From Campus to Career: The Influence of Undergraduate Research on Aspirations, Growth, and Research Mindset in Engineering Education

[1]Kirupa Priyadarsini M, [2]S Pavan Kumar
[1]PSG Institute of Management, PSG College of Technology, Coimbatore, Tamil Nadu,
[2]School of Humanities, Social Sciences and Management, NITK Surathkal, Karnataka
[1]kirupa@psgim.ac.in , [2]pavankumar@nitk.edu.in

***Abstract*—Strengthening student research culture within colleges has become a priority as institutions aim to train students with the skills, mindset, and motivation needed for innovation-driven careers. Undergraduate research, supported by institutional initiatives, is pivotal in fostering early research engagement and shaping students' long-term academic and professional career pathways. This study examines the influence of undergraduate research experience (URE), institutional support, research skills, and confidence on engineering students' career aspirations, personal and professional growth, and research mindset. Data from 215 Tamil Nadu and Karnataka students in Tier 1 and Tier 2 institutions were collected and analyzed using Partial Least Squares Structural Equation Modelling in JAMOVI. Findings show that URE and institutional support significantly boost career aspirations, while research skills and confidence strongly predict growth. Career aspirations and development, in turn, enhance research mindset, with growth emerging as the strongest driver.**

***Keywords*— Career aspirations, institutional support, personal and professional growth, research mindset, undergraduate research experiences, and Partial Least Squares Structural Equation Modelling.**

***JEET Category*—Research**

I. INTRODUCTION

INDIA, home to over 25% of the world's engineers, occupies a unique position in the global scientific and engineering landscape. Despite ranking third worldwide in peer-reviewed science and engineering publications, the nation faces a pronounced gap in research output and innovation when compared to global leaders. According to the National Science Foundation, the United States and China contribute 23% and 16% respectively to global research publications, whereas India accounts for only 5%. Countries such as Germany and the UK each contribute 4%, and Japan 3%. While India's patent filings at the Indian Patent Office are on the rise continuously year after year, this encouraging progress remains insufficient to leverage India's vast engineering talent pool and potential fully. The country's rise in the Global Innovation Index—from 81st place in 2014 to 40th in 2022—reflects the impact of targeted initiatives by agencies like the National Science Technology Entrepreneurship Development Board (NSTED) and the Department of Science and Technology (DST). Yet, the challenge of nurturing a robust research ecosystem persists.

Addressing this gap requires nurturing a research mindset of students at undergraduate level, particularly among engineering students. Undergraduate Research Experience (URE) serves as a transformative platform that bridges the divide between theoretical learning and real-world applications. Globally, higher education institutions increasingly recognize the importance of research engagement early in students' academic journeys. Institutions that provide structured opportunities—such as research-focused courses, technical guidance, financial support, and access to well-equipped libraries and laboratories—can significantly enhance students' research capabilities and motivation. The recent policy developments in India, such as the introduction of a four-year undergraduate research degree enabling direct entry into doctoral programs (as per UGC's draft) and the establishment of the National Research Foundation (NRF) with substantial funding, are promising strides toward this goal.

Guided by the developments unfolding, the present study examines the impact of undergraduate research in shaping research culture among students, focusing on the interplay between research experience, institutional support, Research skills, Confidence, personal and professional growth, and students' career aspirations in research. By exploring how early exposure to research can influence attitudes, skills, and long-term engagement in scholarly activities, this research aims to

Kirupa Priyadarsini M
PSG Institute of Management, PSG College of Technology
Avinashi Road, Peelamedu, Coimbatore , Tamilnadu – 641004
kirupa@psgim.ac.in

provide actionable insights and recommendations for policymakers, higher education administrators, and engineering educational institutions. The ultimate objective is to contribute to the development of a sustainable, research-driven academic environment in India—one that can not only close the current research gap but also harness the nation's vast engineering talent to achieve global leadership in innovation.

II. Review of Literature

Undergraduate Research Experience

Undergraduate research experience refers to the involvement of undergraduate students in research activities, typically under the guidance and mentorship of faculty members. This experience encompasses conducting original research projects or investigations that enhance students' understanding of disciplinary knowledge and research methods. It is characterized by active participation in scholarly inquiry, where students formulate research questions, design experiments or studies, and interpret results. URE is a high-impact educational practice where students actively participate in faculty-guided research, fostering learning and development of critical thinking skills (Waterman & Hemmestra, 2018). It refers to "students conducting original research projects or investigations under mentorship during their undergraduate studies, which enrich their understanding of disciplinary knowledge and research methods (Wallington, 2015)". According to Linn et al, (2015) and Hunter et al, (2009) and URE is "An authentic scholarly inquiry undertaken by undergraduates that involves formulating questions, designing and conducting experiments or studies, and interpreting results with mentorship support".

