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Application of Analytic Hierarchy Process in Engineering Education

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Abstract

Analytic Hierarchy Process (AHP) provides a mathematical technique to formulate a problem as a hierarchical structure and believes in an amalgamation of quantitative and qualitative criteria. It is this uniqueness of AHP that makes it one of the important inclusive systems, considered to make decisions with multiple criteria. This paper focuses on conducting Analytic Hierarchy Process, based on the data collected from several Engineering colleges in the state of Telangana. This paper aims to understand the reasons for removing the staple Engineering streams such as Mechanical engineering, Production engineering, Electronics and Instrumentation engineering and introducing new and contemporary streams such as Artificial Intelligence and Data Science, Artificial Intelligence and Machine Learning and Internet of Things**.** The World Economic Forum's latest "Future of Jobs**"** report highlights the impact of 'double disruption' of Automation, followed by COVID-19. The report indicates that while 85 million jobs will be displaced, 47% of core skills will change by 2025. The topic thus is of immense value since it looks closely at the paradigm shift mentioned above and its further consequences. The result of the present study would be helpful to indicate the exact rankings of the programming and non-programming branches in the engineering field and thus would be instrumental in gauging learners' inclination towards studying specific branches. This paper aims to analyze the growing demand of programming branches over traditional, non-programming branches.

Keywords: Analytic Hierarchy Process, Pair-wise comparison, Priority vector.
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1. Introduction

The process of choosing the optimal alternative among all potential options is classified as decision-making, however in practice, attaining an optimized result can be difficult because decision-makers are frequently challenged with diverse decision-making problems [1]. Multi-criteria decision-making (MCDM) is one of the most significant fields of decision theory, and it is used to find the optimum solution out of all the possibilities [4]. MCDM has been improved by the development of several approaches, including: Analytic Hierarchy Process (AHP) (Saaty 1980)[8]; Techniques for determining superiority and inferiority [10]; Simos' technique of ranking [6]; multi-attribute utility theory (MAUT) [3]; elimination and selection in accordance with reality [7]; For enrichment evaluations, a preference ranking organization method is used [2]; and selecting based on benefits [9]. These MCDM techniques are commonly used to help solve real-world decision-making difficulties. Saaty's (1980) AHP is a popular MCDM method that has gotten a lot of attention in the industry, including education and management. Earlier many researchers have done a good amount of work on decision making [5].

Students with technological capabilities will have excellent work possibilities in the post-COVID global economic landscape. According to the World Economic Forum, 92 per cent of firms are speeding up their digitalization efforts, with more than 90 per cent using technology such as artificial intelligence, big data analytics, and cloud computing. Students who graduate with specialized technical skills will have access to desirable job possibilities in fields such as IT, cloud services, and healthcare.

It is observed that, many Engineering colleges have dropped the non-programming branches such as Mechanical Engineering, Production Engineering, Electronics & Instrumentation Engineering etc. and these are being replaced by Computer Science Engineering-Emerging Technology courses such as Artificial Intelligence & Data Science, Artificial Intelligence & Machine Learning, Internet of Things & Cyber Security etc. The authors of the paper are motivated by this scenario to present a paper on this topic. This paper tries to prove that, Emerging Technology courses are providing more employability skills required by the students in the current scenario. With this goal, variables were selected and study was done to observe the results.

There are not too many discussions to understand this issue with the application of AHP method. In this context, the approach towards understanding the change in terms of choices of courses among engineering students, using AHP technique is not only a novel idea but also presents a vivid picture to understand the paradigm shift.

2. The Physical Importance of all Criteria

Scope of Employment (C_1):

The Emerging Technology courses have a wide scope of employability in many sectors like telecommunication, transportation, corporate sector, medical etc. These graduates progress more quickly in terms of developing the necessary abilities to obtain and

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manage a job, resulting in better chances. However, while having such abilities increases these graduates' chances of finding work, it does not guarantee it [3]. Subject-specific knowledge and abilities are essential for work. Other talents, undoubtedly, play an important role in the lives of students, assisting them in obtaining not just a job, but also a profession of their choice. Acquiring the right skills not only ensures sustenance but also promotes growth in the employment sector. Subject-related skills are those that students gain throughout their degree program, whereas transferable skills are those that people learn on the job and may be used to other occupations inside or outside of their organization, allowing them to go further in their careers [5]. Because information technology has such a strong influence on today's global marketplaces, this study focuses mostly on IT workers. IT firms are constantly developing and adopting new technology.

