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Competency Mapping to assess the Employability Readiness of Engineering Students in the Higher Education Institutions (HEIs)

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Abstract

The employability of engineering graduates has emerged as a critical concern in the evolving job market, necessitating higher education institutions (HEIs) to adopt competency mapping strategies to enhance student preparedness. This study evaluates the impact of competency mapping on career preparedness and professional growth among engineering students, along with the influence of demographic factors such as age & gender on competency levels. A mixed-method research approach was employed, involving a survey of 200 engineering students from various HEIs in the Delhi NCR region. Statistical analyses, including ANOVA as well as regression models, were conducted to determine the significance of competency mapping in employability readiness. Findings reveal a significant positive correlation between competency mapping & career preparedness ($R^2 = 0.275$, $p < .001$) and professional growth ($R^2 = 0.570$, $p < .001$). Gender-based differences in competency levels were observed, with male students exhibiting slightly higher scores than females ($p = .019$). Age also influenced competency levels, with younger students (18-20 years) demonstrating the highest competency scores ($p = .038$). These results suggest that competency mapping plays a crucial role in equipping engineering students with the skills required for industry demands. The study underscores the need for HEIs to integrate structured competency frameworks into curricula, ensuring a balance between technical and soft skills. Future research should explore longitudinal impacts of competency mapping and the role of emerging technologies in competency-based learning.

Keywords: Competency Mapping, Employability Readiness, Career Preparedness, Professional Growth, Engineering Education, Higher Education Institutions (HEIs)

1. Introduction

Higher education (HE) is seen as a significant contributor to social development and economic prosperity (Al Hinai et al., 2020). Higher education institutions use many ways to cultivate proficient project management graduates, one of which is group-based examinations to enhance students' technical and interpersonal abilities (Tumpa, 2023). Higher education institutions prioritize the development of Industry 4.0 in response to changes in the industrial workforce. Collaboration between corporations and HEIs grow in significance (Halili et al., 2022). HEI may use institutional and labor market indicators to inform decisions on enhancements to course offerings, curriculum, and faculty credentials. Indicators may assist higher education institutions in evaluating students' acquisition of skills needed for the labor market, facilitating their employment, retention, or transition between jobs. Securing better job opportunities is a strong reason prompting people to go for a Higher Education Course, while institutions of higher learning are mainly focused on preparing their graduates for the labor market, in turn, making it easier for them to be employed (Dos Santos et al., 2023). To that end, making sure the learning outcomes match the needs of the industry becomes of vital importance.

Competency Mapping is a very essential tool in this matching process, in that it is a way of finding out the basic capacities needed in organizations and mapping them onto definite roles and duties in the staff. The competencies necessary for a certain job are contingent upon several circumstances (Kaur, & Kumar, 2013). Competency mapping encompasses the creation and maintenance of competencies in accordance with evolving organizational demands (Anisha, 2012). The requisite information, abilities, and competences for entrance into engineering and technology professions must be integrated into the curriculum, and pedagogical methodologies should be developed to attain these objectives. Conversely, millions of job opportunities remain unfilled, and companies have difficulty in locating competent candidates. The employability of graduates has emerged as a significant concern in the context of global transformation (Aleryani, & AlMunifi, 2019). Employability is identified as a crucial personal asset that may be enhanced to assist individuals in navigating an always evolving job market, marked by uncertainty and instability (Rakowska, & de Juana-Espinosa, 2021).

Engineering students in Higher Education Institutions

Employability is a fundamental concept in research regarding student trajectories and the transition from academic environments to the workforce. This concept encompasses various nuances, signifying that an employable individual possesses knowledge, skills, and attributes that render them advantageous and valuable in a particular context (Stiwne, & Jungert, 2010). HEIs must evolve to cultivate graduates who demonstrate capabilities that extend beyond discipline-specific knowledge. As a result, learning, and not teaching, and measurement of students' skills are the most significant if higher educational institutions change their approach (Phang et al., 2021). Especially, this change concerns the majors that call for the use of practical skills and solving skills. Engineering students globally are tasked with many tough academic duties often leading to difficulties in the adaptation process and success in their studies thereby indicating the demand for education being more competency-based and learner-centered that can be the solution to their problem. As young people start their pursuit of higher education, they feel a mixture of excitement and apprehension while confronting new challenges and experiences (Alexan, & Karkouti, 2024). Higher education consistently confronts the challenge of ongoing transformation, driven by rapid advancements in information and communication technology, an increase in student enrollment and diversity, and the transition towards a knowledge-based society (Al Shobaki, & Naser, 2017). A problem in higher education is fostering the cultivation of employability skills to align with employer expectations after graduation (Siby, et al., 2023). Over the last several years, there has been a substantial increase in interest all over the world in Engineering Education (EE). This interest is a direct result of the need of enhancing the education of engineers who are capable of handling complex problems and overcoming engineering challenges (Lima et al., 2018).

