Nurturing Research Mindset through Undergraduate Research Experience (URE) and Mentoring in Engineering Institutions

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***Abstract*—Engineering research in India in its current state highlights the need for a research on the impact on Research Experience (especially at the Undergraduate level) and Mentoring Effectiveness on research mindset. The comparatively low percentage of scholarly research, the introduction of 4-year research degree and a direct PhD call for inculcating a research culture and research mindset at the undergraduate level of engineering education. For students to imbibe a research-oriented mind set, it is essential that there is effective mentorship, their research experiences are enriching, with development of research skills, and leading to personal and professional growth. This research study carried out with engineering students in the final and prefinal years attempts to measure all the five constructs measured above and tries to assess the interplay between the study variables. The sample size was 215 and data was collected using a structured and validated instrument. Suitable hypotheses were formulated and a conceptual framework was designed. The data was analyzed using the smart PLS software tool. The results indicate that out of the seven hypothesis formulated five were accepted. URE had an impact on a student's research mindset, through research skills enhancement and personal and professional development. Mentoring effectiveness had an impact on the research mindset through development of research skills. The indirect effect of different paths in the conceptual model were also tested. The study results led to drawing insights for improving research mindset through the improvement of research experiences and effective mentorship.**

***Keywords*— Undergraduate Research Experience, Research Mindset, Research Skills Development, Personal and Professional Growth, Partial Least Square based Structural Equation Modeling.**

***JEET Category*—Choose one: Research**

I. INTRODUCTION

India, home to 25% of the world's engineers and ranked third globally in peer-reviewed science and engineering publications, still faces significant challenges in engineering research. According to the National Science Foundation of United states, U.S. and China lead in research contributions with 23% and 16% respectively, while India lags behind with just 5%. Germany and the UK each contribute 4%, and Japan 3%. Although India's patent output at the India Patent Office (IPO) increased from 2,511 in 2018-19 to 5,629 in 2020-21, the progress remains insufficient. The country has climbed from 81st in the Global Innovation Index (GII) in 2014 to 40th in 2022, thanks to the initiatives of NSTED (National Science Technology Entrepreneurship Board) and DST (Department of Science and Technology). However, further efforts are essential. Encouraging students to engage in research and improve patent outputs is crucial. The introduction of a 4-year undergraduate research degree, allowing direct entry into PhD programs as per the UGC draft, is a positive step. The recent approval of a National Research Foundation (NRF) by the Department of Higher Education, with substantial funding, is seen as a milestone in advancing India's research capabilities. file,

Engineering research in India in its current state, highlights the need for a research on the impact of Student's Research Experience and Mentoring Effectiveness on research mindset. The comparatively low percentage of scholarly research suggests a gap in research skills among students, which needs to be addressed at the undergraduate level. Enhancing research skills and fostering a research mindset early in students' academic careers could lead to greater innovation and more patent-worthy research, driving the country's global competitiveness. A research study can identify effective methods for integrating research experiences into undergraduate education, could help maintain and improve India's innovation ranking. With the introduction of the 4-year undergraduate research degree and the possibility of direct PhD entry, there is a need to evaluate how these reforms impact students' research capabilities. Effective mentoring is crucial for developing not just research skills, but also a student's personal/professional growth. Researching the impact of mentoring during undergraduate studies could throw light on improving the competencies of mentors. The establishment of the NRF and increased funding for research underscores the government's commitment to advancing research in India. Understanding how undergraduate research experiences

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contribute to this national agenda is essential for aligning educational strategies with broader research and innovation goals. This research study would provide valuable insights into how undergraduate research and mentoring can be leveraged to address the current gaps in India's research ecosystem, ultimately contributing to the nation's scientific and technological advancement.

