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A Candle in the Dark: Implementation of Course-Based Undergraduate Research Experience (CURE) in India

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Abstract: ***The decline of science in India is attributable to the absence of experimentation as a fundamental component of science education. India's educational framework has, for many decades, remained largely unchanged, lacking any transformative endeavours aimed at enhancing the quality of the curriculum or its delivery. The realm of research, in particular, has not only failed to progress but has endured significant setbacks. Hence, it is imperative to instill a research-oriented mindset in students as early as pedagogically feasible, which includes the undergraduate level. Around the world, the most common approaches to integrating undergraduate research experiences into educational institutions are Undergraduate Research Experiences (URE) and Course-based Undergraduate Research Experiences (CURE). CUREs are distinctive as learning environments because they afford students opportunities to make discoveries that are of interest to the broader scientific community or other stakeholders outside the classroom. CUREs also engage students in iterative work, during which they repeat and build on aspects of their own and others' work in order to ensure the trustworthiness of their findings and generate meaningful scientific knowledge. But in India, there is no policy or curriculum for this type of research-based scientific study for the future generations to come. This paper aims to summarise the state of knowledge about CURE instruction and bring out achievements and shortcomings in the Indian education system specifically on research and recommendations for future research and practice.***

Keywords: Researchers, Gross expenditure, Broader Scientific Enterprise, Fundamental Competencies, Rejuvenation of Higher Education, Institutional Commitment, Multidisciplinary Integration

1. Introduction

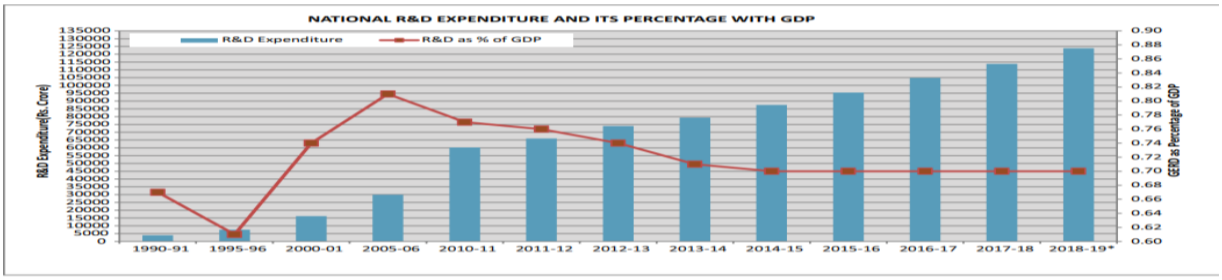
India's educational framework has, for many decades, remained largely unchanged, lacking any transformative endeavours aimed at enhancing the quality of the curriculum or its delivery [1]. Previous initiatives to revamp the system have been modest and fragmented, failing to exert any substantial influence on the education landscape. The realm of research, in particular, has not only failed to progress but has endured significant setbacks. Responsibility for this stagnation can be attributed to both government policies and the actions of educators themselves. The separation of teaching and research within the country has led to entire generations of students graduating from universities without contributing to a single original research endeavour [2]. Consequently, many of these graduates lack the requisite employable skills and industry knowledge [3]. In 2015, amid India's vast population of 1.3 billion, the research landscape painted a concerning picture with merely 216 researchers per million people [4]. India's commitment to research and development remains inadequate at a mere 0.62 percent of its Gross Domestic Product (GDP). These figures fall considerably below the global best practices. By way of comparison, countries such as France allocate 2.25 percent of their GDP to research, while the United States dedicates 2.74 percent, sustaining a research workforce of around 4,300 researchers per million population [5]. China also stands out for its substantial research investment, devoting over 2.11 percent of its GDP and maintaining 1,200 researchers per million population. The contrast accentuates the significant room for advancement in India's research and development sector. Additionally, when it comes to higher education, India's research expenditure accounts for a mere four percent of its GDP [6]. This statistic emphasizes the necessity for substantial investment in research and development within India's educational institutions to foster innovation, scientific discovery, and competitiveness on a global scale. In 2018, there were 161,412 students enrolled in PhD programs, representing less than 0.5 percent of the total student enrolment in higher education. This encompasses students in universities, colleges, and standalone institutes pursuing undergraduate and postgraduate programs [7]. This statistic highlights the need for a more robust and inclusive approach to doctoral research education in the country to cultivate a strong research culture and encourage a larger number of students to engage in advanced research pursuits.

However, the challenges within India's education system can be traced back to its foundation in early schooling. Observers have long highlighted the issue of students merely "reciting" textbooks during examinations, devoid of critical thinking, and unfortunately, this practice persists throughout higher education [10]. Hence, it is imperative to instill a research-oriented mindset in students as early as pedagogically feasible, which includes the undergraduate level. This holds true for both the natural sciences and social sciences. One strategy to achieve this is by incorporating undergraduate research into the higher education curriculum [11]. By systematically teaching undergraduate students the art of effective research, they are more likely to develop a genuine interest in their fields of study and may subsequently be more inclined to pursue research-intensive academic programs and careers in the future. Notably, Prime Minister Narendra Modi, in his address at the 106th Indian Science Congress in January, urged policymakers to propose

measures for introducing research into Central and State Universities across India [12].

