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Insights Into Technological Competence and Industry Relevance in Engineering Education: A Factor Analysis Approach

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Abstract:
This study aims to evaluate various aspects of technology and industry among engineering students from a prestigious Indian university. Our objective is to survey engineering students using 52 questions rated on a 5-point Likert scale, covering themes such as Technological Autonomy, Efficiency Enhancement, Technological Safety Standards, Collaborative Technology, Technological Empowerment, Surveillance Concerns, Technology Skepticism, Computer-Based Problem Solving, Advanced Tool Utilization, and Technology Adaptability, among others. Our aim is to simplify the intricate data and uncover hidden patterns through factor analysis using SPSS software. This statistical technique enabled us to identify underlying dimensions and latent factors influencing the students' responses, providing deeper insights into their perceptions and engagement with technology. By condensing the numerous variables into a smaller number of factors, we aimed to reveal non-obvious connections, and highlight the primary constructs represented by the survey items. The factor analysis process is pivotal in enhancing our understanding of the significant factors that shape the technological outlook and competencies of Indian engineering students, offering valuable perspectives on their interaction with and attitudes toward technology and industry.

Keywords: Technology Survey, Factor Analysis, SPSS, Technological Autonomy, Efficiency Enhancement, Technological Empowerment, Latent Factors.

I. INTRODUCTION

The fast development of Technology has changed and affected the context in all fields: education, industry, life, among others. Particularly, the context of learning in engineering education has changed with the introduction of new tools, methodologies, and learning environments in the process of preparing students to have the necessary skills to work. Many improvements will be gathered if there is a considerable increase in successful enhancing of curricula and support systems for learners with the way that students will use engineering learning Technologies to develop their competencies.
The first way through which the aspect of students' technological engagement can be understood is by carrying out broad surveys. Surveys capture wide aspects of factors that may influence the learning experience of students and the outcomes of the learning process. These may come under headings of factors like autonomy in technology, the impetus it gives to efficiency, levels of safety in technology, joint technology, levels of empowerment in technology, surveillance, skepticism of technology,

problem solving with the help of technology, use of advanced tools, adaptability toward technology, likeness toward technology, technology use learning, technical problem use at hand, personal discovery, courses available online, books and e-books, video tutorials and webinars, websites and mobile apps, online forums and communities, technology blogs and podcasts, courses and workshops in universities available online, coding boot camps, version control cut-edge development, community engagement, contribution into open source, virtualization familiarity, programming competitions, internship experiences, technology competence, problem-solving skills, teamwork and collaboration, communication skills, flexibility, openness, ethics in technology, start-up skills, project management skills, continuous learning, global orientation, technology consultancy, awareness of and access to technology, awareness of new tools and technologies, technology proficiency, access to tools and technology, technical support, early adoption, technology relevance, technology enrichment, technology assimilation, technology mastery, technical expertise, and scalable.

This paper is based on a survey of 600 undergraduate engineering students at India's top university, with the objective of assessing their involvements and industry-related competencies in technology. The questionnaire requested 52 questions targeted at a large area of themes that technological learning and professional development are concerned with, all in a 5-point Likert scale. The complex data is analyzed using SPSS software, which brings forth the underlying patterns by implementing factor analysis. Factor analysis is a statistical technique revealing the structure inherent in the data, summarizing it by reducing the number of its variables to a smaller number of factors (Costello & Osborne, 2005). This will give us the leeway to study the relationship among survey items and identify the dimensions represented in the survey.

Factor analysis is well established in the application of educational research, as it gives the appropriate framework of robustness to multifaceted phenoma, including student engagement and learning outcomes. In the current analysis exercise, we apply this technique in an effort to pry out the latent factors influencing technological engagement and competencies of engineering students. These findings will inform educators, policymakers, and stakeholders on critical areas to focus on in the enhancement of engineering education.

Factor analysis has been proven useful in different dimensions of the education environment by previous researchers. For instance, Shrestha et al. (2019) have effectively used factor analysis to establish the factors affecting student engagement in online learning. This will, therefore, imply the need to establish underlying dimensions that will contribute to better learning experiences. Similarly, Alavi et al (2002) applied factor analysis to explicate the impacts of different pedagogies on students to provide helpful information on pedagogies' configuration that could better achieve effective results. Factor analysis in our study provided seventeen distinct factors that characterize the technological engagement of the engineering students. These are: Responsible Technological Utilization, Innovative Problem Solving, Collaborative Learning and Integration, Practical Technological Application, Global Technological Empowerment, Technical Learning Adaptability, Professional Technological Competency, Innovative Community Engagement, Competent Technological Realism, Efficient Entrepreneurialism, Ongoing Collaboration, Knowledge of Adaptive Technology, Competitive Technological Support, Integrated Technological Mastery, Project Management, Secure Technology Management, and Critical Technological Insight. All of these are parts of technological engagement, so the entire concept of engineering education can be considered highly complex and broad.

With the awareness of these factors, education policies can be designed to develop full-fledged technological abilities among engineering students. The study contributes to the growing body of knowledge in technology-enhanced learning and provides practicable recommendations for developing engineering education in a fast-technological-change context.

We used SPSS software to perform factor analysis on the survey data. We were able to simplify the intricate information and find hidden patterns thanks to this statistical technique, which made it possible to do a more thorough and targeted study. We were able to discover the underlying dimensions reflected in the data and investigate the complex relationships between the different survey items thanks to the factor analysis process. By doing this, we were able to identify underlying variables that affect the students' answers to various topics.