II. Literature Review

A. Undergraduate Research Experience

A undergraduate research experience of a student (URE) refers to the engagement of engineering students in scholarly research activities, typically under the supervision / mentorship of a faculty member. The experience aims to enhance students' understanding of the research process, enhancing their problem-solving / critical thinking abilities and provide them with hands-on experience in their field of study. Undergraduate research often involves close mentorship from faculty members, which helps students navigate the complexities of research and provides personalized guidance (Lopatto, 2004). Participating in research helps students develop a cluster of competencies, including data collection and analysis, scientific writing, and oral communication (Hunter, Laursen, & Seymour, 2007). According to Council of Undergraduate Research "Undergraduate research is defined as a mentored investigation or creative inquiry conducted by undergraduates that seeks to make an original intellectual or creative contribution to the discipline". On the contrary, "Course-based undergraduate research experiences (CUREs) are learning experiences in which whole classes of students address research questions or problems that are of interest to the scientific community" (McLaughlin, 2015). By providing critical exposure to research techniques and methodologies (Ahmad, Zubair & Al-Thani, Noora. (2022)), such research experiences encourage undergraduate students to pursue advanced degrees and career pathways in research. According to Chamely-Wiik, et al., (2023), Undergraduate research (UGR) is considered one among ten high-impact educational practices that have been shown to enhance student performance and success. It involves students in active problem-solving and hands-on learning.

B. Mentorship Effectiveness

Research experiences at UG level have become an integral aspect of higher education, enabling students with invaluable avenues to actively engage in hands-on, authentic research endeavors and cultivate a multitude of essential competencies, (The Science of Effective Mentorship in STEMM, 2019) (Lopatto, 2004). One crucial factor influencing the efficacy and impact of these experiences is the quality and effectiveness of the mentorship provided to student researchers.

Mentorship Effectiveness can be understood as the degree to which the mentoring relationship between faculty and undergraduate researchers facilitates the achievement of desired outcomes, such as enhanced research skills, increased interest in pursuing advance education in STEM disciplines, and elevated research productivity through collaborative publications (Girves et al., 2005) (Morales et al., 2017). Effective mentorship in the context of undergraduate research experiences is characterized by a multifaceted and dynamic process, involving the provision of guidance, support, and feedback, as well as the cultivation of a nurturing and intellectually stimulating environment.

C. Research Skills Development

According to Dewey, J., & Hoey, L. (2017) Research skills are a set of transferable abilities that enable individuals to independently and systematically acquire, process, and apply information to address complex problems and generate new knowledge.

D. Personal and Professional Growth

Personal and professional growth refers to self-improvement, it also pertains to career advancement. In the context of undergraduate research, they involve enhancing skills and knowledge for academic and professional development. Participating in undergraduate research enhances personal growth through skill development and boosts academic productivity and career initiation opportunities. Woska, Pires, da, Costa., Angélica, Ferreira, Melo., Patrícia, Espíndola, Mota, Venâncio., Mirelle, Amaral, de, São, Bernardo., Priscilla, Rayanne, e, Silva, Noll., Matias, Noll. (2024). It also includes skill development and confidence building, acquiring soft skills like time management and leadership, crucial for post-graduation success. Maslyn, A, Greene., Susan, K., Duckett. (2023). According to Ashika, Naicker., Evonne, Singh. (2022) it includes critical thinking and knowledge synthesis, while professional growth involves skill transfer and collaborative learning, enhancing students' research engagement and career readiness. Some authors like
Graham, S., Sellers., Merideth, Freiheit., Michael, Robert, Winter., Domino, A., Joyce., Darron, A., Cullen., David, H., Lunt., Kevin, M., Hubbard. (2024). Also refer to higher-level learning and training in course specific areas like genetic analysis for future careers

E. Research Mindset

Research mindset –is defined as students' attitudes, beliefs, and behaviours towards research, primarily their inclination towards research. Kavale, S. M., & Carberry, A. R. (2023). Studies exploring research mindsets among undergraduate students have shown that UREs, faculty mentorship, and institutional support significantly influence students' inclination to think critically, engage in scholarly activities, and view research as an essential component of their education (Linn et al., 2015; Nagda et al., 1998).A positive research mindset is associated with increased research productivity, persistence in research activities, and a higher likelihood of pursuing graduate studies or research-related careers (Kardash, 2000; Thiry et al., 2012).

