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

Avirup Saha
School of Education Technology
Jadavpur University
Kolkata, India
avirupsaha28@gmail.com

Joydeep Mukherjee
School of Education Technology
Jadavpur University
Kolkata, India
joym761@gmail.com

***Abstract*—E-learning[3] is experiencing a surge in Information and Communication Technologies (ICT)[21]. As a result, web-based e-Learning systems[3] are being groomed for growth, even though poor content and design difficulties prohibit this. To optimize its utilization, elements such as content, design and other aspects must be considered.Multiple-criteria decision-making(MCDM) approaches were used to identify and prioritize elements for improving the quality of e-learning systems. In that analysis[21] for obtaining the best result Analytical hierarchical process(AHP)[29] was used and Fuzzy AHP[13] and TOPSIS[8] technique was kept for future exploration. However, fuzzy AHP[26] and TOPSIS[8] is not suitable in this study. There is another approach called VIseKriterijumska Optimizacija I Kompromisno Resenje(VIKOR)[6] which is productive for this domain but shares less advantage. Combining AHP and VIKOR,a derived method is proposed which is AHP-VIKOR[12]. It is excellent for achieving the most desired result for optimization in this case with a significant improvement. From an extensive literature review[21] it is revealed that content is the most salient factor, whereas organization is the frivolous factor. Structural Equation Modeling (SEM)[7] was used to create a positive optimized Web-based E-Learning system. As a learning methodology, the Successive Approximation Model (SAM)[15] should be adapted over the ADDIE model. ISO/IEC 27001:2013[5] is ideal for this particular study. Based on the certain MCDM methods the procedures were completed 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.**

***Keywords*—** Multiple-criteria decision-making(MCDM), Structural Equation Modeling (SEM) ,Successive Approximation Model (SAM),ISO/IEC 27001:2013 , AHP, VIKOR, TOPSIS, AHP-VIKOR.

I. Introduction

THE 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**. *Fundamental quality, performance quality* and *excitement quality*[18] are three of **categories of characteristics** and sustaining all of them will benefit the E-Learning platform's[28] optimum implementation. There is a scope of improvement which is motivation for improving 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 that used **AHP**[21] can be improved using the other approaches to improve the impact. Using these approaches identification of factors can be implemented and can design *more powerful e-learning model*. The potential of **Multiple-criteria decision-making(MCDM)**[30] methods, alternate modeling system like **Structural Equation Modeling (SEM)**[7] to create a positive optimized **Web-based E-Learning system**[3], standardization of the optimum quality of all software-intensive products like **ISO/IEC 27001:2013**[5] and usage of **Successive Approximation Model (SAM)**[15] are the driving forces behind this research paper.

II. Literature Survey

Franklin[13] proposed several criteria mathematical approaches and **De Condorcet**[33] improved it. **Ramsey**[33] suggested about decision-making axioms. **Esogbue et al.**[31] applied fuzzy set methodologies to sort out the real-world problems and **Balmat**[31] shared a classical set theory extension that deals with inconsistent data which is Fuzzy set theory. **Thomas L. Saaty**[16] shared a method for organizing and analysing complex decisions, using math and psychology which is known as Analytical Hierarchical Process. **Belton & Gear**[16] improved and created Modified AHP (RAHP) and again this got changed into **Ideal Mode AHP or BG-AHP**[13] which was supported by Saaty. **Moreno-Jime nez et al.**[21] applied AHP in larger scale to obtain proper decision for identifying the weight ratios among strategic factors. **Qin et al.**[31] 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. For achieving the best alternatives **Dursun's study**[29] focuses on 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.**[29] 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. **Mahahusudhan and Eze et al.**[7] confirmed that Web based learning system promotes the relationship between instructors and students. Taha et al.[7] suggested the ambiance of the classroom to be provided by the home environment. **Akyuz & Samsa**[7] said to consider Course content which should be appropriate for learning purposes. By using a **Structural Equation Modelling (SEM)** approach[21] positive relationship among the quality of e-learning, independent variables & moderating variables can be explored. **Branson**[22] coined the term **"ADDIE"** and **Russell Watson**[2] refined it. **Hannum**[2] identified the important complement of the model to the development of educational and training programs. **Michael Molenda**[20] 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)**. **Morrison et al.**[1] implemented conventional e-learning materials using the ADDIE paradigm however **Kruse**[15] criticised as ADDIE model is excessively linear, rigid, constricting and time-consuming to apply for implementation. **Allen & Sites**[1] showed interest to build quick and meaningful design and develop learner-friendly E-learning content using SAM. ISO/IEC 9126-1[17] was part of **Web Quality Model (WQM)**[21] model which was proposed by Vida and Jons. Wang et al. proposed standard **ISO/IEC 27001:2013**[5] for this domain. **Abdul et al.** proposed that the **SERVQUAL methodology**[21] is designed to assess the difference between consumers' expectations and their actual user experience.