Specifically, factor analysis helped us to:

1. Simplify Complex Data: We were able to manage and comprehend the data more effectively by condensing the numerous variables into a smaller number of elements.
2. Expose Hidden Patterns: By highlighting connections and patterns that were not immediately obvious, the technique offered fresh perspectives on how the students felt about technology and the business world.
3. Determine Underlying Dimensions: We could ascertain the primary dimensions or constructs that the survey items collectively represented by separating out the principal components. This aided in comprehending the more general issues that the students' answers encompassed.
4. Identify Latent Factors: By using factor analysis, we were able to identify the underlying variables that underlie the observed variables, or latent factors. These elements contributed to a better comprehension of the main areas influencing students' use of and engagement with technology.

In general, the utilisation of factor analysis played a pivotal role in honing our comprehension of the survey outcomes and pinpointing the noteworthy elements that mould the technical outlooks and proficiencies of Indian engineering students.

II. RELATED WORKS

It is an area under extensive investigation exploring the integration of technology into engineering education. There has been abundant research focusing on technological engagement and skills development, and more recently, on pedagogical strategies. This section lays out key studies that inform the context and methodology of our own research.

Various studies have focused on factors that are influential in students' engagement with technology. For instance, Shrestha et al. (2019) looked at the factors that would affect e-learning engagement among students. Theirs was able to recognize some critical elements, which include instructional design and learner characteristics, that positively affect engagement with high e-learning environments. This research underscores the fact that a well-designed frame of instruction will foster student engagement.Alavi, et al. (2002), on the other hand, conducted a study on information technology and management education. They found that the applications of technology in educational environments improve learning and, by extension, the value of education. They mentioned that technology gives great support in developing interactive learning and in demonstrating better student performance.

The students of engineering must, however, be equipped with technological skills, which can meet the needs of the modern workplace. By applying multivariate statistics in social sciences, Stevens (2009) provided excellent understanding of the way factor analysis, as a statistical tool, could be used for the analysis of educational data to find out the trends of development. The paper helps the application of more sophisticated statistical analysis in order to determine the latent factors that contribute to students' technological skills. Field (2013) laid out a very detailed guide of the IBM SPSS software that included a step-by-step analysis based on this software: critical for carrying out a robust factor analysis. This work is critical in giving the practical techniques in data analysis necessary in the interpretation of complex data sets in education and policy for meaningful quality improvement in developing the right skills necessary for workforce preparation.

This basis of effective pedagogic strategies brings in technology to put in place learning outcomes. The idea that statistical tools in educational research can possibly inform pedagogic decisions and thereby aid in the improvement of methodologies in teaching is seen through the use of SPSS for the analysis of data in this educational research by Pallant (2020). His work focuses on the indispensability of a data-informed approach in order to serve practices of education better. The literature has similarly pointed out the role of technology in supporting collaborative learning. In this regard, Johnson and Johnson (2009) claimed the following: cooperative learning coupled with technology as an agent for teamwork and collaboration has advantages. Their research further indicated that technology-supported collaborative learning environments result in both improved academic performance higher student satisfaction.

In order to cope with fast progressions in technology, an engineering student needs to be continuously learning and adaptable. From another perspective, Mezirow (2000) introduced the concept of transformative learning, such that it refers to "critical reflection" and continuous alteration in accordance with emerging information and new experience. This theoretical foundation to the already established importance of technology in enhancing continuous learning and adaptability among students.

Furthermore, he discusses the notion of lifelong learning highlighted by Aspin and Chapman (2000), which says that there is still a need to continue learning within a society that is knowledge-based. He said that technology plays the role of an essential enabler that allows the individual to continue learning in a knowledge-based society where knowledge keeps evolving through technological change.

The literature highlights the pluralistic roles which technology plays in augmenting engineering education. Technology is an ever important ingredient in engaged students' building, skills development, collaborative learning, and continuous adaptation to learning practices. This research extends the argument a little further with insights into factors that greatly influence the engagement of engineering students with technology by using the factor analysis approach. The findings are aimed at eliciting actionable recommendations for educators and policymakers in the design of an effective curriculum and support system that makes maximum use of the potential presented by the application of technology.

III. METHEDOLGY

We conducted a comprehensive survey involving 600 engineering students from a prestigious Indian university to assess various aspects of technology and industry. The survey included 52 questions, each rated on a 5-point Likert scale, encompassing themes such as Technological Autonomy, Efficiency Enhancement, Technological Safety Standards, Collaborative Technology, Technological Empowerment, Surveillance Concerns, Technology Skepticism, Computer-Based Problem Solving, Advanced Tool Utilization, Technology Adaptability, Technology Preference, Applied Technology Learning, Technical Troubleshooting, Independent Exploration, Online Courses, Books and E-books, Video Tutorials and Webinars, Websites and Apps, Online Forums and Communities, Tech Blogs and Podcasts, University Courses and Workshops, Coding Bootcamps, Version Control, Cutting-Edge Development, Community Engagement, Open Source Contribution, Virtualization Familiarity, Programming Competitions, Internships, Tech Competence, Problem-Solving Skills, Teamwork and Collaboration, Communication Skills, Adaptability and Flexibility, Ethical Awareness, Startup Skills, Project Management Skills, Continuous Learning, Global Perspective, Technology Consultancy, Technological Awareness, Awareness of New Tools and Technology, Technology Proficiency, Technology Accessibility, Technical Assistance, Early Adoption, Technological Relevance, Technology Enrichment, Technology Integration, Technology Mastery, Technical Proficiency, and Scalable Solutions.