Career Aspirations in Research

According to Estrada, Hernandez, & Schultz (2018), Career aspirations (CAs) in research refer to "undergraduate students' interests, plans, and motivation to pursue advanced education and professional roles in research fields." the intention of undergraduate students to engage in scientific research careers or graduate study pathways following their undergraduate education, reflecting their commitment to continued academic and professional development (Linn, Palmer, Baranger, Gerard, & Stone, 2015). Participation in undergraduate research experiences significantly enhances students' clarity about research careers. It helps them assess their fit in research roles and often confirms or refines their career goals. These experiences enhance professional identity, build confidence, and expose students to academic and professional networks, which are essential for long-term retention in research careers. URE has an impact on career aspirations in research positively (Priyadarshini, M. K., & Kumar, S. P., 2024). The hypothesis formulated is as follows.

H_1: URE has a significant impact on CAs in research among engineering students

Institutional Support

Brew (2010) defines institutional support as "the provision of resources, mentoring, infrastructure, and policies by higher education institutions that facilitate and sustain student and faculty research activities." Eagan et al. (2013) say the institutional support is "the extent to which an institution fosters an environment that enables and encourages undergraduate research participation through formal programs and dedicated resources." Robust institutional support is related to increased research productivity, enhanced skill acquisition, and improved student satisfaction with the research process (Kumar, S. P., 2025).

Institutions that provide resources such as funding, mentoring, dedicated research spaces, and administrative support foster a sense of community, belonging, and academic engagement—key drivers for persisting in research pathways. Students exposed to both high-quality research experiences and supportive institutional environments show greater intention and readiness to pursue advanced research roles, graduate studies, and careers in academia or industry research (Mastronardi, M., (2021), Priyadarsini, M. K.,et al (2025), Chamely-Wiik, D (2023). The context helps us in formulation the below mentioned hypothesis.

H_2: Institutional support for undergraduate research has a positive impact on engineers' career aspirations in research

Research Skills Acquired by Engineers

The development of research skills and student confidence represents a critical intersection in higher education that profoundly influences both personal and professional trajectories. Research skills encompass the ability to collect, evaluate, and synthesize information, conduct systematic investigations, and apply evidence-based approaches to problem-solving. The development of research competencies enables students to appropriate knowledge and analyze their environment in more critical and logical ways, facilitating their ability to face and solve relevant problems (Angeloska-Galevska, N., 2023). This process supports the growth of critical and highly capable individuals who can significantly enhance their performance in various activities.

Confidence

Confidence, or self-efficacy, is "an individual's belief in their capability to organize and execute the courses of action required to manage prospective situations" Bandura (1997)". It indicates the "the strength of one's conviction about their ability to perform specific tasks successfully." Lent, Brown, & Hackett (1994). Students' confidence, particularly research self-efficacy, refers to individuals' beliefs in their capability to successfully perform research-related tasks and navigate academic challenges (Whelan, K., Castelli et al. 2022). The development of research competencies appears to follow a progressive pattern where initial skill acquisition builds foundational confidence, which then enables students to tackle more complex research challenges.

Personal and Professional Growth

Pascarella E T (2005) state that Personal and professional growth is "development in cognitive, interpersonal, and career-related competencies fostered through educational experiences." While Kember, D., Lee, K., & Li, N. (2001) indicate that Personal and professional growth involves acquisition of skills, values, and attitudes contributing to maturity and career preparedness. However, for this paper the definition given by Hunter, A. B., Laursen, S. L., & Seymour, E. (2007) is more apt, which states that personal and professional growth is defined as "the process by which students enhance their self-understanding, ethical reasoning, communication skills, and disciplinary knowledge through research participation."

Student community has reported that performing scientific research significantly contributes to their intellectual activity and enhances their creative thinking and cognitive abilities (Ferguson, C. L.,et al, 2024), Alipina, K. B,et al, 2023). The above discussions lead us to the following hypotheses.