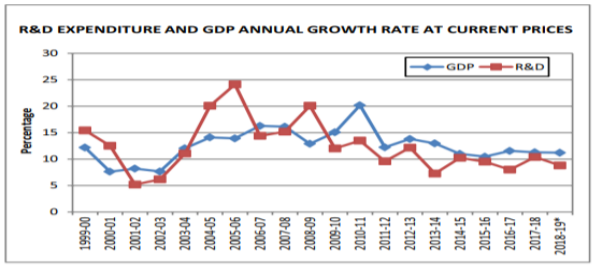
2. Achievements of the Indian Education System on Research

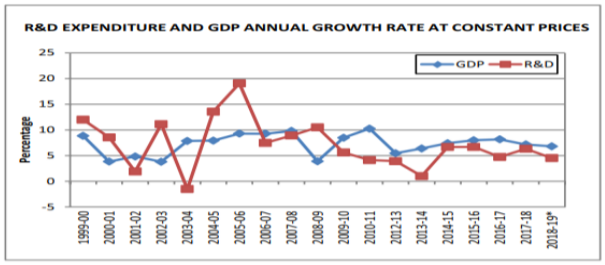
The Gross expenditure on R&D (GERD) in India has been consistently increasing over the years and has nearly tripled from Rs. 39,437.77 crore in 2007- 08 to Rs. 1,13,825.03 crore in 2017-18. It is estimated to be Rs. 1,23,847.70 crore in 2018-19. India's GERD as a percentage of GDP remained at 0.7% during the years 2017-18 and 2018-19 respectively. India's per capita R&D expenditure has increased to PPP $ 47.2 in 2017-18 from PPP $ 29.2 in 2007-08.



* Estimated. Source: NSTMIS, Department of Science & Technology, Government of India

R&D expenditure and GDP, in absolute terms, have shown a consistent rising trend over the years.





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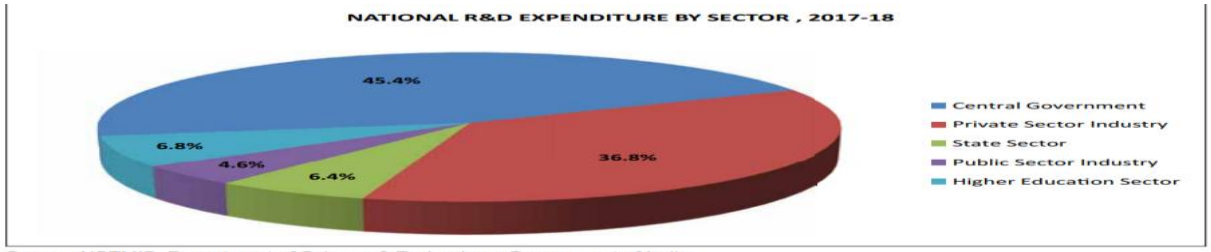
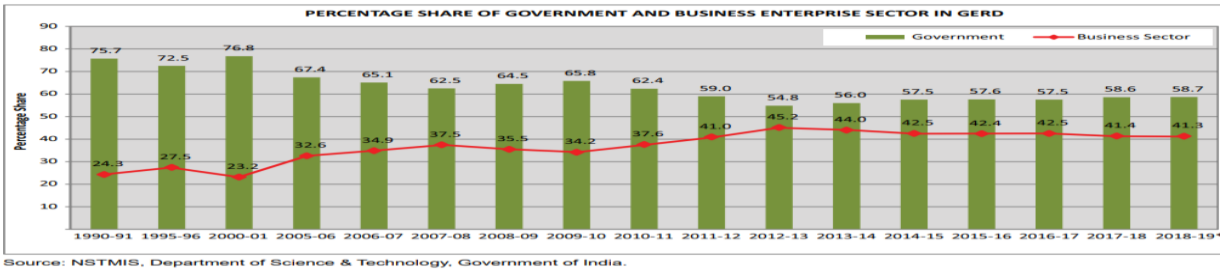