Employers also seek talented candidates that can adapt to today's fast-paced work environment and are eager to learn new skills. While working to improve employability, the International Labor Organization emphasized fast globalization, new working environments, and technological advancement. This will necessitate investing in their workforce's skill development and training.

The Indian economy has been moving toward digitalization since 2015, necessitating a highly qualified and capable workforce. Through numerous open online learning platforms such as MOOCS, SWAYAM, and others, where at least 350 online courses enable students to virtually attend courses taught by the best faculty, many jobs will be created in the future.

Right Employability Skills (C_2):

Computer Science and Technology is more of an applied computer science than a completely theoretical discipline. It focuses on addressing user needs in an organizational and societal environment by performing the following tasks: Selection, creation, application, integration, and administration of computing technologies.

As a result, computer graduates must have particular abilities and knowledge in order to obtain relevant positions at work; they must be able to anticipate changes in the field of technology and express the value of the same to an individual or organization. Every year, the software sector employs roughly 10 million people. In the $124–130 billion market, it contributes 67 percent. For the fiscal year 2016-17, it grew at a rate of 12- 14 percent.

Because the software business is growing, it generates strong cash flows and a high return on equity. Nonetheless, rather than adding new staff, numerous IT organizations are deploying automation to improve digitalization. Employability skills are a continuous practice that can be included into the curriculum as well as the unpredictable work environment of an organization. This emphasizes the need of having the appropriate employment skills.

Higher pay package (C_3):

Computer Science Engineering is a field that is in high demand in the industry. As a result, obtaining a professional degree or certification in Computer Science will make one a valued asset to a company, especially in the IT area. Furthermore, the pay packages in these companies are fairly high.

Wide career options and career stability (C_4):

According to data from popular study destinations,

- Computer and Information Technology (IT) occupations are expected to expand by 12% in the United States by 2028, according to the Bureau of Labor Statistics.
- By 2023, the number of Software and Application Programmers in Australia is predicted to increase from 121,300 to 146,800.
- Immigration.ca reports that "Qualified Software Engineers are being hired by Canadian employers as quickly as they become available."

Freedom to work from anywhere (C_5):

Computer science and information technology have an impact on everything from scientific research to health development, transportation, banking, and communications, among other things. Microwave ovens, refrigerators, and door locks are now all connected to our Wi-Fi networks.

Applications in all the Fields (C_6):

Artificial intelligence applications have advanced tremendously in recent years. Its applications can be found in virtually every industry.

Artificial Intelligence Applications in E-Commerce

- Personalized Purchasing
- Assistants with Artificial Intelligence
- Preventing Fraud

Applications of Artificial Intelligence in Education

- Educators will benefit from automated administrative tasks
- Creating Intelligent Content
- Virtual Assistants
- Personalized Education

Applications of Artificial Intelligence in Lifestyle

- Vehicles that drive themselves
- Filters for Spam
- Recognition of faces
- System of Recommendation

Navigation, robotics, human resources, healthcare, agriculture, gaming, automobiles, social media, marketing, chat bots, finance, and many more fields have been transformed by AI applications.

3. Significance of each Alternative

Artificial Intelligence & Data Science (AI&DS) (A_1):

The Artificial Intelligence and Data Science Program teaches students how to do intelligent data analysis, which is a critical component in many real-world applications. Data science has evolved as one of the most high-growth, dynamic, and rewarding occupations in technology during the last 10 years.

This course intends to teach not only essential technologies like artificial intelligence, data mining, and data modeling, but also advanced topics like machine learning and big data analytics. Students will gain cross-disciplinary skills in fields such as statistics, computer science, machine learning, and logic, as well as data scientists, and will have

career opportunities in healthcare, business, e-commerce, social networking companies, climatology, biotechnology, genetics, and other important fields by the end of this course. Students will learn statistical, mathematical reasoning, machine learning, knowledge discovery, and visualization abilities as part of this program.

Artificial Intelligence & Machine Learning (AI&ML) (A_2):

The student under B.Tech Artificial Intelligence and Machine Learning is required to write the code of the said machine. This code in essence works as a guiding instruction for the machine, where it can perform tasks with less human intervention.

Internet of Things/Cyber Security (IOT/CS)(A_3):

B.Tech CSE (IoT& Cyber Security including Block chain Technology), undergraduate program familiarizes students with the functional and operational aspects of IoT, Cyber Security and Block chain Technology. Cyber security is a specialist topic of Information Technology (IT) that is considered a sub-discipline of Computer Science.