Career preparedness and professional growth of engineering students

Career preparedness is described as a developmental process transitioning from education to the workplace (Shrestha, 2022). The term career preparedness refers to the readiness and capacity of a person to begin working and advance in their chosen field. This calls for an awareness of the needs of the labor market, the knowledge and abilities that are necessary, and the ability to respond to changes in the working environment (Rachmawati et al., 2024). The engineering profession has historically been a technical domain grounded on theoretical and scientific principles. Engineers must have enough soft skills in personal and social conduct, alongside technical knowledge, and hard talents, to satisfy contemporary work market requirements (Baytiyeh, 2012). Nonetheless, one of the major obstacles that a graduate is usually confronted with is the identification of the right job, a procedure that is frequently seen as the development of an individual's tasks and professional experiences over time (Arif et al., 2019). This concept affirmatively indicates the importance of recognizing the skills and knowledge needed for a successful career.

In reaction to this necessity, the study intends to measure the employability efficiency of engineering learners in Higher Education Institutions (HEIs) by the use of competence mapping, especially by showing how technical skills and soft skills together affect job readiness as well as job prospects in the future. With regard to Industry 4.0, HEIs have the significant responsibility of equipping graduates with needs-satisfying competencies in the labor market. By evaluating the effect of competency mapping and demographic variables (gender and age) on career readiness, the current research aims to identify gaps within existing education programs and propose improvements. The study significance offers insights to HEIs towards strengthening curriculum planning, bridging industry-academia gaps, and optimizing graduates' employability under a highly competitive labor market.

2. Review of Literature

Competencies originate from distinct job families within the firm and are often categorized into areas such as strategy, connections, innovation, and emotional intelligence. The mapping of workers may be conducted independently or by supervisors (Janagama, S. 2017).On the other hand (Rathee, V., & Mittal, P. 2024) examined the employability competencies of work-ready professionals in higher education using bibliometric and network visualization methodologies. Similarly (Abelha, M.,et al., 2020) Conducted a thorough evaluation of graduate employability and competency development. It examined the function of higher education institutions in fostering the development of competencies for employment. Likewise (Butum, L. C., & Nicolescu, L. 2019) analyzed the factors impacting the employability of college grads in order to develop strategies for incorporating employability skills into course work, as well as identify and understand the necessary skills and competencies to improve graduates' chances of finding work after graduation. Meanwhile (Nirmala, C., & Dsouza, S. J.2022) examined the significant ramifications of universities and colleges in formulating a curriculum framework that incorporates aptitude training and prioritizes skill development as an essential component of higher education to render students' industry-ready. Artificial intelligence is transforming workforce skill development and career planning, crucial for maintaining organizational competitiveness in a dynamic market (Johnson, S. 2023). The swift convergence of Education 4.0 and Industry 4.0 necessitates adaptive learning models that provide individuals with skills suited for the evolving workforce (Vadisetty, R., & Polamarasetti, A. 2024). Likewise (Padovano, A., & Cardamone, M 2024) emphasized the necessity of facilitating a flexible and adaptive competency-based curriculum (CBC) in industrial engineering and management (IEM) education to address the requirements of a continually changing industrial environment and labor market. On the other hand (Aljohani N. R., et al., 2022) concentrated on three main constituencies: educational institutions, businesses, and students. By analyzing current trends in crucial skills that are increasing the social impact of learning and by identifying and developing students' abilities and competencies, it provides analytical insights that can improve students' satisfaction, retention, and employability.

Hypothesis 1: Competency mapping significantly impacts the career preparedness and professional growth of engineering students.

Employers hope that graduates of engineering programs are prepared to take on their first positions in the rapidly growing civil engineering industry shortly after graduation (Bae, H.,et al., 2022). On the other hand (Siddiky, M. R., & Akter, S. 2021) examined the determinants of students' profession selection and identified their employment readiness methods. Furthermore, the study aimed to provide a theory that may explain students' profession choices from a socio-environmental viewpoint. Likewise (Isaeva, T., & Grigorash, O. 2022) evaluated the career preparedness of emerging engineers, concentrating on the corporate competency frameworks of major firms in the agro-industrial sector and railway transportation. Ranking and survey findings from employers and university faculty to identify the most critical key competencies for young engineers.

Hypothesis 2a: There is a significant association between the demographic factor (gender) and the competency level of engineering students

The dynamics of gender in higher education need concentrated attention and are a topic that raises substantial interest in the legal framework governing education (Tazo, M. I., et al., 2020). Similarly (Chans, G. M., et al., 2023) examined the influence of institutional elements and personal attributes of female engineering students on the enhancement of sophisticated thinking.

Hypothesis 2b: There is a significant association between the demographic factor (age) and the competency levels of engineering students.

The cultivation of generic skills and competencies has emerged as a fundamental aspect of modern engineering education, driven by heightened social and occupational complexity (Boelt, A. M., et al., 2022). On the other hand (Zivotic-Kukolj, V., & Asgari, N. 2023) investigated the impact of gender and age on engineering placement students' perceptions and performance using confidence-competence metrics. Meanwhile (Tordai, Z., & HolikZ, I. 2018) studied the emerging problems for higher education, and put fresh light onto the need of competence development in engineering education. To solve the challenges (Daryono, R. W., et al., 2024) investigated the capabilities and practical experience of engineering graduates, which may be resloved via collaboration with the construction sector.