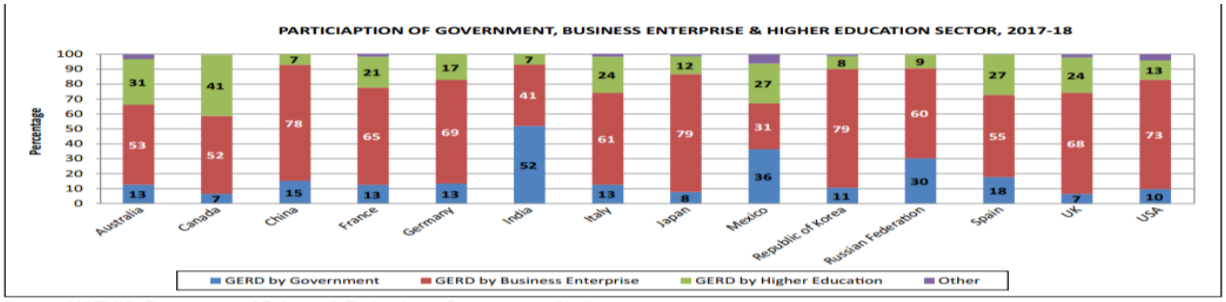
Source: NSTMIS, Department of Science & Technology, Government of India

Business Enterprise (Industrial) sector participation in GERD has been just over 40% during the last 5 years. Public sector R&D units spent 0.29% of their sales turnover on R&D as compared to 1.48% by Private sector in 2017-18.



Source: NSTMIS, Department of Science & Technology, Government of India.

India stands in contrast with select developed and emerging economies with nearly 60% participation in GERD being made by the government including Higher Education Sector.



Source: NSTMIS, Department of Science & Technology, Government of India.

3. 'Undergraduate Research': Concepts and definitions

The Council on Undergraduate Research (CUR) defines "undergraduate research" (UR) as an "inquiry or investigation conducted by an undergraduate student that results in an original intellectual or creative contribution to the field" [13]. CUR is the foremost organization overseeing and affiliating institutions that facilitate undergraduate research programs on their campuses. This concept was initially introduced in 1969 by Margaret McVicar, who served as the Dean of Undergraduate Education at the Massachusetts Institute of Technology (MIT) and was initially known as the Undergraduate Research Opportunities Program (UROP).Typically, undergraduate students from various disciplines collaborate with faculty members, researchers, graduate students, or fellow undergraduates in research areas aligned with their interests. They support collaborative research by either pursuing their own research ideas or participating in existing research projects [14].

Around the world, the most common approaches to integrating undergraduate research experiences into educational institutions are Undergraduate Research Experiences (URE) and Course-based Undergraduate Research Experiences (CURE) [15]. In the case of URE, a small group of students is chosen to assist a mentor in laboratory research, typically spanning several semesters. Selection for URE often involves competitive tests and a review of academic records. In contrast, CURE is a course-based program overseen by a researcher or graduate student, incorporating lectures, grading, and assignments. CURE is seamlessly integrated into undergraduate courses to enrich student learning, making it a more extensive program compared to UREs. URE usually involves one mentor working with one student, whereas CURE features one mentor guiding multiple students within a class [16]. Overall, CURE is a more inclusive form of undergraduate research, providing a larger number of students, often an entire class, with the opportunity to engage in research. On the other hand, URE tends to be more competitive, attracting self-motivated and interested students. In some instances, participation in a CURE serves as a stepping stone toward securing a URE placement [17].

According to a study conducted by the Course-Based Undergraduate Research Experiences Network (CUREnet), Course-Based Undergraduate Research Experiences (CUREs) entail engaging students in research that contributes to a broader scientific enterprise, extending beyond the confines of a single course [18]. In the context of CUREs, students are encouraged to generate tangible outcomes, which may encompass co-authored research papers, policy documents, or reports containing original findings. Although it's not always imperative for a student to make groundbreaking discoveries in terms of new theories or practices, their experiences and documented findings can significantly contribute to advancing ongoing research and may even offer potential solutions to the research questions they've been addressing [18].This approach emphasizes the importance of experiential learning and active involvement in the research process, even at the undergraduate level. It encourages students to contribute meaningfully to the broader scientific community and to apply their learning to real-world research problems, which can have a lasting impact on their academic and professional development. While Undergraduate (UG) research initially began with the concept of Undergraduate Research Experiences (URE), it quickly became evident that this approach could be costly, and many institutions encountered various challenges in strengthening UG research within their campuses. As a result, Course-Based Undergraduate Research Experiences (CURE) emerged as a viable alternative to achieving similar objectives. In a publication, the Council on Undergraduate Research (CUR) commends institutions that adopt a curriculum that is supportive of research. This support is demonstrated by institutions documenting their endeavors in this regard [19]. The authors of this publication highlight that such a curriculum serves to "expose" students to the significance of research. Even if students may not directly engage in research activities in the future, it helps them develop an "appreciation for research methodology within their specific area of study."