H_3: Research skills acquired by engineers have a positive influence on their personal and professional growth

H_4: Students confidence has an impact on their personal and professional growth positively

Career Aspirations (CA) in Research Impacts Personal and Professional Growth

Best practices for fostering career aspirations in research involve comprehensive approaches that address both skill development and psychological support. Successful programs provide students with significant autonomy combined with appropriate support, demonstrating improved learning, confidence, and attitudes toward research. Students show inclination toward research-informed practice and express keenness to maintain newly established favorable relationships with research. focusing on research skills show positive impacts at both individual and organizational levels, with participants reporting increased professional development growth through research confidence, career planning intentions, and practical application of newly acquired research skills (Tajuria, G.,et al.,2024), leading us to the hypotheses

H_5: CA in research impacts personal and professional growth

Impact of career aspirations in research and personal and professional growth on research mindset

The impact of career aspirations and professional development on the research mindset among undergraduate engineering students is significant. Research experiences not only enhance students' technical skills but also foster a culture of inquiry and critical thinking, which are essential for a robust research mindset. The following sections elaborate on the key aspects of this relationship. While URE positively affects students' research mindset, through increased career aspirations in research fields. Participation in structured undergraduate research experiences (SURE) enhances self-efficacy, which mediates the relationship between perceived learning gains and aspirations for graduate studies (Strayhorn, 2010). Mentorship and resources significantly contribute to students' professional growth and confidence in their research capabilities McClellan, G. S., et al., (2023). Engaging in research projects enhances students' problem-solving skills, communication abilities, and technical knowledge, which are vital for their future careers (Kistler, 1987). Early exposure to research fosters long-term career direction and personal growth, particularly for underrepresented students (McClellan, G. S., et al.,2023). This leads us to the following hypotheses

H_6: Career aspirations in research impact research mindset

H_7: Personal and professional growth prospects have a positive impact on research mindset

III. METHODOLOGY

The research paper attempts to fulfil the following objectives.

1. To measure if URE and Institutional support influence Career aspiration (CA) in research
2. To explore the impact of research skills and confidence in overall growth of the students (personal and professional).
3. To measure the impact of CA in research and personal and professional growth on research mindset

The study employed a descriptive–relational research design to capture both the current status of undergraduate research engagement and the interrelationships among the study's core constructs. The descriptive component provided a factual account of how undergraduate students participate in research activities, while the relational component examined how variables such as research experience, institutional support, career aspirations, confidence, Research skills, personal professional growth, and research mindset are interconnected.

The research focused on final-year and pre-final-year undergraduate students from Tier 1 and Tier 2 engineering institutions in Tamil Nadu and Karnataka, specifically those with prior exposure to research projects, academic internships, or similar scholarly activities. A convenience sampling approach was adopted due to accessibility and time considerations. Following Kline's (2011) guideline of a minimum of 200 participants for studies involving Structural Equation Modeling, the survey reached 272 students, of whom 215 provided valid responses for analysis.

Primary data were collected using a questionnaire developed from an extensive review of relevant literature. The instrument underwent reliability testing to ensure internal consistency and validity checks to confirm construct accuracy. The questionnaire was disseminated electronically using Google Forms, yielding responses from sixty five students in Tier 1 institutions and one hundred and fifty students in Tier 2 institutions.

Structural Equation Modeling (SEM) was employed in this study as it allows for the simultaneous examination of multiple relationships among observed and latent variables, providing a more holistic understanding of the research model. SEM is

particularly suited to testing such theoretical models where variables may influence each other both directly and indirectly. JAMOVI was selected as the analytical platform because it provides a user-friendly interface for SEM, supports Confirmatory Factor Analysis (CFA) for validating measurement models, and produces key fit indices (e.g., CFI, TLI, RMSEA, SRMR) necessary for assessing model adequacy. Additionally, JAMOVI integrates seamlessly with R, allowing for reproducibility and transparency of analysis while requiring minimal coding for those preferring a graphical workflow. The hypothesized model is given in Fig 1 and the hypothesis formulated are consolidated in table 1. In this context, SEM in JAMOVI enabled the study to:

1. Validate the measurement of constructs through CFA.
2. Test the hypothesized relationships between constructs in a single comprehensive model.
3. Provide robust statistical evidence for the proposed linkages in the conceptual framework.

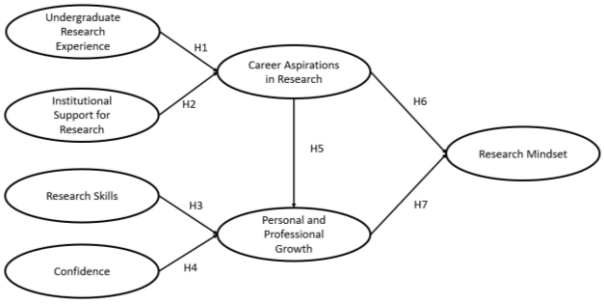

Fig. 1. Hypothesized Framework

IV. Results and Discussions

Partial Least Squares -Structural Equation Modeling (SEM) represents a sophisticated multivariate statistical technique utilized for the analysis and estimation of intricate causal relationships involving latent variables—constructs that are not directly observable but are measured through a variety of indicators (Hair et al., 2016). This methodological approach is particularly appropriate for research where the primary emphasis lies in development of theoretical frameworks, and involves rigorous hypothesis testing.

