses the ideas of 'accepted advantage' and 'acceptable stability'. VIKOR is particularly powerful[47] under such an environment where the decision-maker is unable, or does not know how to express his preference at the early stage of product development.

3.2.4 Other MCDM methodologies

There are other methodologies also however calculating the data for every methodology is beyond the scope. However, for future reference, the following processes which are not used can be explored further. Many other MCDM[42] methods are identified besides the above methods. These are:

1) Goal Programming

2) Simple Additive Weighting

3) Simple Multi-Attribute Rating Technique

4) Data Envelopment Analysis

5) Case-based Reasoning

6) Multi-Attribute Utility Theory

8) PROMETHEE

9) ELECTRE

10) Fuzzy Set Theory

11) Fuzzy TOPSIS[25]

12) Fuzzy VIKOR

13) Fuzzy AHP[25]

etc.

3.2.5 Proposed Method for e-learning: AHP-VIKOR approach or Combined AHP and VIKOR Method

The **AHP-VIKOR method** is a combination of **AHP method** and **VIKOR method** where using the analytical hierarchy process the prioritized factors are identified and segregated to reduce the sub-criteria number for maintaining the manageable quantity and then the VIKOR method is used to obtain optimized sub-criteria to get maximum quality.

The proposed methodology[40] is designed in such a way that makes the use of Multiple Criteria Decision Making techniques as efficient as possible. The advantages of the **AHP-VIKOR model**[31] is that it can extract indicator weights over other models. As the criteria weights are extracted according to Analytical Hierarchical Process then the rest of the part is handled by use of the VIKOR model so it provides the best outcomes when the priority is ranking.

So using these discussed concepts reviewer will become familiar with all the terminologies and details used in this thesis. Using these concepts in section 3.3.2 the related works based on MCDA and E-learning will be explored.

3.3 Instructional design methodology

The process of designing and developing instructions is explained using instructional design models. There are a variety of models that can be applied in various circumstances. Some of these are:

1. **ADDIE Model**
2. **Bloom's Taxonomy**
3. **Dick and Carey Model**
4. **Merrill's Principles of Instruction**
5. **Gagne's Nine Events of Instructions**
6. **Action Mapping by Cathy Moore**
7. **Kemp Design Model**
8. **SAM Model etc.**

Depending on usage these model can have their maximum efficiency however **ADDIE model** and **SAM** is the most preferable for educational purpose. Discussion in detail and their comparison with other models is beyond the scope. In this study only ADDIE & SAM[4] is chosen for comparison for this educational purpose as they are the most suitable for this job.

3.3.1 ADDIE Model

Perhaps the most well-known way for producing learning solutions is the ADDIE instructional design methodology. **ADDIE** stands for **Analyze, Design, Development, Implementation, and Evaluation**. However, **ADDIE** isn't the only option these days. A common alternative[1] to **ADDIE** is **SAM**, which stands for **Successive Approximation Model**. **ADDIE** is a **five-stage approach** that guides the creation of successful training materials. **Analyze, Design, Develop, Implement, and Evaluate** are the acronyms for **ADDIE** model.

Analyze: *In this stage, the situation is assessed in order to identify the learning* *material's aims and objectives, as well as the learners' requirements, needs, competencies, and expertise.*

Design: *Establish the instructional objectives, such as the information individuals want their students to acquire and the learning outcomes you want them to achieve.*

Build: *Analyze how individuals can facilitate learning in achieving the goals users set out earlier, and develop teaching tactics correspondingly.*

Implementation: *The approaches by pushing existing educational materials through their paces with learners.*

Evaluate: *Assess and assess the effectiveness of the training materials you created and delivered. Make a list of what needs to be altered.*

3.3.2 SAM Model

The Successive Approximation Model (SAM)[19] is a *streamlined variation of the ADDIE Model* to elicit input and developing functioning models early in the process.

This paradigm was created by **Allen Interactions' Dr. Michael Allen**[2], who produces courses utilizing a **recursive approach** instead of a **linear method**. **Preparation, Iterative Design** and **Iterative Development** are the three elements of the most basic **SAM paradigm**. The crucial word here is *iterative*, which serves as the model's foundation and indicates that each stage should be repeated and examined.

The most significant distinction[1] is that **SAM** is an **agile technique** that allows many stages to be completed at the same time, whereas **ADDIE** is **linear** and frequently needs one step to be completed and approved before going on.

SAM[19] consists of three main phases. First, in the preparation phase, SAM starts with **gathering all the information** and **background knowledge relevant to the project**. This technique is coined as term **"savvy start"**'[19]. SAM permits for uninterrupted material reevaluation and inspection, as well as input from all parties. It's also intended to be the "fast and easy" process to deploy.

Development: Creating a learning course with text, storyboards, images, audio and video is a great way to get started.

Implement: Execution of the course is done in this step.

Evaluate: The step depicts the measurement of the student learning and retention, as well as project goals, to evaluate course performance.

Evaluation/Analysis: Analyzing and evaluating measurements the learning course evolves accordingly.

Repeat: The last stage continues with the previous procedures until the final attempt is complete.

So, it can be concluded that **ADDIE** applies *Step-by-step tactics*[4]. This process emphasizes for the need of explicit instructions and for this backtracking is difficult. It's significantly more difficult to determine the specific date and location of the problem's onset.

SAM, on the other hand, is a *parallel-processing system*[19, 2]. It begins with brainstorming, and once everything is laid out, the subsequent steps take place simultaneously.

Related Work

Concepts that are discussed in section 3 will be handy for the reviewer to understand the research works that are done so far.

In this section, the earlier research works will be discussed and the techniques and approaches taken will be showcased which will be also helpful while working on the current thesis paper.

The data, algorithms and other aspects that were used for similar or same algorithms with better outputs all are described in this section.

1. **Literature Survey On Decision Making Methodologies**

   The very first mentions to **several criteria** mathematical approaches to **support decisions** appeared in the year 1772 by **Franklin**[18] and in 1785 by **De**

Condorcet[46] it was improved.

Edgeworth's[46] (1881) and **Pareto's**[42] (1896) study shared a huge effect in this domain. In the twentieth century, **Ramsey(1931)**[18] suggested the very first **decision-making axioms**.

Esogbue et al.[42] applied fuzzy set methodologies to sort out the real-world problems. As per **Balmat**[42] classical set theory extension that deals with inconsistent data is **Fuzzy set theory**.

Belton and Gear (1983)[20] improved the AHP model. **Modified AHP (RAHP)** refers to a change to the original AHP [17]. **Saaty (1994)**[17] openly supported the modified AHP model , currently known as the **Ideal Mode AHP** or **BG-AHP**[25].

According to **Ido Millet**[20] and **Thomas Saaty**(2000)[20], a closed framework is recommended for working. A network for pairwise correlation was proposed using Saaty scale or direct Scale but in **1990 Holder & Dyer**[20] confirmed that the *Saaty scale is not efficient.*

Marvin Troutt et al. (2009)[40] proposed that when an alternative is contributed to or omitted from the existing option set ranking inversion may occur.

In 2006, according to **Joaquin Perez et al.**[20] **ranking asymmetry** can occur when an option is incorporated or dropped from the present data set, therefore all of the AHP's uses are potentially flawed. Both included component **AHP** and **Multiplicative Analytic Hierarchy Process (MAHP)** exhibit rank inversion, according to a 2003 research by **Antoniestam**[20] and **Pedro Duarte Silva**[33], however **MAHP**[17] does indeed have a lower likelihood of ranking inversion than introduced component AHP.

According to **Barzilai** and **Lootsma** (1994)[20], multiplicative **AHP** modifies **WPM** and causes rank inversion.

Qin et al.[42] suggested that **TOPSIS** is a methodology that is used in *multi-dimensional computing space for achieving that alternative which is closer to ideal and farther from negative ideal solution.* **Wang and Elhag**[10] in 2006, **Ho et al.** in 2010 and The negative optimal situation, according to **Sakthivel et al.**(2015), comprises the maximal cost criterion and minimised benefit requirements.

Moreno-Jime´nez, Polasek, Radcliffe & Schiederjans[12] in 2003 applied **AHP** in larger scale to obtain proper decision for identifying the weight ratios among strategic factors.

Dias & Ioannou[12] in 1996, **Lam & Zhao**[12] in 1998 proposed that as *AHP is not statistically dependent* so **absolute size** of the sample is not problem however the concern is if the available observations constitute an **accurate qualitative representation of the field** under analysis or not.

For achieving the best alternatives **Dursun (2016)'s study**[40] focuses on the the **fuzzy VIKOR approach** however fuzzy VIKOR has a drawback in that it only has *one level of criteria for alternatives* and *no integration with AHP* whereas *three levels of alternatives are allowed for AHP and VIKOR*.

Rawashdeh et al.[40] shared that **VIKOR** is now widely used to solve **MCDM problems** in a variety of sectors, including **environmental policy, data envelopment analysis** and **employee training selection**. After computation of the normalised priority weights for each factors using the concept of **Pairwise Comparison Judgment Method (PCJM)**[40] in the **integrated AHP-VIKOR methodology** optimised solution can be achieved but in case of *more than two alternatives* it is inconsistent.

In case of determining crucial factors there are other research works as well from which the salient features will be established and the methodologies will be operated on them to check the most convenient output for improving the e-learning model.

With a subtle reference to **Hwang** and **Yoon**, **Chen and Hwang (1992)**[33] suggest the **TOPSIS (technology for order priority based on resemblance to an ideal solution)** technique (1981). The primary assumption is that the adopted solution should be the equivalent to the ideal resolution while being the furthest away from the negative-perfect solution.

2. Literature Survey On Criteria Determination

Meyer & Barefield[8] proposed that as an *administrative support*, the institute should provide access to reference books and supplementary assets via web platforms. Administrators contribute towards advantageous e-learning input in a timely manner. **Administration's enough guidance and motivation** to engage online is crucial as well.

Akyüz & Samsa[8] said to consider *Course content*, the E-learning materials that to be shared should be appropriate for learning purposes. The content's supporting modules in e-learning should be straightforward to comprehend. Students can develop their **rational reflection, cognitive, and interpretative skills** through e-learning.

Oh et al., Ricart et al.& Ong & Manimekalai[8] shared in case of *Course design*, the module approach should be well suited for e-learning. It is to be used to achieve an acceptable learning outcome for the course. Adequate academic tasks and assignments should be provided by E-learning.

To incorporate the criteria and assess the environmental vulnerability of Taiwan's major basins, **Chang** (2013)[5] used the combined AHP-VIKOR technique.

When it comes to *Social Support*, all students should have an equal opportunity to participate in the Q&A and class discussion. **Taha et al.**[8] suggested the **ambiance of the classroom to be provided by the home environment**.

Through online classrooms, e-learning will foster student cooperation.

From *Technical support perspective*[8] the installation and operation of the e-learning framework need to be simple. For e-learning, minimal system requirements and sufficient technical assistance are to be given.

Both instructors and learners should get an e-learning **orientation and guideline** for sorting any **technical difficulties**. In the case of *Instructor Characteristics*, Teachers'[8] availability to accommodate the expectations of students during discussion is required. E-learning empowers instructors to teach in a more interactive manner during sessions.

Remote education should aid instructors in completing exact summative evaluations. Remote learning strengthens the instructor's content and activity portrayal.

Tarhini et al. & Darawsheh et al.[21] confirmed students who are unable to relocate, wish for degrees from renowned colleges and universities are interested in remote learning.

In case of **Learner Characteristics**, students can acquire the *course's intended learning goals* attributable to the course resources. E-learning makes it *simple* and *quick* to adapt to new technologies. E-learning provides *increased motivation* and a *different learning style.*

Mahahusudhan[9] in 2008 and **Eze et al.**[9] in 2018 confirmed that Web based learning system promotes the **relationship between instructors and students**.

They also shared that E-learning is much more user-friendly and convenient for both the instructor and the student. E-learning allows the instructor to upload the lecture so that students can listen to it again later whenever required. **Virtual education** enables participants to relate and contribute in this way.

So, as a conclusion the **Quality of an E-Learning** provides improvement in student's achievement while also making it intriguing to the session as well.

3. Literature Survey On Structural Modelling

By using a **Structural Equation Modelling (SEM) approach**[8] positive relationship among the **quality of e-learning, independent variables & moderating variables** is explored.

Muhammad et al.[27] shared twenty-two factors all total and using **AHP** shared the *optimized model* and speculated that instead of AHP other multi-criteria decision analysis techniques can be explored to get a comparison which one will share the fruitful outcome.

4. Literature Survey On Instructional Design Methodologies

Branson[29] coined the term "ADDIE" in 1975. **Dick** and **Cary** devised the **ADDIE model** at *Florida State University's Centre for Educational Technology* in 1978, and **Russell Watson** refined it in 1981. In the year 2005, **Hannum**[2] saw the model as an important complement to the development of educational and training programs.

The Army, Navy, Air Force, and Marine Corps were obligated to follow the **Inter-service Procedures for Instructional Systems Development (IP-ISD)**[26] in 1978, hence **Branson** demonstrates a visual depiction of the **IP-ISD**, which exemplifies five top-level headings: *analyse, design, develop, implement* and *control*.

Rishad Kolothumthodi in the year 2008[29] conducted a research for **B.Ed. Trainees** on the Development and Validation of E-content on Communication: *Elements, Process* and *Types*. The study's findings demonstrated that E-content may be utilized to teach communication at the B.Ed. level.

Kannan and Muthumanickan[26] (2010) performed a research on the production and verification of an E-content package for **XI grade learners** focusing on *p-block components*. Above-average students stand to profit the most from the E-content program on p-block elements for XI grade students, followed by mediocre and lower mediocre students.

Michael Molenda[29] in 2015 confirmed that **ADDIE Model** is merely a **colloquial moniker for a systematic approach to instructional development** that is almost **interchangeable** with *instructional systems development (ISD)*[26].

Reiser & Dempsey[4] in 2007 aimed to boost the retention of knowledge along with the promotion of acquisition and application of new leanings. **Clark**[19] tried to enhance the engagement of learners.

Onguko et al.[1] introduced **ADDIE Model** and **Quigley**[4] improved it in 2019. **Treser**[2] shared that ADDIE consists of *versatility* and *simplicity* as data gathering and continual revisions is its main priority.

Glenberg[39] offered a non-quantitative concept for spacing effects during the year 1979. It has many similarities to the SAM technique and has served as a source of inspiration for our modeling efforts.

Allen & Sites[19] in 2012 showed interest to build quick and meaningful design and develop learner-friendly E-learning content using SAM.

It was immediately apparent that the fundamental structure of SAM could be implemented not just to free recall but also to *other memory paradigms* such as **paired-associate recall and recognition**, as **Gillund** and **Shiffrin**[39] highlighted in 1984.

Morrison, Ross, Kalman & Kemp[19] implemented conventional e-learning materials using the **ADDIE paradigm** however in 2009 **Kruse**[19] criticised as it is very methodical and this makes ADDIE model *excessively linear, rigid, constricting, and time-consuming* to apply for implementation.

Though in 2015 and 2016 **Matusov & Allen interactions**[1] criticizes the SAM Model for being concerned with engagement than effective learning. Aside from that, due to the incorporation of comparable aspects, it has a **laborious procedure** and might lack **cohesiveness**.

Djouab and **Bari** proposed a modification to the **ISO 9126 software quality model**[27]. The expanded model, on the other hand, was not verified, nor were the usage directions provided.