4. Benefits, impacts and best practices

The Council on Undergraduate Research (CUR) enumerates a wide range of advantages associated with undergraduate research, including the enhancement of student learning, the provision of effective mentorship, increased enrollment in graduate education, higher retention rates, the development of stronger critical thinking abilities, enhanced creativity, improved problem-solving skills, the cultivation of intellectual independence, and a better understanding of research methodologies [20]. Numerous initiatives have sought to explore and establish links between the benefits of undergraduate research and a student's propensity for pursuing studies in the sciences and social sciences, as well as their inclination toward graduate studies and ultimately, research-intensive careers. While many of these assessments rely on self-report surveys, some also analyze the final research output to demonstrate a direct correlation between undergraduate research and higher education outcomes. In

some cases, Grade Point Averages (GPA) at the conclusion of a course are used to quantify the success and benefits of participating in undergraduate research [21].For instance, consider the experience of Professor George Spilich in the Department of Psychology at Washington College, where the introduction of "research-based" programs led to a remarkable improvement in students' grades for their major subjects [22]. This example underscores the positive impact of integrating research experiences into undergraduate education, not only on student performance but also on their overall academic and intellectual development. Students who engage in Course-Based Undergraduate Research Experiences (CUREs) or undertake extended research commitments during their undergraduate education tend to derive more substantial benefits from these experiences. In contrast, there appears to be minimal, if any, advantage associated with short-term research involvement [23]. Research indicates that participation in undergraduate research fosters the development of knowledge, writing skills, and research acumen, and enhances the confidence of the participants in their respective fields [24]. It is crucial for students to invest sufficient time in their chosen research area, gain a profound understanding of the issues, formulate research inquiries, and base their findings on sound data analyses. Fundamental competencies such as writing and research, if acquired at an earlier stage, can empower students to craft authentic and original research papers as they progress to advanced academic levels. Nonetheless, as previously mentioned, the subsequent influence of undergraduate (UG) research is significantly contingent on the quality of mentorship students receive throughout their research journey. During a phase when students are in a formative academic stage and have yet to chart the course of their future careers, it becomes imperative that they receive comprehensive guidance from a well-intentioned and competent mentor. A mentor plays a pivotal role in helping students engage deeply in a collaborative setting with researchers, scientists, technicians, and peers. This collaborative environment not only involves a thorough analysis of their chosen research domain but also addresses the peripheral issues associated with it. Some liken undergraduate research to an "apprenticeship," where students learn by critically examining problems and taking "intellectual ownership" of the tasks they undertake [27]. Students stand to gain significantly from their mentor's experiences, their subject expertise, and insights into research methodologies, and, ultimately, have the privilege of formulating their own research queries, challenging the unanswered, and cultivating a scientific ethos.

Mentors can encompass a range of individuals, including graduates, post-doctoral fellows, or faculty members. Additionally, there are "peer mentors" involved in undergraduate research initiatives. Within a research team, a senior undergraduate student can undertake the role of mentoring a junior counterpart [28]. According to David Lopatto, an educational expert in the United States, whose work was supported by the Survey of Undergraduate Research Experiences (SURE), approximately 80 percent of the survey respondents indicated that collaborating with fellow undergraduate peers had a moderate to significant positive impact on their undergraduate research encounters. The findings also revealed that peer mentors derived substantial benefits from the process, as they found satisfaction in their role as mentors/teachers, gained confidence, honed their communication skills, and achieved a notably deeper understanding of their research subject matter. Consequently, faculty members are not obligated to be directly engaged in mentorship at all times. Fellow peers are entirely capable of fulfilling this role effectively, especially when a conducive environment is established. Furthermore, collaborative teamwork represents a standard practice in research procedures, and participation in such endeavors can empower students to cultivate leadership abilities, foster a sense of teamwork, enhance their interpersonal competencies, and bolster their research acumen. To assess the impact of undergraduate (UG) research on various institutions, several success stories offer valuable insights that India can draw from. For instance, at Washington College's Psychology department, introduced a "research-based curriculum" following extensive discussions with students, even in the absence of department faculty involvement [29]. The faculty initiated discussions about their research projects in the first and second-year classes and extended invitations to interested students to join them in these endeavors. Another highly effective approach incorporated in middle and upper-level classes involves integrating research projects into laboratory sessions. The outcomes of this initiative have been multifaceted. Students often take these projects as "starting points for their own ideas," leading to further exploration and development of concepts based on their areas of interest. This process fosters the establishment of sustainable student-mentor relationships, which are essential for nurturing and guiding students in their research pursuits. The results of this approach have been highly satisfactory, and this exercise has had a positive impact on the faculty's teaching methods, leading to more effective undergraduate education.

This example illustrates how a proactive approach to undergraduate research can yield positive outcomes, not only for students but also for the faculty involved. It showcases the potential for integrating research into the curriculum and creating a collaborative learning environment that benefits both students and mentors. While numerous universities and departments have successfully incorporated undergraduate (UG) research into their curricula over the years, it's particularly instructive to examine the Massachusetts Institute of Technology (MIT), renowned as a pioneer in this realm. MIT's Undergraduate Research Opportunities Program (UROP) has set a significant precedent for enhancing the quality of undergraduate education and promoting interdisciplinary research. It has served as a model for emulation by various institutions worldwide, including Boston University, the University of Delaware, the University of California at Irvine, and the Royal Institute of Melbourne, among others [30]. Furthermore, institutions such as Johns Hopkins University, the School of Engineering at the University of California, Berkeley, the University of Minnesota, the University of Utah, and Stanford University have introduced analogous programs, albeit under distinct titles. This widespread adoption underscores the influential role played by MIT and its UROP program in advancing undergraduate research and enriching educational experiences.