PLS -SEM proves to be advantageous in contexts where the conceptual framework is intricate, encompassing a multitude of constructs, indicators, and structural associations. Furthermore, it is particularly well-adapted for instances where the dataset does not satisfy the rigorous statistical prerequisites mandated for covariance-based SEM, such as multivariate normality or substantial sample sizes (Hair et al., 2019). By employing a variance-based estimation methodology, PLS-SEM affords enhanced flexibility in accommodating smaller sample sizes, non-normative data distributions, and formative measurement models, thereby establishing itself as a pragmatic option for exploratory and predictive inquiries across the domains of social sciences, management, and engineering education.

Consequently, following thorough deliberation, PLS-based SEM was selected for this research endeavor, and the SMART PLS tool was employed to evaluate the model. A systematic validation of the Measurement Model, succeeded by the validation of the structural model, is imperative to ensure the robustness and dependability of the SEM findings. The validation of the Measurement/Outer model concentrates on the quality of the measurements, whilst the validation of the structural/inner model underscores the significance of structural relationships (Hair et al., 2019; Henseler et al., 2009).

Measurement Model Validation in JAMOVI Software

It involves using statistical techniques to assess psychometric properties of a measurement instrument. This process is crucial for ensuring that the instrument accurately measures the intended constructs. In the context of JAMOVI, Confirmatory Factor Analysis (CFA) is a commonly used method for this purpose. CFA helps in testing the construct validity by confirming whether the data fits the hypothesized measurement model. The process involves several steps, including data screening, reliability testing, and model fit assessment, which are essential for validating the measurement model. Measurement model validation refers to evaluating whether the measures in a study (such as questionnaire items or test scores) accurately represent the theoretical constructs they are intended to measure, and whether the structure of the items conforms to expectations.

The commonly used quantitative techniques include two steps

a) Reliability Testing: Checks the internal consistency among the items (Cronbach's alpha, Split-half reliability).
b) Confirmatory Factor Analysis (CFA): Tests a hypothesized factor structure; uses fit indices (RMSEA, CFI, TLI) to assess how well the model fits observed data.
c) Validity Assessment: i. Convergent Validity: Items supposed to measure the same construct have high correlations. ii. Discriminant Validity: Items measuring different constructs have low correlations.

TABLE I
SUMMARY OF HYPOTHESES FORMULATED

Hypothesis	Predictor's Variables	Dependent Variable
H1	Undergraduate Research Experience positively impacts	CAs in Research
H2	Institutional mentoring has a positive impact on	Career aspiration in Research
H3	Research Skills has a positive impact on	Personal Professional Growth
H4	Confidence of Engg Student positively impacts	Personal Professional Growth
H5	CAs in Research has a positive impact on	Personal and Professional Growth
H6	CAs in Research has a positive impact on	Research Mindset
H7	Personal Professional Growth has a positive influence on	Research Mindset

TABLE II
MEASUREMENT MODEL VALIDATION

Variable	Cronbach 's Alpha	AVE	Shaprio Wilk	VIF
U R E	0.93	0.64	0.92	1.34
Institutional Support	0.89	0.67	0.88	1.65
Research Skills Development	0.96	0.66	0.97	1.78
Confidence	0.88	0.70	0.89	2.10
CAs in Research	0.87	0.69	0.92	1.46
Personal Professional Growth	0.87	0.56	0.86	1.19
Research Mindset	0.86	0.67	0.87	1.82