Age and gender have been viewed as pivotal demographic variables that have an impact on career readiness and professional development of engineering students (Wong, M. 2025). Age is correlated with maturity, self-regulation, and decision-making, influencing employability and career planning Gender significantly influences opportunities, support, and confidence levels, particularly in male-dominated profession areas such as engineering Experiments indicate female students experience structural and cultural issues influencing their career development (Abdi, S., et al.,2023). Age and gender are therefore paramount variables in deciphering various career paths in engineering education (Fouad, N. A., et al.,2020). While there are studies that examine different aspects of employability, skill development, and competency models, few explicitly examine the quantifiable effect of systematic competency mapping on employability readiness in HEIs. The majority of studies are scattered, examining either generic skills or individual demographic variables such as gender and age without bringing these together with a holistic competency mapping model. In addition, there is no empirical evidence to support the association between competency mapping practices and industry-focused professional development

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outcomes. Moreover, literature does not have a consistent framework that comprehensively integrates technical and soft skill development according to Industry 4.0 demands. This research fills these gaps by investigating the intersection of competency mapping, demographic factors, and employability readiness in a structured, statistically verified framework.

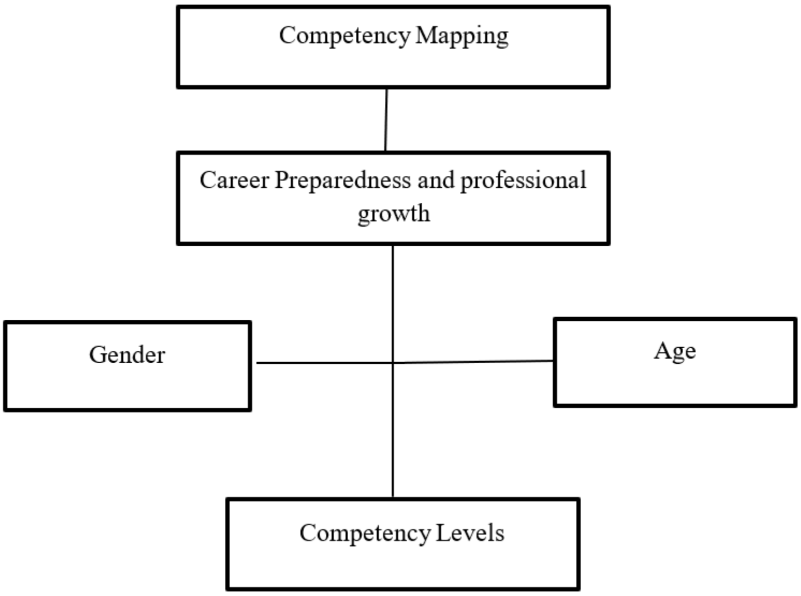

Figure 1: Research Model

3. Research Methodology

The current study is carried out following a mixed-method strategy, using both quantitative as well as qualitative approaches for a holistic study. The research is carried out in the Delhi NCR area, targeting engineering students in Higher Education Institutions (HEIs). A stratified random sampling approach has been employed, featuring a sample size of 200 participants. The research design is characterized by its descriptive and exploratory nature, employing a structured questionnaire as the primary research instrument. The research studies competency mapping and demographic factors (gender and age) as independent variables, measuring their effect on career readiness, professional development, and competency levels as dependent variables. Primary and secondary sources are utilized for data collection, providing a balanced study. MS Excel and SPSS are utilized for statistical analysis, using methods like Mean, Standard Deviation, ANOVA, and Regression to arrive at meaningful conclusions. This methodology provides an in-depth analysis of competency development and workforce readiness among engineering students.

Table 1: Summary of Respondents' Demographics

S.N.	Demographic Variables		Freq.	%
1	Gender	Female	82	41%
		Male	118	59%
2	Age Group	18 to 20 Years	55	27.50%
		21 to 23 Years	91	45.50%
		Above 24 Years	54	27%
3	Year of Study	Final Year	49	24.50%
		First Year	59	29.50%
		Second Year	47	23.50%
		Third Year	45	22.50%
4	Type of Institution	Government	63	31.50%
		Private	137	68.50%
5	Location of Institution	Rural	50	25%

		Semi-Urban	72	36%
		Urban	78	39%
6	Skill Development programs Adopted	No	68	34%
		Yes	132	66%

Demographic characteristics of the respondents indicate a comparatively balanced gender distribution, with males making up 59% and females 41% of the whole sample. Most participants (45.5%) are in the age group of 21 to 23 years, and the remaining ones are almost evenly distributed between 18–20 years (27.5%) and over 24 years (27%). In terms of academic year, the majority of the respondents are in the first year (29.5%), followed by the last year (24.5%), second year (23.5%), and third year (22.5%), which shows a relatively even distribution across years of study. The vast majority (68.5%) study in private institutions, with only 31.5% studying in government colleges. Urban-based institutions have the largest proportion (39%), followed by semi-urban (36%) and rural (25%) settings. Finally, 66% of the respondents stated that they had attended skill development programs, and this indicates a strong desire to improve employability skills.