F. Research Gap

Longitudinal studies to investigate the extended effects of UREs on research mindset, career choices, and research productivity Hunter, A. B. et al (2007). Research should explore variations in the quality of UREs, including factors such as mentorship effectiveness, research project complexity, and students' level of autonomy Kardash, C. M. (2000). Mentoring availability and in few cases mentoring styles have been studied , influence the outcomes of mentorship on students' research mindset but not effectiveness Johnson, W. B., & Huwe, J. M. (2003). Faculty mentors' abilities to effectively support students in developing a research mindset. Taraban, R., Logue, A. W., & Roberts, T. A. (2016).Integrating Research Skills in Curricula: Investigating how research skills can be effectively integrated into academic curricula across disciplines can promote a research mindset beyond UREs. Hensel(2012), N. H., Engle, J., & Knaub, A. P. (2012). How research skills acquired in UREs transfer to other academic and professional contexts, contributing to students' overall skill development. Kardash, C. M., Wallace, M. L., & Wallace, K. A. (2012). There is a need to explore how UREs and faculty mentorship contribute to students' broader personal and professional growth beyond academic skills, such as leadership, resilience, and adaptability. Eagan, M. K., Hurtado, S., Chang, M. J., Garcia, G. A., Herrera, F. A., & Garibay, J. C. (2013). Comprehensive measures to assess students' personal and professional growth resulting from UREs and mentorship is essential. (Reference: Seymour, E., Hunter, A. B., Laursen, S. L., & Deantoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. Science Education, 88(4), 493-534.)

III. METHODOLOGY

A. Objectives

1. To assess the impact of research experience (at UG level) and Mentorship Effectiveness on Research Skills, Personal/Professional Growth and Research Mindset
2. To explore the impact of research skills development on Personal and Professional Growth and Research Mindset
3. To measure the mediation effect of Research skills between
    a. URE and PPE
    b. Research Skills between Mentorship and Research Mindset
    c. PPG between RS and Research Mindset

B. Research Design

The study utilized a descriptive and relational research design, It is descriptive as it attempts to describe the state of affairs as it exists (Creswell, 2012) and is relational because it explores the relationships among various constructs. Participants included undergraduate students from Tier 1 (NIT/IISc) and Tier 2 engineering institutions in Tamil Nadu and Karnataka, specifically targeting final-year and pre-final-year students with research, project, or internship experience. A convenience sampling method was employed, with Kline (2011) suggesting a sample size of 200 as appropriate for studies using Structural Equation Modeling or path modeling. In this study, 272 respondents had taken part, of which 215 were valid and useable. Data was collected using Google Forms.The survey included 65 participants from Tier 1 institutions and 150 from Tier 2 institutions.. Primary data were gathered through a structured questionnaire (included in appendix), which underwent reliability testing and validity testing. The questionnaire's details were derived from an extensive literature review and are elaborated below

C. Measurement Scale

1) Undergraduate Research Experience (URE)

Undergraduate was assessed using a scale adapted from Luchini-Colbry, K.,et.al (2013). This scale consisted of 13 items, with example statements such as, "Participating in the research experience enabled me to take what I have learned in class and apply it to a setting outside of the classroom". Respondents rated several such statements on a scale from 1 to 5, where 1 was for strong disagreement and 5 was for strong agreement. Priyadarsini, M. K., & Kumar, S. P. (2024) research discusses the URE scale in more detail.

2) Research Mindset

The research mindset scale comprised five items that assessed students' views on the importance of research for academic and intellectual development, their motivation to engage in research, and their appreciation for scientific inquiry. Additionally, the scale explored students' openness to *new* ideas, their approach to solving research questions, and the positive impact of research on their overall learning and knowledge acquisition. Since no existing scales addressed these aspects, a new scale was created using a generative artificial intelligence tool.

3) Mentorship Effectiveness

The Mentorship Effectiveness Scale adopted for this study was initially formulated by Berk et al. (2005) was used to evaluate the effectiveness of faculty -mentoring relationships. The scale consists of 12 items that assess various behavioral characteristics of the mentors.

4) Research Skills Development

The research skills development scale was adopted from Carolanne M. Kardash's (2000) paper, it evaluates the enhancement of various research skills among undergraduate interns participating in a structured research experience. Some sample statements in the scale includes the gains and benefits accruing due to research internships / projects like "Readiness for more demanding research, Understanding how scientists work on real problems, Learning lab techniques, Tolerance for obstacles" etc.,

The entire methodology of the paper is depicted in the following flowchart for clarity and comprehension