The measurement model depicted in table 2 demonstrated robust results for the scales, providing strong support for the reliability and validity of the constructs under investigation. The results of questionnaire reliability, convergent validity, normality and multicollinearity are depicted here. Internal consistency reliability was excellent, with Cronbach's alpha coefficients ranging from 0.863 to 0.960, substantially exceeding the widely accepted minimum threshold of 0.70 for exploratory research (Nunnally & Bernstein, 1994) and comfortably within the range considered indicative of high measurement stability. These values suggest that the items within each construct are strongly interrelated and consistently measure their respective latent variables. Convergent validity was also well established, as evidenced by Average Variance Extracted (AVE) values ranging from 0.564 to 0.702, all above the recommended minimum of 0.50 (Fornell & Larcker, 1981), thereby indicating that, on average, the constructs explain more than half of the variance in their respective indicators. Moreover, assessment of multicollinearity using the Variance Inflation Factor (VIF) revealed values between 1.19 and 2.10, which are far below the conservative upper limit of 3.0 suggested in methodological literature (Hair et al., 2019). This finding confirms that there is no problematic overlap among the constructs that would impair the estimation of structural paths. Examination of normality using the Shapiro–Wilk test (Shapiro & Wilk, 1965) yielded coefficients ranging from 0.86 to 0.97. While some constructs (e.g., Research Skills Development, 0.97) exhibited near-perfect normality, others (e.g., Institutional Support, 0.88; Personal Professional Growth, 0.86) showed mild departures from the ideal distribution. The combined evidence from the reliability, convergent validity, and multicollinearity diagnostics supports the conclusion that the measurement model is statistically sound and suitable for subsequent Structural Equation Modeling and hypothesis testing. The Cronbach alpha was computed using the formula

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{Sum\ of\ Variances}{Total\ Variance}\right)$$

TABLE III
MEASUREMENT MODEL HTMT CRITERION

HTMT Criterion	URE	IS	RS	C	CA	PPG	RM
U R E	1	0.707	0.756	0.862	0.725	0.77	0.573
Institutional Support		1	0.733	0.739	0.623	0.687	0.51
Research Skills			1	0.726	0.623	0.641	0.507
Confidence				1	0.745	0.834	0.553
CAs					1	0.803	0.523
Personal Professional Growth						1	0.694
Research Mindset							1

Discriminant validity was examined using the Heterotrait–Monotrait Ratio of correlations (HTMT) as recommended by Henseler, Ringle, and Sarstedt (2015) and is depicted in table 3. The HTMT values among the constructs ranged from 0.507 to 0.862, with the majority falling well below the conservative threshold of 0.85, indicating satisfactory discriminant validity. The only value exceeding the 0.85 criterion was observed between Undergraduate Research Experience and Confidence (HTMT = 0.862), which still remained below the more liberal cut-off point of 0.90 often deemed acceptable in behavioural and social sciences research. This finding suggests that while these two constructs are conceptually related, they are empirically distinguishable. Overall, the HTMT assessment confirms that the constructs in the measurement model are sufficiently discriminant, supporting the appropriateness of their use in subsequent structural equation modelling.

Confirmatory factor analysis (CFA) was conducted within the PLS-SEM framework to assess the adequacy of the measurement model, the results of which are shown in table 4. Indicator reliability was demonstrated through high standardized loadings, with the vast majority exceeding the recommended threshold of 0.70 (Hair et al., 2019). Loadings ranged from 0.666 to 0.804 for Undergraduate Research Experience, 0.844 to 0.937 for Institutional Support, 0.794 to 0.945 for Career Aspirations in Research, 0.730 to 0.811 for Research Skills Development, 0.850 to 0.948 for Confidence, 0.684 to 0.839 for Personal Professional Growth, and 0.735 to 0.879 for Research Mindset. While two items (UREXp5 = 0.666; PPG2 = 0.684) fell slightly below the ideal cut-off, they were retained as the constructs' average variance extracted (AVE) values exceeded 0.50, indicates adequate convergent validity in place (Fornell & Larcker, 1981). All factor loadings of the indicators were statistically significant at $p < .001$ with z-values well above the critical value of 1.96, confirming that each indicator made a meaningful contribution to its corresponding latent variable. These findings provide empirical support for psychometric properties (reliability and validity) of the measurement model, justifying progression to structural model assessment.

TABLE IV
CONFIRMATORY FACTOR ANALYSIS

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
Institutional Support	IS1	0.937		
	IS2	0.844	21.9	< .001
	IS3	0.875	20.1	< .001
	IS4	0.888	22.8	< .001
	IS5	0.862	20.9	< .001
	IS6	0.885	20	< .001
Career Aspirations in Research	CA1	0.794		
	CA2	0.929	16.4	< .001
	CA3	0.907	14.5	< .001
	CA4	0.945	15.9	< .001
Research Skills	RS	0.780		
	RS	0.769	18.2	< .001
	RS	0.811	18.4	< .001
	RS	0.730	17.2	< .001
	RS	0.811	23.1	< .001
Confidence	C1	0.915		< .001
	C2	0.914	22.9	< .001
	C3	0.85	17.1	< .001
	C4	0.948	24.2	< .001
	C5	0.873	22.2	< .001
	C6	0.878	19.4	< .001
Personal Professional Growth	PPG1	0.839	21.9	
	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 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