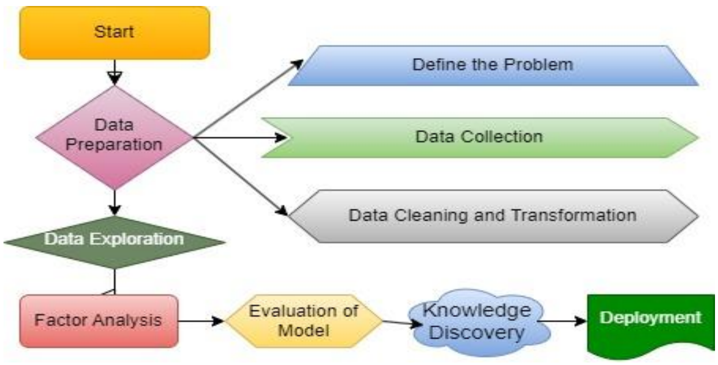

Fig:01 Methodology

Most of the central steps that the methodology guided in this research comprise survey design, collection of data, cleaning and transformation of data, the exploration of data, factor analysis, evaluation of the model, and knowledge discovery. The explanations given below salvage more meaning from each step so as to present the research in a better manner.

1. Survey Design

An online questionnaire was developed using Google Forms to collect data on technological engagement patterns among engineering students. The questionnaire was a sum of 52 items, all designed with a 5-point Likert scale, targeting variables that capture trends in effects related to technological education and professional issues. Variables included but were not limited to technological autonomy, efficiency enhancement, technological safety standards, collaborative technology, technological empowerment, and many others covering the theme of technological engagement.

Survey was conducted on 600 students of an elite engineering institute in India. The survey target population reflects the criteria to have a representation of the students at different levels of exposure and usage of technology. The survey is online and runs for a month.

2. Data Cleaning and Transformation

At the end of data collection, the data set was entered into SPSS software, which was intended for data cleaning and transformation purposes. First, missing values and outliers were checked: any incomplete or inconsistent responses were removed to ensure the integrity of the dataset.

Later on, the responses provided were transformed into numerical values to help in further analysis. Strongly Disagree was denoted as 1, Disagree as 2, Neutral as 3, Agree as 4, and Strongly Agree as 5. These numerical values transformed the variables into numbers that could be analyzed further with some statistical techniques.

3. Exploratory Data Analysis:

The data set was explored and summarized using descriptive statistics. The computed measures of the survey items include the mean, median, mode, standard deviation and frequency distributions. This analysis has provided a few insights into central tendencies and variability of responses, pointing to a number of trends and patterns of note.

4 Factor Analysis

To expose the dimensions lying behind the technology engagements, factor analysis was done using SPSS. Factor analysis is a statistical technique for finding underlying latent variables that explain patterns of correlations between observed variables. The steps followed were as under:

•Extraction Method: The technique for extraction of factor or principal component used was Principal Component Analysis (PCA).

•Rotation Method: Rotations were made using the Varimax process aimed at making the percentage structure simpler and easier to understand, and bear.

The criteria applied in the extraction of factors included factors with eigenvalues of more than 1 and those which had factor loadings of above 0.4 so that only factors of importance adding variance to the data set were considered to be meaningful.

5. Model Fit

The model was evaluated for the explained variance and the factors' interpretability. This done by determining if the data were suitable for factor analysis using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. If the KMO>0.6, and Bartlett's test is significant, $p < 0.05$, the researcher was allowed to proceed with the factor analysis.

6. Knowledge Discovery & Deployment

This was the phase that involved data discovery and deployment. The factors that have been determined were then tested and labeled with their contributions to meaningful interpretations. The factors were then grouped into thematic groups with actualization and use.

The factor analysis obtained was subjected to key educational strategies and policies. The latent factors intricately described the dimensions of technological engagement on the part of the engineering students. These would be a valuable guide to developing suitable intervention and support systems in a targeted manner to improve the technological competencies in engineering education.

This carefully details an approach that strengthens the scaffold for the scrutiny of technological engagement among engineering students based on their survey data. The study, therefore, results in the generation of very stable findings on the underlying factors governing students' technology engagement because of the use of rigorous data cleaning techniques, data transformation, and advanced statistical methods. The findings will thus be of wide applicability to the field of education research, where the gained knowledge can be applied in supporting the development of relevant, effective strategies, and policy formulation.

IV. RESULT AND DISCUSSION

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
Technological Autonomy	3.15	1.416	595
Efficiency Enhancement	3.19	1.429	595
Technological Safety Standards	3.19	1.408	595
Collaborative Technology	3.11	1.398	595
Technological Empowerment	3.22	1.434	595
Surveillance Concerns	3.18	1.371	595
"Technology Skepticism"	3.11	1.393	595
"Computer-Based Problem Solving"	3.26	1.400	595
Advanced Tool Utilization	3.20	1.420	595
"Technology Adaptability"	3.11	1.369	595
"Technology Preference"	3.19	1.372	595
"Applied Technology Learning"	3.13	1.408	595
"Technical Troubleshooting"	3.27	1.367	595
"Independent Exploration"	3.16	1.382	595
ONLINE COURSES	3.17	1.406	595
BOOKS AND E BOOKS	3.23	1.337	595
VIDEO TUT AND WEBINARS	3.24	1.397	595
WEBSITES AND APPS	3.18	1.417	595
ONLINE FORUMS AND COMMUNITIES	3.12	1.408	595
TECH BLOGS AND PODCAST	3.13	1.394	595
UNIVERSITY COURSES AND WORKSHOPS	3.05	1.373	595
CODING BOOTCAMPS	3.19	1.420	595
VERSION CONTROL	3.19	1.339	595
"Cutting-edge Development"	3.25	1.365	595
"Community Engagement"	3.19	1.384	595
"Open Source Contribution"	3.14	1.402	595
"Virtualization Familiarity"	3.04	1.351	595
"Programming Competitions"	3.18	1.382	595
INTERNSHIPS	3.12	1.407	595

