Sayantan Mandal *Editor*

Roadmap for Humanities and Social Sciences in STEM Higher Education

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A tribute to
the educator,
social reformer,
and my father,

Sakti Mandal
(1948–2021)

Acknowledgments

The experience of working at the Department of Humanities and Social Sciences (HSS) in the Indian Institution of Technology Jammu (IIT Jammu) and teaching social sciences to the tech-students have worked as a primary trigger in initiating this book. The insights helped me in grasping the intricacies and multifaceted interconnections of the issues associated with the trajectory of HSS in STEM higher education. Simultaneously, engaging in stimulating discussions, debates, and encounters with distinguished academic leaders, scholars, and researchers from diverse disciplinary backgrounds has been a truly enlightening and inspiring experience in conceptualizing this book. These experiences and inputs have not only helped me understand the dire need for such a publication but also inspired me to bring this project to fruition despite the numerous challenges encountered.

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resonate with me. And, even though he is not there with us today, his legacy continues to guide me and many others in striving to make a positive impact on society. This book is one such effort on my part and my sincere tribute to him.

Sayantan Mandal

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About the Editor

Sayantan Mandal is a senior assistant professor at the Department of Humanities and Social Sciences of the IIT Jammu. Previously, he worked at the National Institute of Educational Planning and Administration (NIEPA, Government of India) and the University of Delhi, New Delhi. He has graduated from the Aarhus University, Denmark, and has done his Ph.D. (with Cum Laude) from the University of Deusto. At IIT Jammu and NIEPA, Dr. Mandal coordinated two large-scale studies on Teaching and Learning and technologies in Indian Higher Education and co-authored the Indian Higher Education Report 2017 on Teaching, Learning, and Quality.

Part I
Introduction: The Concept and the Connect

Chapter 1
Roadmap for Humanities and Social Sciences in STEM Higher Education: An Introduction

Sayantan Mandal

Abstract The emerging limelight on technical and professional subjects has changed many facets of Higher Education. On a global scale, nations have established mechanisms to satisfy the demand for specialized skills that correspond directly to the needs of the labour force. Consequently, the demand for disciplines and subjects providing direct linkages with the world of work, including Technical and Professional higher education, skyrocketed, and HEIs providing degrees and diplomas in such disciplines mushroomed all over. The influx also questioned the conventionally perceived importance of different academic streams, thereby differentiating them based on the cost–benefit analysis. The prevalent narrative, which is fuelled by a utilitarian viewpoint that prioritizes immediate economic returns, tends to downplay the inherent value of HSS subjects. The importance of traditional liberal arts subjects, particularly humanities and social sciences (HSS) subjects, seems to be shrinking in favour of their more vocationally oriented counterparts. Consequently, in practice, HSS remains in the periphery and seldom gets integrated into the STEM HEIs in the true sense. Therefore, a fresh look at the field is required, where it becomes essential to re-discover how HSS can be and remain complementary in STEM higher education without being subordinate to it. In light of these complexities, it is necessary to set out on a voyage of rediscovery, one that not only restores HSS to its rightful place in higher education but also imagines its future within the framework of STEM.

1.1 Higher Education Transformation and Expansion

Higher Education Institutions (HEIs) have incurred unprecedented transformation by becoming more autonomous in their core structure and functioning, calling for an undisputed invitation to a new set of responsibilities. Beyond promoting higher-order learning through an effective community of inquiry (Garrison et al., 1999),

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today's HEIs are considered a means to an end, with the responsibility of employability ostensibly transferred from governments to the HEIs (Cheng et al., 2022). With an increased emphasis on technology, employability, and innovation, the traditional paradigms of higher education have shifted. This shift has not only redefined the function of educational institutions, but also reconceived the very purpose of education.

One of the distinguishing features of this realignment is the ascent of technical and professional education. On a global scale, nations have established mechanisms to satisfy the demand for specialized skills that correspond directly to the needs of the labour force. This transition has led to a proliferation of institutions offering degrees and certifications in technical and professional fields. The exponential expansion of these disciplines has been truly remarkable, heralding a new era of higher education marked by its relevance to the labour market. Consequently, the demand for disciplines and subjects providing direct linkages with the world of work, including Technical and Professional higher education, skyrocketed, and HEIs providing degrees and diplomas in such disciplines mushroomed all over.