Students will gain the information and abilities needed to safeguard computer operating systems, networks, and data from cyber-attacks in Cyber Security courses. Because of the rising occurrence of cybercrime, cyber security as a profession has evolved over time. Any industry that transacts online or handles sensitive data requires a Cyber Security expert to protect its data from such criminals. Because cyberspace is a global platform that anybody may access from anywhere in the world, the scope of cyber security is equally distributed.

Cyber security is a lucrative and rapidly expanding subject that focuses on safeguarding businesses from digital threats and keeping their data and networks secure. Experts in cyber security identify flaws, offer software and hardware programs to limit risks, and create rules and processes to ensure security. The demand for qualified cyber security specialists is expected to expand as more firms transfer their activities online and cyber-attacks become more common, particularly in healthcare and financial institutions. Information security analysts, for example, are expected to expand by 40% between 2020 and 2038, according to the Bureau of Labor Statistics.

Mechanical Engineering (Mech) (A_4):

Students in this program will learn how to become Mechanical Engineers. The goal of this curriculum is to prepare students to use mechanical engineering principles in the design, manufacture, and maintenance of mechanical systems.

Production Engineering (PE) (A_5):

Production engineering is a branch of engineering that is closely related to mechanical engineering. Production engineers are educated to increase the efficiency and effectiveness of manufacturing and service industries. Manufacturing technology, which is a branch of mechanical engineering, is combined with management science in production engineering. A production engineer works in a variety of industries, dealing with engineering methods and management difficulties relating to manufacturing.

Electronics and Instrumentation Engineering (A_6):

Electronics and Instrumentation Engineering is a program combining motor skills and academic skills which carve out a career in various fields of electronics, measurement, and complex process understanding.

4. Methodology

The AHP technique is broken down into the following steps.

I) Choosing criteria and structuring a decision-making problem
II) Prioritization of criteria using pair wise comparison
III) On each criterion, compare options in pairs
IV) Calculating a relative score for each option

4.1 Prioritization Methods:

There are a few methods for determining alternate priorities, like as i) Geometric Mean Method, ii) Additive Normalization Method, iii) Stochastic Vector Method are available to find the priorities of alternatives. The Geometric Mean Method (GMM) is employed in this paper.

4.1.1 Geometric Mean Method (GMM):

The weights for the criteria or alternatives are determined using this procedure. The alternate pair-wise comparison matrix is shown in Table 1. Here $K_1, K_2, \ldots\ldots, K_n$ represents the alternatives which are to be ranked and $k_{11}, k_{12}, \ldots\ldots, k_{nn}$ represents expert opinions. The Geometric Mean Method, which is used to calculate the priority weight vectors, is described below.

	K_1	K_2	……	K_n
K_1	k_{11}	k_{12}	……	k_{1n}
K_2	k_{21}	k_{22}	……	k_{2n}
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
K_n	k_{n1}	k_{n2}	……	k_{nn}

Table 1: Pair-wise comparisons

Obtain the geometric row means of each row as

$$\text{Priority vector } k_1 = (k_{11} \times k_{12} \times \ldots\ldots \times k_{1n})^{\frac{1}{n}}$$

$$\text{Priority vector } k_2 = (k_{21} \times k_{22} \times \ldots\ldots \times k_{2n})^{\frac{1}{n}}$$

$$\text{Priority vector } k_n = (k_{n1} \times k_{n2} \times \ldots\ldots \times k_{nn})^{\frac{1}{n}}$$

The normalized vector of $(k_1, k_2, \ldots\ldots, k_n)$ becomes the solution vector.

Table 2 describes AHP Measurement scale about the importance of Saaty's crisp numbers.

Intensity of importance	**Definition**	**Explanation**
1	Same importance	Two elements contribute same to the property
3	Moderate importance of one over another	Experience and judgment some favor one over the other
5	Essential or high	Experience and judgment highly favor

	importance	one over another
7	Very strong importance	An element is highly favored and its dominance is demonstrated in practice
9	Extreme importance	One of the most possible orders of affirmation is evidence favoring one element over another.
2,4,6,8	Lying between two adjacent judgments	Comprise is needed between two judgments
Reciprocals	Whenever activity i compared to j is assigned one of the above numbers, the activity j compared to i is assigned its reciprocal	
Rational	Ratios occurring from forcing consistency of judgments	

Table 2: AHP Measurement Scale

Table 3 lists the number of courses offered in selected engineering colleges.