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
TECH COMPETENCE	3.34	1.376	595
PROBLEM SOLVING SKILLS	3.21	1.411	595
Teamwork and Collaboration	3.19	1.421	595
Communication Skills	3.25	1.346	595
Adaptability and Flexibility	3.24	1.393	595
ETHICAL AWARENESS	3.14	1.410	595
STARTUP SKILLS	3.17	1.425	595
PROJECT MANAGEMENT SKILLS	3.18	1.397	595
CONTINOUS LEARNING	3.12	1.393	595
GLOBAL PERSPECTIVE	3.19	1.415	595
"Technology Consultancy"	3.13	1.330	595
"Technological Awareness"	3.19	1.374	595
AWARENESS OF NEW TOOLS AND TECH	3.24	1.388	595
"Technology Proficiency"	3.14	1.390	595
Technology Accessibility	3.11	1.368	595
"Technical Assistance	3.20	1.374	595
Early Adoption	3.08	1.381	595
Technological Relevance	3.36	1.393	595
Technology Enrichment	3.21	1.412	595
Technology Integration	3.20	1.422	595
Technology Mastery	3.29	1.365	595
Technical Proficiency	3.26	1.401	595
Scalable Solutions	3.17	1.426	595

Fig:02 Descriptive Statistics

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KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.547
Bartlett's Test of Sphericity	Approx. Chi-Square	65804.664
	df	1326
	Sig.	.000

Fig:03 Kaiser–Meyer–Olkin (KMO) test

1. Utilising the Kaiser–Meyer–Olkin (KMO) test, one may assess the statistical appropriateness of data for factor analysis. The test assesses how well each variable and the entire model are sampled. Values between 0 and 1 are returned by KMO. a general guideline for understanding the data. Insufficient sampling is indicated by KMO values less than 0.5. The KMO value in our finding is 0.547, indicating that the sample size is both sufficient and of high quality.
2. The idea that the correlation matrix is an identity matrix is tested in Bartellets test. A matrix that has every diagonal element set to 1 and every diagonal element set to 0 is called an identity matrix. We may reject the null hypothesis since our significant statistical test p value, which is less than 0.05, indicates that the correlation matrix is not an identity matrix.

Communalities|

	Initial	Extraction
Technological Autonomy	1.000	.969
Efficiency Enhancement	1.000	.977
Technological Safety Standards	1.000	.976
Collaborative Technology	1.000	.971
Technological Empowerment	1.000	.977
Surveillance Concerns	1.000	.952
"Technology Skepticism"	1.000	.945
"Computer-Based Problem Solving"	1.000	.978
Advanced Tool Utilization	1.000	.979
"Technology Adaptability"	1.000	.977
"Technology Preference"	1.000	.975
"Applied Technology Learning"	1.000	.984
"Technical Troubleshooting"	1.000	.961
"Independent Exploration"	1.000	.976
ONLINE COURSES	1.000	.977
BOOKS AND E BOOKS	1.000	.963
VIDEO TUT AND WEBINARS	1.000	.971
WEBSITES AND APPS	1.000	.985
ONLINE FORUMS AND COMMUNITIES	1.000	.971
TECH BLOGS AND PODCAST	1.000	.955
UNIVERSITY COURSES AND WORKSHOPS	1.000	.964
CODING BOOTCAMPS	1.000	.975
VERSION CONTROL	1.000	.976
"Cutting-edge Development"	1.000	.955
"Community Engagement"	1.000	.968
"Open Source Contribution"	1.000	.977
"Virtualization Familiarity"	1.000	.958
"Programming Competitions"	1.000	.972
INTERNSHIPS	1.000	.982

Communalities

	Initial	Extraction
TECH COMPETENCE	1.000	.985
PROBLEM SOLVING SKILLS	1.000	.990
Teamwork and Collaboration	1.000	.982
Communication Skills	1.000	.964
Adaptability and Flexibility	1.000	.974
ETHICAL AWARENESS	1.000	.972
STARTUP SKILLS	1.000	.982
PROJECT MANAGEMENT SKILLS	1.000	.966
CONTINOUS LEARNING	1.000	.979
GLOBAL PERSPECTIVE	1.000	.979
"Technology Consultancy"	1.000	.953
"Technological Awareness"	1.000	.965
AWARENESS OF NEW TOOLS AND TECH	1.000	.983
"Technology Proficiency"	1.000	.977
Technology Accessibility	1.000	.972
"Technical Assistance	1.000	.972
Early Adoption	1.000	.975
Technological Relevance	1.000	.978
Technology Enrichment	1.000	.982
Technology Integration	1.000	.981
Technology Mastery	1.000	.975
Technical Proficiency	1.000	.979
Scalable Solutions	1.000	.971

Extraction Method: Principal Component Analysis.