III. METHODOLOGY

Among all the methodologies[14][31] **AHP, VIKOR & AHP-VIKOR** will be applied to estimate and analysis which method is suitable for designing most optimised e-learning model. These **Multiple-criteria decision-making(MCDM)**[21] is utilized previously in other fields in larger scale however for designing ideal e-learning model these methods are not explored rigorously. The method called is **AHP-VIKOR** which is combination of AHP and VIKOR also showcases its effectiveness in this domain. After calculation sub-criteria with mean less than **3.63** are excluded. After going though particular methodologies of AHP,VIKOR and AHP-VIKOR[23] the conclusion is drawn. A literature survey of 213 responses with no inconsistent data set was applied. 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**[4][13][23] to be applied for ranking of the **accepted sub-criteria** for building **most optimised models**.

Why TOPSIS, Fuzzy AHP Model are discarded?

1) **TOPSIS**[24] encompasses vector normalizing and this vector normalised value for a particular criterion may vary depending on the assessment unit, which is troublesome for this study.

2) **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 uses weight(Maximum utility factor). 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[8] for getting maximum efficacy so the VIKOR approach is recommended above the TOPSIS method.

3) AHP assists decision-makers in choosing between options and Fuzzy logic is an approach for dealing with ambiguous data and imprecise information. The **Fuzzy AHP**[26][30][19] can be preferred by decision-makers whenever they need to make a decision under ambiguous scenarios. In this study the main criteria and sub-criteria are explicitly indicated and the conclusion will not be made under uncertain circumstances so the Fuzzy-AHP approach is excluded. As the same fuzzy logic exists in the **Fuzzy TOPSIS** so it is also removed from the list.

IV. PROPOSED APPROACH

Proposed approaches are the expected solutions of the problem statement. Concepts, terminologies and relevant topics on which previously published works are done based on those past work, what improvements may be made are the proposed approaches. **AHP**[21][13], **VIKOR methodology**[9] and **AHP-VIKOR**[23] is utilized to calculate the final criteria and sub criteria to determine the accuracy of E-learning model in this study. The other generalized methods that to be implemented are: Optimized **Learning Management System (LMS)**[27] to be built. Trainer and learner[3] should stuck to their goal. Online Tools to be efficient, workload to be distributed among **administrators**[28]. **Detailed schedule** to be planned and modules that student will use should be simple and topic wise. **Graphic organizing** along with story boarding[32] to be applied for engaging purpose. Well-groomed[3] course with **gamification**[11][10] is attractive to complete sessions. Certification, perks and other rewards can create healthy competitive environment and **blended learning** is booster for that. Mobile compatibility for study materials will remove digital divide. Feedback[3] from learner and instructor, notifications regarding course details and eye catching websites is helpful for E-Learning optimization. Active mentors can energize students for reaching goals. **ISO/IEC 27001:2013** to be utilized for optimal quality communication. **SERVQUAL methodology**[21] and **Web Quality Model (WQM)** characteristics are not that efficient but combined goals are features can be adapted for improvement purpose. **Machine learning**[25] based proctored test, customized LMS and **24X7 help desk** involvement will lead to best E-Learning model establishment. OS independent LMS, progress-tracker can build a proper E-Learning Model.

V. EXPERIMENTATION & RESULT

A **literature survey** was taken using google-form where **213 responses** were captured and each individual shared only one response and all the data are kept intact for future use. None of the data were discarded for being *incomplete, vague* and *inconsistent*.

Total **22 sub criteria** and **4 main criteria** is considered[21]. There were 5 categories the sub criteria and criteria were marked. 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.*

TABLE I: 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		

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

$$CONTENT > USABILITY > DESIGN > ORGANIZATION.$$

These used data is shared in the Table I. Tables are shared respectively after applying AHP Method:

TABLE II: 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 III: 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 IV: 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 V: 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 VI: 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 case of AHP: Using the **Global weightage** which is *normalized version* of **Local Weightage** is applied to predict the importance and calculating that the ranking is provided.