The new **ISO/IEC 9126-1**[6] was part of **Web Quality Model (WQM)**[27] model which was proposed by **Vida** and **Jons**.

The **SERVQUAL methodology**[27] was designed to analyse website satisfaction and quality. The methodology was designed to assess the difference between customers' expectations and their actual user experience.

The **proposed approaches** will be reviewed in the next section, with more efficacious choices for building an efficient E-Learning model being highlighted based on the currently working choices.

Chapter 4

Proposed Approach

In the Earlier section, 3 reviewers are shared concepts, terminologies and explained relevant previously published works. Now, based on past work, what improvements may be made now utilizing the proposed algorithm will be described in this part.

In this chapter, an overview is shared based on solutions to the problems that are shared in section 2.2. Different approaches and their comparison, data set that are used in the survey for applying algorithms and other crucial factors all are scrutinized in this chapter.

4.1 Proposed Multiple-criteria decision-making (MCDM) Method Based On E-learning

Since this study is based on the e-learning and main motive is to maintain the *highest quality factor* so data set is taken based on quantity, profession and other aspects are considered. The main outcome of this research is to design a model to evaluate the quality of e-learning[27].

Despite the fact that the researchers have developed a range of E-Learning quality modelling techniques and frameworks, these e-learning assessment methods have several shortcomings. Keeping those drawbacks minimized the survey is done to utilize the approaches.

In the first phase, the calculation is done based on **AHP**[27]. Then in the second phase, **VIKOR methodology**[12] is applied and afterward the proposed algorithm **AHP-VIKOR**[31] is utilized to calculate the final criteria and sub-criteria to determine the accuracy of E-learning model.

Opricovic and **Tzeng**[10] shared in 2004 that the **TOPSIS technique** involves **vector normalizing** and for that the normalised value for a given criteria may change depending on the evaluation unit which is problematic for this study.

The **TOPSIS approach**[33] incorporates **n-dimensional Euclidean distance**, which might reflect an *equilibrium* between **overall and individualized commitment** on its own, but in an unique manner from **VIKOR**, which employs weight ν. Both approaches provide a list of rankings but VIKOR's top-ranked option is the most near to the **optimal alternative**[10]. However,**TOPSIS** gives the *highest-ranked alternative* which is the **best** in terms of the **ranking index** doesn't imply it's always the greatest option.

The **VIKOR technique** presents a compromise solution with an advantage rate in addition to ranking. As the purpose of the study is based on the importance of sub-criteria and the ranking provided which will be close to the ideal solution for obtaining maximum efficacy so the **VIKOR method** is proposed over **TOPSIS method** in this study.

As **AHP** is a *multi-criterion decision-making strategy* that assists decision-makers in *choosing between options* and **Fuzzy logic** is an approach for dealing with **ambiguous data and imprecise information** so the **Fuzzy AHP**[35] can be preferred by decision-makers whenever they need to make a **verdict under ambiguous scenarios**. However, because the **main criteria** and **sub-criteria** are explicitly indicated in this study, and the **conclusion** will not be made under **uncertain circumstances**, the **Fuzzy-AHP approach** is not required so this method to be excluded cause it will not share more efficiency than **AHP method** and for this same fuzzy logic existence in the Fuzzy-TOPSIS that is also taken off from the list of methods that will be continued for further research purpose.

The **comprehensive analysis** given by **Mardani et al.**[46] in 2015 comprises systematically classified information on **methodologies** and **applications** spanning the years **2000–2014** and includes *almost 400 publications* organised into *15 areas.* Based on numerous **criterion assessment, energy, environment** and **sustainability** were identified as the categories with the most commonly employed **diversified decision-making methodologies** and approaches. However there is a greater scope to implement the MCDM in the study for exploration which may lead to improvement of existing E-Learning model also.

As can be seen, there are several aspects on which the **E-Learning model** may be productive; however, because quality varies, it would be challenging to handle all of the features in an ideal manner if the requirements were implemented in the actual world. Although, if just the most relevant factors are picked and the model is executed, the **most streamlined model** can be established but some of the 22 **sub-criteria**[27] considered for this study might be deleted if they are not a vital aspect to continue with once a given proposal is made. In that instance, **AHP** is effective by preserving the **relative weight** or **relevance of the data set** while removing some of the criteria to retain the quality of the model that will be deployed. But in the case of **ranking**, the AHP will not share maximum effectiveness. As the **VIKOR approach** outperforms in paper than the **TOPSIS method**, it is recommended as the **ranking method**. Now, if a **hybridization**[46] can be utilized, the **AHP-VIKOR approach** is the **most excellent strategy**.

A new **literature review**[27] to be conducted and based on the **sub-criteria** all the calculation to be done. The most important quality factors to be determined depending on the survey and all are to be graded from **essential** to **non-essential** based on the survey findings. Once factors are determined **AHP-VIKOR** to be applied for ranking of the **accepted sub-criteria** for building **most optimised models**.

4.2 Generalized Improvements

Optimized **Learning Management System (LMS)**[36] is always a boon to learners to achieve their goals with ease. Some aspects of the eLearning system must be preserved to strengthen it. These strategies can assist in providing the **most expedient eLearning platform**.

The *trainer* and *learner* both should stuck to his or her own goal[3] which will led to **proper direction** and will help to isolate if their effort is productive or not. Before starting of eLearning course, the goal should be fixed by the **trainer** and the **learner** to *give* or *get* maximum from it.

Online Tools (Ex: *Asana, Wrike, Trello* etc.) can be used for **improving productivity** of **Project Management** by the E-Learning team without any data loss. These tools are handy and to be used as per requirement.

While planning strategy for deployment of E-Learning project it is mandatory to distribute the **workload**[36] in an organized manner to ensure its success. *Content creators, Training faculties, Project managers, Instruction designer, Subject matter expert* etc. should ensure its *quality, creation, implementation* and *take responsibilities of various other phases* as well.

Learning management system (LMS)[36] to be involved in this whole process to produce **effective** and **organized** eLearning system. **Content** to be planned to outline fundamentals of eLearning strategy based on the target learner, content ideas and its media type. Sorting out all the contents and keeping track of all details help to manage and implement the course easily.

A **detailed schedule**[36] helps all to achieve desired targets. This **scheduled details** will help to *create a course, prioritize task* and will help to start and end the course including the key dates of the event so that all the engaged individuals can have a track of progress. Learner's **motivation** and **reason of taking course** to be discovered by the **course designers** to organize the outline of the course and design it accordingly so that learner's adaptation gets easier. It will also give the learner **huge boost** to solve with **maximum potential** and improve its completion rate.

For a learner learning goals in a single module can be overwhelming and potentially feckless. While designing a course if each module confers a simple goal then the learner confers utmost ability to retain most of the information from the subject.

Traditional learning[14] is always *outperformed* by visual representation. **Storyboarding**[45] helps in **team collaboration**. It aids in the *visualization* of the learning design. For identifying design weakness and to sort out budget effectively **story-boarding**[22] is productive. As learner can grasp the subject easier in visual mode so story-boarding is the best way to deliver courses to learner.

The **Graphic organizer** with a collection of images and voice overs to tell a story helps a learner to learn in a shorter span along with **long term memory**. As the visual representation is appealing so it makes learners more engaging and can keep focus also. They get a boost to share perceptions with others to clarify their doubts as well. For making a topic or concept understandable to the students *story-telling* can be a way and by the help of **story explanation** can be done in a lucid manner however it should be relatable so that pupils can compare the topic with it and memorize easily anywhere anytime and *exaggeration* should not be there else classes will be stretched and will lead to **unnecessary time consumption. Students may find this more confusing and complicated rather than clearing the concept**. This will also make the students **inattentive** and led to **frustration**. Story arc[22] should circle around the **topic, characters** can be the key factors for understanding the main topic, narration and story line to complete.

It should be made easy for students by attracting with **illustration of major plots**. The **enticing course title** always attracts apprentices. If the title is given keeping the audience in consideration for example after selecting *keywords identification, precise* and *motivating title, variation of title for sorting the suitable one*, checking with different versions to identify what appeals then it will be better to attract the learners easily.

A **well-groomed course** design can make a learner discomfited while completing the course. For this reason, a hassle-free course with **congruous interactivity and basic concept** connects more than **clumsy overwhelming design**. Longer, *more difficult courses are less successful than shorter*[36], *more consumable training.* The optimized time may vary from person to person depending on their **endurance, capability, attention retention** throughout the course and other aspects as well but **lesser and to the point engaging course** with **proper design, interactivity and conclusion** is always boon for individuals.

Learner who do not have **Personal Computer** or **laptop** can be victimized for digital divide so to reach maximum learner courses optimized for *mobile device will be thoughtful*[14]. Using various **authoring tool** course creators can produce **responsive design without sacrificing visual and functional quality**. This will help the learner to continue the eLearning on mobile without any issue.

Promotion of courses with **conspicuous placard** may attract more students to involve in the course. An interesting course with easy enrolment and appealing offers attracts learners.

Gamification[14] of E-Learning course is always compelling for the learner. It is the most effective and powerful method of motivating students. **Gamification** is always entertaining for the learners[13]. The gamification mechanism, which includes *perks, badges, a leader board, a score, a fun activity* and *statistics* encourages healthy competition among learners. This configuration is **highly entertaining** and **accentuates the objectives** that have been established.

Certification[32] on the **completion of the course** motivates the student and such reward after completing courses has some benefits also and showcasing certification for future use is also beneficial. It should also be recognized that the certification that will be provided can be utilized in the future or be useful for other course availability or other features to be addressed, which will encourage students to complete the course to earn the certificate.

Blended learning[43] which uses online and in person learning can be learner-oriented in case of eLearning. Numerous **BELSs**[43] have constructed systems that incorporate a *multitude of capabilities* to promote active learning, such as **WebCT (www.webct.com)**[43] and **Cyber University of NSYSU (cu.nsysu.edu.tw)**[43]. **Multimedia** and **classroom** sessions are also used in this type of learning. So blended learning is an option to provide interactive session with main instructor without any hassle.

Learners or instructors who are **geographically dispersed** and also have **incompatible timetable** will find this online learning platforms better suit their demands (**Pituch** & **Lee**, 2006)[43].

To have a powerful impact on the learner real-life incentives like **offers, premium course unlocking, vouchers, goodies** etc. can retain more learners and these motivate the rewarded learner and others as well to get **serious** and **more engaging** with the eLearning course to achieve these kinds of **rewards**. However, customized **incentives** depending on the complexity of the courses is always effective. **Incentives** can be given based on *duration* and *performance ratio* which will also help to know him/her capability.

Best way to improve eLearning platform is to work on **feedback**[11] from learner and instructor both and **redesigning** and **rescheduling** the plan accordingly to reduce **major flaws**. To build an impeccable E-Learning course **learner, instructor, designer, manager** and **other involved individuals** should give their valuable insight so that the best outcome can be achieved. Learners completing a course and reviewing its content and other aspects using the feedback form is always crucial for an E-Learning course designer. Such review showcases how efficacious the effort of the whole implementation was and if there is any flaw in it then there is also scope to improve by working on it.

Learners are always intrigued in accepting a **notification** or **stimulated email**. If an automated push mails are designed into the **eLearning course / learning management system**[11] for learner then after completion of certain **certification**[32] or courses they can **track the progression status of course**.

Besides that, **automated mail** with **encouragement, information, motiva-**

tion messages will be very engaging for the learner to continue session and continue with more courses to hone skills.

If students miss any live session, they will be shared classes via mail also and further doubt classes to be scheduled so that no individual face issue while going through any topic. Mails regarding other new important courses can also help learners to track all important course schedules accordingly. These emails assist the provider in increasing **call to action (CTA)** by persuading more learners to do a specified activity.

Auto enrolment[34] saves time to get attached with provider. Many learners like from *same school* or *college* or *friend circle* or *same employees* or *colleagues* from organization can automatically connect through *HR* or *teacher* or *member* database via any application of social media or any other source can be included in relevant course.

Using **LMS**[36] this learner enrolment process gets easier and with **LMS** learner can be assigned other courses as well if he/she is **idle condition** after tracking a learning path. Learning path is also helpful for the users to the reach goal within lesser time.

Groups also can be effective for *healthy competition* and to *train individuals* in one go management design with portals can be very effective. Individual portals for each group can be a solution as well.

Administration, scalability[28] and **single setting management** of portals can help lot to reduce effort of manager. **Design of eLearning tool** with **eccentric design** and **eye-catching logo, creative representation with robust back end technology** always have potential to **gain more learner**.

Active mentors can motivate learners more. Their involvement holds an important role to educate them. Besides that, **manager, supervisor, employees** can share their *aspects* and *inspire* the learner to uplift their morale as well.

Chua and **Dyson**[6] established the **ISO 9126 quality model** as a tool for evaluating and improving the quality of e-learning systems. **ISO/IEC 9126**[23] is a **global standard** that aims to ensure the **optimised performance** of all **software-intensive products** solution which includes systems such as **safety-critical**, in which lives are at risk if software fails. This global standard is to be followed properly to maximize the utilization of the E-Learning model however "ISO/IEC 9126[6] is not suitable[23] for measuring the design quality of software products. This casts serious doubts as to the validity of the standard as a whole". **ISO/IEC 9126-1** to be utilized for this particular study.

Though the **Web Quality Model (WQM)**[27] was failed but its motive to be fulfilled for achieving better performance.

The **SERVQUAL methodology**[27] was designed to fill customers' expectations and their actual user experience. So this quality to be taken care of as well for designing a better model.

Rolling indistinguishable course can be humdrum but the variety of different courses with adaptive ability can bring change to it and interactivity level can be improved by hybridization of media.

Individual **accomplishment, report cards, course advancement** and **training histories** potentially improve instructional strategies for individuals and comparable developing learners can utilize the **flexible LMS**[36] to share the same course design, as well as other study materials. Improvement continuously in **LMS** regarding training and other qualities is healthy for learners and instructors to obtain the most optimized output.

"The first impression is always the last impression" and if the first impression on the learner is not effective then the learner may not be interested to take the course and losing a learner in such a manner is not appreciated. Effective sessions to grab the learner's attention give a higher **retention rate** for completing the course. Eye-catching representation to build up rapport and impression motivates to reach the **goal** and **stubby introduction** is powerful enough to leave an impression on learners.

Prerequisite knowledge check helps the learner to gauge their improvement after completing the course. By testing the earlier **memorized knowledge** of the learner, instructor can **design the course** based on it how to proceed further and **live adaptation** is always lively *to gain knowledge better than routinized teaching* however the instructor should be **trained** and **professional** at it otherwise it can create **adverse impression**[11].

Learners may be questioned about real-life experiences relevant to the material, and they may be given challenges to solve, with the instructor sharing a more effective alternative answer as a cherry on top. If the learner has previously received such **training**, the learner should be informed of what additional benefits the additional student will get, since this will drive the learner to finish the session.

Real-world implementation of the **traditional knowledge**[22][32][43] always makes a differentiation to grab the subject easily and help the learner to gain more interest in that topic also. Learner input on this topic can also be massively valuable.

Track of courses that to be improved or change of content for syllabus to be done for optimization. **LMS** with **reports** can be useful for **updating data in a shorter time frame;** otherwise, it might be **stressful** and disrupt the learner's schedule.