Fig:04 Communalities

3. Communalities: The percentage of each variable's variance that the components (e.g., the underlying latent continuum) can account for. It can be defined as the total squared factor loadings for the variables and is also denoted as h2. Our results' communality values are approaching more than0.5, thus each one can be taken into consideration for additional research. There is no need to eliminate any variable from further component analysis processes and the extracted factors have taken these variables into account.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared ..	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	7.530	14.480	14.480	7.530	14.480
2	3.664	7.046	21.526	3.664	7.046
3	3.333	6.410	27.936	3.333	6.410
4	3.237	6.225	34.161	3.237	6.225
5	3.105	5.971	40.132	3.105	5.971
6	2.989	5.748	45.881	2.989	5.748
7	2.924	5.623	51.504	2.924	5.623
8	2.762	5.311	56.815	2.762	5.311
9	2.700	5.192	62.006	2.700	5.192
10	2.567	4.936	66.942	2.567	4.936
11	2.456	4.724	71.666	2.456	4.724
12	2.387	4.591	76.257	2.387	4.591
13	2.369	4.555	80.812	2.369	4.555
14	2.272	4.369	85.181	2.272	4.369
15	2.195	4.221	89.401	2.195	4.221
16	2.082	4.004	93.405	2.082	4.004
17	2.009	3.864	97.269	2.009	3.864
18	.218	.420	97.689		
19	.148	.285	97.974		
20	.122	.234	98.209		
21	.105	.202	98.410		
22	.082	.157	98.567		
23	.073	.140	98.707		
24	.070	.135	98.842		
25	.059	.113	98.955		
26	.053	.101	99.056		
27	.047	.090	99.146		
28	.044	.085	99.230		
29	.039	.075	99.305		
30	.036	.069	99.375		
31	.034	.066	99.440		
32	.029	.057	99.497		
33	.027	.052	99.549		
34	.026	.050	99.599		
35	.026	.049	99.648		
36	.022	.043	99.691		
37	.020	.038	99.730		

Fig:05 Total variation Explained-01

Total Variance Explained

Component	Extraction Sums ...	Rotation Sums of Squared Loadings		
	Cumulative %	Total	% of Variance	Cumulative %
1	14.480	3.924	7.545	7.545
2	21.526	2.954	5.681	13.226
3	27.936	2.942	5.657	18.883
4	34.161	2.940	5.653	24.537
5	40.132	2.935	5.644	30.181
6	45.881	2.932	5.638	35.818
7	51.504	2.926	5.628	41.446
8	56.815	2.924	5.624	47.069
9	62.006	2.923	5.621	52.690
10	66.942	2.920	5.616	58.306
11	71.666	2.919	5.614	63.920
12	76.257	2.912	5.601	69.521
13	80.812	2.904	5.585	75.106
14	85.181	2.903	5.583	80.689
15	89.401	2.895	5.568	86.257
16	93.405	2.879	5.536	91.793
17	97.269	2.848	5.476	97.269

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared ..	
	Total	% of Variance	Cumulative %	Total	% of Variance
38	.017	.034	99.763		
39	.016	.030	99.793		
40	.014	.028	99.821		
41	.014	.027	99.848		
42	.014	.026	99.874		
43	.012	.022	99.896		
44	.011	.021	99.917		
45	.008	.016	99.933		
46	.007	.013	99.945		
47	.006	.012	99.957		
48	.006	.011	99.968		
49	.005	.010	99.979		
50	.005	.010	99.988		
51	.004	.007	99.996		
52	.002	.004	100.000		

Fig:06 Total variation Explained-02

4. Total variation Explained: The number of retrieved components whose sum should equal the number of items undergoing factor analysis is actually reflected in the eigenvalue. The eigenvalues of every factor that can be extracted from the analysis are displayed in the next item. There are three subsections in the Eigenvalue table. Eigen values at first, extracted sums of squared loadings, and sums of squared loadings rotated.

   The existence of eigenvalues greater than one is necessary to determine the number of components or factors indicated by the variables that have been chosen. According to our research, 17 components have eigenvalues greater than 1.
   Cumulative%: The cumulative percentage of variance explained by the current and all previous factors is shown in this column. It is evident from the given output that the first 17 factors together account for almost 97% of the variance in total.

   Extraction Sums of Squared Loadings: The number of rows in this table panel represents the number of factors that were kept in the extraction sums of squared loadings. There are 17 rows, one for each of the 17 characteristics that we recommend being kept in this research.
   Rotation Sums of Squared Loadings: The distribution of variance following the varimax rotation is shown by the values in this table panel. Varimax rotation redistributes the total amount of variance accounted for over the 17 extracted elements in an attempt to maximise the variance of each factor.

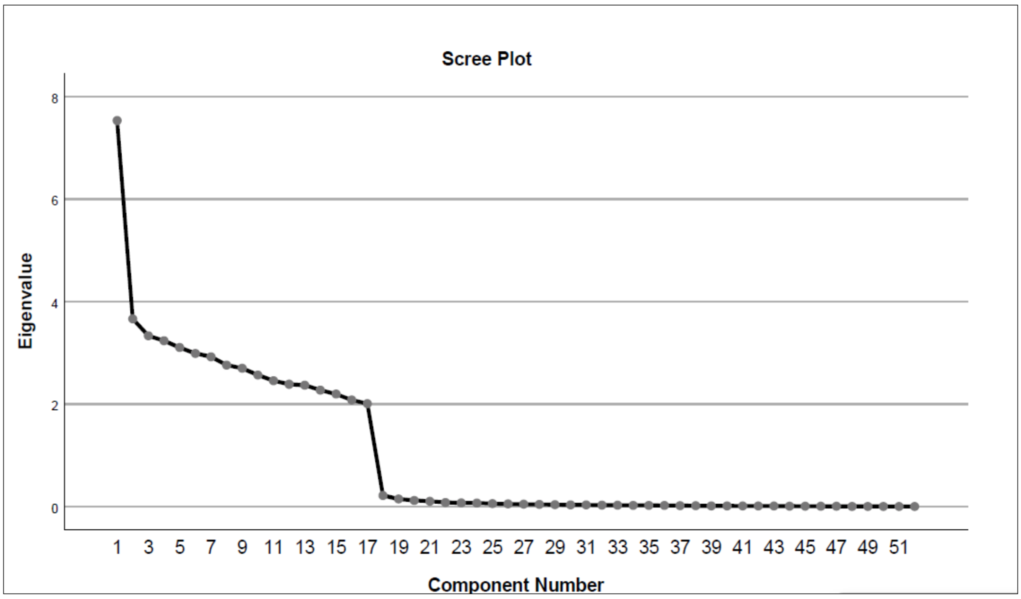

Fig:07 scree plot

5. A graph of the eigenvalues versus each factor is called a scree plot. The graph helps in figuring out how many components to keep. The point at which the curve begins to flatten is the relevant point. The curve is shown to start flattening between factors 15 and 17. Additionally, take note that only 17 factors have been kept because factor 17 and beyond have eigenvalues smaller than 1.