The influx of this new role also questioned the conventionally perceived importance of different academic streams, thereby differentiating them based on the cost–benefit analysis. This emerging limelight on technical and professional subjects has changed many facets of Higher Education (HE) today. In the process, the importance of the traditional liberal arts subjects, particularly Humanities and Social Sciences (HSS) subjects, seems to be shrinking in favour of their more vocationally-oriented counterparts (Koen, 2006). The HSS subjects such as Literature, Sociology, Philosophy, History, and so on may no longer be considered equally crucial for developing students in higher education (Lyman, 2001). The prevalent narrative, which is fuelled by a utilitarian viewpoint that prioritizes immediate economic returns, tends to downplay the inherent value of HSS subjects.

Here it is important to add that there is a general acknowledgement about the importance of HSS across science, technology, engineering, and mathematics (STEM) Higher Education Institutions (HEIs) and industries. What seems to be forgotten by the narrow utilitarian perspective is that HSS was meant to broaden the learners' intellectual horizons and empower them to think critically, debate, and grapple with ambiguities inherent in subjects. The HSS subjects were never intended to be mere repositories of knowledge; rather, they were conceived as intellectual expansion agents. These subjects have historically played a crucial role in fostering critical thinking, provoking debates, and cultivating the ability to confront the complexities that characterize the human experience. In a world increasingly shaped by interdisciplinary collaborations and nuanced problem-solving, the significance of humanities, social sciences, and mathematics subjects grows.

Much recently, Vaziri and Bradburn (2022), through a Systematic Literature Review (SLR), concluded flourishing outcomes on integrating HSS subjects with STEM. Further, education policies worldwide recognize the growing demand for humanities and social sciences across the sciences to ensure the unity and integrity of knowledge in a sustainable manner (Marcone, 2022). For instance, the National Education Policy ([NEP], Government of India, 2020) asserts the following positive

outcomes on promoting HSS into the web of technical and professional subjects: increased creativity and innovation, critical thinking and higher-order thinking capacities, problem-solving abilities, teamwork, communication skills, more in-depth learning and mastery of curricula across fields, increased social and moral awareness, and general engagement and enjoyment of learning (NEP, 2020). The international organizations, such as the Organization of Economic Cooperation and Development (OECD), European Union (EU), World Bank (WB) and International Labour Organization (ILO), among others have highlighted the importance of skills and competencies, which are directly correlated to HSS to build resilient and successful knowledge society.

The discussion that has surrounded the integration of the arts, humanities and social sciences into the fields of STEM has, in essence, shed light on a variety of advantages. Research and evaluations conducted in the field of higher education have, time and time again, highlighted the favourable effects connected with the combination of these two fields (Altbach, 2013; Faulconer et al., 2020; Metcalfe et al., 2006). In addition to increased creativity and originality, these benefits include the development of critical thinking as well as higher-order cognitive skills. In addition, it has been demonstrated that the incorporation of HSS leads to improvements in problem-solving abilities, teamwork, communication skills, and a greater grasp of a variety of academic disciplines.

The widespread acknowledgement of these benefits, especially in the age of automation and Artificial Intelligence (AI), has resurfaced the discussion of HSS and its importance in contemporary and future societies. This in turn has given rise to reverberations in the educational policies at international and national spheres. As the policies have reinforced the benefits of HSS, a significant number of educational institutions is now increasingly recognizing its importance. Unfortunately, many of these institutional policies, especially, that of the STEM HEIs, often put lesser significance on the HSS or mention it rather rhetorically, or as a compulsion to adhere to the larger policy mandates. Consequently, in practice, HSS remains in the periphery and seldom get integrated into the STEM HEIs in true sense.

1.2 Need for a Non-hierarchical Perspective

It is worthwhile to mention that while HSS subjects have long-term and holistic benefits, it is equally important for the HSS subjects to evolve and change according to the present needs and development of society, especially with the metamorphosis of technology, automation and AI, the global economy, industries and world of work without losing their core episteme. However, while it is acknowledged that HSS subjects cannot linger in their classical avatar, a required evolution does not mean 'change to serve the STEM better'. This view has an inherent hierarchical bias, which puts STEM on a higher pedestal and consider HSS as subordinate. This standpoint is prevalent in several STEM HEIs, which recommends HSS to upgrade, but mainly

to serve its 'master'. It is important to mention that the first step is to recognize HSS as equals and it is important for all disciplines to evolve, for their own sake.