5. The Case for India

One of the root causes contributing to the challenges within higher education in India is the affiliation system, where a single university can be linked to a staggering number of over 500 colleges. This vast web of affiliations not only poses significant logistical and administrative difficulties for the parent university but also results in the fragmentation and isolation of these affiliated colleges. Regrettably, within this structure, genuine communication and collaboration between academic disciplines remain largely absent. This situation contradicts one of the fundamental principles of a university, which is to serve as an institution where students and educators can freely exchange ideas, where different academic fields intermingle, and where mutual learning and innovation occur [33]. Indian universities and their affiliated colleges have struggled significantly in this regard. As a consequence, much of the research conducted in India operates in isolated silos, often yielding results that are either irrelevant or redundant for practical applications. Furthermore, research in India primarily takes place within specialized research institutes rather than on university campuses [34]. However, it's noteworthy that roughly 80 percent of higher education students are enrolled in these university campuses offering undergraduate programs [35]. Unfortunately, the lack of interaction between academic departments results in a dearth of interdisciplinary education and research within these campuses. Consequently, undergraduate research can serve as a catalyst to establish communication bridges between academic departments and strengthen faculty-student relationships. This initiative can also cultivate a genuine interest in research among undergraduate students and faculty members who often resort to last-minute projects during their final year. Alarmingly, a substantial portion of this work is merely copied from unreliable websites [36].This paradigm shift can lead to an increased number of doctoral and post-doctoral candidates, who can subsequently assume faculty positions [37]. These candidates, in turn, can contribute to the re-evaluation and redesign of curricula to align them with the demands of the future job market. The introduction of research at the undergraduate level can, directly and indirectly, address several challenges in higher education, including the deficiency in both the quality and quantity of publications, faculty shortages, the lack of scholarly attributes among students, and outdated syllabi. Undergraduate research has the potential to enhance the overall delivery of classroom education, fostering a more dynamic and engaging learning environment. While the experiences of other countries offer valuable insights, it's important to acknowledge that these models may not fully capture the complexities and diversity inherent in the Indian education system [38]. Therefore, the integration of undergraduate (UG) research should be implemented in a manner that complements the existing teaching system rather than disrupting it. The Council on Undergraduate Research (CUR) provides a roadmap for institutions looking to initiate collaborative research within their campuses. This roadmap is applicable whether the institution boasts a cadre of "scholarly" faculty or is predominantly composed of teaching-focused faculty. CUR's guidelines, known as the 'Characteristics of Excellence in Undergraduate Research (COEUR),' outline several essential steps for establishing such frameworks. However, it's crucial to customize these steps to suit the unique dynamics of the Indian higher education system [39].

5.1 The significance of "institutional commitment" is accorded high importance within the COEUR framework. In India, the initial phase of introducing research-integrated programs in three-year undergraduate courses can be led by Grade 1 and Grade 2 autonomous colleges, as recognized by the University Grants Commission (UGC). These colleges enjoy a greater degree of autonomy from regulatory constraints and have a well-established record of delivering high-quality education. As part of this commitment, the institution must duly acknowledge and appreciate the contributions of both faculty and students. It should also establish a dedicated office for undergraduate (UG) research to formalize the process. Furthermore, these institutions should allocate a portion of their internal budgets specifically for the nurturing of UG research and related activities [40].

5.2 Various Types of Undergraduate (UG) Research Experiences: In the initial stages, particularly in government-run universities facing constraints in financial and infrastructural resources, Course-Based Undergraduate Research Experiences (CURE) can prove to be a valuable approach for undergraduate colleges. Moreover, considering the substantial student population in higher education institutions, CURE can establish a more inclusive system of research and education by offering opportunities to a broader group of students. To effectively implement CURE, it's essential to have proficient instructors. In India, these instructors can comprise faculty members, PhD students, or post-doctoral students. An effective way to engage external instructors is by leveraging the expertise of specialized research institutes in India, such as the Indian Institutes of Science Education and Research (IISERs), the Indian Institute of Science (IISc), the Tata Institute of Fundamental Research (TIFR), the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), and others. Researchers from these elite research institutes can dedicate specific credit hours to help undergraduate students grasp the intricacies of ethical research and involve them in ongoing research activities. It's time to dissolve the traditional separation between research and teaching institutions and usher in an era where high-quality research from specialized institutes seamlessly blends with university-level teaching. This approach aligns with the recommendations put forth in the 2009 Yashpal Committee Report on the 'Renovation and Rejuvenation of Higher Education' [41].