Documentation formats[38] like as **PDF, DOC, PPT, Excel** and **others** can be deployed in the **LMS**. **File compatibility** can also be a crucial factor. The use of a **customized filter** is usually *advantageous* of *configuring* and *achieving the intended outcome.*

Regarding progress of learner the **database should be updated** and if required **sorted statistics** can be handy. LMS using optimized interface can be used so that data can be transferred easily and can be **synchronized** easily in **well-organized manner**.

The architecture of the **LMS** should be well known to the individuals who are involved. **Administrative access level** should be **watertight** so that no data breaching is seen.

Robust architecture[11] should be mapped with *appropriated rights and privileges* among **manager, instructors, designer** and **learners** etc. Relevant access can help to do works without any confusion. Access to system can be accommodating to liberate **labour** and **time** and if everyone know there responsibility well enough then it can be *supportive to delegate tasks without any hiccups.*

Automated task with such integration to be introduced to reduce **hurdles**. Mapping of individuals to **relevant responsibility** and **distributed workload** is always fruitful to execute such eLearning course. Taking all the **conditions in account organization** should check the **performance** of the eLearning course. It is necessary to determine whether the output meets expectations and what **quick improvements** are required to attain the **objective**.

Testing after *deployment* and after several checks it can be known if the output is *optimized or not* and precaution measurement and practice of live sessions to do better at the time of lecturing can give a better solution. Media that are used and all applications are working perfectly or not after deployment to be checked thoroughly. Initially enormous **tests** to be done to get better results also. **Try and error method** can be *tedious* but *helpful* and can provide optimized solution to achieve goal.

Students can be given the identical topics but with **distinct presentations** to determine which one is **more acceptable** and produces the **finest outcomes**. **Designer** should check for *debugging* as well to fix the glitch as soon as possible.

If mobile-responsive eLearning is produced, management should be aware of optimized back-end development tools so that learners don't face issues irrespective of devices. **Windows** or **Mac** or **Linux**, OS dependencies should not bring digital divide in such courses.

To achieve optimized **LMS** organization should be active, and they should be *lively enough to provide solution within a short span* so that learner can work on the course seamlessly however for monitoring students **machine learning**[34] can be introduced so that **proctored test** gives the **learner vibes of actual exam** without any **malpractice**.

Since eLearning will be accessible all over the world and learners will be able to utilize the course at any time, a **24-hour help desk** should be available *to handle any difficulties* that arise. **Help desks** should be developed for both **students** and **instructors** so that they may contact an automated help desk at **any time** and **look up answers** to their questions in **FAQs**.

These are the proposed approaches for this study which will help in the next section for isolating and prioritizing factors to build a **properly balance E-Learning Model**.

In the next Chapter 5 **Experimentation and Result** will be shared of collected data set.

Chapter 5

Experimentation and Results

In this section process of the methodology and the results will be shared. All the tables and graphs deducted from this survey will be discussed here. In the first phase, a **literature survey** was taken using Google-form where **213 responses** were captured and each individual shared only one response so all the data are kept intact for future use. None of the data were discarded for being *incomplete, vague* and *inconsistent.*

Among them **138(64.8%)** were *Male* candidates and **75(35.2%)** were *Female* candidates. Main 4 types of candidates: **Secondary, Undergraduate, Graduate and Post Graduate** shared their view for selecting the criteria and sub criteria.

The demographic profile of the respondents are **58 students, 16 Academicians participated, 86 Corporate Employees, 16 Public sector employees, 11 Doctors, 7 Business Man, 16 Entrepreneurs** and **1 Investment Banker** were part of this survey.[16]. The study[27] was targeted toward a certain demographic.

The first category included employees from the private sector **(Corporate Employees)** and the public sector**(Public Sector Employees)**, notably those involved in the development of learning apps. The second set of responders was **educational administrators**, who had past experience with e-learning websites or are aware of the role of e-learning applications in the **delivery of education**. **Academicians** were the third group, which included course instructors and educators. Students made up the fourth category, with subgroups based on jobs like **entrepreneur, doctor, business** and **investment banking**, where learning is a *never-ending process* that necessitates distance learning via e-learning websites like **Udemy, Coursera, W3 Schools** etc.

There are **Doctor, Entrepreneur, Public Sector Employees, Corporate Employees, Academicians** and **Students** who were the respondents of this survey[16]. *Secondary students* were **20(9.4%)**, *Undergraduate* **38(17.8%)**, *Graduate* **81(38.0%)** and *Post Graduate* **74(34.7%)**.

Total **22 sub criteria** and **4 main criteria** is considered[27]. There were 5 categories the sub criteria and criteria were marked. These are *Very important, Important, Neutral, Less Important* and *Not Important*. The **mean** [3.1.1] and **standard deviation** [3.1.2] were calculated from the survey data and after these methodologies were use to do analysis. From Chapter 4 all the proposed approaches will be discussed and mathematical implementations will be done to conclude in section6 which is the best approaches to improve e-learning.

Section 5.1 the analysis of collected data will be shared. In this study, there are four **Main Criteria**: **Content, Usability, Design** & **Organization** and **22 sub-criteria** are considered in this study.They are: **Timely, Relevant, Multilingual, Variety of Presentation, Accuracy, Reliability of content, Attractiveness, Appropriateness, Color, Multimedia Elements, Text, Browser Compatibility, Index, Navigation, Consistency, Links, Logo, Domain, User Friendly, Reliability of Usability, Availability** & **Interactive Features.**

Table 5.1: Demographic profile of participants

All responses	Male	Female		
213	138	75		
All responses	Secondary	Under Graduate	Graduate	Post Graduate
213	20	38	81	74
All responses	213	Percentage		
Students	58	27.23		
Academicians	16	7.51		
Corporate Employee	86	40.38		
Public Sector Employee	18	8.45		
Entrepreneur	16	7.51		
Doctor	11	5.16		
Business	7	3.29		
Investment Banker	1	0.47		

5.1 Analysis of Collected Data

The data is shared in table format in Table 5.2 to understand the distribution of the collected data among the criteria and sub-criteria.

Table 5.2: Analysis of data collected through the survey

			Contribution Level						
Criteria	**Sub-Criteria**	**Total**	**Very Important**	**Important**	**Neutral**	**Less Important**	**Not Important**	**Mean**	**St. Deviation**
CONTENT	**Timely**	213	65	69	45	27	7	3.74	0.66190
	%		30.52	32.39	21.13	12.68	3.29		
	Relevant	213	74	70	38	21	10	3.83	0.67901
	%		34.74	32.86	17.84	9.86	4.69		
	Multilingual	213	51	71	44	27	20	3.50	0.62928
	%		23.94	33.33	20.66	12.68	9.39		
	Variety of Presentation	213	58	71	43	27	14	3.62	0.64351
	%		27.23	33.33	20.19	12.68	6.57		
	Accuracy	213	74	57	41	32	9	3.73	0.65306
	%		34.74	26.76	19.25	15.02	4.23		
	Reliability of Content	213	84	64	29	20	16	3.85	0.68783
	%		39.44	30.05	13.62	9.39	7.51		
DESIGN	**Attractive**	213	43	77	51	25	17	3.49	0.64897
	%		20.19	36.15	23.94	11.74	7.98		
	Appropriateness	213	60	69	45	25	14	3.64	0.64420
	%		28.17	32.39	21.13	11.74	6.57		
	Color	213	57	65	44	38	9	3.58	0.63592
	%		26.76	30.52	20.66	17.84	4.23		
	Multimedia Elements	213	58	69	45	28	13	3.62	0.64105
	%		27.23	32.39	21.13	13.15	6.10		
	Text	213	52	75	51	24	11	3.62	0.65814
	%		24.41	35.21	23.94	11.27	5.16		
	Browser Compatibility	213	61	58	46	35	13	3.56	0.62466
	%		28.64	27.23	21.60	16.43	6.10		
ORGANIZATION	**Index**	213	51	68	44	30	20	3.47	0.62126
	%		23.94	31.92	20.66	14.08	9.39		
	Navigation	213	60	66	46	29	12	3.62	0.63939
	%		28.17	30.99	21.60	13.62	5.63		
	Consistency	213	59	64	48	30	12	3.60	0.63528
	%		27.70	30.05	22.54	14.08	5.63		
	Links	213	60	68	45	25	15	3.62	0.64079
	%		28.17	31.92	21.13	11.74	7.04		
	Logo	213	51	64	59	30	9	3.55	0.64370
	%		23.94	30.05	27.70	14.08	4.23		
	Domain	213	58	61	51	30	13	3.57	0.62998
	%		27.23	28.64	23.94	14.08	6.10		
USABILITY	**User Friendly**	213	72	59	36	38	8	3.70	0.65204
	%		33.80	27.70	16.90	17.84	3.76		
	Reliability	213	68	63	44	28	10	3.71	0.65009
	%		31.92	29.58	20.66	13.15	4.69		
	Availability	213	56	65	46	31	15	3.54	0.62716
	%		26.29	30.52	21.60	14.55	7.04		
	Interactive Features	213	57	81	37	23	15	3.67	0.66746
	%		26.76	38.03	17.37	10.80	7.04		

5.2 Methodology

In this section, all the methodology will be applied to estimate and analysis which method is suitable for designing the most optimised e-learning model. **AHP,VIKOR** and **AHP-VIKOR** is analysed here.

These **Multiple-criteria decision-making(MCDM)**[27] methods are utilized in other fields in larger scale however for designing an improved E-learning model these methods are not explored rigorously and the method called is AHP-VIKOR which is combination of AHP and VIKOR also showcases how effective it can be.

In the table 5.2 the average mean is **3.63** and maximum mean was of sub-criteria **Reliability of Content** i.e **3.85** which is under main criteria of **Content** and minimum was of sub-criteria **Index** i.e **3.47** which is under main criteria of **Organization**. The other means are as follows:

Timely*(3.74),* ***Relevant****(3.83),* ***Multilingual****(3.50),* ***Variety of Presentation****(3.62),* ***Accuracy****(3.73),* ***Attractiveness****(3.49),* ***Appropriateness*** *(3.64), Color(3.58),* ***Multimedia Elements****(3.62),* ***Text****(3.62),* ***Browser Compatibility****(3.56),* ***Navigation****(3.62),* ***Consistency****(3.60),* ***Links****(3.62),* ***Logo*** *(3.55),* ***Domain****(3.57),* ***User Friendly****(3.70),* ***Reliability of Usability****(3.71),* ***Availability****(3.54)* & ***Interactive Features****(3.67).*

Among these 22 sub-dimensions 8 sub-dimensions are with mean greater than **3.63**. Only these sub-criteria were accepted for further calculation using the AHP method.

The accepted sub-dimensions are: *Reliability of Content(**Content**): 3.85, Relevant(**Content**): 3.83, Timely(**Content**): 3.74, Accuracy(**Content**): 3.73, Reliability of Usability(**Usability**): 3.71, User Friendly(**Usability**): 3.70, Interactive Features(**Usability**): 3.67 and Appropriateness(**Design**): 3.64.*

Reliability of Content of main criteria **Content** was given the most importance in a survey. **84(39.44%)** of respondents shared this view and the least Very important factor was **Attractive** . **43(20.19%)** respondents supported **attractiveness** as most important factor. Among the sub-criteria of **Content** the **Reliability** has the most mean of **3.85** and the lowest mean is of **Multilingual** with mean of **3.50**.

In case of main criteria **Design** the **Appropriateness** is the maximum with mean **3.64** and minimum sub-criteria is **Attractiveness** with mean of **3.49**. For **Organization** criteria most mean has sub-criteria **Link** with mean of **3.62** and minimum sub-criteria is **Index** with **3.47**. For **Usability** the majority goes to sub-criteria named **Reliability** with mean of **3.71** and mean with least value has **Availability** with value of **3.54**.

As sub-criteria with mean less than **3.63** are excluded so the criteria that are prioritized the quality will be maintained for designing the E-learning Model.

After discarding the less important sub-criteria (Fig 5.1) the remaining will be used in AHP model.

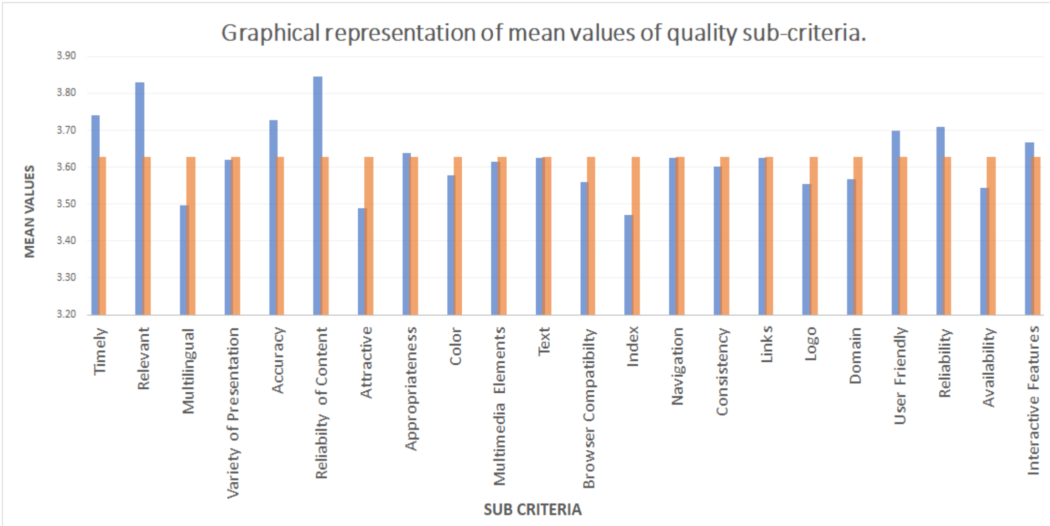

Figure 5.1: Graphical representation of Mean values of All Sub-criteria Quality Factors

Now in the next section 5.2.1 the **AHP model steps** are calculated and analyzed.

5.2.1 AHP Model Steps

AHP method provides a coherent foundation for a crucial decision by defining its criteria and alternative possibilities and tying those parts to the broader purpose so initially it is chosen for designing the E-learning Model. Steps of the **AHP model** are as follows:

STEP 1: Developing the structure with a goal at the top level, the attributes/criteria at the second level and the alternatives at the third level. The five options **More Important, Important, Neutral, Less Important** and **Not Important** are given **weightage of *5, 4, 3, 2, 1* respectively.**

STEP 2: Determination of the Relative importance of different attributes or Criteria with respect to the goal is done(A pair-wise comparison matrix is created with the help of a scale of relative importance).

STEP 3: A normalized pairwise comparison matrix is used to determine the cumulative criterion weight.

STEP 4: The criteria weight is multiplied column by column in the non-normalized matrix.

STEP 5: Ratio is taken of Weighted Sum value and Criteria Weight. Each row is calculated and the taking its average λ_{max} is obtained.

STEP 6: Using formula

$$C.I = (\lambda_{max} - n)/(n - 1) \tag{5.1}$$

Consistency index (C.I.) is generated and $C.R. = C.I./RI$. So, the consistency ratio is calculated as well.

If the value of the C.R. is lesser than the proportion to the inconsistency of C.R. **(The C.R. value for standard inconsistency is 0.10)**, it is regarded as a **moderately consistent matrix**, and the decision-making process is completed using the *AHP approach*, with a rank assigned.

Random index is the consistency index of randomly generated pairwise matrix

In the Fig. 5.2 only the accepted sub-criteria are granted for the **AHP process**. **Mean** of the sub criteria are taken in account and **locally ranked** based on the contribution level of weightage. There is **Global Ranking** as well depending on the contribution of weight. In Fig. 5.2 the mean values vs Sub criteria is plotted.