A fresh look at the field is therefore required, where it becomes essential to rediscover how HSS can be and remain complementary in STEM higher education. Also, it is equally important to chalk out the future of the HSS subjects in the STEM HEIs, not just as a peripheral department or amalgamation of disciplines but as an integrated core of the STEM higher education fabric. In light of these complexities, it is necessary to set out on a voyage of rediscovery, one that not only restores HSS to its rightful place in higher education but also imagines its future within the framework of STEM.

In its alignment, the edited volume attempts to provide a divergent understanding derived from the nuances of intersectional spaces between HSS and STEM. It begins by navigating the locus of HSS in STEM and capitalizes on its out-grouping from mainstream academics, specifically in tech institutes. Thereafter, the present book attempts to re-envision ethics as a tool for facilitating enhanced trans-disciplinary communications in academia and beyond that, including the industry, through specific case studies, further corroborated by specific applications of such organic cross-disciplinary interactions. Finally, the edited volume aims to provide a roadmap for HSS in STEM Higher Education through the Innovation, Diversification, Expansion, and Assessment (IDEA) framework. The chapters of this book delve into these intricacies, examining obstacles, revising instructional approaches, and revealing a road map that guides the incorporation of humanities and social sciences into STEM-focused HEIs.

1.3 Recognizing the Importance of HSS

The declining significance of traditional liberal arts subjects in the STEM-dominated HE landscape represents a nuanced shift in educational priorities. While the rise of STEM disciplines is undeniably relevant to the current technological and economical progress, it is essential to recognize the enduring value of traditional HSS subjects. These disciplines cultivate a well-rounded, intellectually engaged, and socially conscious citizenry—qualities that are indispensable not only for personal development but also for the advancement of society as a whole (Doidge et al., 2020). The dialogue surrounding the integration of HSS into STEM education should seek to strike a balance, recognizing the complementary nature of both disciplines in preparing students to confront the complex challenges of the modern world.

Central to this discussion is the realization that disciplines such as literature, psychology, sociology, and philosophy cultivate an environment conducive to the inculcation of critical values necessary for leading fulfilled lives. These disciplines serve as crucibles for the development of morally accountable individuals who recognize that life extends beyond achieving measurable milestones and conforming to societal norms. They cultivate a sense of conscience and subjective perspectives that

challenge the conventional pursuit of quantitative success inherent in conventional education systems.

The boundaries between the HSS and the STEM, which sometimes do translate into hierarchical compartments, bear an analogical similarity to the knowledge-information divide. The truncated attention to STEM in solving the 'problems of the world' is resulting in people with minds sans conscience, because there is a tendency on our part to presume the supremacy of a techno-managerial approach to problem-solving. It is important to recognize that the real-world problems are complex in nature, intertwined with social, cultural, political, historical and ethical layers. Moreover, they need complex problem-solving interdisciplinary skills. STEM surely contributes to solving the technical aspects of the problems, but it often overlooks the socio-political-economic and ethical understandings, which can result in technocratic solutions and, thus, limiting the sustainability of the solutions provided, or end up creating another technical problems to be solved by yet another technical interventions—thus continuing the vicious cycle (Roy et al., 2016).

In other words, technocratic solutions often solve the symptoms, as they perceive the problems as independent and not interconnected ones. Therefore, the inclusion of HSS disciplines in STEM is not only desirable but also an absolute necessity as it re-wires the mechanistic, fact-centric and isolated interpretation of problems and helps us to understand the problems as complex and interconnected ones.

1.4 Understanding the Problem: Bridging the Gap Between HSS and STEM

The complexities surrounding the integration of HSS and STEM education draw our attention to the following critical thoughts.

Integration Across Disciplines: A crucial concern arises: Can the entirety of Humanities and Social Sciences seamlessly integrate with the diverse faculties of different departments? This investigation emphasizes the need for an interdisciplinary educational environment that is cohesive.

STEM's Willingness to Embrace HSS: The capability of STEM Higher Education to integrate Humanities and Social Sciences must also be investigated. Is the STEM community prepared to embrace the incorporation of HSS and foster interdisciplinary collaborations and consider HSS as equals?

Course Alignment and Communication: The alignment of HSS offerings with the requirements of STEM students is an additional crucial factor. Are the appropriate courses designed, and is there effective communication between STEM and HSS departments while the formulation of the courses, to guarantee comprehensive educational support and effective development of the learners?