5.3 Effective Resource Utilization and External Partnerships: The Council on Undergraduate Research (CUR) also emphasizes the concept of "achieving more with less." By engaging professionals from research institutes as instructors for undergraduate (UG) research, the higher education system can effectively address faculty shortages and alleviate their workloads [42]. While this approach serves as a means of sourcing instructors, it is highly advisable that faculty members within undergraduate colleges progressively become actively engaged in the UG research process to ensure a profound impact on the system. However, it's crucial to acknowledge the need to reward faculty and instructors for their participation in this endeavor, as it's

essential to foster productive collaboration and deliver high-quality outcomes. Given the substantial workloads carried by faculty members in undergraduate colleges, establishing a committee becomes necessary to deliberate on methods of equitably distributing responsibilities among faculty members within departments [43]. To promote this collaborative system, it's imperative for both the university and state governments to engage in discussions regarding the nature and extent of rewards necessary to encourage and sustain this approach.

5.4 Sustaining Multidisciplinary Integration: In order to preserve and enhance the multidisciplinary essence of the undergraduate (UG) research program, it is essential to integrate the University Grants Commission's (UGC) choice-based credit system with the UG research program. This integration will enable the fluid movement of students across various disciplines, campuses, and external organizations [44]. To achieve this, the course content must be meticulously crafted through collaborative efforts involving scientists and experts from different fields of education. This collaborative curriculum should serve as a foundational framework that introduces students to the world of research before they formally engage in a collaborative research environment. In essence, this approach fosters an academic environment that encourages students to explore a wide array of subjects and research domains, fostering interdisciplinary learning and collaboration. It ensures that the UG research program transcends the boundaries of traditional academic disciplines, promoting a holistic and well-rounded educational experience for students.

5.5 Incorporating Fundamental Research Skills: Students should be introduced to basic research skills during their first year through the Council on Undergraduate Research's (CUR) 'professional skills workshops.' These workshops aim to equip students with essential abilities such as composing research papers and reports, creating posters, delivering conference presentations, networking with available resources, and identifying paper competitions, fellowships, and graduate programs, among other competencies [45]. As part of this initial training, students can also be tasked with crafting practice papers on subjects found in their textbooks. In their second year, students should be granted the flexibility to choose their specific area of interest and align themselves with either ongoing research projects or initiate new ones with the guidance of their mentors or instructors. However, it's essential to underscore that the decision to engage in undergraduate (UG) research should remain voluntary and optional. In their third year, students should focus on writing their research papers and submitting them for conferences. Ensuring the ongoing professional development of mentors is critical, achieved through engagement with senior faculty members or external resources, to guarantee the provision of high-quality mentoring to students. Furthermore, UG students who have gained research experience should be considered for PhD programs, as they are already well-versed in the research process. Therefore, in India, a preference should be accorded to students with prior UG research experience when reviewing PhD proposals.

5.6 Collaborative Conferences Across Institutes: To align with the principles outlined by the Council on Undergraduate Research (CUR), organizations like the University Grants Commission (UGC) should take the lead in organizing conferences that provide a platform for undergraduate (UG) researchers to present their papers in front of their peers. These conferences serve as a testing ground for students before they venture into larger, national, or even international conferences [46]. Mentors play a pivotal role in helping students publish their work in existing UG research journals and may also offer co-authorship opportunities. While institutions have the flexibility to adapt and tailor their approaches to UG research, adhering to the fundamental guidelines advocated by CUR can provide a structured framework for a meaningful UG research program. This approach ensures a purposeful and systematic implementation of UG research initiatives.

6. Conclusion

India is actively seeking to bolster its global standing through initiatives like the 'Institutes of Eminence' (IoE) program [48], the 'Study in India' campaign [49], and the formulation of a New Education Policy [50]. At this juncture, it's imperative to direct attention towards enhancing the quality of undergraduate education. India is endowed with a substantial demographic dividend that, if effectively harnessed, can significantly contribute to the country's economic development. However, the Indian education system is in need of comprehensive reform. While a select few institutions have been designated as IoEs, affording them greater autonomy to conduct research and develop programs, there remains a multitude of state public universities, affiliated colleges, and autonomous colleges that are striving to measure up to these elevated standards. New data indicates that India's higher education landscape is evolving rapidly. For example, as of 2023, the 'Institutes of Eminence program has made notable progress in granting greater autonomy to select institutions for conducting research and improving the quality of education. Additionally, the 'Study in India' campaign, aimed at attracting international students, has been gaining traction, and the implementation of the New Education Policy is shaping the future of education in the country. However, it remains crucial to ensure that these advancements in higher education extend to the undergraduate level to tap into India's vast potential and drive economic growth.As India seeks to establish a stronger global presence in education, these efforts should not be limited to a handful of prestigious institutions but should encompass the broader spectrum of higher education, including state public universities and affiliated and autonomous colleges. This inclusivity will be essential for India to harness its demographic dividend effectively and elevate the overall quality of its educational system. Educational institutions globally are reaping the advantages of integrating undergraduate (UG) research into their academic practices. Some renowned universities, like MIT, have even progressed to a more advanced phase known as Super UROP [51]. In India, to address the decline in the number of researchers and counteract the problem of subpar research output, it is imperative for both central and state governments to explore a concept that has demonstrated positive outcomes in numerous educational settings

worldwide. The Indian education system accommodates approximately 20 million first-generation learners, who will eventually require structured guidance to harness education as a tool to confront real-world challenges. Furthermore, particular attention should be directed towards encouraging young women in this group to pursue fields in STEM (Science, Technology, Engineering, and Mathematics) [52].