Rotated Component Matrix[a]

	Component 1	2	3	4	5	6
WEBSITES AND APPS	.978					
ETHICAL AWARENESS	.976					
Technological Autonomy	.975					
Scalable Solutions	.972					
PROBLEM SOLVING SKILLS		.978				
"Independent Exploration"		.977				
Technology Enrichment		.976				
ONLINE COURSES			.974			
Teamwork and Collaboration			.970			
Technology Integration			.969			
Early Adoption				.978		
"Applied Technology Learning"				.974		
INTERNSHIPS				.974		
GLOBAL PERSPECTIVE					.979	
CODING BOOTCAMPS					.978	
Technological Empowerment					.976	
"Technology Proficiency"						.979
"Open Source Contribution"						.977
Advanced Tool Utilization						.968
Adaptability and Flexibility						
Technical Proficiency						
VIDEO TUT AND WEBINARS						
AWARENESS OF NEW TOOLS AND TECH						
"Community Engagement"						
"Computer-Based Problem Solving"						
TECH COMPETENCE						
"Technical Troubleshooting"						
Technological Relevance						
ONLINE FORUMS AND COMMUNITIES						

Rotated Component Matrix[a]

	Component 7	8	9	10	11	12
WEBSITES AND APPS						
ETHICAL AWARENESS						
Technological Autonomy						
Scalable Solutions						
PROBLEM SOLVING SKILLS						
"Independent Exploration"						
Technology Enrichment						
ONLINE COURSES						
Teamwork and Collaboration						
Technology Integration						
Early Adoption						
"Applied Technology Learning"						
INTERNSHIPS						
GLOBAL PERSPECTIVE						
CODING BOOTCAMPS						
Technological Empowerment						
"Technology Proficiency"						
"Open Source Contribution"						
Advanced Tool Utilization						
Adaptability and Flexibility	.969					
Technical Proficiency	.969					
VIDEO TUT AND WEBINARS	.968					
AWARENESS OF NEW TOOLS AND TECH		.979				
"Community Engagement"		.978				
"Computer-Based Problem Solving"		.973				
TECH COMPETENCE			.978			
"Technical Troubleshooting"			.975			
Technological Relevance			.973			
ONLINE FORUMS AND COMMUNITIES				.971		

Fig:08 Rotated Component Matrix-01

Rotated Component Matrix[a]

	Component				
	13	14	15	16	17
WEBSITES AND APPS					
ETHICAL AWARENESS					
Technological Autonomy					
Scalable Solutions					
PROBLEM SOLVING SKILLS					
"Independent Exploration"					
Technology Enrichment					
ONLINE COURSES					
Teamwork and Collaboration					
Technology Integration					
Early Adoption					
"Applied Technology Learning"					
INTERNSHIPS					
GLOBAL PERSPECTIVE					
CODING BOOTCAMPS					
Technological Empowerment					
"Technology Proficiency"					
"Open Source Contribution"					
Advanced Tool Utilization					
Adaptability and Flexibility					
Technical Proficiency					
VIDEO TUT AND WEBINARS					
AWARENESS OF NEW TOOLS AND TECH					
"Community Engagement"					
"Computer-Based Problem Solving"					
TECH COMPETENCE					
"Technical Troubleshooting"					
Technological Relevance					
ONLINE FORUMS AND COMMUNITIES					

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
STARTUP SKILLS						
Efficiency Enhancement						
"Programming Competitions"						
"Technology Preference"						
"Technical Assistance						
UNIVERSITY COURSES AND WORKSHOPS						
CONTINOUS LEARNING						
Collaborative Technology						
"Virtualization Familiarity"						
"Technology Adaptability"						
Technology Accessibility						
BOOKS AND E BOOKS						
Technology Mastery						
Communication Skills						
Technological Safety Standards						
TECH BLOGS AND PODCAST						
PROJECT MANAGEMENT SKILLS						
VERSION CONTROL						
"Technology Consultancy"						
Surveillance Concerns						
"Technological Awareness"						
"Technology Skepticism"						
"Cutting-edge Development"						

Fig:09 Rotated Component Matrix-02

Rotated Component Matrix[a]

	Component					
	7	8	9	10	11	12
STARTUP SKILLS				.967		
Efficiency Enhancement				.962		
"Programming Competitions"					.974	
"Technology Preference"					.974	
"Technical Assistance					.971	
UNIVERSITY COURSES AND WORKSHOPS						.973
CONTINOUS LEARNING						.969
Collaborative Technology						.967
"Virtualization Familiarity"						
"Technology Adaptability"						
Technology Accessibility						
BOOKS AND E BOOKS						
Technology Mastery						
Communication Skills						
Technological Safety Standards						
TECH BLOGS AND PODCAST						
PROJECT MANAGEMENT SKILLS						
VERSION CONTROL						
"Technology Consultancy"						
Surveillance Concerns						
"Technological Awareness"						
"Technology Skepticism"						
"Cutting-edge Development"						

Fig:10 Rotated Factor Matrix

Rotated Factor Matrix: This table shows the rotated factor loadings, which show the association between the variables and the factor as well as the weights assigned to each variable for each factor.