Challenging Conventions: The essence of the Humanities and Social Sciences is posing provocative queries rather than repeating the obvious. Instead of propagating repetitive narratives, does the HSS discipline present intellectually stimulating challenges?

Innovation in Pedagogy: Effective education is characterized by its willingness to experiment with pedagogical approaches. Are Humanities and Social Sciences as well as STEM primed to engage jointly in pedagogically innovative experiments that enhance the learning experience?

Shifting Perspectives: The symbiotic relationship between HSS and STEM demands a shift from the traditional role of support to one of coequal significance. This is in contrast to the traditional function of support. Are both areas of study willing to move beyond the idea that they are only providing support for one particular department and instead embrace the spirit of working together in a way that is both mutually beneficial and productive?

These profound questions develop into a succession of inquiries that punctuate the current difficulties. Further, in the setting of the postmodern world, individuals have intersectional identities that are formed by a complicated interplay of factors, including gender, ethnicity, sexual orientations, economic conditions, educational backgrounds, and perceived social standing. These different aspects have a profound impact on how learners understand the world around them.

In addition, this amalgamation resonates with the incorporation of learners from various walks of life, representing a multitude of ethnicities, classes, castes, and social groups. Given that many students are first-generation learners in their families and lack a foundational understanding of STEM, as well as HSS subjects, this inclusivity is especially significant. Integration of the humanities and social sciences into the pedagogical practices of higher education is a potent instrument for bridging these multifaceted gaps empathetically.

Here, it seems important to highlight that at their foundation, the Sciences frequently inculcate society with a tendency toward dogmatism, resulting in an almost unwavering focus on the facts, numbers and objective realities. Humanities, in stark contrast, equip individuals with the capacity for critical and aesthetic appreciation of the world, fostering a culture of interrogating and directing curiosity, valuing the complex subjective realities and interconnections between objectivity and subjectivity. This propensity for inquiry, coupled with a rational and emotionally balanced approach to inquiring, fosters effective interdisciplinary communication. Therefore, the case for incorporating HSS subjects into STEM courses becomes indisputable; a synergy that not only enriches but also transforms the educational landscape.

1.5 Global Recognition of the Importance of HSS: Policy Discourse

The inclusion of HSS in STEM curricula has also taken on increased global significance in today's world of rapid technological development and specialized expertise. In order to cultivate interdisciplinary excellence and develop well-rounded individuals able to tackle a variety of challenges, education policies and frameworks around the world emphasize the importance of integrating HSS with STEM fields.

The policies of many nations recognize the shortcomings of compartmentalizing education and stress the importance of a more rounded education. One example is the European Higher Education Area's (EHEA) emphasis on 'learning outcomes,' which include not only technical skills but also broader competencies like critical thinking, communication, and ethical awareness (Kennedy, 2006). Universities are strongly encouraged to adopt multidisciplinary approaches that help close the gap between the humanities and the natural and physical sciences through the Bologna Process, a landmark initiative under the EHEA (Sursock et al., 2010).

Multiple global policy documents and initiatives emphasize the significance of combining HSS and STEM education, as critically discussed in the chapter by Singhai, Mishra and Roy in this book. The Sustainable Development Goals (SDGs) of the United Nations recognize the interdependence of societal and technological challenges. The SDGs emphasize the need for educational approaches that combine technical knowledge with an understanding of cultural, ethical, and societal dimensions in order to address these challenges. This sentiment is echoed by the UNESCO 'Global Citizenship Education: Topics and Learning Objectives' framework (2015) or the World Conference on Education for Sustainable Development (2021), which promotes education that equips students with the skills and values necessary to contribute to sustainable development.

The World Bank has recognized the value of a broad education that includes both technical and softer skills (Aubert, 2005). It highlights the importance of 'soft skills' such as critical thinking, communication, and problem-solving in its World Development Report (World Bank, 2018). These abilities, typically associated with the humanities and social sciences, are regarded as crucial for survival and prosperity in today's dynamic, interconnected global economy.

The 'Future of Education and Skills 2030' (OECD, 2018) project of the OECD emphasizes the need for a comprehensive education that prepares individuals for a world that is rapidly changing. While the project does not explicitly mention the integration of HSS and STEM, its emphasis on 'transversal skills' (Larraz et al., 2017), such as critical thinking, creativity, and socio-emotional skills, aligns with the goals of HSS disciplines. The project emphasizes the significance of equipping students with skills beyond technical proficiency.