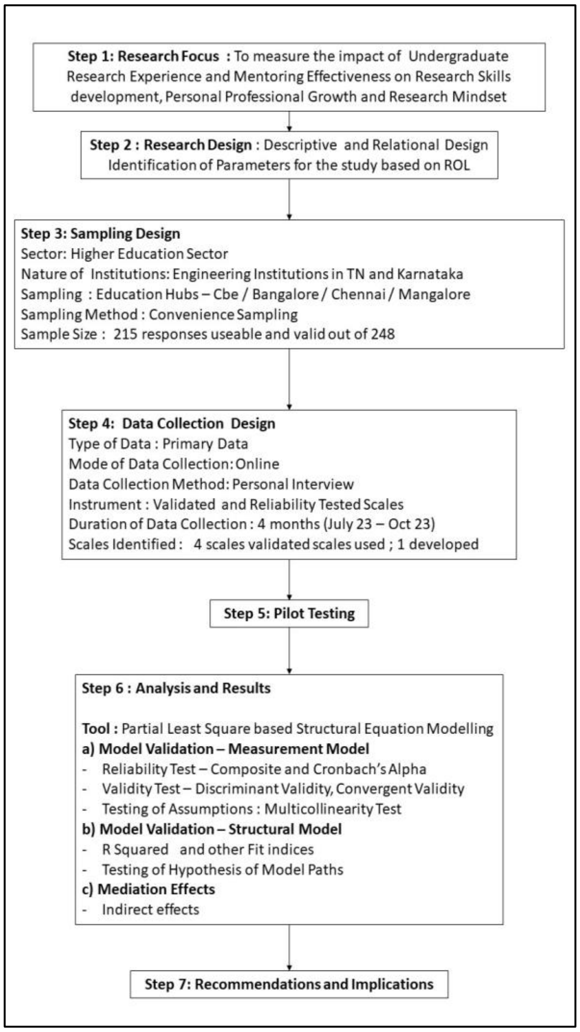


Fig. 1. Research Methodology

5) *Personal and Professional Skills*

Mourão and Fernandes, (2020) define Professional development as the "growth and maturation of knowledge, skills, and attitudes arising from formal and informal learning at work throughout one's life". It is closely connected with any kind of learning and development accumulated through targeted Interventions (Fernandes et al., 2019). The measurement scale comprised of 19 statements developed by Kardash, C. M. (2000). The sample statements include gains /benefits accruing due to Research Experience like "Understanding of the research process, Readiness for more demanding research, understanding how scientists work on real problems, learning lab techniques" etc., and the level of agreeableness on the same was measured. The study hypotheses is given in table I

IV. Results and Discussions

Partial Least Squares based Structural Equation Modeling (PLS-SEM) is a statistical technique used to estimate complex models with latent variables (Hair et al., 2016). PLS-SEM is particularly useful when the research goal is prediction, the model is complex, and the data may not meet the assumptions required for covariance-based SEM (Hair et al., 2019).

Table I
Hypothesis Formulated

Hypo thesis	Predictor's Variables	Dependent Variable
H1	Undergraduate Research Experience positively impacts	Research Skills Development
H2	Mentorship Effectiveness positively impacts	Research Skills Development
H3	Undergraduate Research Experience positively impacts	Personal Professional Growth
H4	Research Skills Development has a positive impact on	Personal Professional Growth
H5	Research Skills Development has a positive impact on	Research Mindset
H6	Personal Professional Growth has a positive influence on	Research Mindset
H7	Mentorship Effectiveness positively impacts	Research Mindset

Unlike covariance based methods, PLS-SEM does not require multivariate normal data and can handle smaller sample sizes (Wong, 2013). PLS-SEM has been widely adopted across various disciplines, including social sciences, strategic management, and information systems (Hair et al., 2019). Recent developments in PLS-SEM, such as the introduction of PLS predict for out-of-sample prediction and new model comparison criteria, have further expanded its applications (Hair et al., 2019). However, researchers should be cautious when using PLS-SEM and ensure that it is the most appropriate method for their research objectives and data characteristics (Rigdon et al., 2017). Therefore, after careful consideration, PLS based SEM was used for this research purpose and SMART PLS tool was administered to test the model. A stepwise validation of Measurement Model, followed by structural model are necessary for ensuring the robustness and reliability of SEM results. Measurement/Outer model validation focuses on measurement quality, while structural /inner model validation emphasizes structural relationships (Hair et al., 2019; Henseler et al., 2009).