The adoption of UG research not only enhances the quality of education but also cultivates a culture of inquiry and innovation among students, enabling them to tackle complex, real-world problems effectively. To harness the full potential of India's education system, it's crucial to embrace UG research as a standard practice across the country. This approach should be a priority for both central and state governments, especially considering the significant number of first-generation learners and the need to promote STEM education, particularly among young women. The Indian education system is at a pivotal juncture and should seek innovative approaches to elevate its existing pedagogical model, which predominantly relies on textbooks. By incorporating undergraduate (UG) research into educational institutions, India can not only raise the calibre of its students and faculty but also stimulate the creation of pertinent scholarly research that will have a positive impact within the country and beyond its borders. This strategic shift towards UG research has the potential to revitalize the educational landscape by fostering a culture of inquiry, critical thinking, and problem-solving among students. It will equip them with the skills and knowledge necessary to address contemporary challenges and engage in meaningful research. Additionally, it will facilitate the production of research outputs that hold value for both the nation and the global academic community. By embracing UG research, India can bolster its position on the international stage, not only as an educational hub but also as a generator of valuable knowledge and research contributions. This transformation is integral to ensuring that the Indian education system remains relevant, competitive, and responsive to the demands of the modern world.

References

[1] When using the word ‘research’, this brief refers to research in both hard sciences and social sciences.
[2] MHRD, 2009, “The Committee to Advise on Renovation and Rejuvenation of Higher Education”, *Ministry of Human Resource Development*, 2009, 2.1.2, 13, Accessed on October 28, 2018
[3] Aspiring Minds 2018, “National Employability Report Engineers – Annual Report 2016”, *Aspiring Minds*, 2016, Accessed on November 2, 2018.
[4] UNESCO 2018, “R&D Data Release”, *UNESCO Institute for Statistics*, 2018, Accessed on October 4, 2018.
[5] UNESCO 2018, “R&D Data Release”, *UNESCO Institute for Statistics*, 2018, Accessed on October 4, 2018.
[6] DST 2017, “Research and Development Statistics At A Glance”, *Ministry of Science and Technology, GoI*, 2017, 4, Accessed on November 28.
[7] AISHE, 2018, “All India Survey on Higher Education 2017-18”, *Ministry of Human Resource Development*, 2018, II, Accessed on November 30, 2018.
[8] UGC 2017, “UGC (Declaration of Government Educational Institutes as Institutes of Eminence) Guidelines, 2017”, *University Grants Commission*, 2017, Accessed on November 15, 2018.
[9] Antara Sengupta, “Budget for university education — More for less at the cost of more”, *Observer Research Foundation*, February 9, 2018.
[10] Geetha Venkatraman, “Teaching Students to Think”, *Economic and Political Weekly*, Vol.42 No.34 (August 2007): 3449-3451
[11] Antara Sengupta, “Undergraduate research: A way forward to better global rankings of Indian institutes”, *FirstPost*, April 20, 2017.
[12] PIB release, 2019, “Text of PM’s inaugural address at the 106th Indian Science Congress”, *Press Information Bureau, GoI*, Januray 03, 2019.
[13] Thomas J. Wenzel, “Conceptual Issues About Undergraduate Research”, *Council on Undergraduate Research.*
[14] “Home: Undergraduate Research Opportunities Program”, *Massachusetts Institute of Technology*, accessed October 3, 2018.
[15] Marcia C Linn et al., “Undergraduate research experiences: Impacts and opportunities”, *Science Magazine*, Vol. 347, No. 6222 (February 2015)
[16] L. C. Auchincloss et al., “Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report”, *CBE – Life Sciences Education*, Vol.13 (Spring 2014): 30
[17] Marcia C Linn et al., “Undergraduate research experiences: Impacts and opportunities”, *Science Magazine*, Vol. 347, No. 6222 (February 2015)
[18] L. C. Auchincloss et al., “Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report”, *CBE – Life Sciences Education*, Vol.13 (Spring 2014)
[19] Nancy Hensel (ed.), “Characteristics of Excellence in Undergraduate Research”, *Council on Undergraduate Research*, 2012: 14.
[20] “Organization: Mission”, Council on Undergraduate Research, accessed October 14, 2018.
[21] Marcus Fechheimer, Karen Webber, and Pamela B. Kleiber, “How Well Do Undergraduate Research Programs Promote Engagement and Success of Students?”, *CBE—Life Sciences Education*, 2011, 10: 156–163
[22] George Spilich, “Does Undergraduate Research Pay Off”, *Council on Undergraduate Research Quarterly*, December 1997, 57
[23] Marcus Fechheimer, Karen Webber, and Pamela B. Kleiber, “How Well Do Undergraduate Research Programs Promote Engagement and Success of Students?”, *CBE—Life Sciences Education*, Vol. 10 (Summer 2011): 158
[24] Mack Mariani et al., “Promoting Student Learning and Scholarship through Undergraduate Research Journals”, *American Political Science Association*, Volume. 46, Issue 4 (October 2013): 830-835
[25] David Lopatto, “Undergraduate Research Experiences Support Science Career Decisions and Active