The report 'Skills Mismatch in Europe' by the International Labour Organization (ILO, 2014) emphasizes the significance of a skill set that combines technical expertise with broader competencies. It recognizes that addressing skill mismatches

necessitates not only technical skills, but also the capacity to communicate effectively, work in teams, and think critically. These skills are frequently developed through exposure to HSS disciplines. The ILO also acknowledges the importance of a broad skill set for long-term employability and career advancement, including cognitive and socioemotional skills developed through HSS courses.

It is evident that the recent global education policies emphasize the importance of integrating HSS and STEM. These policies emphasize critical thinking, ethical awareness, and cultural sensitivity, in addition to technical skills. The global recognition of HSS emphasizes the need for a harmonious blend of disciplines to produce graduates who are proficient in their fields and prepared to tackle the complex challenges of our interconnected world (Field, 2016; Van der Wende, 2011). Education systems can prepare students to contribute meaningfully to society, innovation, and sustainable development by bridging HSS and STEM.

1.6 Understanding the Perceptions: Positioning HSS in STEM Higher Education in India

Even though the policies vouch for it, without a few handful exceptions, HSS subjects are mostly marginalized in Indian STEM-focused Higher Education Institutions. This happens due to a limited understanding of these disciplines and a hierarchical mentality (Altbach, 2013; Peterson, 2012). This prevalent perception has persisted throughout the years, irrespective of several policy recommendations, and advocacies. This rigid segmentation and hierarchical approach contribute to discrimination, marginalization, othering and devaluation of HSS subjects.

The exponential expansion of STEM fields are paralleled by their direct relationship to technological progress, and innovation. This growth and emphasis are also partially responsible for the present position of HSS in STEM higher education. The digital era has ushered in an unprecedented transformation across multiple industries, resulting in a surge of professionals with expertise in science, technology, engineering, and mathematics. This has inexorably shifted the educational landscape toward the development of technical competencies, a trend driven by the promise of lucrative employment opportunities and the shaping of future industries.

On the other hand, the traditional liberal arts subjects that make up Humanities and Social Sciences frequently find themselves at a crossroads in today's educational environment, battling obstacles that affect their perception of importance. This phenomenon results from a limited comprehension of these disciplines. Unfortunately, these policy proclamations also have had limited success in altering the perceptions of HSS among STEM professionals. This rigid segmentation and hierarchical approach contribute not only to discrimination but also to the marginalization and devaluation of HSS subjects.

The promise on immediate employability associated with STEM courses has also significantly contributed to this perceived decline in the significance of conventional

HSS subjects. The traditional HSS disciplines, which have historically provided broader perspectives, critical thinking, and ethical reasoning, have experienced a discernible decline in perceived value. This transition is most pronounced when the immediate employability factor outweighs the long-term intellectual enrichment that HSS subjects provide (Blockmans, 2007). In recent times, with growing impetus on micro-credentials, and focus on the extrinsic values of education, it further pushes the non-employment related subjects, prioritizing on the intrinsic values, to the periphery (Marginson, 2023). Consequently, traditional HSS subjects are frequently viewed as tangential to the immediate requirements of the job market, whereas STEM disciplines align seamlessly with the advancing technological landscape and changing markets. However, these views are, although dominant, but not supported by the education policies in India. Even a cursory look at the major policies since independence can clarify it.

1.7 Integrating HSS with STEM: Perspectives from the Indian Education Policies

HSS and STEM fields are intrinsically interdependent, and in an era where education is frequently compartmentalized into distinct disciplines. Integrating these apparently disparate domains of knowledge has the potential to create a new educational paradigm, one that fosters holistic excellence and equips students with a diverse array of skills essential for navigating the complexities of our ever-changing world. The transformative potential of integrating humanities and arts with STEM education has been revealed by findings from diverse educational contexts. Indian education policies are a canvas to understand them critically.

In the post-independent India, the **Sarker Committee (1948)** on technical higher education, was appointed by the Central Bureau of Education (1948). The Sarkar committee report underlines the vision of industrialization in the post-war era and the need for quality technical experts. The committee had a broad vision, and instead of looking at technical higher education in isolation, it proposed that the following subjects could be integrated into the technical courses: (i) Industrial Administration, Industrial Hygiene, and Economics, (ii) Humanities, (iii) Mathematics and Statistics, (iv) Chemistry, and (v) Physics. The idea was to widen the students' mental horizons and for their holistic development. The Sarkar Committee report was highly motivated by the vision of the Massachusetts Institute of Technology, USA (MIT). The MIT model focused on (i) Engineering, (ii) Science, (iii) Humanities and Social Sciences, and (iv) and nurtured a robust environment where each of the four schools can flourish independently, yet in coexistence with each other.