Hypothesis 1: Competency mapping significantly impacts the career preparedness and professional growth of engineering students.

- **Impact of Competency mapping on career preparedness**

Table 2: Summary Table for the Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.525	0.275	0.272	2.95512

A model summary table displays the degree to which the regression model explains the data and how well it matches the data. A rather positive correlation between the two data sets is shown by an R-value of 0.525. With an R-squared value of 0.275, we may deduce that the model's independent variables account for around 27.5% of the variance in the dependent variable. Even if the Adjusted R Square (a measure that takes into consideration the number of predictors and potential bias) drops somewhat to 0.272, the model still provides a good description of the data without overfitting. The estimate's standard error is 2.95512; smaller values indicate a more accurate model; this measure indicates the average distance that the observed data points have from the regression line. Overall, the model's predictive power is medium, and it does a good job of explaining the variation in the outcome variable.

Table 3: ANOVA Table

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	656.601	1	656.601	75.189	0
	Residual	1729.079	198	8.733		
	Total	2385.68	199			

The ANOVA table is commonly used to confirm the overall significance of a regression model. The Regression row suggests a sum of squares of 656.601 with 1 degree of freedom, which tells us that the model explains a certain fraction of the total variation in the dependent variable. The Residual part indicates that there is still a sum of squares equal to 1729.079 besides 198 degrees of freedom, showing the variance left. The value of the total sum of squares is 2385.680, which indicates that the model explains a good part of the variance. The mean square for the regression is 656.601 (with 1 degree of freedom), whereas the mean square for residuals is 8.733. In addition, the F-value of 75.189 indicates that there is a significant impact on the model, and the significance value (Sig.) is .000, so it rejects H0 at the 0.05 level. Consequently, the independent variable(s) used in the model are the main predictors of the dependent variable due to the fact that the regression model is statistically significant at a high level.

Table 4: Coefficients Table

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.31	1.246		5.065	0
	Competency mapping	0.603	0.07	0.525	8.671	0
a. Dependent Variable: Career preparedness						

The results of a linear regression analysis that examined how competency mapping affected job preparedness are shown in the table. With everything else being equal, a one-unit change in competency mapping leads to a 0.603 increase in career preparedness, as indicated by the 0.603 unstandardized coefficient (B) for competency mapping. Competency mapping and career preparation have a high positive link with a beta value of 0.525. In addition, the results show a t-value of 8.671 and a Sig. of 0.000, which confirms a statistically significant relationship between the two variables at the 0.01 level, implying a probability of less than 1%. When the competency mapping is at its lowest, there is a constant term of 6.310 that represents the expected career readiness. Overall, the results support the idea that competency mapping is an important indicator of a successful career, as shown by the examination.

The findings were found to be statistically significant ($p < .001$) in the ANOVA and coefficients table, the portion of Hypothesis 1 is accepted.

➢ **Impact of Competency Mapping on Professional growth**

Table 5: Summary Table for the Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.755	0.57	0.568	2.21689

A table of model summary contains the results of regression analysis. Here, 0.755 is the correlation coefficient (R), which shows that the independent and dependent variables are in a strong positive relationship. A value of R Square equal to 0.570 is the percentage of the variance in the dependent variable predicted by the model. The value of Adjusted R Square equals 0.568, a number that allows for the predictors in the model, revealing the model as being less dynamic and therefore more stable. The estimate of the Standard Error of the Model is 2.21689, indicating the average deviation of the real data from the regression line; smaller values often indicate a better fit.

Table 6: ANOVA Table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1290.268	1	1290.268	262.539	.000[b]
	Residual	973.087	198	4.915		
	Total	2263.355	199			

The ANOVA table provides the results of a regression study that was conducted to determine the extent to which the regression model is able to adequately account for the variability of the dependent variable. The Regression Sum of Squares is 1290.268 with 1 degree of freedom, which shows that the model explains the variance of the dependent variable. The Residual Sum of Squares is 973.087 with 198 degrees of freedom, thus indicating the variance is still unexplained. The Total Sum of Squares is 2263.355, which represents the combined variance of the dependent variable, a result of the Regression as well as the Residual parts. The Mean Square for Regression is 1290.268 and that for Residual is 4.915. The F-statistic of 262.539 is a very determinant significance assessment of the regression model. The p-value (Sig.) is 0.000 ($p < 0.001$) that indicates statistical significance of the model and hence the independent variable's strong power to forecast the dependent variable. This implies that the regression model is adequately adjusted to the data.

Table 7: Coefficients Table

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.206	0.935		2.361	0.02
	Competency mapping	0.846	0.052	0.755	16.2	0
a. Dependent Variable: Professional growth						

A strong positive correlation between competency mapping and career advancement is shown in the table of regression analysis. Given that all other factors stay constant, the projected gain in professional progress is 0.846 units for every one unit increase in competency mapping, according to the unstandardized coefficient (B = 0.846). A very positive effect of competency mapping on career advancement is indicated by the standardized coefficient (Beta = 0.755). There is a statistically significant correlation, as shown by the t-value of 16.203 and the p-value of 0.000, which is less than 0.05. Furthermore, in the case of zero competency mapping, the constant value (2.206) denotes a notional baseline level of progress. Thus, the model informs that competency mapping is highly likely to be a great predictor of professional growth. Based on the highly significant p-values (< .001) in the ANOVA and coefficients tables, the portion of Hypothesis 1 is accepted.