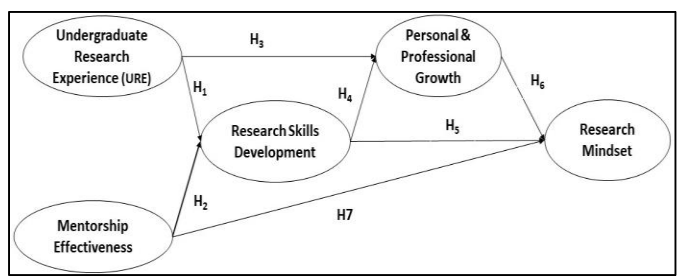


Fig. 2. Conceptual Framework

A. *Measurement Model Validation*

Measurement model validation also referred to as outer model validation, focuses on the relationships between the study constructs and their measured indicators (statement used to measure the constructs). This validation is done to check the reliability and validity of the study constructs. It includes the following three steps a) Reliability Assessment b) assessing Convergent Validity and finally c) assessing Discriminant Validity

TABLE II
MEASUREMENT MODEL VALIDATION

Variable	Cronbach 's Alpha	AVE	Shaprio Wilk	VIF
Undergraduate Research Experience	0.916	0.583	0.926	2.778
Mentorship Effectiveness	0.944	0.696	0.970	2.910
Personal Professional Growth	0.872	0.594	0.867	3.601
Research Mindset	0.84	0.641	0.87	2.618
Research Skills Development	0.953	0.629	0.971	1.913

HTMT Criterion	URE	ME	PPG	RM	RSD
Undergraduate Research Experience	1				
Mentorship Effectiveness	0.801	1			
Personal Professional Growth	0.753	0.652	1		
Research Mindset	0.784	0.727	0.826	1	
Research Skills Development	0.904	0.779	0.808	0.85	1

1) Reliability Assessment: To assess the internal consistency of the study's five constructs, we calculated composite reliability and Cronbach's alpha. A Cronbach's alpha exceeding 0.70 generally signifies acceptable reliability, suggesting that the items effectively measure the intended construct (Hair et al., 2016). As shown in Table II, all alpha values for our constructs surpassed 0.80, indicating high reliability.

2) Convergent Validity: CV is a measure of how closely related different methods of measuring the same construct are. This is assessed based on the values of Average Variance Extracted. The AVE values for each construct and shown in table II. If the value is more than 0.50, it suggests that the construct explains more than half of the variance of its indicators, and the constructs have good convergent validity (Fornell & Larcker, 1981).

The results show that the AVE Scores for all the 5 study constructs had convergent validity as the AVE scores were above 0.5. Factor loading for few sample items are depicted in table III represent the strength of relationships between latent variables and observed indicators. Hair et al. (2016) recommend that standardized factor loading should ideally be 0.70 or higher, signifying that the indicator explains at least 50% of the variance in the latent variable.

3) Discriminant Validity: This is estimated using the Heterotrait-Monotrait Ratio of Correlations (HTMT) depicted in table II, is a criterion used to assess discriminant validity. Introduced by Henseler et al. (2015), the HTMT compares how strongly items relate to different constructs versus how strongly they corelate to the same construct. A commonly accepted threshold for HTMT is 0.85; values exceeding this threshold indicate a lack of discriminant validity, referring that the constructs may not be sufficiently distinct from one another (Henseler et al., 2015; Franke & Sarstedt, 2019). The HTMT is favored for its effectiveness in measuring discriminant validity compared to traditional methods like Fornell-Larcker method. The results here clearly indicate that there is discriminant validity.