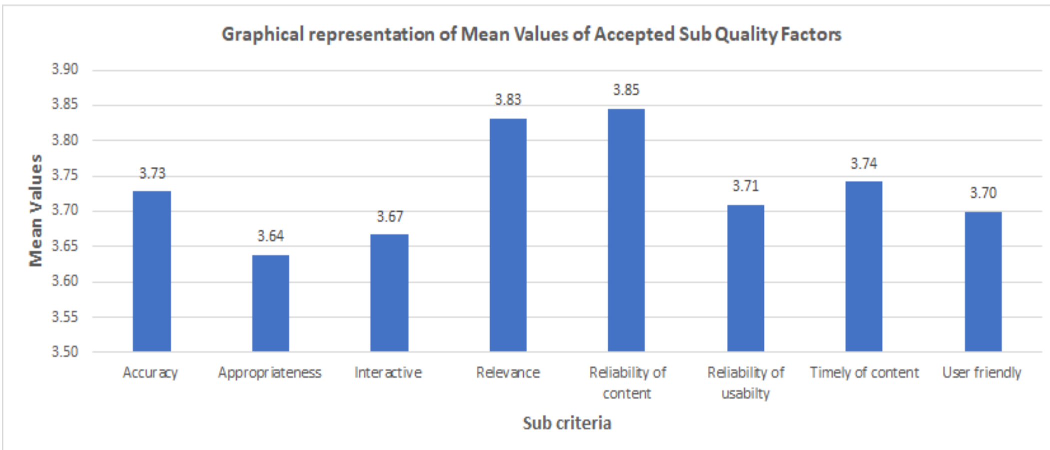

Figure 5.2: Graphical representation of Mean Values of Accepted Sub Quality Factors

In the table 5.3 Local and Global ranking is shown. The weightage is calculated depending on the priority as well.

Table 5.3: Overall weights and rankings of criteria and sub-criteria

Overall weights and rankings of criteria and sub-criteria							
Factors	Global Weight	Global Weight with Contribution %	Global Ranking of Factors	Sub-Factors	Local Weight	Local Weight with Contribution %	Local Ranking of Sub Factors
CONTENT	0.255	25.55	1	Timely	0.247	24.71	3
				Relevant	0.253	25.29	2
				Accuracy	0.246	24.61	4
				Reliability of Content	0.254	25.39	1
DESIGN	0.247	24.68	3	Appropriateness	1.000	100.00	1
USABILITY	0.252	25.17	2	User Friendly	0.334	33.40	2
				Reliability	0.335	33.49	1
				Interactive Features	0.331	33.11	3

Table 5.4: Global weights and global rank of main criteria

Global weights and global rank of Main Criteria		
Criteria	Weights (Global)	Rank (Global)
Content	0.25550	1
Usability	0.25167	2
Design	0.24677	3
Organization	0.24607	4

Table 5.5: Local weights and rank of sub-criteria of content

Local weights and rank of sub-criteria of Content		
Criteria	Weights (Local)	Rank (Local)
Reliability of Content	0.25387	1
Relevant	0.25294	2
Timely	0.24706	3
Accuracy	0.24613	4

Table 5.6: Local weights and rank of sub-criteria of usability

Local weights and rank of sub-criteria of Usability		
Criteria	Weights (Local)	Rank (Local)
Reliability	0.33489	1
User Friendly	0.33404	2
Interactive Features	0.33107	3

Table 5.7: Local weights and rank of sub-criteria of organization

Local weights and rank of sub-criteria of Organization		
Criteria	Weights (Local)	Rank(Local)
NA	0.00	NA

Table 5.8: Local weights and rank of sub-criteria of design

Local weights and rank of sub-criteria of Design		
Criteria	Weights (Local)	Weights (Local)
Appropriateness	1.00	1

In these above mention tables all the factors with less or more weightage of the sub-criteria and criteria. In **Table 5.4** the **global weights** and **global rank** of the **main criteria** are shared and with those details as well the Global rank also provided so while designing a e-learning model the most priority can be given to the most weightage carrying criteria and that is Content. With percentage of **33.89%** [The main criteria Organization has the least weightage so it is discarded and using rest of the main criteria the percentage is taken here]. As per global ranking **Content** is provided *Globally Rank 1* then the **Usability** is given as *Global Rank 2*, the **Design** is awarded as the *Global Rank 3* and with least global weightage **Organization** stands *Globally in Rank 4*.

In **Table 5.5** the sub-criteria of content are ranked locally. In case of ranking **Reliability of Content** is regarded as the most important with most weightage. The second rank is given to **Relevant of Content**. **Timely** is third and **Accuracy** is ranked locally last of criteria Content.

From **Table 5.2.1** it can be seen that **Reliability of Usability** is considered **Locally Rank 1** with highest weightage. User friendly is the second ranked under main criteria of Usability. The third one is Interactive Features.

In case of Table 5.2.1 none of the criteria was able to cross threshold of **mean 3.63** so the **organization** as main criteria shares the last criteria to take it in account as per Table 5.4. In Table 5.4 organization has the least weightage with 24.61%. Though the availability of weightage was there but none of the sub-criteria itself was able to surpass the mean so the main criteria organization itself with other sub-criteria got accepted as redundant.

The Table 5.2.1 shares the only sub-criteria that is important is **Appropriateness** of **Design**. Other **sub-criteria of Design** except **Appropriateness** are not able to excel the **mean of 3.63**. So those are also discarded.

After that **"Pairwise Comparison Matrix"**[27] also calculated and then after making the Pairwise Comparison Matrix normalizing its the **Normalized Pairwise Comparison Matrix** is created. After that **Criteria Weights** are taken using the *average of row wise normalized pairwise comparison matrix*. These Criteria weights are then multiplied with all the original Pairwise Comparison Matrix.

After that added up in a row wise to obtain **Weighted Sum Value**. Once the weighted sum value and the criteria weight is determined then the **ratio** is taken of **Weighted Sum** and **Criteria Weights**. The value of $(WeightedSum : CriteriaWeights)$ of *Accepted Sub-criteria* is added and **average** is taken for getting λ_{max}.

The λ_{max} is obtained as 7.976. Now the number of **Accepted Sub-criteria** is 8 so for getting C.I. formula is applied. As $C.I = (\lambda_{max} - n)$ so
$C.I = (7.976 - 1)/(8 - 1) = 0.003342335$.

Now the **Consistency Index** is there so need to check if $Consistencyratio <$ **0.10** And after calculation found Table 5.2.1 is **reasonably consistent**.

The **Random Index(R.I)** [27] is kept standard as per AHP and C.R is checked for consistency checking.

Table 5.9: Consistency Ratio(C.R) check using R.I and C.I for Ranking

N	Random Index (RI)	Consistency Ratio (CR)
1	0	**0**
2	0	**0**
3	0.58	**0.005763**
4	0.9	**0.003714**
5	1.12	**0.002984**
6	1.24	**0.002695**
7	1.32	**0.002532**
8	1.41	**0.002370**
9	1.45	**0.002305**
10	1.49	**0.002243**

Now using the **Global weightage** which is *normalized version* of **Local Weightage** is applied to predict the importance and calculating that the ranking is provided. In Table 5.2.1 the ranking is shared.

Table 5.10: Overall Sub-Criteria Rank Based on Global Weightage

Criteria	Global Weightage	Rank
Reliability of Content	0.1292	1
Relevant	0.1287	2
Timely	0.1257	3
Accuracy	0.1252	4
User Friendly	0.1243	5
Interactive Features	0.1232	6
Appropriateness	0.1222	7
Reliability	0.1216	8

From Table 5.2.1 it is noticeable that while creating an E-learning framework using AHP, **Content Reliability** is the *most significant sub-criterion*, whereas **Reliability under Usability** is the least *disconcerting*. With percentage of **12.92% Reliability of Content** holds globally Rank 1. **Relevant** is the 2^{nd} factor with

12.87% to draw attention while developing efficient E-learning Model. **Timely** with **12.57%** & **Accuracy** with **12.52%** is respectively **3rd** and **4th** factor to keep in mind while deploying the model. **User friendly** sub-criteria comes in 5th rank with weight contribution of **12.43%**. Interactive feature and Appropriateness are rank 6th and 7th with **12.32%** and **12.22%**. The **least significant factor** among the *accepted sub-criteria* is **Reliability of Usability** with **12.16%**.

So after following all the steps of *AHP Model* **Fig 5.3** is established as **"Quality Evaluation Model Using AHP"**.

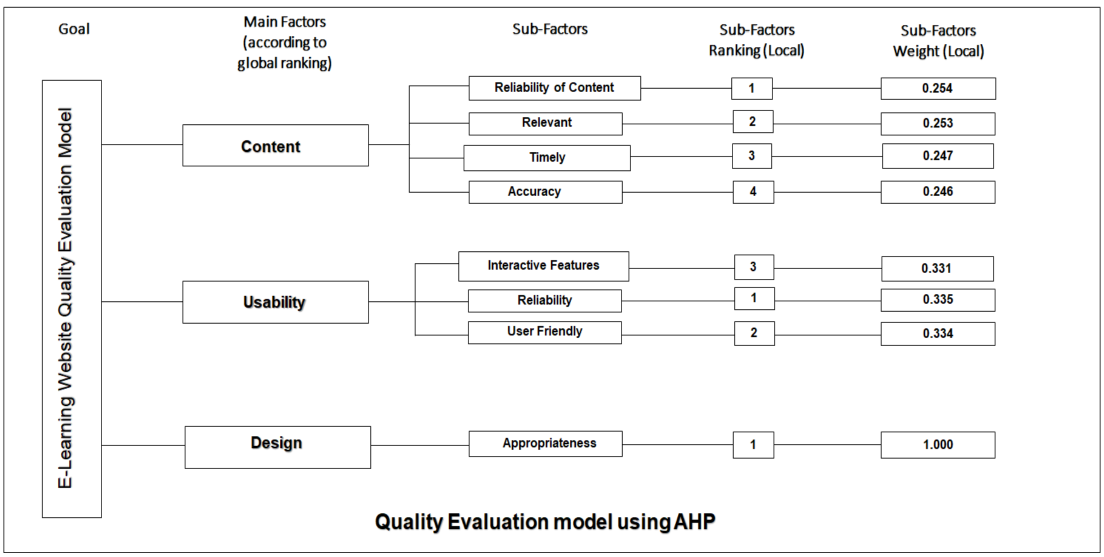

Figure 5.3: Quality Evaluation Model Using AHP

So, using the **AHP model** the decision can be taken for constructing an *efficient E-learning Model*. However the more effective method is yet to explore. It is needed to be traverse through other **Multiple-criteria decision-making(MCDM)** or **multiple-criteria decision analysis(MCDA)** to build the optimized model for this study.

The **priority order** the order of **Main Criteria** using **AHP method** is:

$CONTENT > USABILITY > DESIGN > ORGANIZATION$

While researching the methodologies that are found among them one is a **VIKOR Approach**. In the next section 5.2.2 VIKOR method analysis will be showcased to check which one is more efficient for this particular E-learning model establishment.

5.2.2 VIKOR Model Steps:

In this section the VIKOR methodology process will be explored with experimental data to rank the sub-criteria based on priority factors.

Steps of **VIKOR model** is as follows:

STEP 1: Weightage Factor is determined using scale of relative importance. After that **Best and Worst value**[7, 12] of **importance level** is calculated depending on the Sub-criteria. After that a matrix of criteria and different alternatives are determined.

STEP 2: Decision matrix is normalized to obtain **Normalized Decision Matrix**.

STEP 3: Weight of the Normalized Decision Matrix is calculated.

STEP 4: Calculate the **ideal solutions** and negative ideal solution or **Nadir Solution**[12].

STEP 5: On this phase **distance** for the each alternatives are calculated.

STEP 6: Once the distance is calculated **relative closeness to the ideal solution** is also gets calculated.

STEP 7: Depending on the **Preference order** the **Rank** is provided to the alternative to get solution.

By following these steps the solution is provided using the **VIKOR method.**

Initially the weightage factor is calculated based on the importance level. The sum of weightage goes to 15. Here the weightage factor differs from **AHP**. Here average is taken and using that factor that calculation is done.

In the Table 5.11 the weightage factor is shared accordingly.

Table 5.11: Normalized Weightage Factor

Weightage Factor	**0.333**	**0.267**	**0.200**	**0.133**	**0.067**

For **Very Important** the weightage factor is calculated as **0.333**, for **Important** it is **0.267**. For **Neutral** the factor goes to **0.200** and **Less Important, Not Important** is marked as **0.133 & 0.067** respectively.

Now the determination of Best and Worst Value is calculated. For that the F_i^+ is denoted as Best Value and F_i^- as Worst Value.

$$F_i^+ = Max(F_{ij}) \tag{5.2}$$

$$F_i^- = Min(F_{ij}) \tag{5.3}$$

Best values respectively 84, 81, 59, 38, 20 and Worst values are 43, 57, 29, 20, 7. Now Normalization of S_j and R_j to be calculated. Now S_j and R_j to be calculated. For that the formula to be used is :

$$S_j = \sum \left[\frac{w_i(f_i^+ - f_{ij})}{(f_i^+ - f_{ij})} \right] \tag{5.4}$$

$$R_j = Max \left[\frac{w_i(f_i^+ - f_{ij})}{(f_i^+ - f_{ij})} \right] \tag{5.5}$$

Now once S_j and R_j is calculated then Q_j to be calculated. Q_j is for **group utility function**. Using Q_j ranking of the alternatives will be done. So the formula is dependent on S_j, R_j, S^+, S^-, R^+, R^- and ν.

The values of S^+, S^-, R^+ and R^- are calculated using formula. S^+ is Min(S_j), S^- is Max(S_j), R^+ is Min(R_j), R^- is Max(R_j) and $\nu = 0.5(Standard)$. The formula for Q_j is as follows:

$$Q_j = \frac{\nu(S_j - S^+)}{(S^+ - S^-)} + (1 - \nu) \left(\frac{R_j - R^+}{R^- - R^+} \right) \tag{5.6}$$

Now using **equation 5.6** the **Ranking** will be done using **VIKOR Methodology**.

In Table 5.12 the data is shared of the S_j, R_j & Q_j.

Table 5.12: Sub-Criteria wise value of S_j, R_j & Q_j

Sub Criteria	Sj	Rj	Qj
Timely	0.52929	0.15447	0.19355
Relevant	0.52073	0.14000	0.10545
Multilingual	0.56089	0.26829	0.67511
Variety of Presentation	0.54141	0.21138	0.41256
Accuracy	0.56882	0.26667	0.71792
Reliability of Content	0.54274	0.20000	0.39097
Attractive	0.54279	0.33333	0.73614
Appropriateness	0.54885	0.19512	0.41460
Color	0.55370	0.21951	0.50639
Multimedia Elements	0.54802	0.21138	0.45172
Text	0.53002	0.26016	0.47124
Browser Compatibility	0.58733	0.25556	0.79885
Index	0.57200	0.26829	0.74093
Navigation	0.55615	0.19512	0.45781
Consistency	0.56576	0.20325	0.53578
Links	0.55484	0.19512	0.45005
Logo	0.57285	0.26829	0.74600
Domain	0.58209	0.22222	0.68161
User Friendly	0.55688	0.24444	0.58969
Reliability	0.55544	0.20000	0.46622
Availability	0.56958	0.22764	0.62149
Interactive Features	0.50293	0.21951	0.20563

From **Table 5.12** the S_j, R_j & Q_j can be checked. Now depending on that a sorting is made from their **minimum value** and **ranking** is obtained.