Learning", *CBE- Life Sciences Education*, 6(4) (Winter 2007): 297-306
[26] Melanie T. Jones, Amy E. L. Barlow, Merna Villarejo, "Importance of Undergraduate Research for Minority Persistence and Achievement in Biology", *The Journal of Higher Education*, 81(1), 2010: 82-115. Also see: Anthony Carpi et al., "Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM", *Journal of Research In Science Teaching*, 54(2), 2017: 169-194
[27] "Home: The Importance and Value of Mentoring Undergraduates", *Council on Undergraduate Research*, Accessed on October 21.
[28] David Lopatto, "Undergraduate Research as a High-Impact Student Experience", *Association of American Colleges and Universities*, Vol.12, No. 2 (Spring 2010)
[29] George Spilich, "Does Undergraduate Research Pay Off", *Council on Undergraduate Research Quarterly*, (December 1997): 58
[30] "MIT News: MIT's much-imitated UROP turns 30", Massachusetts Institute of Technology, Accessed on November 1, 2018.
[31] MIT 2013, "Student Experience Survey", *Massachusetts Institute of Technology*, Summer 2013
[32] Philip G. Altbach, "A World-Class Country Without World-Class Higher Education: India's 21st Century Dilemma", *International Higher Education, Boston College*, 40 (2005): 19
[33] Pankaj Chandra, "The decay of the campus" in *Building Universities that Matter*, (Hyderabad: Orient Blackswan, 2017), 222
[34] MHRD, 2009, "The Committee to Advise on Renovation and Rejuvenation of Higher Education", *Ministry of Human Resource Development*, 2009, 2.1.2, 13, Accessed on October 28, 2018
[35] AISHE, 2018, "All India Survey on Higher Education 2017-18", Ministry of Human Resource Development, 2018, iv, Accessed on November 30, 2018.
[36] Anurag K Agarwal, "Plagiarism, UGC & Higher Education", *Daily News & Analysis*, April 9, 2018.
[37] Parth Shastri, "35% teaching posts vacant in IIT and higher education institutes: HRD minister", *Times of India*, Jan 19, 2019.
[38] Pawan Agarwal, *Indian Higher Education: Envisioning the Future* (New Delhi: SAGE Publications India, 2009), 2
[39] Nancy Hensel (ed.), "Characteristics pf Excellence in Undergraduate Research", *Council on Undergraduate Research*, (2012): 2 & 22.
[40] UGC 2017, "Public Notice – UGC (Categorization of Universities for Grant of Graded Autonomy) Regulations, 2017", *University Grants Commission*, June 2017, Accessed on October 20, 2018.
[41] MHRD, 2009, "The Committee to Advise on Renovation and Rejuvenation of Higher Education", *Ministry of Human Resource Development*, 2009, 13-14, Accessed on October 28, 2018
[42] Nancy Hensel (ed.), "Characteristics pf Excellence in Undergraduate Research", Council on Undergraduate Research, (2012).
[43] Nancy Hensel (ed.), "Characteristics pf Excellence in Undergraduate Research", Council on Undergraduate Research, (2012): 5.
[44] UGC 2015, "Minimum Course Curriculum For Undergraduate Courses Under Choice Based Credit System", *University Grants Commission*, 2015.
[45] Nancy Hensel (ed.), "Characteristics pf Excellence in Undergraduate Research", Council on Undergraduate Research, (2012):15.
[46] Nancy Hensel (ed.), "Characteristics pf Excellence in Undergraduate Research", Council on Undergraduate Research, (2012):11.
[47] "Home: NIUS Proposal 2004", *HBCSE-TIFR*, Accessed on October 15, 2018.
[48] PIB release, 2018, "Government declares 6 educational 'Institutions of Eminence'; 3 Institutions from Public Sector and 3 from Private Sector shortlisted", *Press Information Bureau, GoI*, July 09, 2018.
[49] PIB release, 2018, "'Study in India' programme to attract foreign students to study in India", *Press Information Bureau, GoI*, March 23, 2018.
[50] The new National Education Policy
[51] "About: SuperUROP", *Massachusetts Institute of Technology*, Accessed on October 30, 2018.
[52] World Bank brief 2015, "Educating India's Children", *World Bank*, Accessed on November 1, 2018.