TABLE III
MEASUREMENT MODEL VALIDATION

Latent Variables	Measurement Indicators	Factor Loading	z	P-value
Undergraduate Research Experience	URExp1	0.804		
	URExp2	0.796	18.7	< .001
	URExp3	0.698	17.2	< .001
	URExp4	0.742	14.9	< .001
	URExp5	0.666	18.4	< .001
	URExp6	0.753	18.6	< .001
Mentorship Effectiveness	Mntr1	0.856		
	Mntr2	0.897	29.8	< .001
	Mntr3	0.839	29	< .001
	Mntr4	0.866	29.4	< .001
	Mntr5	0.867	25.5	< .001
Personal Profesional Growth	PPG1	0.839		
	PPG2	0.684	11.2	< .001
	PPG3	0.697	14.4	< .001
	PPG4	0.810	16.4	< .001
	PPG5	0.791	15.8	< .001
	PPG6	0.751	14	< .001
	PPG7	0.809	16	< .001
Research Skills Development	RSDev1	0.780		
	RSDev2	0.769	18.2	< .001
	RSDev3	0.811	18.4	< .001
	RSDev4	0.730	17.2	< .001
	RSDev5	0.811	23.1	< .001
Research Mindset	RM1	0.824		
	RM2	0.735	13.2	< .001
	RM3	0.879	18.1	< .001
	RM4	0.754	17.5	< .001
	RM5	0.801	19.6	< .001

B. Structural Model Validation

To validate the structural model in Structural Equation Modeling (SEM), it is essential to evaluate the issue of multi collinearity. The next step is to assess the significance of path coefficients, as well as the model's explanatory and predictive power using R^2.The results of the structural model are discussed below:

1) Measuring Collinearity Problems: Examine the structural model for potential collinearity issues among the predictor constructs. High levels of collinearity can bias the estimation of path coefficients. Variance Inflation Factor (VIF) values should be below 5 to rule out multi collinearity problems (Kline, 2011). The results of VIF values are shown in table 1. The results indicate that among the five constructs there is no multi collinearity problem

2) Evaluate Significance of Path Coefficients: The next step is to evaluate the significance of the path coefficients using t-values or p-values obtained from bootstrapping procedures. Significant paths ($p < 0.05$) indicate that the relationships are statistically different from zero. In the study results, the path coefficient (β) range between 0.152 to 0.783. Out of the seven hypothesis that were formulated, hypothesis H3 and H7 had low path coefficient as well as the p value was above 0.05, hence these two hypotheses are refuted.

TABLE IV
MEASUREMENT MODEL VALIDATION

Hypothesis and Paths	Estimate	β	t-value	p-value	Hypothesis
H_1: Undergraduate Research Experience→ Research Skills Development	0.76	0.78	10.4	< .001	Accepted
H_2: Mentorship Effectiveness → Research Skills Development	0.13	0.15	2.42	0.01	Accepted
H_3: Undergraduate Research Experience → Personal Professional Growth	0.17	0.16	1.04	0.30	Refuted
H_4: Research Skills Development → Personal Professional Growth	0.70	0.65	3.68	< .001	Accepted
H_5: Research Skills Development → Research Mindset	0.39	0.36	2.96	0.00	Accepted
H_6: Personal Professional Growth → Research Mindset	0.40	0.40	4.18	< .001	Accepted
H_7: Mentorship Effectiveness → Research Mindset	0.16	0.167	1.75	0.081	Refuted

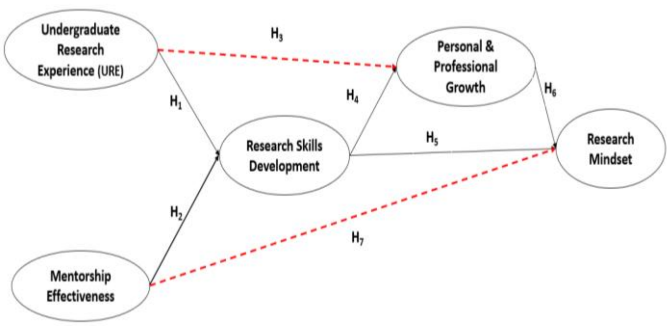


Fig. 3. Results of Hypothesis testing (--- Rejected paths ; →Accepted paths)

The other hypothesis that are accepted are described as follows: Undergraduate research experience has a positive impact on research skills development it has the highest path coefficient(0.78). The next highest path coefficient of 0.658 was for H4 Research skills development had a positive impact on personal & professional growth, followed by the path personal and professional growth had a positive impact on research mindset. H1, H4 and H6 clearly show that a good undergraduate research experience can go a long way in building a research mindset among Engineering students. Research literature consider the relevance of the path coefficients based on their magnitude, where larger coefficients suggest more substantial relationships (Hair et al., 2016). The results also clearly indicate that the development of research skills had an impact on research mindset, while mentorship effectiveness has a positive influence on the research skills development. While five out of the seven hypothesis formulated were proved, it is also essential to look at the indirect effects. In Structural Equation Modeling (SEM), indirect effects refer to "the influence of an independent variable on a dependent variable through one or more mediators". In Structural Equation Modeling (SEM), indirect effects refer to "the influence of an independent variable on a dependent variable through one or more mediators". The results of indirect effects are given in the table 5