1. From our research findings, Factor 1 includes the components: Websites and Apps, Ethical Awareness, Technological Autonomy, and Scalable Solutions. We have named this factor "Responsible Technological Utilization." This factor highlights the critical balance between practical technology use and ethical considerations, emphasizing autonomous engagement with technology and the implementation of scalable, ethically responsible solutions.
2. From our research findings, Factor 2 includes the components: Problem Solving Skills, Independent Exploration, and Technology Enrichment. We have named this factor "Innovative Problem Solving." This factor emphasizes the importance of developing strong problem-solving abilities, fostering independent exploration of technology, and enriching technological knowledge to drive innovation and effective solutions.
3. From our research findings, Factor 3 includes the components: Online Courses, Teamwork and Collaboration, and Technology Integration. We have named this factor "Collaborative Learning and Integration." This factor underscores the significance of collaborative efforts in learning environments, particularly through online courses, and highlights the seamless integration of technology to enhance teamwork and collective problem-solving skills.
4. From our research findings, Factor 4 includes the components: Early Adoption, Applied Technology Learning, and Internships. We have named this factor "Practical Technological Advancement." This factor emphasizes the importance of early adoption of new technologies, hands-on learning through practical applications, and gaining real-world experience through internships to advance technological skills and knowledge.
5. From our research findings, Factor 5 includes the components: Global Perspective, Coding Bootcamps, and Technological Empowerment. We have named this factor "Global Technological

Empowerment." This factor highlights the significance of cultivating a global outlook, enhancing coding skills through intensive bootcamps, and fostering technological empowerment to equip individuals with the skills and confidence needed to thrive in a global tech landscape.

6. From our research findings, Factor 7 includes the components: Technology Proficiency, OpenSource Contribution, and Advanced Tool Utilization. We have named this factor "Expert Technological Proficiency." This factor emphasizes the importance of developing advanced skills in technology, actively contributing to open source projects, and proficiently utilizing sophisticated tools to achieve high levels of technological expertise.
7. From our research findings, Factor 7 includes the components: Adaptability and Flexibility, Technical Proficiency, and Video Tutorials and Webinars. We have named this factor "Adaptive Technical Learning." This factor highlights the importance of being adaptable and flexible in the ever-evolving tech landscape, achieving high levels of technical proficiency, and utilizing video tutorials and webinars for continuous learning and skill enhancement.
8. From our research findings, Factor 8 includes the components: Awareness of New Tools and Technology, Community Engagement, and Computer-Based Problem Solving. We have named this factor "Innovative Community Engagement." This factor underscores the significance of staying updated with new tools and technologies, actively engaging with the community, and leveraging computer-based problem-solving techniques to drive innovation and collaborative progress.
9. From our research findings, Factor 9 includes the components: Tech Competence, Technical Troubleshooting, and Technological Relevance. We have named this factor "Competent Technological Relevance." This factor emphasizes the importance of maintaining high technical competence, effectively troubleshooting technical issues, and ensuring technological practices remain relevant and up-to-date in a rapidly evolving landscape.
10. From our research findings, Factor 10 includes the components: Online Forums and Communities, Startup Skills, and Efficiency Enhancement. We have named this factor "Entrepreneurial Efficiency." This factor highlights the role of engaging with online forums and communities, developing startup skills, and focusing on enhancing efficiency to drive entrepreneurial success and innovative solutions.
11. From our research findings, Factor 12 includes the components: University Courses and Workshops, Continuous Learning, and Collaborative Technology. We have named this factor "Continuous Collaborative Learning." This factor emphasizes the importance of ongoing education through university courses and workshops, fostering a culture of continuous learning, and leveraging collaborative technology to enhance collective knowledge and skills.
12. From our research findings, Factor 11 includes the components: Programming Competitions, Technology Preference, and Technical Assistance. We have named this factor "Competitive Technological Support." This factor emphasizes the value of participating in programming competitions, having preferences for specific technologies, and providing or receiving technical assistance to enhance technological skills and knowledge.
13. From our research findings, Factor 13 includes the components: Virtualization Familiarity, Technology Adaptability, and Technology Accessibility. We have named this factor "Adaptive Technology Familiarity." This factor highlights the importance of being familiar with

virtualization technologies, adapting to new technological environments, and ensuring technology is accessible to a broad range of users.

14. From our research findings, Factor 14 includes the components: Books and E-books, Technology Mastery, and Communication Skills. We have named this factor "Integrated Technological Mastery." This factor underscores the importance of mastering technology through diverse resources like books and e-books while effectively communicating technical knowledge and skills.
15. From our research findings, Factor 15 includes the components: Technological Safety Standards, Tech Blogs and Podcasts, and Project Management Skills. We have named this factor "Informed Project Management." This factor highlights the significance of adhering to technological safety standards, staying updated through tech blogs and podcasts, and applying project management skills to ensure informed and effective management of technological projects.
16. From our research findings, Factor 16 includes the components: Version Control, Technology Consultancy, and Surveillance Concerns. We have named this factor "Secure Technology Management." This factor emphasizes the importance of managing version control, providing expert technology consultancy, and addressing surveillance concerns to ensure secure and effective technology management practices.
17. From our research findings, Factor 17 includes the components: Technological Awareness, Technology Skepticism, and Cutting-Edge Development. We have named this factor "Critical Technological Insight." This factor highlights the balance between maintaining awareness of emerging technologies, exercising skepticism towards new developments, and engaging in cutting-edge technological advancements.

V. CONCLUSION AND FUTURE SCOPE

This study aimed to investigate the technological engagement of engineering students by conducting a comprehensive survey and applying factor analysis to uncover underlying dimensions. We collected data from 600 students at a prestigious university in India, ensuring a broad representation of perspectives. After meticulous data cleaning and transformation, we utilized factor analysis to identify key factors that reflect various aspects of technological engagement.