Structural Model Results using JAMOVI

The structural model results (shown in table 5) indicated that all hypothesized relationships were positive and statistically significant at the 1% level, thereby supporting all seven proposed hypotheses. Undergraduate Research Experience exerted a moderate positive effect on Career Aspirations in Research ($\beta = 0.445$, $t = 4.59$, $p < 0.01$), while Institutional Support also contributed positively, albeit to a lesser extent ($\beta = 0.235$, $t = 2.65$, $p < 0.01$). Research Skills ($\beta = 0.420$, $t = 5.39$, $p < 0.01$) and Confidence ($\beta = 0.444$, $t = 6.73$, $p < 0.01$) emerged as significant predictors of Personal Professional Growth, with confidence having a marginally stronger influence. Career Aspirations positively influenced both Personal Professional Growth ($\beta = 0.171$, $t = 3.22$, $p < 0.01$) and Research Mindset ($\beta = 0.198$, $t = 3.50$, $p < 0.01$), though these effects were relatively smaller.

Model fit indices indicated a strong correspondence between the hypothesized PLS-SEM model and observed data. The SRMR and RMSEA values (SRMR = 0.054; RMSEA = 0.037–0.041) fell well within recommended thresholds, supporting the model's absolute fit. Incremental fit indices (CFI, TLI, NNFI, NFI, RFI, IFI, RNI all ≥ 0.99) further confirmed an excellent fit relative to a baseline model, while the parsimony-adjusted PNFI (0.955) indicated effective model specification. Collectively, these results provide compelling evidence of both excellent absolute and comparative fit for the proposed structural model.

TABLE V
RESULTS OF HYPOTHESES TESTING

Hypothesis and Paths	Estimate	β	t-value	Hypothesis
H1: Undergraduate Research Experience→ Career Aspirations in Research	0.379	0.445	4.59*	Supported
H2: Institutional Support → Career Aspirations in Research	0.191	0.235	2.65*	Supported
H3: Research Skills → Personal Professional Growth	0.389	0.42	5.39*	Supported
H4: Confidence → Personal Professional Growth	0.432	0.444	6.73*	Supported
H5: Career Aspirations in Research → Personal Professional Growth	0.199	0.171	3.22*	Supported
H6:Career Aspirations in Research → Research Mindset	0.224	0.198	3.50*	Supported
H7: Personal Professional Growth → Research Mindset	0.786	0.81	13.76*	Supported

*Significant at 0.01 level

The z value and t value is computed using the formula $Z = (Sample\ Mean - \mu)/(s/\sqrt{n})$ where s is the std deviation and n is the number of samples and Mu represents the population mean

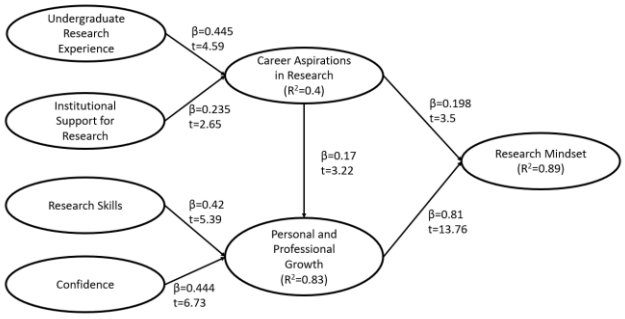

Fig. 2. Results of the Structural Model

The most substantial effect observed in the model was from Personal Professional Growth to Research Mindset ($\beta = 0.810$, $t = 13.76$, $p < 0.01$), underscoring the pivotal role of ongoing personal and professional development in fostering a robust research orientation. Collectively, these findings support the theoretical proposition that experiential learning, institutional resources, skill enhancement, and internal psychological factors jointly contribute to the development of research career pathways and mindsets.