TABLE VII: 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

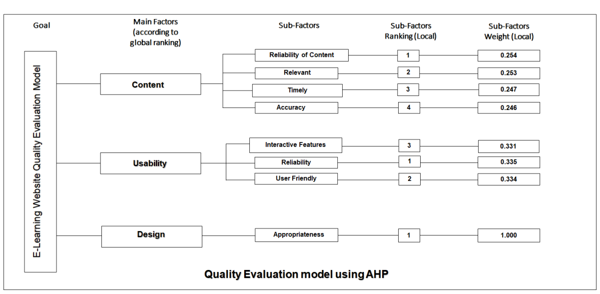

Fig. 1: Quality Evaluation Model Using AHP

Using VIKOR method: 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.

$$F_i^+ = Max(F_{ij}) \tag{1}$$

$$F_i^- = Min(F_{ij}) \tag{2}$$

Best values respectively 84, 81, 59, 38, 20 and Worst values are 43, 57, 29, 20, 7 and then Normalization of S_j and R_j to be calculated.

$$S_j = \sum \left[\frac{w_i(f_i^+ - f_{ij})}{(f_i^+ - f_{ij})} \right] \tag{3}$$

$$R_j = Max \left[\frac{w_i(f_i^+ - f_{ij})}{(f_i^+ - f_{ij})} \right] \tag{4}$$

Now once S_j and R_j is calculated then Q_j to be calculated. Q_j is for **group utility function**.

S^+ is Min(S_j), S^- is Max(S_j), R^+ is Min(R_j), R^- is Max(R_j) and $\nu = 0.5(Standard)$ and the formula for Q_j is as follows:

$$Q_j = \frac{\nu(S_j - S^+)}{(S^+ - S^-)} + (1 - \nu)\left(\frac{R_j - R^+}{R^- - R^+}\right) \tag{5}$$

Now using **equation 5** the **Ranking** will be done using **VIKOR Methodology**.The DQ value is calculated as $\left[\frac{1}{(22-1)}\right] = 0.047619048$.

TABLE VIII: 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

Besides calculation of Sub-Criteria the Main-Criteria were also ranked in a same manner.

TABLE IX: 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

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

$CONTENT > USABILITY > DESIGN > ORGANIZATION$

Using AHP-VIKOR: 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.

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

TABLE X: 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. Using those equations the value of S_j&R_j is calculated. Now using value of value of S_j&R_j value of Q_j is generated.

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

TABLE XII: 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**

Main criteria are ranked using same method.

TABLE XIII: 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

Priority Order of Main Criteria using AHP-VIKOR Method is: $CONTENT > USABILITY > DESIGN$

VI. Comparative Analysis

The overall percentage of efficiency is **3.884%** using the AHP(ideal vs. obtained).

In case of **VIKOR methodology**[9] plot showcases that the quality increased by **18.58434%**.

The AHP-VIKOR is a blended multiple criterion problem[4] which is subset of **(HMCDM o Hybrid multiple criteria decision making)**[12]. Using **AHP-VIKOR method** on the E-learning model the improvement was nearly **21.27190%**.

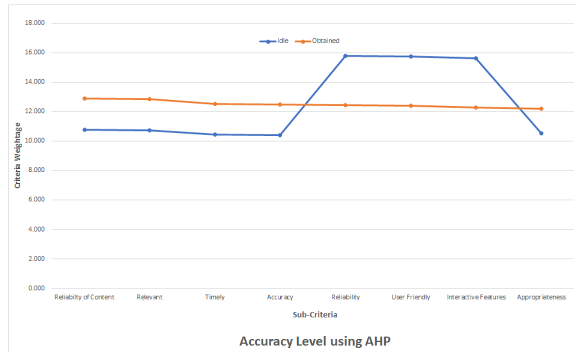

Fig. 2: Accuracy level plot using AHP Model

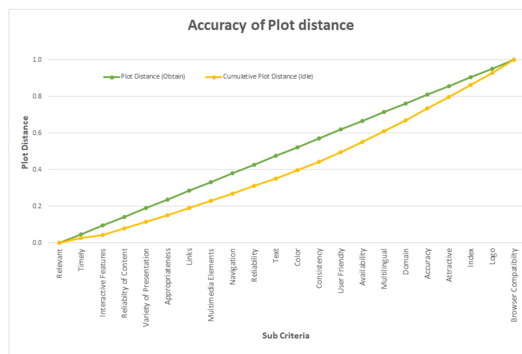

Fig. 3: Ideal vs. Obtained Accuracy Plot Distance for VIKOR Method

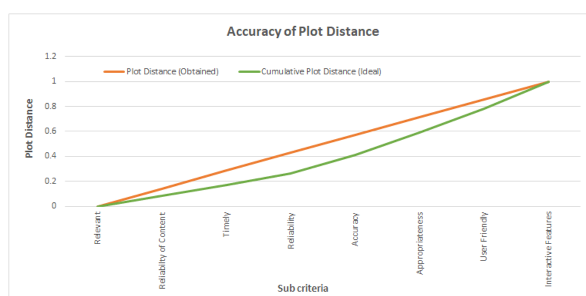

Fig. 4: Ideal vs. Obtained Accuracy Plot Distance for AHP-VIKOR Method

It is seen that using AHP method with respect to ideal data set the obtained data set shares **3.884%** more efficiency where as using

VIKOR method the same improvement is of **18.584%**. Finally using the proposed method **AHP-VIKOR methodology** the improvement was of **21.272%**. The graph is as follows.