Hypothesis 2a: There is a significant association between the demographic factor (gender) and the competency level of engineering students

Table 8: Descriptive Statistics Table

Competency level of Engineering Students								
	N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					LB	UB		
Male	118	19.822	2.98323	0.27463	19.2781	20.3659	11	25
Female	82	18.7561	3.3428	0.36915	18.0216	19.4906	8	25
Total	200	19.385	3.17129	0.22424	18.9428	19.8272	8	25

The table presents descriptive statistics on the competency level of engineering students, disaggregated by gender. Out of a total of 200 students, 118 of them were male while the rest, 82, were female. The male students presented an average level of expertise more than the female students with data showing that the mean score of males was 19.82 with an SD of 2.98 while the mean score of females was 18.76 with a corresponding SD of 3.34. The standard error of .27463 for males and .36915 for females is indicative of a small sampling error in the estimates of the means. The confidence interval of 95% also shows that for the male subjects, the true mean competency level falls in the range of 19.28 - 20.37 while for the female subjects it is in the range of 18.02 - 19.49. The overall average value has been evaluated for all the students together from where the total mean competency level of the students has been found to be 19.39 (SD = 3.17) and the distribution of scores was from 8 to 25, corresponding to some variation in the perception of competency across the group. The results of the data analysis point to the fact that on average, male students see themselves more somewhat more competent than their female peers.

Table 9: ANOVA Table

Competency level of engineering students					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	54.97	1	54.97	5.592	0.019
Within Groups	1946.385	198	9.83		

Total	2001.355	199			

The ANOVA table analyzes the performance variability among engineering students. The f-value of 5.592 and the significance level (Sig.) of 0.019 imply the existence of statistically significant differences between the groups at the 5% significance level. Such a situation means that the discrepancy in the competency levels existing among the groups would hardly have developed by probability. The 54.970 is the variation due to the differences between the groups, while the 1946.385 is the difference within each group. It implies that group membership has played a key role in the competency level of engineering students; to be more specific, group membership has been the influencer. The ANOVA table indicates that the p-value of .019 represents statistically significant, leading to the acceptance of Hypothesis 2a.

Hypothesis 2b: There is a significant association between the demographic factor (age) and the competency levels of engineering students.

Table 10: Descriptive Statistics Table

Competency level of Engineering Students								
	N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
18-20 Years	55	20.2364	2.86074	0.38574	19.463	21.0097	12	23
21-23 Years	98	18.8776	3.30031	0.33338	18.2159	19.5392	8	24
Above 24 years	47	19.4468	3.08438	0.4499	18.5412	20.3524	13	25
Total	200	19.385	3.17129	0.22424	18.9428	19.8272	8	25

The table descriptive statistics shows the level of student competence in engineering in different age groups. The highest mean competency level is seen in the students who are 18-20 years old (M = 20.24, SD = 2.86) and the lowest mean is in the 21–23 years group (M = 18.88, SD = 3.30). In descending order, students over 24 years (M = 19.45, SD = 3.08) is the second group. In an almost parallel result, the 18–20 years group also has a very slim confidence interval (95% CI: 19.46–21.01) which means that stand by their response more than the 21–23 span of years group who are represented in the wider interval (95% CI: 18.22–19.54). The mean competence level for the whole sample of 200 students is 19.39 (SD = 3.17), with individual scores ranging from as low as 8.00 to as high as 25.00.

Table 11: ANOVA Table

Competency level of engineering students					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	65.28	2	32.64	3.321	0.038
Within Groups	1936.075	197	9.828		
Total	2001.355	199			

This analysis of variance table 11 examines the disparities in competency levels among engineering students across three age groups. The F-statistic of 3.321 and a p-value of 0.038 denote statistical significance, showing that at least two age groups exhibit significantly different mean skill levels. The disparities among age groups are reflected in the Between Groups sum of squares (65.280), while the variance within each age group is denoted by the Within Groups sum of squares (1936.075). The mean square between groups (32.640) exceeds the mean square within groups (9.828), with 2 degrees of freedom between groups and 197 degrees of freedom within groups. An ANOVA table showing a p-value of.038 demonstrates statistical significance, thereby supporting the adoption of Hypothesis 2b.

4. Discussion

The findings of the study offer significant insights into the role of competency mapping in shaping career preparedness and professional growth among engineering students. The study also explores the influence of demographic factors such as age as well as gender on competency levels.