The analysis of indirect effects, which are shown in table 6, revealed that several mediating pathways significantly linked the exogenous variables to Research Mindset (RM). Personal Professional Growth (PPG) emerged as the dominant mediator. Confidence exhibited the most substantial indirect influence on RM through PPG ($\beta = 0.359$, $z = 6.313$, $p < .001$), closely followed by Research Skills ($\beta = 0.341$, $z = 5.391$, $p < .001$). Career Aspirations in Research (CA) also mediated relationships, with a significant indirect effect on RM via PPG ($\beta = 0.138$, $z = 2.931$, $p = .003$). Undergraduate Research Experience (URE) influenced RM indirectly both via CA alone ($\beta = 0.088$, $p = .004$) and through the sequential CA → PPG pathway ($\beta = 0.062$, $p = .014$). Institutional Support (IS) had a marginally significant mediation via CA ($\beta = 0.047$, $p = .051$) but was significant in the sequential path through CA and PPG ($\beta = 0.033$, $p = .025$). These results underscore that while CA plays an important mediating role, the strongest transmission of effects to RM operates through PPG, highlighting personal and professional development as the central mechanism in translating skills, confidence, and aspirations into a sustained research orientation.

TABLE VI
RESULTS OF INDIRECT EFFECTS

Indirect Effects	Description	β	z	p
IE1	Career Aspirations ⇒ PPG ⇒ RM	0.138	2.931	0.003
IE2	UG Research Exp ⇒ CA ⇒ RM	0.088	2.844	0.004
IE3	UG Research Exp ⇒ CA ⇒ PPG ⇒ RM	0.062	2.456	0.014
IE4	Institutional Support ⇒ CA ⇒ RM	0.047	1.954	0.051
IE5	Institutional Support ⇒ CA ⇒ PPG ⇒ RM	0.033	2.239	0.025
IE6	Research Skills ⇒ PPG ⇒ RM	0.341	5.391	< .001
IE7	Confidence ⇒ PPG ⇒ RM	0.359	6.313	< .001

V. DISCUSSIONS AND IMPLICATIONS

The findings of this study reinforce the critical role that undergraduate research experience (URE) and institutional support play in shaping students' career aspirations in research. Both hypotheses under the first objective were confirmed, indicating that practical exposure to research projects, coupled with institutional support in terms of mentorship, infrastructure, and funding, significantly influences students' intent to pursue research-oriented careers. This aligns with earlier studies which demonstrate that undergraduate research not only enhances technical competence but also fosters career clarity and ambition in research domains. It helps them assess their fit in research roles and often confirms or refines their career goals. Students gain advanced research and communication skills, increased research competence, and broader professional skills, all of which are highly valued in research-based careers. These skill gains persist into graduate school and beyond.

The second objective examined the relationship between research skills, confidence, and personal and professional growth. The significant positive results suggest that engaging in research activities develops skills such as critical-thinking, problem solving, data analysis, and academic communication. These skills contribute not only to professional advancement but also to personal development by enhancing self-efficacy, resilience, and the ability to work independently. These findings support theory of self-efficacy, suggesting that mastery experiences, such as successful research completion, boost confidence, which in turn accelerates professional readiness. The study also tested and confirmed the impact of career aspirations in research on personal and professional growth revealing a reinforcing loop: as students envision themselves in research careers, they are more motivated to invest in skill development, networking, and professional opportunities that further strengthen their overall growth.

The third objective explored how career aspirations in research and personal/professional growth collectively impact research mindset. Both relationships were found to be statistically significant, affirming that students who perceive research as a viable career path, and who recognize the personal/professional benefits of research, are more likely to develop a sustained, intrinsic orientation toward scholarly inquiry. This resonates with the work of Healey et al. (2014), which suggests that research mindset is cultivated when career relevance and personal benefit are simultaneously evident to the learner. When undergraduate research aligns with the institution's strategic vision, it reinforces the value of research, motivates faculty engagement, and legitimizes student participation, creating a campus culture that sustains research aspirations. Students exposed to both high-quality research experiences and supportive institutional environments show greater intention and readiness to pursue advanced research roles, graduate studies, and careers in academia or industry research. The dual impact leads to continued professional involvement, evidence-based practice participation, and advanced educational aspirations, contributing to a robust and research-ready workforce.

CONCLUSION

This research paper emphasized the role of undergraduate research, backed by strong institutional support, in driving research culture within colleges. The results confirm that when students are provided with meaningful research opportunities and the necessary resources, their career aspirations in research are significantly enhanced. Moreover, the development of research skills and confidence directly fuels personal and professional growth, which emerges as the strongest driver of a sustained research mindset. These findings highlight that institutional strategies aimed at fostering research engagement—through structured programs, mentorship, and infrastructure—can produce graduates who are not only career-ready but also equipped to contribute meaningfully to innovation and scholarship. Strengthening research ecosystems at the undergraduate level is therefore not merely an academic enrichment exercise but a strategic investment in the nation's research capacity. By aligning institutional practices with this objective, colleges can cultivate a new generation of engineers

committed to advancing knowledge and driving societal progress. Undergraduate research, when paired with robust institutional support, significantly enhances students' career aspirations in research, boosts their skills and confidence, and fosters sustained personal and professional growth. Colleges that invest in structured research programs, dedicated mentoring, and strong infrastructure can create graduates with a lasting research mindset. Strengthening research ecosystems at the undergraduate level is a strategic move—not only improving student outcomes but also expanding the nation's capacity for innovation and scholarly impact.