S.No	Name of the college	TS EAMCET CODE	Number of courses	Percentage
1.	MuffakhamJah College of Engineering & Technology	MJCT	10	15
2.	CVR College of Engineering	CVRH	10	15
3.	Geetanjali College of Engineering and Technology	GCTC	9	13
4.	Guru Nanak Institute of Technology	GNIT	8	12
5.	Guru Nanak Institutions Technical Campus	GURU	9	13
6.	Methodist College of Engineering and Technology	METH	6	8
7.	Nalla Narasimha Reddy Educational Society Group of Institutions	NNRG	8	12
8.	Lords Institute of Engineering & Technology	LRDS	8	12

Table 3: Number of Courses from selected Engineering Colleges

Table 4 exhibits Program-wise intake in three consecutive academic years 2019-2020, 2020-2021 and 2021-2022.

MJCT											
	CSE	INF	ECE	CIV	MECH	PE	EEE	EIE	AI&DS	AI&ML	IOT/CS
2019-2020	120	120	120	120	120	60	60	60	0	0	---
2020-2021	120	120	120	120	120	0	60	60	60	0	---
2021-2022	120	120	120	120	120	0	60	0	60	60	---
CVRH											
2019-2020	300	240	240	120	120	---	120	60	0	0	0
2020-2021	300	240	240	60	60	---	60	60	60	60	60

2021-2022	300	240	120	60	60	---	60	60	120	120	60
GCTC											
2019-2020	240	60	240	120	120	---	120	---	0	0	0
2020-2021	240	60	240	60	60	---	60	---	60	60	120
2021-2022	240	60	240	60	60	---	60	---	60	180	120
GNIT											
2019-2020	180	60	120	120	120	---	60	---	---	0	0
2020-2021	180	60	120	120	120	---	60	---	---	60	60
2021-2022	180	60	120	120	120	---	60	---	---	60	60
GURU											
2019-2020	300	60	300	180	300	---	120	---	0	0	0
2020-2021	300	60	300	180	300	---	120	---	60	60	60
2021-2022	300	60	300	180	180	---	120	---	60	60	60
METH											
2019-2020	120	---	120	120	120	---	60	---	0	---	---
2020-2021	120	---	120	120	60	---	60	---	60	---	---
2021-2022	120	---	120	60	60	---	60	---	120	---	---
NNRG											
2019-2020	180	0	180	60	120	---	60	---	0	0	---
2020-2021	180	60	180	60	60	---	60	---	0	0	---
2021-2022	180	60	180	30	30	---	30	---	60	60	---
LRDS											
2019-2020	180	120	120	180	180	---	60	---	0	0	---
2020-2021	180	180	120	180	180	---	60	---	60	120	---
2021-2022	180	180	120	180	120	---	60	---	60	180	---

Table 4: Program-wise intake in three consecutive academic years

5. **Weight Vectors of each Criteria**

To find the weight vectors of each criterion Geometric Mean Method (GMM) has been applied. The data furnished below is fetched from inputs collected from the major stake holders like students, parents, alumni and employers. Table 5 to Table 10 shows the measurement of the weight vectors of Criteria 1 to 6. Table 11 displays the weight vectors of all Criteria and Table 12 presents average weights of each Alternative with respect to all Criteria.

	AI&DS	**AI&ML**	**IOT/CS**	**Mech**	**PE**	**EIE**	**Weight Vector**
AI&DS	1	1/2	2	3	5	7	2.1720
AI&ML	2	1	3	4	5	7	3.0717
IOT/CS	1/2	1/3	1	2	3	5	1.3076
Mech	1/3	1/4	1/2	1	2	3	0.7937
PE	1/5	1/5	1/3	1/2	1	2	0.4869
EIE	1/7	1/7	1/5	1/3	1/2	1	0.2965

Table 5: Weights of C_1 (Scope of Employment)

	AI&DS	AI&ML	IOT/CS	Mech	PE	EIE	Weight Vector
AI&DS	1	1	2	4	3	5	2.2209
AI&ML	1	1	2	3	3	4	2.0396
IOT/CS	1/2	1/2	1	2	2	2	1.1224
Mech	1/4	1/3	1/2	1	1	2	0.6609
PE	1/3	1/3	1/2	1	1	2	0.6933
EIE	1/5	1/4	1/2	1/2	1/2	1	0.4291

Table 6: Weights of C_2 (Right Employability Skills)