4.1 Impact of Competency Mapping on Career Preparedness and Professional Growth

The present study demonstrates that competency mapping significantly impacts both career preparedness and professional growth among engineering students. The model summary for career preparedness indicates an R Square value of 0.275, suggesting that competency mapping explains approximately 27.5% of the variance in career preparedness. The results is similar to the research by (Boahin, 2014) found that competency-based training programs contribute to a 30% improvement in student readiness for employment. Similarly, (Otache, & Edopkolor, 2022) reported a moderate positive relationship ($R = 0.52$) between competency assessment frameworks and students' ability to secure job placements. The significant F-statistic ($F = 75.189$, $p < .001$) in our study further reinforces the reliability of competency mapping as a predictor of career preparedness. For professional growth, the study reports a stronger relationship, with competency mapping explaining 57% of the variance (R Square = 0.570). This finding aligns with research by (Shivanjali & Tripti, 2019), who found that structured competency development programs lead to long-term professional growth among graduates, with a reported explanatory power of 55%. The standardized coefficient (Beta = 0.755) in our study is also consistent with findings by (Akkermans, et al., 2013), who observed that higher competency mapping scores correlate with an increased likelihood of career advancement opportunities.

4.2 Influence of Gender on Competency Levels

Our analysis indicates that male students exhibit slightly higher competency levels ($M = 19.82$) compared to female students ($M = 18.75$), with the ANOVA results confirming a significant difference ($F = 5.592$, $p = .019$). This result is somewhat consistent with prior research by (Akudugu, 2017), who found that male students tend to score higher on technical competency assessments, largely due to greater exposure to practical training and industry interactions. However, in contrast, a study by (Chen, et al., 2023) found no significant gender-based differences in competency scores among engineering students, attributing the lack of disparity to equal access to skill development programs. The observed difference in our study may be influenced by variations in participation rates in skill enhancement initiatives, where males might have had more opportunities for hands-on learning.

4.3 Influence of Age on Competency Levels

The study finds significant differences in competency levels across different age groups ($F = 3.321$, $p = .038$). The youngest age group (18-20 years) exhibited the highest mean competency level ($M = 20.23$), followed by students above 24 years ($M = 19.44$), and then students aged 21-23 years ($M = 18.87$). This finding aligns with research by (Agut, et al., 2003), who reported that younger students, particularly freshers, show higher enthusiasm and engagement in competency-building activities, resulting in higher scores in competency assessments. However, our results deviate from studies like those of (Ma'dan, et al., 2020), which suggest that older students (above 24 years) exhibit higher competency scores due to greater exposure to industry-relevant projects and internships. This discrepancy may be attributed to the structure of skill development programs offered by the participating institutions, where younger students may have been more actively involved in training programs.

5. Conclusion

The research underlines the indispensable role of competency mapping in students' employability skill development and career promotion in engineering education in Higher Education Institutions (HEIs). One is that the results for policymakers emphasize the need to introduce competency-based education frameworks in HEIs that grant both technical and soft skills for handling Industry 4.0 expectations. Educators are expected to change from a curriculum-focused, content-heavy type of education program to a more adaptive, learner-centered pedagogy that includes building competency in all stages of the academic cycle. Specifically, the two sides of the educational institutions must insert competence mapping in the curriculum even from the first year in such a way that students are evaluated regularly and assisted in the right direction for their skills development. To step up this conversion process:

- HEIs must introduce competency audit tools in the first year to assess and personalize students' skill development trajectories from the outset.
- Employers should design hiring rubrics that jointly evaluate both technical and soft skills, ensuring a more holistic representation of job readiness.
- AI-powered platforms (e.g., LitQ, TalentNeuron) can be leveraged to track real-time skill gaps and inform curriculum design, offering dynamic alignment between academic training and industry needs.

Furthermore, employers are also encouraged not to use traditional and ineffective degree-based selection techniques any longer. The concept of competence-based recruitment, which is designed to depict job readiness more precisely, should be a shift in recruitment strategies. Moreover, recruitment processes must be driven not only by theoretical knowledge but also by the individuals' problem-solving skills, behavioral skills, and knowledge in different domains. Thus, the involvement of these foundational components will ensure that the whole recruitment process is in line with the requirements of the workplace.

The future will see a huge one AI convergence to personalize and automate the measurement of skills. These AI technologies can spot the gaps in the skills of a person, propose custom-tailored learning paths, and even predict career paths based on a person's ever-changing competence profile. With the help of AI, dynamic competency frameworks can be developed that keep pace with changes in industry requirements in real time, thus making it possible to establish and maintain strong feedback connections and interaction between industry and academia. For successful change to take place, it is indispensable that the higher learning institutions (HEIs), the industrial sector, and the government join forces in setting up digital competency mapping systems, defining national-level competency standards, and embedding them into accreditation standards. Longitudinal studies undertaken through the use of machine learning and AI analytics can be included in the lead of evaluating the real-world effectiveness of competence-centered education on the course that has been taken along for career advancement thereby will be the step to set up in the stage of evaluating the real-world effectiveness of competence-centered education. The embedding of these strategies not only substantially narrows the gap between education and employment but also paves the way for the development of future-ready human resources who are not just suitable for their first job but for lifelong adaptability to the ever-changing professional landscape.