The factor analysis revealed 17 critical factors that encapsulate different dimensions of technological engagement. These factors include Responsible Technological Utilization, which emphasizes ethical and responsible technology use; Innovative Problem Solving, which focuses on creative approaches to technological challenges; and Collaborative Learning and Integration, highlighting the importance of teamwork in technology contexts. Other factors such as Practical Technological Advancement and Global Technological Empowerment reflect the application of technological knowledge in real-world scenarios and the influence of global trends on student learning, respectively. Additionally, factors like Adaptive Technical Learning and Expert Technological Proficiency underscore the need for continuous adaptation to technological changes and advanced skill development.

These findings provide a comprehensive understanding of how engineering students interact with technology, offering valuable insights into their competencies and areas for improvement. The identified factors can guide the development of targeted educational strategies and policies, aiming to enhance students' technological skills and readiness for future challenges in a rapidly evolving technological landscape.

Fig:11 Extracted Factors

Each of these factors highlights distinct dimensions of how students engage with technology. For instance, Responsible Technological Utilization focuses on ethical and responsible use of technology, while Innovative Problem Solving emphasizes creativity and analytical skills in addressing technological challenges. Collaborative Learning and Integration highlight the importance of teamwork and effective integration of technological tools in collaborative settings.

All these findings suggest different scopes of future work and implementations. These activating factors might stimulate more curriculum development to fulfill various technological competencies, hence supporting personalized learning. Educators learn from these insights to enhance their teaching practices, and the policymakers get to create strategies and policies that may respond to the needs of the industry and the technological changes. Future work could be validated and extended with a longitudinal and cross-cultural study. In addition, the study of the influence that emerging technologies have on these factors would enrich integration strategies to ensure relevance to education. Collaborations with industry can further align educational programs with real expectations, orienting students to succeed in a dynamically changing technological landscape.

References:

1. Alavi, M., Yoo, Y., & Vogel, D. R. (2002). Using information technology to add value to management education. Academy of Management Learning & Education, 1(2), 139-153.
2. Anderson, T. (2008). The Theory and Practice of Online Learning. Athabasca University Press.
3. Aspin, D. N., & Chapman, J. D. (2000). Lifelong learning: Concepts and conceptions. International Journal of Lifelong Education, 19(1), 2-19.
4. Berk, R. A. (2009). Multimedia Teaching with Video Clips: TV, Movies, YouTube, and MTV in the College Classroom. Jossey-Bass.
5. Bryman, A., & Cramer, D. (2011). Quantitative Data Analysis with IBM SPSS 17, 18 & 19: A Guide for Social Scientists. Routledge.
6. Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. Practical Assessment, Research, and Evaluation, 10(1), 7.
7. Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications.
8. Dillon, A., & Gabbard, R. (1998). Hypermedia as a Computer-Based Learning Environment. In Handbook of Human-Computer Interaction (2nd ed., pp. 649-674). Elsevier.
9. Eisenhardt, K. M. (1989). Building Theories from Case Study Research. Academy of Management Review, 14(4), 532-550.
10. Fabrigar, L. R., & Wegener, D. T. (2012). Exploratory factor analysis. Oxford University Press.
11. Field, A. (2013). Discovering statistics using IBM SPSS statistics. Sage.
12. Fink, A. (2013). How to Conduct Surveys: A Step-by-Step Guide. Sage Publications.
13. Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). Multivariate Data Analysis (7th ed.). Pearson.
14. Holton, E. F., & Naquin, S. S. (2005). Training Evaluation: A Literature Review. Human Resource Development Quarterly, 16(3), 437-457.
15. Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. Educational Researcher, 38(5), 365-379.
16. Kline, P. (2015). Principles and Practice of Structural Equation Modeling (4th ed.). Guilford Press.
17. Kumar, R. (2014). Research Methodology: A Step-by-Step Guide for Beginners (4th ed.). Sage Publications.
18. Lee, J. A., & Lee, S. H. (2012). An Examination of Factors Affecting the Use of Technology in Learning: A Case Study of Engineering Students. Journal of Engineering Education, 101(3), 447-464.
19. Liu, S., & Zhang, Y. (2020). Big Data and Technology Adoption in Education. Computers & Education, 149, 103807.

20. Mezirow, J. (2000). Learning to think like an adult: Core concepts of transformation theory. In J. Mezirow (Ed.), Learning as transformation: Critical perspectives on a theory in progress (pp. 3-33). Jossey-Bass.
21. Moore, G. C., & Benbasat, I. (1991). Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. Information Systems Research, 2(3), 192-222.
22. Mouakket, S. M. (2015). The Effect of Social Media on Engineering Students' Learning: An Exploratory Study. Educational Technology Research and Development, 63(3), 391-407.
23. Nielsen, J., & Budiu, R. (2012). Mobile Usability. New Riders.
24. Pallant, J. (2020). SPSS survival manual: A step by step guide to data analysis using IBM SPSS. McGraw-Hill Education.
25. Schriesheim, C. A., & Hill, K. D. (1984). A Comparison of Two Factor Analysis Methods: Principal Components and Common Factor Analysis. Journal of Applied Psychology, 69(1), 30-35.
26. Shrestha, E., Mehta, R. S., Mandal, G., Chaudhary, K., & Pradhan, N. (2019). Factors affecting e-learning engagement among students: A study on the influence of instructional design and learner characteristics in an online learning environment. Education and Information Technologies, 24(5), 3503-3520.
27. Stevens, J. P. (2009). Applied multivariate statistics for the social sciences. Routledge.
28. Wang, H., & Lee, L. (2020). Exploring the Relationship Between Technological Competency and Academic Performance: A Study of Engineering Students. International Journal of Engineering Education, 36(4), 1225-1237.