However, the **consistency** needed to be check to confirm if the alternative that is given priority is correct or not and if correct acceptance of choice needed to be confirmed.

As $Q(a_2) - Q(a_1) \geq DQ$ is required to be checked for consistency confirmation. The DQ value is calculated and that is: $\left[\frac{1}{(22-1)}\right] = 0.047619048$.

As the DQ value is found now checking if $(a_m - a_1) \geq DQ$ correct for this data set or not else other way to be included for final ranking. Now it is checked for $a_2 - a_1, a_3 - a_1, ..., a_m - a_1$ and for every case DQ value is lesser then am_1 value. From this it is confirmed that data set is consistent.

So in case of S_j, R_j & Q_j acceptance of Rank choice depends on **two cases**.

Case I: $Q(a_2) - Q(a_1) \geq DQ$

Case II: Choice of **Random Acceptance stability**, where Q_j is the best choice from **S and R** with $\nu \geq 0.5$.

The values of $(a_m - a_1)$ are as follows:

Multilingual(0.570), **Variety of Presentation**(0.307), **Accuracy**(0.612), **Reliability of Content**(0.286), **Attractive**(0.631), **Appropriateness**(0.309), **Color** (0.401), **Multimedia Elements**(0.346), **Text**(0.366), **Browser Compatibility**(0.693), **Index**(0.635), **Navigation**(0.352), **Consistency**(0.430), **Links**(0.345), **Logo**(0.641), **Domain**(0.576), **User Friendly**(0.484), **Timely**(0.088), **Reliability**(0.361), **Availability**(0.516) & **Interactive Features**(0.100)

Table 5.13: All Sub-Criteria Ranking of E-learning Model using VIKOR Method

Criteria	Sub Criteria	Rank	Qj
Content	Relevant	1	0.105
Content	Timely	2	0.194
Usability	Interactive Features	3	0.206
Content	Reliability of Content	4	0.391
Content	Variety of Presentation	5	0.413
Design	Appropriateness	6	0.415
Organization	Links	7	0.450
Design	Multimedia Elements	8	0.452
Organization	Navigation	9	0.458
Usability	Reliability	10	0.466
Design	Text	11	0.471
Design	Color	12	0.506
Organization	Consistency	13	0.536
Usability	User Friendly	14	0.590
Usability	Availability	15	0.621
Content	Multilingual	16	0.675
Organization	Domain	17	0.682
Content	Accuracy	18	0.718
Design	Attractive	19	0.736
Organization	Index	20	0.741
Organization	Logo	21	0.746
Design	Browser Compatibility	22	0.799

In this Table 5.13 **Sub-Criteria** with their **Main-Criteria** is shown. The **Rank** is provided based on Q_j value.

The Relevant of Content is Ranked **1** with Q_j value **0.105**. The lesser value of Q_j the greater priority is given to that Sub-Criteria. Timely of Content with Q_j value **0.194** comes to 2^{nd} place. **Interactive Features of Usability** is Rank 3 with Q_j value **0.206**. **Reliability of Content** with Rank 4 Q_j value is **0.391**. **Variety of Presentation(Content)**, **Appropriateness(Design)**, **Links(Organization)**

are provided 5^{th},6^{th} & 7^{th} rank respectively with Q_j value of **0.413, 0.415, 0.450**. **Multimedia Elements of Design** is 8^{th} with Q_j= 0.452, **Navigation of Organization** is 9^{th} with Q_j= 0.458. **Reliability** of Usability is regarded as Rank 10^{th} with Q_j value 0.466. **Text**(Design) with Q_j value 0.471 ranked as 11^{th}. **Color**(Design) is ranked 12^{th} with Q_j value of 0.506. **Consistency** of Organization claims rank 13^{th} with Q_j value of 0.536. User Friendly of Usability is ranked 14^{th} with value of 0.590. Availability(Usability) with Q_j value 0.621 is ranked 15^{th}. **Multilingual**(Content,0.675), **Domain**(Organization,0.682), **Accuracy**(Content,0.718), **Attractive**(Design,0.736), **Index**(Organization,0.741), **Logo**(Organization,0.746) are ranked $16^{th}, 17^{th}, 18^{th}, 19^{th}, 20^{th}, 21^{st}$ respectively and **Browser Compatibility** of Design is assigned the least Rank of 22^{nd} with Q_j value of 0.799.

Besides calculation of Sub-Criteria the Main-Criteria were also ranked in a same manner. In Table 5.14 the data is shared were all the Main Criteria are ranked based on weightage.

Table 5.14: All Main Criteria Ranking of E-learning Model using VIKOR Method

	Content	**Usabilty**	**Organization**	**Design**
	0.1055	0.2056	0.4501	0.4146
	0.1935	0.4662	0.4578	0.4517
	0.3909	0.5897	0.5358	0.4712
	0.4126	0.6214	0.6816	0.5063
	0.6751		0.7409	0.7361
	0.7179		0.7459	0.7989
Q_j	**0.4159**	**0.4708**	**0.6020**	**0.5632**
RANK	1	2	4	3

In Table 5.14 Content is the Most Important factor and Organization is the Least Important factor to be dealt with. Usability ranked 2^{nd} and Design is regarded as Rank 3. **Content** has the highest contribution and least Q_j value of *0.4159* among Main-Criteria and **Organization** has the highest Q_j value of *0.6020*. **Usability** has Q_j value *0.4708* & Design has Q_j value of *0.5632*.

The **priority order** of **Main Criteria** using **VIKOR method** is:

$CONTENT > USABILITY > DESIGN > ORGANIZATION$

In the next Section 5.2.3 AHP-VIKOR is discussed in brief. This is **proposed approach** for using while designing a E-learning Model.

5.2.3 AHP-VIKOR Model Steps:

In this section hybridized methodology is utilized for designing the E-learning Model. The approach consists of two individual **Multiple-criteria decision-making(MCDM) Methods**. These are AHP and VIKOR. In section 5.2.1 AHP model steps are used for experimentation and result and in section 5.2.2 VIKOR model steps are calculated and analyzed. The combination of both method will be seen while using data-set in this study.

The purpose of **AHP** and **VIKOR** in same model is for adding their individual advantage in one model which will provide more efficient outcome for the data set. Using AHP in data set priority factors will be segregated which will be useful for providing criteria weightage. Then using VIKOR ranking process will be done to obtain most optimised result. The same 213 responses will be there and **22 sub-criteria** with **4 main criteria** will be considered with 5 priority standard i.e *Most Important, Important, Neutral, Less Important* & *Not Important.*

Steps for **AHP-VIKOR** are as follows:

STEP 1: Conversion of**discrete sub-criteria** of **continuous main criteria** using a **reliable classification method**[15].

STEP 2: Assign AHP-based weights to targeting criteria and their corresponding sub-criteria for creating **pairwise matrix data set**.

STEP 3: Construction of a **decision pairwise matrix** and derive **multi-disciplinary spatial data set** and replace original **normalized pairwise matrix** values of sub criteria by calculated weights of AHP as alternatives .

STEP 4: Once replaced after calculation implementation of **VIKOR MCDM approach** for ranking and weighting of the alternatives in order to generate **hybridized AHP-VIKOR model** is processed.

By following these above mentioned steps **AHP-VIKOR method** is implemented to design an **optimized E-learning model**.

Initially the Weightage Factor is determined using scale of relative importance. After that **Best and Worst value**[7, 12] of **importance level** is calculated depending on the Sub-criteria. The factor is same as Table 5.11.

From Table 5.1 the mean value is calculated using the new importance factor. The means are as follows:

Timely(0.249452269), **Relevant**(0.255399061), **Multilingual**(0.233176839), **Variety of Presentation**(0.241314554), **Accuracy**(0.248513302), **Reliability of Content**(0.256338028), **Attractive**(0.232550861), **Appropriateness**(0.24256651), **Color** (0.238497653), **Multimedia Elements**(0.241001565), **Text**(0.241627543), **Browser Compatibility**(0.237245696), **Index**(0.231298905), **Navigation**(0.241627543), **Consistency**(0.240062598), **Links**(0.241627543), **Logo**(0.236932707), **Domain** (0.237871674), **User Friendly**(0.246635368), **Reliability of Usability**(0.247261346), **Availability**(0.236306729), **Interactive Features**(0.244444444)

After the calculation of mean Average Mean was found as 0.24190 and lesser mean than **0.24190** is rejected and rest are carried forward for the next part calculation where the accepted sub-criteria will be calculated for **Best** and **Worst** value. The accepted criteria are as follows:

Reliability of Content, Relevant, Timely, Accuracy, Reliability of usability, User Friendly, Interactive Features & Appropriateness. Their means are respectively 0.2563, 0.2554, 0.2495, 0.2485, 0.2473, 0.2466, 0.2444 & 0.2426. Mean with most value is Reliability of Content and least value has the sub-criteria Appropriateness.

Using equation Best and Worst values are calculated.

$$F_i^+ = Max(F_{ij}) \tag{5.7}$$

$$F_i^- = Min(F_{ij}) \tag{5.8}$$

As all are **beneficial criteria** so Max will be Best and Min will be Worst value.

Table 5.15: Best and Worst value in AHP-VIKOR

	Very Important	**Important**	**Neutral**	**Less Important**	**Not Important**
Best (fi+)	**84**	**81**	**45**	**38**	16
Worst(fi-)	57.00	**57.00**	29.0000	20	7

Now based on the best and worst value the S_j & R_j is calculated. The used formulas are:

$$S_j = \sum \left[\frac{w_i(f_i^+ - f_{ij})}{(f_i^+ - f_{ij})} \right] \tag{5.9}$$

$$R_j = Max \left[\frac{w_i(f_i^+ - f_{ij})}{(f_i^+ - f_{ij})} \right] \tag{5.10}$$

Using equation 5.9 & 5.10 the value of $S_j \& R_j$ is calculated.

Table 5.16: Calculated $S_j \& R_j$ value in AHP-VIKOR method

Calculation of Sj and Rj					**Sj**	**Rj**
0.000	0.189	0.200	0.133	0.000	**0.522**	**0.200**
0.123	0.122	0.088	0.126	0.044	**0.504**	**0.126**
0.235	0.133	0.000	0.081	0.067	**0.516**	**0.235**
0.123	0.267	0.050	0.044	0.052	**0.536**	**0.267**
0.198	0.200	0.013	0.074	0.044	**0.529**	**0.200**
0.148	0.244	0.113	0.000	0.059	**0.564**	**0.244**
0.333	0.000	0.100	0.111	0.007	**0.552**	**0.333**
0.296	0.133	0.000	0.096	0.015	**0.541**	**0.296**

From Table 4.16 S_j & R_j is obtained and then using these 2 factors Q_j value is to be calculated.

$$Q_j = \frac{\nu(S_j - S^+)}{(S^+ - S^-)} + (1-\nu)\left(\frac{R_j - R^+}{R^- - R^+}\right) \tag{5.11}$$

Now using equation 5.11 Table 5.17 is generated.

Table 5.17: Calculated Sj Rj and Qj value using AHP-VIKOR method

Accepted Sub-Criteria	**Sj**	**Rj**	**Qj**
Reliability of Content	0.522	0.200	0.3321
Relevant	0.504	0.126	0.0000
Timely	0.516	0.235	0.3647
Accuracy	0.536	0.267	0.6096
Reliability	0.529	0.200	0.3842
User Friendly	0.564	0.244	0.7857
Interactive Features	0.552	0.333	0.8972
Appropriateness	0.541	0.296	0.7166

Using Q_j value of Table 5.17 **Ranking** is provided to accepted sub-criteria. *The lesser Q_j value the greater priority factor*. Based on calculation the **rankings** are:

Table 5.18: Ranking of All Accepted Sub-Criteria Using AHP-VIKOR

Criteria	Sub Criteria	Qj	RANK
CONTENT	Relevant	0.0000	**1**
CONTENT	Reliabilty of Content	0.3321	**2**
CONTENT	Timely	0.3647	**3**
USABILITY	Reliability	0.3842	**4**
CONTENT	Accuracy	0.6096	**5**
DESIGN	Appropriateness	0.7166	**6**
USABILITY	User Friendly	0.7857	**7**
USABILITY	Interactive Features	0.8972	**8**

From the Table 5.18 the **Ranking** is seen where **Relevant of Content** is the placeholder of **Rank 1** and **Interactive features** of **Usability** are regarded as the least important factor among **accepted Sub-Criteria**. **Reliability of Content** with Q_j value **0.3321** is 2^{nd} Rank holder. **Timely of Content** has the Q_j value of **0.3647** and ranked 3^{rd}. **Reliability of Usability**(Q_j value 0.3842) is 4^{th}. **Accuracy of Content** get placed in 5^{th} position with Q_j value **0.6096**, **Appropriateness of Design** with Q_j value **0.7166** is 6^{th} and with Q_j value **0.7166** the sub-criteria **User Friendly of Usability** is 7^{th} in Rank.

Though Ranking is done but it is required to check the consistency of the data set. Without consistency the data set is not acceptable as alternative while designing efficient model. **DQ** value is determined which is dependent on the number of alternatives. Accepted sub-criteria number is **8** so the **DQ** value is $\frac{1}{(8-1)} = 0.142857143$

For consistency checking $a_m - a_1$ is calculated if $Q(a_m) - Q(a_1) \geq DQ$ then data set is reasonably consistent but if there the condition is not satisfied then alternative process to be followed to get the proper ranking of Sub-Criteria.

For **Reliability of Content** the $Q(a_m) - Q(a_1)$ value is *0.3321*. **Timely** has $Q(a_m) - Q(a_1)$ value of *0.3647*. **Accuracy, Reliability, User Friendly, Interactive Features** have $Q(a_m) - Q(a_1)$ value of *0.6096, 0.3842, 0.7857, 0.8972* respectively and **Appropriateness** has $Q(a_m) - Q(a_1)$ value of *0.7166*.

As all the values are greater than **0.3321** so the data set is consistent. So the Ranking of alternatives are close to the **ideal outcome**.

The steps are followed for the main criteria also to determine the ranking and from Table 5.19 the ranking of Main criteria also can be confirmed.

Table 5.19: Accepted Main Criteria Ranking AHP-VIKOR

	Content	**Usability**	**Design**
	0.33212	0.38416	0.71655
	0.00000	0.78571	
	0.36470	0.89721	
	0.60959		
Global Qj value	0.174205342	0.689025864	0.716552
Rank	1	2	3

Content is **Rank 1**, **Usability** is **Rank 2** and Last one is **Design**. Other main Criteria **Organization** was *discarded* as main criteria as none of the sub-criteria was able to surpass the average mean.

Priority Order of Main Criteria using **AHP-VIKOR** Method is:

$CONTENT > USABILITY > DESIGN$

Now in the next section 5.2.4 the reasons why TOPSIS, Fuzzy AHP Model and other models are not included for analysing and calculating.

5.2.4 Why TOPSIS, Fuzzy AHP Model are discarded?

While working on the topic of MCDM the present researcher saw that there are other Multiple-criteria decision-making(MCDM) methods but some of them are not suitable. Many of these Multiple-criteria decision-making(MCDM) methods can be explored in future scope as well however many of the suitable also have their own drawbacks while functioning in this particular domain.