	AI&DS	AI&ML	IOT/CS	Mech	PE	EIE	Weight Vector
AI&DS	1	1/2	3	3	3	6	2.0800
AI&ML	2	1	2	4	5	7	2.8709
IOT/CS	1/3	1/2	1	3	3	5	1.3990
Mech	1/3	1/4	1/3	1	1	2	0.6177
PE	1/3	1/5	1/3	1	1	1/2	0.4723
EIE	1/6	1/7	1/5	1/2	2	1	0.4101

Table 7: Weights of C_3 (Higher pay package)

	AI&DS	AI&ML	IOT/CS	Mech	PE	EIE	Weight Vector
AI&DS	1	1/2	2	4	4	7	2.1955
AI&ML	2	1	3	5	5	8	3.2598
IOT/CS	1/2	1/3	1	2	2	4	1.1775
Mech	1/4	1/5	1/2	1	1	3	0.6493
PE	1/4	1/5	1/2	1	1	1/3	0.4502
EIE	1/7	1/8	1/4	1/3	3	1	0.4057

Table 8: Weights of C_4 (Wide career options and career stability)

	AI&DS	AI&ML	IOT/CS	Mech	PE	EIE	Weight Vector
AI&DS	1	1	1	5	5	7	2.3650
AI&ML	1	1	1	5	5	7	2.3650
IOT/CS	1	1	1	5	5	7	2.3650
Mech	1/5	1/5	1/5	1	1	1	0.4472
PE	1/5	1/5	1/5	1	1	1	0.4472
EIE	1/7	1/7	1/7	1	1	1	0.3779

Table 9: Weights of C_5 (Freedom to work from anywhere)

	AI&DS	AI&ML	IOT/CS	Mech	PE	EIE	Weight Vector
AI&DS	1	1	1	5	5	7	2.3650
AI&ML	1	1	1	7	7	5	2.5014

IOT/CS	1	1	1	6	6	4	2.2894
Mech	1/5	1/7	1/6	1	1	1	0.4101
PE	1/5	1/7	1/6	1	1	1	0.4101
EIE	1/7	1/5	1/4	1	1	1	0.4388

Table 10: Weights of C_6 (Applications in all the fields)

	C_1	C_2	C_3	C_4	C_5	C_6	**Priority vector**
C_1	1	2	2	1	1/2	1/3	0.9346
C_2	1/2	1	1/2	1/2	1/3	1/4	0.4673
C_3	1/2	2	1	1/2	1/3	1/4	0.5887
C_4	1	2	2	1	1/3	1/3	0.8735
C_5	2	3	3	3	1	1/2	1.7320
C_6	3	4	4	3	2	1	2.5697

Table 11: Weight Vectors of all Criteria

	C_1	C_2	C_3	C_4	C_5	C_6	**Average weight**
A_1	2.1720	2.2209	2.0800	2.1955	2.3650	2.3650	2.2307
A_2	3.0717	2.0396	2.8709	3.2598	2.3650	2.5014	2.6506
A_3	1.3076	1.1224	1.3990	1.1775	2.3650	2.2894	1.5351
A_4	0.7937	0.6609	0.6177	0.6493	0.4472	0.4101	0.5813
A_5	0.4869	0.6933	0.4723	0.4502	0.4472	0.4101	0.4859
A_6	0.2965	0.4291	0.4101	0.4057	0.3779	0.4388	0.3898

Table 12: Average weights of each Alternative with respect to all Criteria

Following are the 3-D clustered column charts representing the weights of Alternatives with respect to Criteria. Figure 1 to 6 will show the graphical representation of all the criteria i.e. criteria 1 to criteria 6.