APPENDIX

ACKNOWLEDGMENT

REFERENCES

Alipina, K. B., & Kitapbayeva, A. A. (2023). Formation of research competencies of students. A. Âsaui atyndaġy Halyḳaralyḳ ḳazaḳ-tùrìk universitetìniņ habaršysy, 4, 394-04. https://doi.org/10.47526/2023-4/2664-0686.28

Angeloska-Galevska, N. (2023). Developing research and academic competencies of students through three cycles of studies. The Eurasia Proceedings of Educational and Social Sciences, 33, 63-69.

Brew, A. (2010). Transforming academic practice through scholarship. International Journal for Academic Development, 15(2), 105-116.

Bandura, A. (1997). Bandura (Vol. 2). FrancoAngeli.

Chamely-Wiik, D., Ambrosio, A., Baker, T., Ghannes, A., & Soberon, J. (2023). The impact of undergraduate research experience intensity on measures of student success. Journal of the Scholarship of Teaching and Learning, 23(1).

Eagan Jr, M. K., Hurtado, S., Chang, M. J., Garcia, G. A., Herrera, F. A., & Garibay, J. C. (2013). Making a difference in science education: The impact of undergraduate research programs. American educational research journal, 50(4), 683-713.

Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. CBE—Life Sciences Education, 17(1), ar9.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50. https://doi.org/10.1177/002224378101800104

Ferguson, C. L., & Lockman, J. A. (2024, May). Increasing PhD student self-awareness and self-confidence through strengths-based professional development. In Frontiers in Education (Vol. 9, p. 1379859). Frontiers Media SA.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage Learning.

Hensel, N. (2012). Characteristics of Excellence in Undergraduate Research.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Hunter, A. B., Laursen, S. L., & Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. Science education, 91(1), 36-74.

Kember, D., Lee, K., & Li, N. (2001). Cultivating a sense of belonging in part-time students. International Journal of Lifelong Education, 20(4), 326-341.

Kumar, S. P. (2025). Nurturing Research Mindset through Undergraduate Research Experience (URE) and Mentoring in Engineering Institutions. Journal of Engineering Education Transformations, 92-100.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. Journal of vocational behavior, 45(1), 79-122.

Linn, M. C., Palmer, E., Baranger, A., Gerard, E., & Stone, E. (2015). Undergraduate research experiences: Impacts and opportunities. Science, 347(6222), 1261757.

McClellan, G. S., Creager, K. L., & Savoca, M. (2023). A good job: Campus employment as a high-impact practice. Taylor & Francis.

Mastronardi, M., Borrego, M., Choe, N., & Hartman, R. (2021). The impact of undergraduate research experiences on participants' career decisions. Journal of STEM Education: Innovations and Research, 22(2), 75-82.

Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric theory (3rd ed.). McGraw-Hill.

Priyadarsini, M. K., & Kumar, S. P. (2024). Empowering Engineers for Research Careers–Role of Undergraduate Research Experience and Institutional Support. Journal of Engineering Education Transformations, 775-782.

Pascarella, E. T. (2005). Cognitive impacts of the first year of college. In Improving the first year of college (pp. 115-144). Psychology Press.

Whelan, K., Castelli, K. R., Trizio, C., Howard, O., Thomas, J. E., & Madden, A. M. (2022). Undertaking a research project improves confidence in research skills among student dietitians. Journal of Human Nutrition and Dietetics, 35(5), 934-947.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). Biometrika, 52(3–4), 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Strayhorn, T. L. (2010, October). Work in progress—Diversifying STEM: Underrepresented students' experiences in undergraduate research programs.

In 2010 Ieee Frontiers in Education Conference (Fie) (pp. T3D-1). Ieee.

Tajuria, G., Dobel-Ober, D., Bradley, E., Charnley, C., Lambley-Burke, R., Mallen, C., ... & Kingstone, T. (2024). Evaluating the impact of the supporting the advancement of research skills (STARS) programme on research knowledge, engagement and capacity-building in a health and social care organisation in England. BMC Medical Education, 24(1), 126.