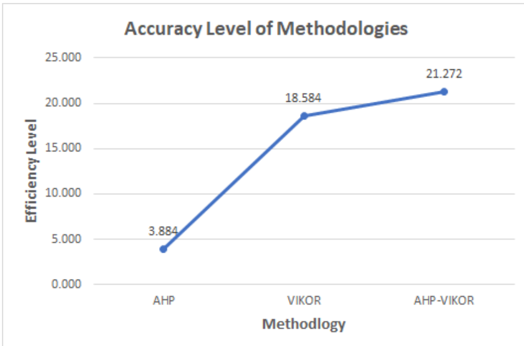

Fig. 5: Accuracy of Methodologies

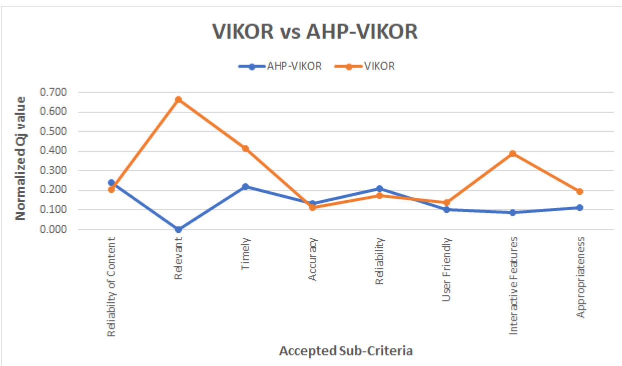

Fig. 6: Accuracy plot of VIKOR and AHP-VIKOR

While sorting *AHP* worked better but struggles while putting ranking so the AHP method is discarded and for further calculation.Only **VIKOR** and **AHP-VIKOR** is utilized.

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 **MCDM** methods the proposed MCDM method i.e **AHP-VIKOR** is the **most constructive method** implicitly with a significant efficiency value showcasing a positive result in this domain.

VII. Conclusion

MCDM) approaches are useful for taking decision in various field however these approaches were not explored for this domain very deeply. **E-learning** is a very much essential for students and instructor 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. Using MCDM approach a comparison was done and it was concluded that for this study the **AHP-VIKOR** is **29.280%** better than **VIKOR method** and it is nearly *4 times better* than **AHP method**. No work is perfect and research for optimizing all the entities, concepts and their implementation is still going on and this proposed method is improved version of so far used models but there is a room for further improvement in future as well. Limitations and future scopes are:

The literature survey was limited due to geographical outreach. The literature survey that was taken could be deemed unreliable, resulting in incorrect decision making if a specific group becomes prejudiced while submitting the survey. So it must be thoroughly scrutinized to ensure its reliability. The methodologies that are used can have better approaches in future however due to timeline constraint the most optimized algorithm which is suitable is utilized. The method AHP-VIKOR has its own drawbacks. For example AHP-VIKOR model is quite sensitive[4] to the weights assigned to the evaluation criteria.

Security level[21] is a great concern which should be explored. Like AHP-VIKOR method various other hybridized methodologies can be explored for comparative analysis and optimised result. 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. IAHP model[13] can deal with categorical inputs and outputs without any transformation so in **AHP-VIKOR** model instead of **AHP** the alternative **IAHP** can be used for hybridization. Taking the literature survey in a broader aspect will provide more efficient outcome. A world wide survey will be useful though some redundant data to be excluded which will be tedious process. Proposed AHP-VIKOR model has significant efficacy however after implementation of this in real world scenario the truthfulness of the result can be judged. There are several other methodologies[31] present but due to lack of literary support and their transparency it is beyond scope. Otherwise there might be other method that would have been more efficient than AHP-VIKOR and a complete redesigning of methodology would showcase a new E-learning model with better productivity.

Finally it can be said If all aspects are considered, the subject is enormous and the scope of the study is also extremely broad. Therefore there is a good probability that this study will be steered in a better way to develop a more optimised Web Service-based model for E-Learning.

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