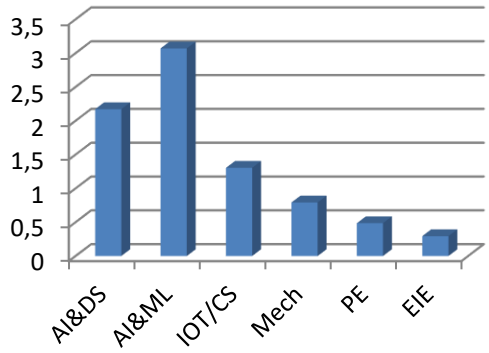

Figure 1: Weights of alternatives with respect to C_1

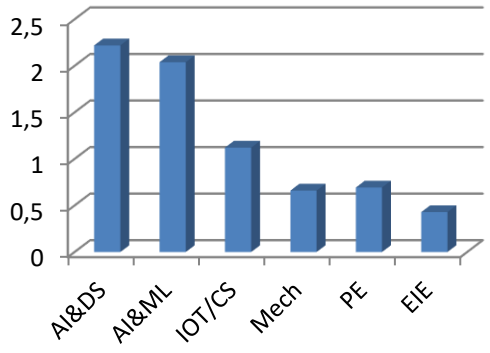

Figure 2: Weights of alternatives with respect to C_2

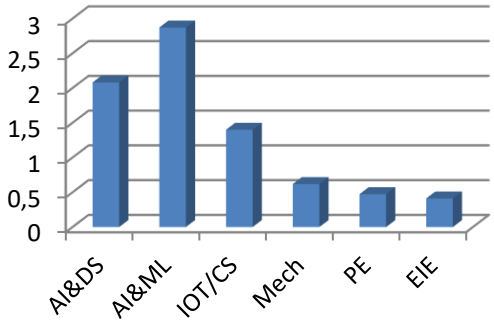

Figure 3: Weights of alternatives with respect to C_3

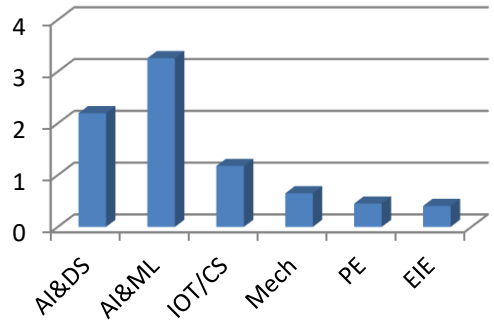

Figure 4: Weights of alternatives with respect to C_4

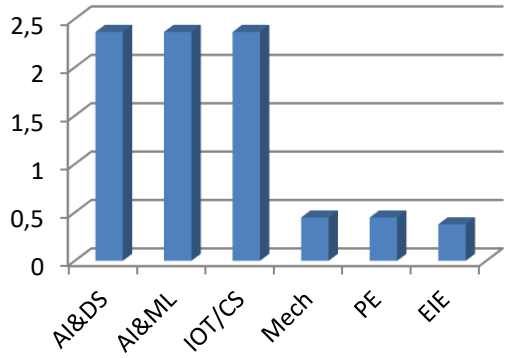

Figure 5: Weights of alternatives with respect to C_5

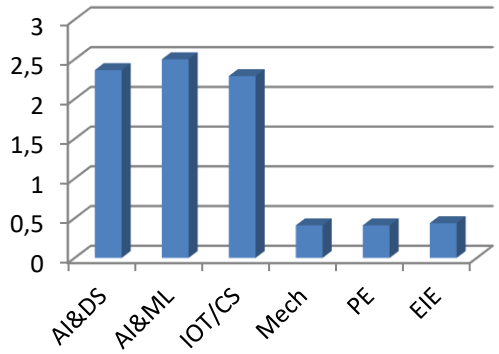

Figure 6: Weights of alternatives with respect to C_6

Table 13 indicates the ranking and weights of alternatives which is further graphically presented through bar chart(Figure 7).

S.No	Alternatives	Weights	Ranks
1	AI&DS	2.2307	2
2	AI&ML	2.6506	1
3	IOT/CS	1.5351	3
4	Mech	0.5813	4
5	PE	0.4859	5
6	EIE	0.3898	6

Table 13: Ranking and Weights of Alternatives

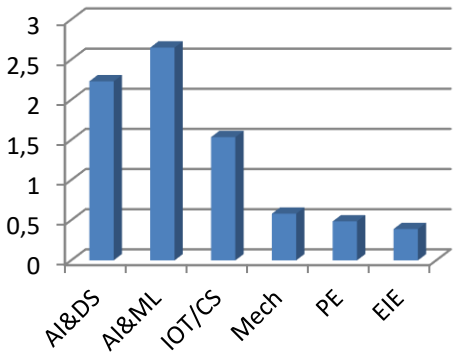

Figure 7: Ranks of Alternatives

6. Conclusions

According to the ranking of the Alternative weights, Artificial Intelligence & Machine Learning branch is the most important branch in the field of engineering education, followed by Artificial Intelligence & Data Science, Internet of Things, Mechanical Engineering, Production Engineering and finally Electronics and Instrumentation Engineering. The authors are of the opinion that the technological disruptions appear to be more powerful in the post-Covid scenario. This is one of the potential reasons behind the current change in the employment scenario, affecting the equilibrium of the workforce. The stakeholders as well as the government policy makers must be aware of the quick transition in the educational field and thus make judicious plans where the boom of a particular field does not create a vacuum or dearth of skilled labourers in another field especially in the core, non-programming branches of engineering education.

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