In article[27] **TOPSIS, Fuzzy AHP Model** were kept for **future scope**[27] to check if these two methods are also more efficient than the explored AHP model. It is seen that the process that **TOPSIS, Fuzzy AHP Model** and many other models also follow some of their own steps which have some weakness or not required while forming E-learning Model. These model are chosen for this study because they are mostly used among other methods and they are also popular for their unique capabilities to provide solutions based on the situations

TOPSIS encompasses **vector normalizing**, and the **normalised** value for a particular criterion may vary depending on the assessment unit, which is *troublesome for this study.* **TOPSIS** utilizes **n-dimensional Euclidean distance**, which, on its own, may indicate an **equilibrium between overall and individualised commitment**, but in a different way from **VIKOR**, which use weight ν (Maximum utility factor).

Both algorithms provide a ranking list, but VIKOR's top-ranked option is the best fit. However, simply because **TOPSIS** offers the highest-ranked choice, which is the best in terms of the ranking index, does not always imply that it is the greatest option.

The **VIKOR approach** offers a **middle-ground option that includes an advantage rate in addition to ranking**. Because the goal of the study is to give which will be *near to optimal solution* for getting **maximum efficacy**, the **VIKOR**

approach is recommended above the **TOPSIS method**.

AHP is a multi-criterion decision-making strategy that assists decision-makers in choosing between options and **Fuzzy logic** is an approach for dealing with *ambiguous data* and *imprecise information*, the **Fuzzy AHP** can be preferred by decision-makers whenever they need to make a decision under **ambiguous scenarios**. However, because the *main criteria* and *sub-criteria* are explicitly indicated in this study and the conclusion **will not be made** under **uncertain circumstances**, the **Fuzzy-AHP** approach is not required, so this method is **excluded** because it will not share more efficiency than the **AHP method**. As the same fuzzy logic exists in the **Fuzzy-TOPSIS** so this is also removed from the list of methods that will be continued for further research purposes.

In the next Chapter 6 an analysis will be shown to understand the comparison of efficiency between traditional MCDA like AHP, TOPSIS, VIKOR etc. and proposed hybrid MCDM i.e AHP-VIKOR.

This comparison will lead to the conclusion that which of these Multiple-criteria decision analyses (MCDA) or Multiple-criteria decision-making (MCDM) methods is the most productive while establishing the E-learning Model.

Chapter 6

Comparative Analysis

In Chapter 5 the experimentation and results are shared that obtained using **Multiple-criteria decision-making (MCDM)** or **multiple-criteria decision analysis (MCDA)**.In this chapter, a comparison will be drawn to identify which method is the most efficient for this particular domain.

6.1 Performance Analysis of Different Methods used in this study

The experimentation and results are shared based on the same data set that is collected through the literature survey. The data is **consistent** and **verified** as well. There is no data present on the applied data set that is redundant or can be discarded due to certain reasons. Only those with a substantial influence (important quality factors) were further evaluated in our study after the survey was done to establish the relevance of the discovered quality variables. Therefore Table 5.1 is reliable data set for continuing the process of analysis and was consistent as well after applying **Multiple-criteria decision analysis(MCDA)** approaches also. The methods that are experimented in this study are **AHP Method, VIKOR Method** and **AHP-VIKOR Method***(Proposed Approach)*

In the next section 6.1.1 performance analysis of the AHP Method will be discussed.

6.1.1 Performance Analysis of AHP Methods

The **AHP** evaluates the results of **each pairwise comparison** using **linear algebra**[17]. Every criterion is assigned a weighting based on its importance. The *more weight a criterion has*, the **more significant** it is to the **overall outcome**. Based on that the calculation was done and it is deducted that the selection of all alternatives i.e all of the **22 sub-criteria** gives greater variation than **accepted *8* sub-criteria** based on the AHP Methodology.

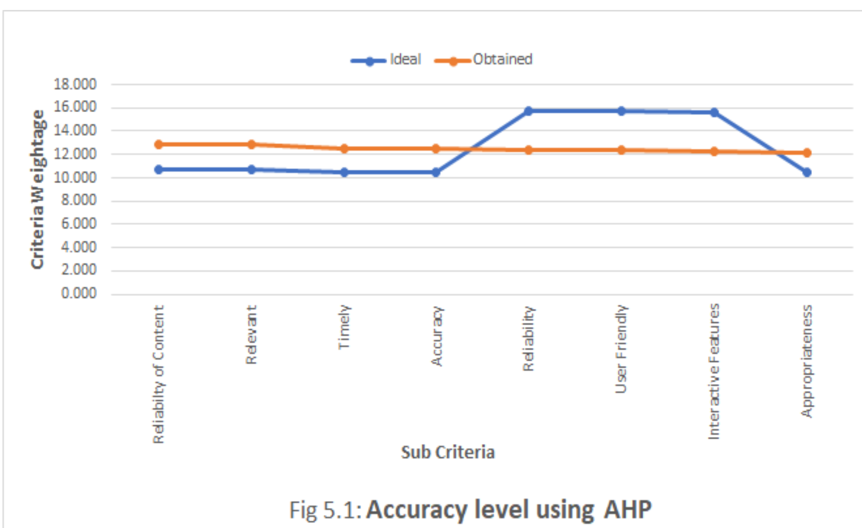

Figure 6.1: Accuracy level plot using AHP Model

From Fig 6.1 it can be depicted that between the ideal result and obtained result there is a significant improvement in quality using **AHP Model**. The obtained result used only *8 sub criteria* over *22 sub-criteria* to provide more precision in quality as a result it successfully provided **3.884%** more improvement than the ideal one.

While calculating it was seen that the Reliability of Content is ideally calculated as 10.747 but the obtained one is of 12.877 which provides 19.822% better result. In case of **Relevant** ideal solution gives 10.708 as weightage but calculated one shares 12.830 which is 19.822% better. **Timely** ideally calculated as 10.458 but obtained one scores 12.531 which is 19.822% better. If **Accuracy** is checked then ideal to obtained ratio is 10.419:12.484 with 19.822% better result. However, in case of **Reliability** ideal is greater than obtained. The ideal solution is 15.786 but obtained is 12.421 and the quality decreases by 21.314% and **User Friendly** 15.746 to 12.390 while is 21.314% lesser one and **Interactive Features** goes to 15.606 to 12.280 with 21.314% decrement. **Appropriateness** has the ideal solution of 10.529 whereas obtained is 12.186 and 15.729% increment is seen as well. The overall percentage of efficiency is **3.884%** using the AHP.

In the next section the 6.1.2 performance analysis of a VIKOR Method will be showcased.

6.1.2 Performance Analysis of VIKOR Methods

VlseKriterijumska Optimizacija I Kompromisno Resenje (*VIKOR*) methodology[12] mainly focused on **ranking and selecting** the best from a set of alternatives, which are associated with **multi-conflicting criteria**[47].

In case of initial weight distribution the 5 parts i.e Very **Important, Important, Neutral, Less Important** and **Most Important** were distributed in priority factor and these are respectively takes weightage of *33.33%, 26.67%, 20%, 13.33%* and *6.67%*.

All the factors are normalized and using Best (Fi^+) and Worst (Fi^-) they are categorized. These re the value of the i^{th} criterion function for the alternatives. As all sub-criteria are **beneficial** for E-learning model so all factors must be *greater* to be the *most important factor*.

The main criteria rank are respectively **Content, Usability, Design, Organization** and they share the **contribution percentage** of *29.981%, 27.167%, 22.424%* and *20.428%* respectively.

The **obtained compromise solution**[12] may be **approved** by **decision makers** since it enhances the majority's utility (expressed by $\text{Min}(S_j)$) while minimising the alternative's individual regret (represented by $\text{Min}(R_j)$).

The measures S_j and R_j are combined in Q_j to provide a compromise solution, which serves as the foundation for a mutually agreed-upon agreement. Here S_j and R_j denote the utility measure and regret measure for alternatives. w_i denotes the weight of each criterion. ν is the weight for the strategy of maximum group utility and $(1 - \nu)$ is the weight of individual regret.

Depending on DQ, $S_j, R_j \& Q_j$ the ranking is provided to the data set. DQ value is 0.048 and other values are also shared in the Chapter 5. From these results the distance is calculated based on their weightage of Q_j. By using the weightage and cumulative values the graph is plotted to check the quality improved in that case and the plot showcases that the quality increased by **18.58434%**.

In the Fig 6.2 the graph is plotted and the efficiency is 18.58434% better in case of obtained result .

N.B: Usually ν **is 0.5** and when $\nu > 0.5$,[44] the index of Q_j will tend to **majority agreement** and clearly when $\nu < 0.5$, the index Q_j will indicate **negative attitude**.

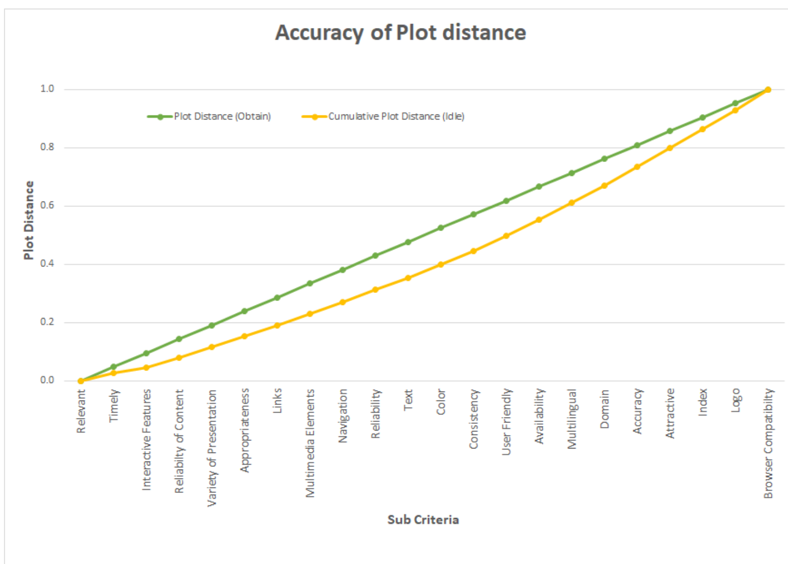

Figure 6.2: Ideal vs. Obtained Accuracy Plot Distance for VIKOR Method

Fig 6.2 demonstrates that in case of distance the sub-criteria the plot starts from initial point where **Relevant** was origin as in both cases ranking starts from origin. However, the difference was seen when the sub-criteria was plotted.

Timely is better with result of **33.357%** and other features **Interactive Features, Reliability of Content, Variety of Presentation, Appropriateness, Links, Multimedia Elements, Navigation, Reliability, Text, Color, Consistency, User Friendly, Availability, Multilingual, Domain, Accuracy, Attractive, Index, Logo** & **Browser Compatibility** were respectively improved version with percentage ***39.780%, 33.420%, 29.498%, 27.088%, 24.6692%, 22.908%, 21.483%, 20.245%, 19.186%, 17.880%, 16.455%, 14.678%, 12.843%, 10.760%, 8.882%, 6.931%, 5.057%, 3.346%*** and ***1.771%***.

From these sub-criteria contributions, the percentages are calculated and when the mean is taken to understand the efficiency. After certain deduction it was concluded that the using **VIKOR method** the improvement was nearly around **18.58434%**.

In the next section 6.1.3 performance analysis of AHP-VIKOR Method will be shared in brief.

6.1.3 Performance Analysis of AHP-VIKOR Method

The AHP-VIKOR is a blended multiple criterion problem[5] solving and decision-making approach for ranking and weighting various attributes of diversely distributed criteria.

It is also known as a subset of **(HMCDM o Hybrid multiple criteria decision making)**[15]. In this method two approaches are hybridized as discussed and the result is shown in the section 5.2.3.

The blended **AHP-VIKOR model** is **highly sensitive**[5] to the weights supplied to the performance standards, according to the outcome of the sensitivity analysis from various scenarios.

Like VIKOR the *most important, important, neutral, less important* and *not important* factors are distributed with weightage of *33.33%, 26.67%, 20%, 13.33% and 6.67%*

In this method **AHP** and **VIKOR** method both are involved so each approach's **best quality determination factor** is inherited in the **AHP-VIKOR methodology** and it is seen that after using the **AHP-VIKOR methodology** there were significant improvement on the designed Model. **Best**(Fi^+) and **Worst**(Fi^-) factors were isolated from the data set and mean were also specified accordingly.

Reliability of Content, Relevant, Timely, Accuracy, Reliability, User Friendly, Interactive Features and *Appropriateness* have the mean of **0.2563, 0.2554, 0.2495, 0.2485, 0.2473, 0.2466, 0.2444** and **0.2426** respectively.

The main criteria rank are respectively **Content, Usability, Design** and **Organization** is removed from the data set as the sub-criteria didn't have mean value more than **0.24190**. Now the maximum contribution of main criteria is of **Content** with **58.146%**, **Usability** comes next with percentage of **21.896%** and **Design** with **19.958%**.

Timely is better with result of 24.074% and other features *Reliability of Content, Reliability of Usability, Accuracy, Appropriateness* and *User Friendly* were respectively improved version with percentage **32.298%, 37.843%, 38.247%, 21.367%** and **9.801%**.

There was no decrement in the slope in case of this plot which shows its consistency. This monotonic increasing function depicts the capability of this **AHP-VIKOR methodology**.

In the Fig 6.3 the graph is plotted and efficiency is **21.2719%** better in can of obtained data set.

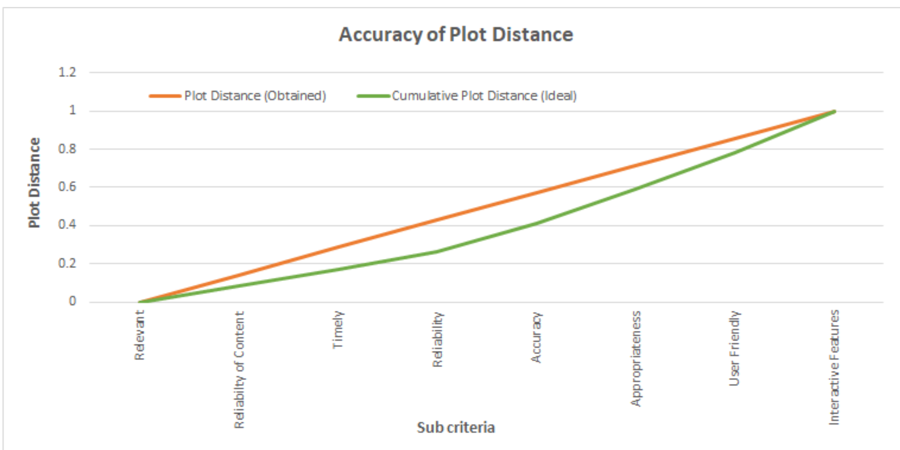

Figure 6.3: Ideal vs. Obtained Accuracy Plot Distance for AHP-VIKOR Method

Fig 6.3 demonstrates that in case of distance the sub-criteria the plot starts from initial point where *Relevant* was origin as in both cases ranking starts from **origin**. However the difference was seen with the sub-criteria was plotted.

From these **sub-criteria contribution** the percentages are calculated and when the mean is taken to understand the efficiency.

After certain deduction it was concluded that the using **AHP-VIKOR method** on the E-learning model the improvement was nearly **21.27190%**.

In the next section 6.2 the **comparison and analysis** will be done with respect to the used methodologies to get the model which is the most effective in the case of optimized E-learning model designing.