References

1. Abdi, S., Sulistiasih, S., Wibowo, D. E., Cantika, I. I., & Violita, E. (2023). The Relationship of Self-Regulation and Career Planning: A Study of Senior High School Students. Bulletin of Counseling and Psychotherapy, 5(3), 270-278.
2. Abelha, M., Fernandes, S., Mesquita, D., Seabra, F., & Ferreira-Oliveira, A. T. (2020). Graduate employability and competence development in higher education—A systematic literature review using PRISMA. Sustainability, 12(15), 5900.
3. Agut, S., Grau, R., & Peiró, J. M. (2003). Individual and contextual influences on managerial competency needs. Journal of Management Development, 22(10), 906-918.
4. Akkermans, J., Brenninkmeijer, V., Huibers, M., & Blonk, R. W. (2013). Competencies for the contemporary career: Development and preliminary validation of the career competencies questionnaire. Journal of career development, 40(3), 245-267.
5. Akudugu, A. (2017). Effectiveness of competency-based training on the acquisition of industry desired competencies of agricultural engineering students in Tamale Polytechnic, Ghana (Doctoral dissertation).
6. Al Hinai, M. R., Bhuiyan, A. B., & Husin, N. A. (2020). An Empirical Review on the Graduate Attributes and Readiness for Employability among the Engineering Graduates in the Higher Education Institutions (HEIs). Indian Journal of Finance and Banking, 4(3), 8-25.

7. Al Shobaki, M. J., & Naser, S. S. A. (2017). The role of the practice of excellence strategies in education to achieve sustainable competitive advantage to institutions of higher education-faculty of engineering and information technology at Al-Azhar University in Gaza a model.
8. Aleryani, A. Y., & AlMunifi, A. A. (2019). A Roadmap to the Development of Key Competencies of Engineering and Technology Graduates. Int. J. Eng. Pedagog., 9(5), 75-88.
9. Alexan, W., & Karkouti, I. M. (2024). Exploring Key Success Factors in First-Year Engineering Education at Egyptian Higher Education Institutions. IEEE Access.
10. Aljohani, N. R., Aslam, M. A., Khadidos, A. O., & Hassan, S. U. (2022). A methodological framework to predict future market needs for sustainable skills management using AI and big data technologies. Applied Sciences, 12(14), 6898.
11. Anisha, N. (2012). Competency mapping of the employees. International Journal of Advancements in Research & Technology, 1(5), 1-7.
12. Arif, S., Iqbal, J., & Khalil, U. (2019). Factors influencing students' choices of academic career in Pakistan. FWU Journal of Social Sciences, 13(1), 35-47.
13. Bae, H., Polmear, M., & Simmons, D. R. (2022). Bridging the gap between industry expectations and academic preparation: Civil engineering students’ employability. Journal of Civil Engineering Education, 148(3), 04022003.
14. Baytiyeh, H. (2012). Disparity between college preparation and career demands for graduating engineers. International journal of engineering education, 28(5), 1221.
15. Boahin, P., Eggink, J., & Hofman, A. (2014). Competency-based training in international perspective: Comparing the implementation processes towards the achievement of employability. Journal of Curriculum Studies, 46(6), 839-858.
16. Boelt, A. M., Kolmos, A., & Holgaard, J. E. (2022). Literature review of students’ perceptions of generic competence development in problem-based learning in engineering education. European Journal of Engineering Education, 47(6), 1399-1420.
17. Butum, L. C., & Nicolescu, L. (2019). Learning and work in the 21st century: A review of employability models for HE graduates: Different levels of analysis. Management Dynamics in the Knowledge Economy, 7(1/23), 71-86.
18. Chans, G. M., Dominguez, A., Caratozzolo, P., Zavala, G., & Camacho-Zuñiga, C. (2023, July). Gender Equity in STEM: Insights from Competency-Based Engineering Education. In International Conference on Future of Education (pp. 33-44). Singapore: Springer Nature Singapore.
19. Chen, J., Kolmos, A., & Clausen, N. R. (2023). Gender differences in engineering students’ understanding of professional competences and career development in the transition from education to work. International Journal of Technology and Design Education, 33(3), 1121-1142.
20. Daryono, R. W., Hidayat, N., Nurtanto, M., & Fu'Adi, A. (2024). The Development of a Competency Framework for Architectural Engineering Graduates: Perspectives by the Construction Industry in Indonesia. Journal of Technology and Science Education, 14(2), 274-290.
21. Dos Santos, H. S., De Lima, Y. O., Barbosa, C. E., Lyra, A. D. O., Argôlo, M. M., & De Souza, J. M. (2023). A Framework for assessing higher Education courses Employability. IEEE Access, 11, 25318-25328.
22. Fouad, N. A., Kozlowski, M. B., Singh, R., Linneman, N. G., Schams, S. S., & Weber, K. N. (2020). Exploring the odds: Gender differences in departing from the engineering profession. Journal of Career Assessment, 28(3), 446-461.

23. Halili, S. H., Fathima, N., & Razak, R. (2022). Exploring relevant employability skills 4.0 for university students' readiness in the work-based learning program. Journal of Technical Education and Training, 14(3), 68-78.