TABLE V
INDIRECT EFFECTS OF THE MODEL

Indirect Effects	Description	β	z	p
IE1	RSD ⇒ Personal Professional Growth ⇒ Research Mindset	0.269	2.765	0.006
IE2	URE ⇒ Personal Professional Growth ⇒ Research Mindset	0.069	1.035	0.30 (N)
IE3	URE ⇒ RSD ⇒ Personal Professional Growth ⇒ Research Mindset	0.21	2.665	0.008
IE4	URE ⇒ RSD ⇒ Research Mindset	0.289	3.082	0.002
IE5	Mentorship ⇒ RSD ⇒ Personal professional Growth ⇒ Research Mindset	0.041	2.112	0.035
IE6	Mentorship ⇒ RSD ⇒ Research Mindset	0.056	1.65	0.09(N)

There are six indirect effects that are measured in this case. The strongest indirect effect, being URE impacting Research Mindset through Research skills development with a standardized coefficient of 0.289. The next indirect effect that is noteworthy is the impact of Research Skills development on Research Mindset through Personal Professional Growth with a coefficient of 0.269. The IE2 and IE6 were found to have no significance.

3) Assess Explanatory Power (R^2): The model's ability to explain the endogenous constructs can be assessed using the R^2 value. This statistic ranges from 0 to 1, with higher values indicating a better fit. Generally, R^2 values of 0.25, 0.50, and 0.75 represent weak, moderate, and strong explanatory power, respectively (Henseler et al., 2009).The R^2 Values for Personal and Professional Growth was 0.663, the R^2 value for Research Skills Development was 0.828 and for Research mindset was 0.761. This indicates a good explanatory power by the model.

4) Interpretation of Indices: The results of the comparative fit indices were found to be good. Fit indices are essential metrics used to assess the performance of structural equation models (SEM) in representing observed data. The Root Mean Square Error of Approximation (RMSEA) is another critical index, where values below 0.06 suggest a good fit, while the Comparative Fit Index (CFI) values close to 1 indicate strong model fit. The use of multiple fit indices is recommended to provide a comprehensive assessment, as relying on a single index can lead to misleading conclusions about model adequacy. The results of the fit indices indicate that CFI (-.994), Tucker Lewis Index (TLI -0.993) Goodness of Fit Index (GFI-0.984) were all high and in acceptable range. The goodness of the model fit was therefore established.

V. RESULTS AND DISCUSSION

Undergraduate Research Experiences (UREs) significantly enhance research skills and promote personal and professional growth, ultimately helping students to imbibe a positive research mindset. Participation in UREs has been shown to improve students' research self-efficacy, which mediates the relationship between their acquired research skills and aspirations for research careers the same is in line with results of Gregerman, S. R. (2013). Students involved in UREs report higher levels of academic engagement, confidence in utilizing scientific literature, and enhanced communication skills, which are supportive for both academic success and professional development. Moreover, UREs encourage a growth mindset by allowing students to engage in inquiry-based learning, where students' develop creativity and problem-solving ability through hands-on research activities. This combination of skill development and personal growth contributes to a more promising way to increase research, equipping students with the tools necessary for lifelong learning and career advancement

Mentorship significantly enhances research mindset by improving research skills, personal growth, and a positive outlook on challenges. Effective mentoring relationships, characterized by mutual trust and clear communication, lead to increased mentee productivity, self-efficacy, and career satisfaction the results are in line with the works of Bearman et al., (2016). The study results prove that a well-defined mentoring relationship clarifies roles and expectations, which helps establish a supportive environment, and is in line with Hibbert-Latimer, (2023). Mentors provide critical feedback and guidance, enabling mentees to develop vital research skills like data analysis and experimental design. Moreover, mentorship promotes a growth mindset, encouraging mentees to view challenges as opportunities for learning. Regular feedback from various sources, including peers and supervisors, is essential for evaluating and improving mentoring effectiveness. Additionally, effective mentorship involves understanding the psychosocial and career support needed for mentees, which can be measured through various assessment tools. All the above aspects when implemented in institutions can help in mentorship cultivating a positive research mindset, equipping mentees with the skills and confidence necessary for success in their academic and professional journeys (National Academies of Sciences, 2019). Undergraduate Research Experiences (UREs) have been shown to positively influence students in several ways. Research indicates that UREs contribute to academic and career success, enhance presentation and interpersonal skills, foster research abilities, and encourage participation in extracurricular activities.