6.2 Comparison and Analysis

This section analyses the efficiency among the **Multiple-criteria decision-making (MCDM) Methodologies** that are used in this study. As we can check the initially **AHP method** is in section 6.1.1, next VIKOR method is discussed in section 6.1.2 and Lastly used the **AHP-VIKOR hybrid method** in section 6.1.3.

6.2.1 Comparison among Methodologies' Own Ideal and Obtained Data Set

It is seen that using the AHP method concerning the ideal data set the obtained data set shares **3.884%** more efficiency whereas using **VIKOR method** it is seen that the ideal and obtain data set differs by **18.584%**. This improvement is seen in the obtained data set over the ideal data set and finally while using the proposed **AHP-VIKOR methodology** it is seen that **21.272%** of improvement was there to the obtained data set with respect to the ideal data set.

Fig 6.4 shared that the efficiency level while dealing with the **ideal** and **obtained** data set. The **AHP model** is consistent however the *Ranking method* of **VIKOR** is better so though **VIKOR** calculated all the **22 sub-criteria** and AHP did that for **8 sub-criteria** but still the efficiency of VIKOR is surprisingly higher with 21.272% which is 3.78 times better than the AHP method.

In case of **hybridized AHP-VIKOR method**, the percentage goes far beyond respect to AHP and by **2.688%** it is better than the VIKOR while dealing with these data set. For AHP-VIKOR the efficiency is of **21.272%** which is 4.47 times better than the AHP model.

Method	Accuracy Level
AHP	3.884
VIKOR	18.584
AHP-VIKOR	21.272

In Fig 6.4 it is seen that the curve is progressive. In *x-axis* efficiency level is shared and *y-axis* shares methodologies like **AHP, VIKOR and AHP-VIKOR**.

While sorting *AHP* worked better but when the calculation comes about ranking *AHP* struggles in this case so the AHP method is discarded and for further calculation **VIKOR** and **AHP-VIKOR** will be continued.

Karthikeyan et al.[20] shared that AHP comprises high computing need even for simple issues, a subjective aspect that relies on emotions to be translated into numerical judgments, and a larger number of pair comparisons necessitated by increased time and effort. These are the reasons why AHP is also not suitable for this E-learning model design.

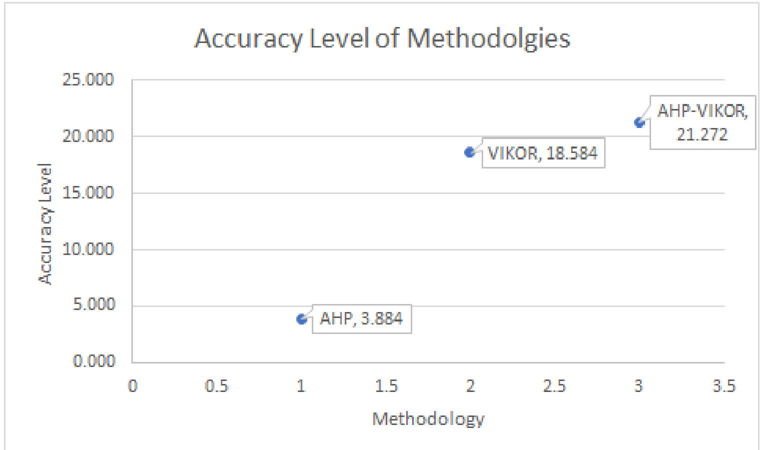

Figure 6.4: Accuracy of Methodologies

It is seen that when **inserting** or **eliminating alternatives** there is *inconsistency* in the location where that manipulated data set is part of it. Due to absence of data about **criteria**[20] and choices or absence of fixation amid **pairwise examinations** the data set loses accuracy but these **reduction of redundant data set or criteria** is advantageous while working on situation where with criteria is based on **importance**. These characteristics of **AHP** helps in **AHP-VIKOR** for obtaining only *most optimized Main criteria* and *Sub-criteria* that are relevant.

In the next section 6.2.2 the final comparison will be done between VIKOR and AHP-VIKOR to utilize the most optimized Multiple-criteria decision-making (MCDM) method.

6.2.2 Comparison between VIKOR & AHP-VIKOR

In this section **VIKOR** & **AHP-VIKOR** compared to showcase which one is the most effective one. VIKOR analysed all of the 22 sub-criteria and **AHP-VIKOR** used only the 8 sub-criteria that was able to outclass the mean value. Now both have the ranking system based on the Q_j values.

Now as **AHP-VIKOR** has lesser **sub-criteria** included in it so the **sub-criteria** as checked for sorting out. These are *Reliability of Content, Relevant, Timely, Accuracy, Reliability, User Friendly, Interactive Features* and *Appropriateness*. Now both have different Q_j values which may differ due to different processes so based on the criteria chosen the Q_j value is normalized for both methodologies to bring into the same page. Now the **lower the Q_j value the higher priority** and the method which has the lower normalized value that will be granted as the best method for designing a properly optimised E-learning model.

Now for **VIKOR method** the Q_j value respectively for *Reliability of Content, Relevant, Timely, Accuracy, Reliability, User Friendly, Interactive Features* and *Appropriateness* are **0.205, 0.664, 0.413, 0.111, 0.172, 0.136, 0.389** and **0.193**. For AHP-VIKOR the values are: **0.241, 0.000, 0.219, 0.131, 0.208, 0.102, 0.08**9 and **0.112**.

Table 6.1: Performance Comparison of VIKOR and AHP-VIKOR method

Sub Criteria	AHP-VIKOR	VIKOR
Reliability of Content	0.241	0.205
Relevant	0.000	0.664
Timely	0.219	0.413
Accuracy	0.131	0.111
Reliability	0.208	0.172
User Friendly	0.102	0.136
Interactive Features	0.089	0.389
Appropriateness	0.112	0.193

Now if both data are compared then **Reliability of Content** for *VIKOR Method* is 17.72% better than *AHP-VIKOR Method* but for Relevant, **AHP-VIKOR** is perfectly greater than **VIKOR Method**. For **Timely AHP-VIKOR** is better that **VIKOR** by 46.93%, for Accuracy **VIKOR** is 17.77% better than **AHP-VIKOR**, In case of **Reliability VIKOR** is better than **AHP-VIKOR** with 21.36%, User Friendly with **AHP-VIKOR** is better than **VIKOR** for 24.95%, for deviation in curve the most effective factor was **Interactive Features** where **AHP-VIKOR** scored 77.08% better that **VIKOR** method and in*Appropriateness* **AHP-VIKOR** lead **42.14%** over **VIKOR** Method.

Fig 6.5 shows the **accuracy of the VIKOR and AHP-VIKOR** Methodology. *Lower the value the greater the priority of the sub-criteria and better efficiency of the particular method.*

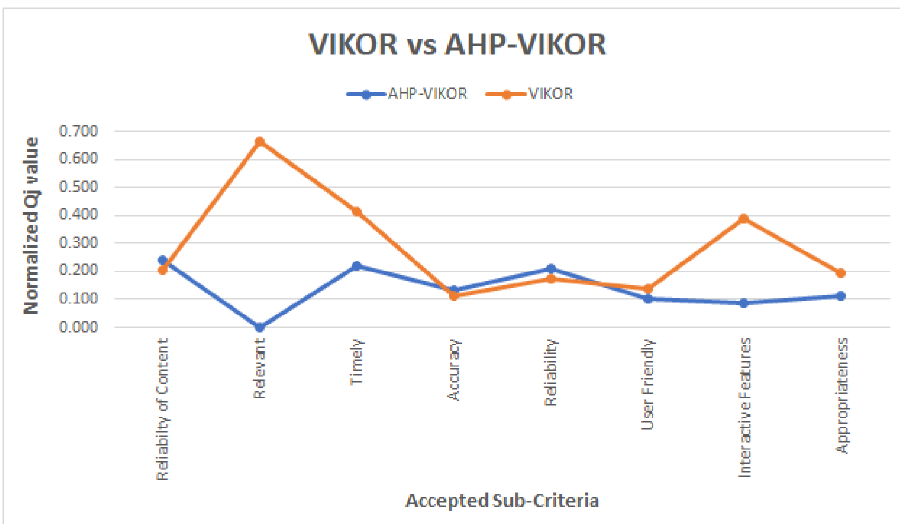

Figure 6.5: Accuracy plot of VIKOR and AHP-VIKOR

x-axis denotes **Normalized** Q_j **value** and **y-axis** denotes **Accepted Sub-Criteria**. It can be seen from the figure that the **VIKOR method** has *greater* *deviation* whereas for **AHP-VIKOR** the consistency is there.

From data set of **VIKOR** and **AHP-VIKOR** it is calculated that that efficiency of the **AHP-VIKOR** is significantly better. Besides that the *consistency* and *decreasing curve tendency* confirms **AHP-VIKOR's** efficiency factor is greater. In the Fig 6.5 initially for *Reliability of Content* both *VIKOR* and *AHP-VIKOR* methodology intersected each other and tendency of VIKOR increases means the *performance level starts deprecating* but for **AHP-VIKOR** the performance level was maintained and reached the **lowest normalized** Q_j **factor** means the *performance* grows up. Now the *VIKOR* curve behaves like **monotonic curve** and increases it performance level. For **Relevant** the normalized Q_j factor was *maximum* between **VIKOR** and **AHP-VIKOR**. In *Timely*, **AHP-VIKOR** improves its *performance* and **VIKOR** method catches up and improved more than **AHP-VIKOR** methodology. In case of *Accuracy* **VIKOR** and **AHP-VIKOR** have tendency of *increasing normalized* Q_j *factor* and again in case of *Reliability of Usability* both improved their **performance balance** and intersects each other before *User Friendly Sub-criteria.* After that **AHP-VIKOR** maintained performance factor but in case of **VIKOR** for *Interactive Features* the *normalized* Q_j *factor* increases again and afterwards from *Appropriateness* the performance improved and finished close to **AHP-VIKOR** but the deviation was still greater than **AHP-VIKOR**. After all these *fluctuations* of **performance** and **normalized** Q_j **factor**, it was calculated that the **AHP-VIKOR** is **the most suitable approach** for **designing E-learning Model**. The proposed approach **AHP-VIKOR Methodology** has shown that it is **29.280%** better than the **VIKOR methodology**.

Based on the discussion it can be concluded that among three **Multiple-criteria**

decision-making (MCDM) methods i.e *Analytical hierarchical process (AHP), VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR)* and *Hybridization of AHP and VIKOR (AHP-VIKOR)* the proposed **MCDM method AHP-VIKOR** is the **most constructive method** implicitly with a significant efficiency value.

The proposed approach showcases a positive result in this domain. **Imprecision** and **ambiguity**[18] are ubiquitous in decision-making, which **fuzzy sets** and **fuzzy decision-making techniques** can effectively handle. In recent years, a *significant amount of research*[30] have been conducted on the **theoretical** and **workable** components of MCDM.

In **real-life decision-making situations**[31], many **contradictory criteria**[18] and **objectives** must be examined at the same time. Considering the concessions necessary to *establish a balance* between the **performance** and **cost** of an **E-learning model** implementation. Besides that individual advantages of the **AHP** and **VIKOR** when combined for one decision-making purpose and after when it is found that it is the *accurate method* that to be used for this particular domain confirms better performance ability that stands out than other **MCDM**.

In the next section, the conclusion is drawn from this study and also given directions regarding future scopes.

Chapter 7

Conclusions and Future Scopes

In this chapter the conclusion based on the study and the recommendation are shared which can be useful in the future and can be utilized for designing more effective Models.

7.1 Conclusions

Multiple-criteria decision-making (MCDM) methods are useful for deciding on the various fields however these approaches were not explored in this domain very deeply. E-learning is a very much essential for students and instructors both so the approaches are considered to design more efficient quality-based model. The user's happiness is directly influenced by the quality of a product or service. Even underdeveloped countries are constantly building e-learning websites to supplement their educational institutions[27]. Academic excellence is the driving force behind the fast development of web-based e-learning services.

So upon review, it can be concluded that this study was for the improvement of the E-learning system that is provided. Using AHP, VIKOR and AHP-VIKOR a comparison was done and it was concluded that for this study the **AHP-VIKOR** is **29.280**% better than the **VIKOR method** and it is nearly **4 times** better than the **AHP method**.

The analysis showcased all the data set that is used throughout the study so that reviewer can understand all the terminologies and concepts and can utilize them in the future as well. No work is perfect and research for optimizing all the entities, concepts and their implementation is still going on. The proposed method is an improved version of existing models but it can be improved further using future methods that will be invented later or the existing methods(i.e: Case-based Reasoning, Data Envelopment Analysis, PROMETHEE etc.) that are not utilized in this study.

In this next section, the limitations are shared which are pushing back this study from implementing the optimized or close to ideal model design.

7.2 Limitations

There are some limitations that are binding this model from reaching the maximum peak of optimization. These shortcomings are:

1. The literature survey was limited due to geographical outreach. This boundary was University and a certain circle of people within the state of a country but the data set should be on a larger scale to get the more accurate output. 213 responses were utilized however geographical reach was limited. If the survey is

done worldwide and the result is done based on that it will be a more optimized.

2. The literature survey that was taken could be deemed unreliable, resulting in incorrect decision-making. For substantial amounts of data collection, a g-form or any other online format form may be chosen to share with professionals; however, there could be an issue if a specific group becomes prejudiced while submitting the survey, so it must be thoroughly scrutinized to ensure that there is no misleading data on the data set.

3. The methodologies that are used can have better the approaches in future however due to timeline constraints the most optimized algorithm which is suitable is utilized.

4. The method AHP-VIKOR has its own drawbacks. For example AHP-VIKOR model is quite sensitive[5] to the weights assigned to the evaluation criteria. Besides that there are other downsides also there of this model.

There are other aspects also which are the limitations of this study which can be removed in future work. In the next section future scopes are shared which will help to improve the drawback of this study.

7.3 Recommendation for Future Work

The study showcases the way to improve the E-learning model. There are many aspects which are discussed in the various chapters of this study.

Finally to conclude this thesis, AHP-VIKOR model shares close to ideal solution for building a better E-learning model. However there are some constraints that are already discussed in section 7.2. Besides that, there are future scopes of this study also. These steps can be a way to secure more efficient model in near future.

These are:

1. Security level[27] is a great concern. Privacy to be kept in case of E-learning.

2. In AHP-VIKOR method various steps are there and these are optimised as well. A hybrid model like AHP-VIKOR other combinations depending on different normalizations can be calculated for this application.

3. Other models that are not explored can be the alternatives as well. Using them in try and error method the efficiency can be checked and utilized in that manner.

4. IAHP model[17] can deal with categorical inputs and outputs without any transformation so in AHP-VIKOR model instead of AHP the alternative IAHP can be used with VIKOR as hybridization.

5. Taking the literature survey in a broader aspect will provide efficient outcome. A worldwide survey will be useful though some redundant data to be excluded which will be a tedious process.

6. In this study the proposed AHP-VIKOR model has significant efficacy however after implementation of this real-world scenario it can be judged properly. The comparison to be done with explored models of this study for confirming the truthfulness of the data set.

7. There are several other methodologies[42] present but due to lack of literary support and their transparency, it is beyond the scope. Otherwise, there might be another method that would have been more efficient than AHP-VIKOR and a complete redesigning of the methodology would showcase a new E-learning model with better productivity.

In general, the topic is humongous and the scope of the study is also very vast so there is a large amount of chance to give direction to this study to establish an optimized Web Service-based model for E-Learning.