With the recommendations of the Sarkar Committee and the support of the Govt. of India, the first set of IITs were established. Followed by the IITs, the Indian Institute of Managements (IIMs) and later, the Indian Institutes of Science (IISc) were established as premier institutes of STEM education. Later, the National Institutes

of Technologies (NITs) were added to the list of Institutes of National Importance. However, although the special treatments, extended findings and other benefits have improved the status of IITs and IIMs, it has also injected a sense of elitism among these institutions (Ørberg, 2018). As a consequence, the 'supremacy of STEM' subjects over 'other' subjects got its stronghold in the mindsets of the teachers and sometimes to the institutional administration as well.

Many decades later, the report of 'The Committee to Advise on Renovation and Rejuvenation of Higher Education', commonly called the Yashpal Committee (2009), points out the efforts by IITs to prevent the isolation of engineering from other disciplines by mentioning their initiatives to introduce 'humanities and other disciplines and expand their scope.' Today, all 23 IITs from Generation I, II and III offer diverse HSS courses to engineering students and have an independent HSS department. And yet, the relevance of HSS subjects is often not fully comprehended by the main stakeholders.

The Kothari Commission Report (1964–1966) emphasized the significance of integrating liberal education, which includes the humanities and social sciences, with science and technology education. It advocated for a comprehensive and well-rounded education system that fosters both technical skills and a broader intellectual development. The report recommended a multidisciplinary approach and emphasized the need to cultivate well-rounded individuals able to contribute to society in multiple capacities.

National Policy on Education 1986, modified in 1992, placed an emphasis on the significance of combining education in the humanities, social sciences, and technology in order to equip students with a comprehensive grasp of society's challenges and human values. It placed a strong emphasis on the significance of instilling both a scientific temperament and a feeling of social duty in its audience. In order to encourage research and education that spans multiple fields of study, the policy also suggested the development of centres for advanced studies in subject areas that cross-disciplinary boundaries.

The National Curriculum Framework (2005) pushed for an all-encompassing, competency-based education rather than one focused on individual subjects. To foster critical thinking, problem-solving, and an overarching grasp of the world, it promoted the integration of other courses, including HSS and STEM. The framework advocated for a multidisciplinary approach to education by highlighting the value of building bridges across traditionally separate fields.

Planning Commission (1950–2014): The Planning Commission was first founded in 1950, and it was eventually succeeded by the NITI Aayog in 2015. The Planning Commission's primary focus was on economic planning, development, and resource allocation. Many of the Planning Commission's reports have advocated or subtly underlined how important it is to take a multidisciplinary approach. For instance, the Xth and XIth Five-Year Plans emphasized the importance of cultivating a competent labour force, which might include a mix of technical skills (STEM) and broader intellectual capacities (HSS).

NITI Aayog (2015 to present): As the successor to the Planning Commission, NITI Aayog continues to concentrate on policy formulation and development. While their primary focus continues to be on economic growth and development, some of their initiatives, such as promoting innovation and entrepreneurship, indirectly recognize the value of multidisciplinary collaboration between HSS and STEM. Initiatives that seek to address social issues through technological innovation, for instance, recognize the need for a comprehensive understanding of both technical and societal aspects.

National Knowledge Commission (2005-2009): Although not a traditional planning commission, the National Knowledge Commission (NKC) was entrusted with recommending reforms in the education sector to encourage the creation, dissemination, and application of knowledge. The National Knowledge Community highlighted the significance of a multidisciplinary approach in education and research. It acknowledged that addressing complex societal challenges necessitates collaboration across disciplines, including HSS and STEM. The NKC's emphasis on interdisciplinary research and innovation indirectly highlighted the importance of integrating knowledge domains.

The most recent **National Education Policy, 2020** (Govt. of India, 2022) has re-championed the need to incorporate various HSS subjects in the curriculum of STEM. The primary reason for the inclusion of HSS subjects in technical higher education curriculum is the analytical nature of HSS disciplines. While the Engineering subjects are more experimental, the HSS subjects present a perfect complement to the Engineering disciplines, thereby, helping in a holistic intellectual flourishing of students.