24. Isaeva, T., & Grigorash, O. (2022, May). Reaching career readiness of engineering students through identification of employability skills and universal competences. In International Scientific Conference on Agricultural Machinery Industry "Interagromash" (pp. 354-365). Cham: Springer International Publishing.

25. Jagacinski, C. M. (2013). Women engineering students: Competence perceptions and achievement goals in the freshman engineering course. Sex roles, 69(11), 644-657.

26. Janagama, S. (2017). An Overview of Competency Mapping. ITIHAS the Journal of Indian Management, 7(2), 15-20.

27. Johnson, S. (2023). Artificial Intelligence in Workforce Skill Development and Career Mapping.

28. Kaur, J., & Kumar, V. (2013). Competency mapping: A gap Analysis. International Journal of Education and Research, 1(1), 1-9.

29. Lima, R. M., de Graaff, E., Mesquita, D., & Aquere, A. L. (2018). Engineering education (research) in higher education institutions.

30. Ma'dan, M., Ismail, M. T., & Daud, S. (2020). Influence of competitiveness factor towards graduate competency level. Asian Journal of University Education.

31. Nirmala, C., & Dsouza, S. J. (2022). A critical evaluation of employability skills of postgraduates and its impact on their job prospects. SDMIMD Journal of Management, 1-14.

32. Otache, I., & Edopkolor, J. E. (2022). Work placement learning and student employability: do student satisfaction, commitment, and achievement matter?. Industry and Higher Education, 36(6), 730-741.

33. Padovano, A., & Cardamone, M. (2024). Towards human-AI collaboration in the competency-based curriculum development process: The case of industrial engineering and management education. Computers and Education: Artificial Intelligence, 7, 100256.

34. Phang, F. A., Pusppanathan, J., Nawi, N. D., Zulkifli, N. A., Zulkapri, I. Z., Che Harun, F. K., ... & Sek, T. K. (2021). Integrating drone technology into service learning for engineering students. International Journal of Emerging Technologies in Learning, 16(15).

35. Rachmawati, D., Sahid, S., Mahmud, M. I., & Buang, N. A. (2024). Enhancing student career readiness: a two-decade systematic. Int J Eval & Res Educ, 13(3), 1301-1310.

36. Rakowska, A., & de Juana-Espinosa, S. (2021). Ready for the future? Employability skills and competencies in the twenty-first century: The view of international experts Human Systems Management, 40(5), 669-684.

37. Rathee, V., & Mittal, P. (2024). Employability skills among work ready professionals in higher education: mapping the field through bibliometric analysis with R studio. Higher Education, Skills and Work-based Learning, 14(6), 1314-1339.

38. Shivanjali, S. M., & Tripti, S. (2019). Competency mapping, a strategic perspective on employee retention. International journal of recent technology & engineering, 8(2).

39. Shrestha, M. (2022). A STUDY ON CAREER PREPAREDNESS BY FOOD TECHNOLOGY STUDENTS (Doctoral dissertation).

40. Siby, T., Martin, J., Burns, J., Beauchamp, D., Patil, P., Pollock, H., ... & Monk, J. (2023). Effects of online career training modules on undergraduate STEM Students' career readiness perceptions. I am J Educ Res, 11, 214-224.

41. Siddiky, M. R., & Akter, S. (2021). The Students' Career Choice and Job Preparedness Strategies: A Social Environmental Perspective. International Journal of Evaluation and Research in Education, 10(2), 421-431.

42. Stiwne, E. E., & Jungert, T. (2010). Engineering students' experiences of transition from study to work. Journal of education and work, 23(5), 417-437.

43. Tazo, M. I., Boyano, A., Fernandez-Gámiz, U., & Calleja-Ochoa, A. (2020). The gender perspective of professional competencies in industrial engineering studies. Sustainability, 12(7), 2945.

44. Tordai, Z., & HolikZ, I. (2018). Student's Characteristics as a Basis for Competency Development in Engineering Informatics Education. International Journal of Engineering Pedagogy, 8(4).

45. Tumpa, R. (2023). Enhancing Job-readiness of Project Management Graduates through Effective Group-based Assessments (Doctoral dissertation, CQUniversity).

46. Vadisetty, R., & Polamarasetti, A. (2024, December). AI-Augmented Skill Development Roadmaps: Tailoring 12-Month Learning Paths for Future-Ready Careers in Education 4.0 and Industry 4.0. In 2024 13th International Conference on System Modeling & Advancement in Research Trends (SMART) (pp. 655-661). IEEE.

47. Wong, M. (2025). The Impact of Undergraduate College Experiences on Career Readiness Skills for Senior Students (Doctoral dissertation, Azusa Pacific University).

48. Zivotic-Kukolj, V., & Asgari, N. (2023, December). How students' gender and age group affect the confidence-competence measures related to Work Integrating Learning (WIL) of engineering placement students in an Australian university. In 34th Australasian Association for Engineering Education Conference (AAEE2023) (pp. 844-852). Gold Coast: Engineers Australia.