HEIs can formulate a separate committee to garner the efforts of students and teachers in building a research culture.

Institutions can support / offer training programs on mentoring skills to research guides who, in turn, motivate students to undertake research

URE requires a lot of hand-holding and through mentorship, students gain valuable insights into the research culture, learn about research ethics, and learn to handle the complexities and challenges inherent in the research process.

Discussions and encouraging students to utilize Library resources, access to databases, and training in them, providing technology/ lab/specialized software or computational support, Funding Support, Access to IT/language/writing, research-based openings in placements can help improve mentoring effectiveness

Shanahan et al. (2015) propose several strategies to enhance research mentorship for undergraduates, emphasizing the necessity of high-quality mentoring as a cornerstone of effective research experiences. One key practice is establishing clear expectations through written agreements, which helps both mentors and mentees understand their roles and responsibilities. Additionally, fostering a supportive and inclusive environment is crucial; mentors should prioritize building strong, trusting relationships with students, which can be achieved through regular, open communication and emotional support. The authors also recommend gradually increasing student autonomy in research projects, allowing them to take ownership of their work. Providing constructive feedback and facilitating networking opportunities are essential for professional development. Furthermore, mentors should engage in peer mentoring and encourage collaboration among students to enhance their learning experiences. Collectively, these practices aim to create a more enriching and productive research environment that addresses the diverse needs of undergraduate students

CONCLUSION

The study underscores the critical role of Undergraduate Research Experience (URE) and mentoring effectiveness in shaping a research-oriented mindset among engineering students. The findings reveal that effective mentorship and enriching research experiences significantly contribute to the development of essential research skills and personal growth. By confirming five out of seven hypotheses, the research demonstrates a positive correlation between URE and the enhancement of students' research mindsets, as well as the influence of mentoring on research skills development. These insights highlight the necessity for educational institutions to prioritize and improve mentorship frameworks and research opportunities at the undergraduate level. Ultimately, fostering a robust research culture through effective mentorship can lead to a more innovative and competent engineering workforce, better equipped to meet the challenges of the future.

APPENDIX

Scales /Survey Questionnaire

Undergraduate Research Experience

Participating in the research experience ………

improved my research skills

increased my interest in graduate study

helped prepare me for graduate study

gave me the opportunity to build a relationship with a research mentor

gave me the opportunity to contribute to the knowledge creation process

helped me to understand the importance of ethical conduct in research

was a worthwhile experience

is something I would recommend to other students

Research Mindset

I view research as an essential aspect of academic and intellectual growth.

I am motivated to pursue research and inquiry in my field of study beyond academic requirements.

Research experiences have deepened my appreciation for the scientific or scholarly process.

I am open to exploring new ideas and approaches to solve research questions.

Engaging in research has positively influenced my overall approach to learning and knowledge acquisition.

Mentorship Effectiveness

My mentor was accessible

My mentor demonstrated professional integrity.

My mentor motivated me to improve my work product.

My mentor acknowledged my contributions

My mentor suggested appropriate resources

My mentor challenged me to extend my abilities

Research Skills Development

Understanding of the research process

Learning to work independently

Skill in the interpretation of results

Ability to analyze data

Understanding primary literature

Skill in oral presentation

Skill in science writing

Personal and Professional Growth (Perceived)

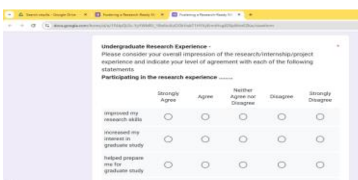
With the research exposure, I have gained confidence to execute my work

My teachers have complimented me about my research skills

I have become a more qualified professional

I feel well prepared to undertake activities that are meant for me

GOOGLE FORM USED FOR DATA COLLECTION



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