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Appendix A

Appendix

I CHARTS

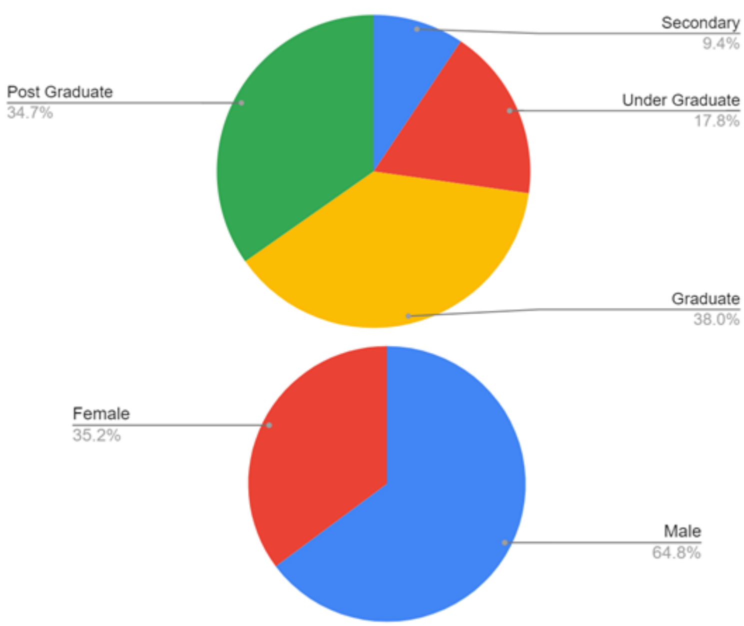

Figure A.1: Qualification and Gender Ratio Chart

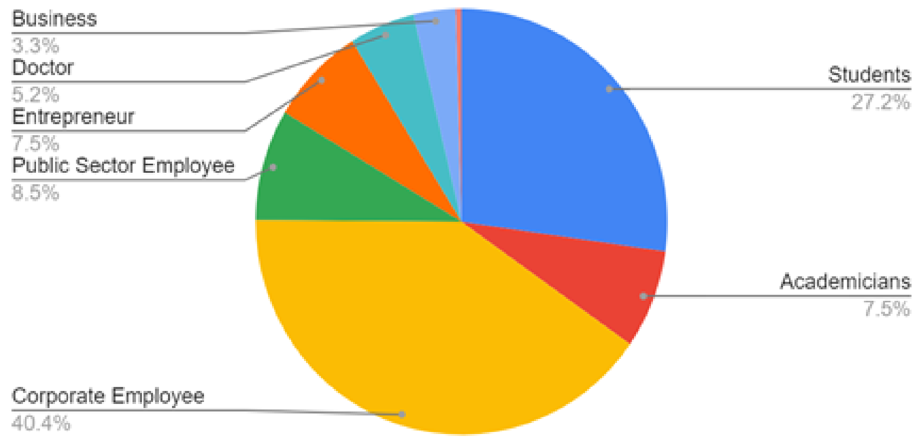

Figure A.2: Demographic Ratio Chart

II TABLES

i) AHP

Pairwise Matrix

Pairwise Comparison Matrix	Reliability of Content	Relevant	Timely	Accuracy	Reliability	User Friendly	Interactive Features	Appropriateness
Reliability of Content	1	1.00368	1.02760	1.03149	1.03671	1.03934	1.04866	1.05677
Relevant	0.99634	1	1.02384	1.02771	1.03291	1.03553	1.04481	1.05290
Timely	0.97314	0.97672	1	1.00378	1.00886	1.01142	1.02049	1.02839
Accuracy	0.96947	0.97304	0.99624	1	1.00506	1.00761	1.01665	1.02452
Reliability	0.96459	0.78740	0.99122	0.99496	1	1.00254	1.01152	1.01935
User Friendly	0.96215	0.96569	0.98871	0.99244	0.99747	1	1.00896	1.01677
Interactive Features	0.95360	0.95711	0.97992	0.98363	0.98861	0.99112	1	1.00774
Appropriateness	0.94628	0.94975	0.97240	0.97607	0.98101	0.98350	0.99232	1

Normalized Pairwise Comparison Matrix

Row/Column sum	Reliability of Content	Relevant	Timely	Accuracy	Reliability	User Friendly	Interactive Features	Appropriateness
Reliability of Content	0.12877	0.13183	0.12877	0.12877	0.12877	0.12877	0.12877	0.12877
Relevant	0.12830	0.13135	0.12830	0.12830	0.12830	0.12830	0.12830	0.12830
Timely	0.12531	0.12829	0.12531	0.12531	0.12531	0.12531	0.12531	0.12531
Accuracy	0.12484	0.12781	0.12484	0.12484	0.12484	0.12484	0.12484	0.12484
Reliability	0.12421	0.10342	0.12421	0.12421	0.12421	0.12421	0.12421	0.12421
User Friendly	0.12390	0.12684	0.12390	0.12390	0.12390	0.12390	0.12390	0.12390
Interactive Features	0.12280	0.12571	0.12280	0.12280	0.12280	0.12280	0.12280	0.12280
Appropriateness	0.12186	0.12475	0.12186	0.12186	0.12186	0.12186	0.12186	0.12186

Criteria Weightage Ratio Multiplied with Non-Normalized matrix

Criteria Weights	0.12916	0.12868	0.12569	0.12521	0.12162	0.12427	0.12316	0.12222
Row/Column	Reliability of Content	Relevant	Timely	Accuracy	Reliability	User Friendly	Interactive Features	Appropriateness
Reliability of Content	0.12916	0.12916	0.12916	0.12916	0.12608	0.12916	0.12916	0.12916
Relevant	0.12868	0.12868	0.12868	0.12868	0.12562	0.12868	0.12868	0.12868
Timely	0.12569	0.12569	0.12569	0.12569	0.12269	0.12569	0.12569	0.12569
Accuracy	0.12521	0.12521	0.12521	0.12521	0.12223	0.12521	0.12521	0.12521
Reliability	0.12458	0.10132	0.12458	0.12458	0.12162	0.12458	0.12458	0.12458
User Friendly	0.12427	0.12427	0.12427	0.12427	0.12131	0.12427	0.12427	0.12427
Interactive Features	0.12316	0.12316	0.12316	0.12316	0.12023	0.12316	0.12316	0.12316
Appropriateness	0.12222	0.12222	0.12222	0.12222	0.11931	0.12222	0.12222	0.12222

λ_{max} Calculation

Sub Criteria	Weighted Sum Value	Criteria Weights	Ratio of WS and CW
Reliability of Content	1.03017	0.12916	7.97618
Relevant	1.02640	0.12868	7.97618
Timely	1.00250	0.12569	7.97618
Accuracy	0.99872	0.12521	7.97618
Reliability	0.97043	0.12162	7.97956
User Friendly	0.99118	0.12427	7.97618
Interactive Features	0.98237	0.12316	7.97618
Appropriateness	0.97482	0.12222	7.97618
		λ_{max}	7.976603652

ii) VIKOR

Calculation of S_j & R_j

Calculation of Sj and Rj					Sj	Rj
0.154	0.133	0.093	0.081	0.067	0.52929	0.15447
0.081	0.122	0.140	0.126	0.051	0.52073	0.14000
0.268	0.111	0.100	0.081	0.000	0.56089	0.26829
0.211	0.111	0.107	0.081	0.031	0.54141	0.21138
0.081	0.267	0.120	0.044	0.056	0.56882	0.26667
0.000	0.189	0.200	0.133	0.021	0.54274	0.20000
0.333	0.044	0.053	0.096	0.015	0.54279	0.33333
0.195	0.133	0.093	0.096	0.031	0.54885	0.19512
0.220	0.178	0.100	0.000	0.056	0.55370	0.21951
0.211	0.133	0.093	0.074	0.036	0.54802	0.21138
0.260	0.067	0.053	0.104	0.046	0.53002	0.26016
0.187	0.256	0.087	0.022	0.036	0.58733	0.25556
0.268	0.144	0.100	0.059	0.000	0.57200	0.26829
0.195	0.167	0.087	0.067	0.041	0.55615	0.19512
0.203	0.189	0.073	0.059	0.041	0.56576	0.20325
0.195	0.144	0.093	0.096	0.026	0.55484	0.19512
0.268	0.189	0.000	0.059	0.056	0.57285	0.26829
0.211	0.222	0.053	0.059	0.036	0.58209	0.22222
0.098	0.244	0.153	0.000	0.062	0.55688	0.24444
0.130	0.200	0.100	0.074	0.051	0.55544	0.20000
0.228	0.178	0.087	0.052	0.026	0.56958	0.22764
0.220	0.000	0.147	0.111	0.026	0.50293	0.21951

S^+, S^-, R^+, R^-, ν value

S^+, R^+	**0.50293**	**0.1400**
S^-, R^-	**0.58733**	**0.3333**
ν	0.5	

Distance Plot Table

Sub Criteria	Plot Distance (Obtain)	Cumulative Plot Distance (Ideal)
Relevant	0.000	0.000
Timely	0.048	0.026
Interactive Features	0.095	0.044
Reliability of Content	0.143	0.079
Variety of Presentation	0.190	0.115
Appropriateness	0.238	0.152
Links	0.286	0.191
Multimedia Elements	0.333	0.231
Navigation	0.381	0.271
Reliability	0.429	0.312
Text	0.476	0.354
Color	0.524	0.398
Consistency	0.571	0.445
User Friendly	0.619	0.497
Availability	0.667	0.552
Multilingual	0.714	0.611
Domain	0.762	0.671
Accuracy	0.810	0.734
Attractive	0.857	0.799
Index	0.905	0.864
Logo	0.952	0.930
Browser Compatibilty	1.000	1.000

iii) AHP-VIKOR

S^+, S^-, R^+, R^-, ν value

S^+, R^+	0.504	0.126
S^-, R^-	0.564	0.333
ν	0.5	

Distance Plot Table

Sub Criteria	Plot Distance (Obtained)	Cumulative Plot Distance (Ideal)
Relevant	0	0
Reliability of Content	0.142857143	0.081203274
Timely	0.285714286	0.170370261
Reliability	0.428571429	0.264294790
Accuracy	0.571428571	0.413337372
Appropriateness	0.714285714	0.588531663
User Friendly	0.857142857	0.780635915
Interactive Features	1	1

III PROGRAMS

The implementation of AHP and VIKOR for this study is available on GitHub.[1]

i) Code for decision making from pairwise matrix using AHP:

```
import numpy as np
import scipy.optimize as spo
import ahpy
from .__version__ import __version__
from .ahpy import Compare
from .ahpy import Compose
criteria_comparisons =
{
    (Reliability of Content', 'Relevant'): 1.00368,
    (Reliability of Content', 'Timely'): 1.02760,
```

[1] https://github.com/AvirupSaha/CodeForAHPVIKORinThesis

```
('Reliability of Content', 'Accuracy'): 1.03149,
('Reliability of Content', 'Reliability of Usability'): 1.03671,
('Reliability of Content', 'User Friendly'): 1.03934,
('Reliability of Content', 'Interactive Features'): 1.04866,
('Reliability of Content', 'Appropriateness'): 1.05677,
('Relevant', 'Reliability of Content'): 0.99634,
('Relevant', 'Timely'): 1.02384,
('Relevant', 'Accuracy'): 1.02771,
('Relevant', 'Reliability of Usability'): 1.03291,
('Relevant', 'User Friendly'): 1.03553,
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('Relevant', 'Appropriateness'): 1.05290,
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('Timely', 'Reliability of Usability'): 1.00886,
('Timely', 'User Friendly'): 1.01142,
('Timely', 'Interactive Features'): 1.02049,
('Timely', 'Appropriateness'): 1.02839,
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('Accuracy', 'Relevant'): 0.97304,
('Accuracy', 'Timely'): 0.99624,
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('Accuracy', 'Appropriateness'): 1.02452,
('Reliability of Usability', 'Reliability of Content'): 0.96459,
```

```
('Reliability of Usability', 'Relevant'): 0.78740,
('Reliability of Usability', 'Timely'): 0.99122,
('Reliability of Usability', 'Accuracy'): 0.99496,
('Reliability of Usability', 'User Friendly'): 1.00254,
('Reliability of Usability', 'Interactive Features'): 1.01152,
('Reliability of Usability', 'Appropriateness'): 1.01935,
('User Friendly', 'Reliability of Content'): 0.96215,
('User Friendly', 'Relevant'): 0.96569,
('User Friendly', 'Timely'): 0.98871,
('User Friendly', 'Accuracy'): 0.99244,
('User Friendly', 'Reliability of Usability'): 0.99747,
('User Friendly', 'Interactive Features'): 1.00896,
('User Friendly', 'Appropriateness'): 1.01677,
('Interactive Features', 'Reliability of Content'): 0.95360,
('Interactive Features', 'Relevant'): 0.95711,
('Interactive Features', 'Timely'): 0.97992,
('Interactive Features', 'Accuracy'): 0.98363,
('Interactive Features', 'Reliability of Usability'): 0.98861,
('Interactive Features', 'User Friendly'): 0.99112,
('Interactive Features', 'Appropriateness'): 1.00774,
('Appropriateness', 'Reliability of Content'): 0.94628,
('Appropriateness', 'Relevant'): 0.94975,
('Appropriateness', 'Timely'): 0.97240,
('Appropriateness', 'Accuracy'): 0.97607,
('Appropriateness', 'Reliability of Usability'): 0.98101,
('Appropriateness', 'User Friendly'): 0.98350,
('Appropriateness', 'Interactive Features'): 0.99232
```

```
}
    subCriteria = ahpy.Compare(name='subCriteria',
    comparisons=criteria_comparisons, precision=3,
    random_index='saaty')
    print(subCriteria.target_weights)
    print(subCriteria.consistency_ratio)

>>>{'Reliability of Content': 1.0302, 'Relevant': 1.0264,
'Timely': 1.0025, 'Accuracy': 0.9987, 'Reliability': 0.9704,
'User Friendly': 0.9912, 'Interactive Features': 0.9824,
'Appropriateness': 0.9748}
>>>0.003342335
```

ii) Code for decision making using beast and worst value from matrix using VIKOR:

```
import numpy as np
import pandas as pd
from decipy import executors as exe
matrix = np.array([
                    [84, 64, 29, 20, 16],
                    [74, 70, 38, 21, 10],
                    [65, 69, 45, 27, 7],
                    [74, 57, 41, 32, 9],
                    [68, 63, 44, 28, 10],
                    [72, 59, 36, 38, 8],
                    [57, 81, 37, 23, 15],
```

```
                    [60, 69, 45, 25, 14],
                   ])
alts = ['MostImportant', 'Important', 'Neutral',
'LessImportant', 'NotImportant']
crits = ['Design', 'Organization', 'Content', 'Usability']
beneficial = [True, True, True, True]
weights = [0.333, 0.267, 0.200, 0.133, 0.067]
xij = pd.DataFrame(matrix, index=alts, columns=crits)
kwargs = {
    'data': xij,
    'beneficial': beneficial,
    'weights': weights,
    'rank_reverse': True,
    'rank_method': "ordinal"
    }
vikor = exe.Vikor(**kwargs) # Vikor
print(vikor.dataframe)
analizer = exe.RankSimilarityAnalyzer()
analizer.add_executor(vikor)
results = analizer.analyze()
print(results)

>>{'Content': 0.415928183, 'Usability': 0.470757818,
   'Design': 0.563156559, 'Organization': 0.602028085}
>>0.047619048
```