The policy promotes interdisciplinary studies, integrating knowledge from different disciplines to address complex real-world problems. It also promotes liberal education, allowing students to explore various subjects before specializing. The policy envisions a flexible curricular framework, allowing students to choose subjects from different streams and gain exposure to a multidisciplinary range of knowledge. The policy also recommends preparing students for global challenges by combining technical expertise with insights into social, cultural, and ethical dimensions. Overall, the NEP 2020 aims to provide students with a well-rounded education that prepares them for a complex and rapidly changing world.

1.8 HSS in STEM Higher Education Institutions is Due for an Overhaul

While it is important for the STEM to recognize and integrate HSS, it is equally important for the HSS to evolve and be directly relevant to partner with STEM in understanding, explaining and solving the complex interconnected problems. HSS, like any other discipline, must self-evaluate, adapt, and become more relevant to the changing world without sacrificing its fundamental nature.

It is essential to note that HSS has been a part of Indian engineering education for decades, albeit to varying degrees and penetration levels. In the past, the HSS portion of the engineering curriculum varied from 15 to 17%. Students were required to choose from a limited selection of courses, including Sociology, English, Micro and Macro Economics, Logic, Psychology, Linguistics, Philosophy, Poetry, Literature, and Indian Philosophy. These courses are frequently stand-alone and sometimes deeply rooted within the subject boundaries. While subject knowledge mastery is undeniable, its very nature may not be equally relevant for a graduate student in STEM-focused higher education institutions. Occasionally, subject rigidity has impeded numerous revolutions, cross-disciplinary collaboration, and cross-HSS pollination. This rigidity has little effect on the overall development of the student body.

This raises numerous compelling questions, including: Why do students lack interest in HSS? Has the delivery of HSS courses fallen behind the times? Has technology become so pervasive in daily life that engineering students no longer require HSS? Is it the case that students only comprehend the importance of HSS upon entering the real world? Is the relationship between HSS and Engineering not properly highlighted in our curriculum and delivery? Do we not offer courses that intersect HSS and Engineering? How can courses in HSS and Modern Engineering be made compatible?

While the chapters attempt to answer some of these questions, it is important to note that HSS departments, particularly in some of the premier institutions of higher education in India, frequently suffer from mutual isolation from which they must emerge. This sometimes results in independent, superficial, often isolated HSS courses that are neither immediately nor long-term relevant to STEM graduates. Similarly, the STEM disciplines frequently disregard the HSS and develop courses that are deeply rooted in the discipline-specifics and far from interdisciplinary.

1.9 STEM Higher Education Requires a Change in Perception Towards HSS

The STEM higher education community also must stop viewing HSS as liability and as ‘service departments’, a frequently used colloquial in some of the technical HEIs. Like a caste-based hierarchical system—technical and/or professional subjects are treated with utmost respect, recognitions, followed by science and business related subjects. And then, comes HSS, often covertly treated as the ‘other’. According to a dominant section of STEM faculty members and institutional administrators, the HSS departments at STEM HEIs are there only because of the mandates from the Government. In other words-HSS in STEM HEIs is predominantly seen an obligation. This overtly elitist and covertly discriminatory trend also help in maintaining a status que and considers HSS as an outcast. While this is certainly not the perception of all technical HEIs in India, this narrow view is a sad reality of many.

Consequently, in practice, it ends up strengthening the biases against HSS instead of wiping them away. While hiring only a handful of faculty members in the HSS departments or 'sprinkling' of HSS courses over a hard-core technical curriculum might not be the most productive method of holistic education, the isolation and negligence towards the HSS subjects is even worse, as it is against the ethos of the development of human beings through holistic and inclusive education.

To accomplish the goal of inclusivity, it is important to pollinate the seeds of multidisciplinary connections in the true sense. Educational managers and teachers play a major role there. First, this change would require an overhaul in the thinking process, which is also promoted by the major policies in India. It is important for the STEM HIEs to embrace authentic and complementary multidisciplinary, which comes with the role of dialogue.

The question one has to explore here is how cross-disciplinary dialogues on re-modelling can provide opportunities for developing these interpretive skills in future professionals. This will be a major step in creating authentic multidisciplinary STEM Education. However, it has its own difficulties as well. For instance, teachers will have to leave the comfort of subject silos, collaborate with other colleagues from a diverse disciplines and familiarize with their curricula, pedagogies, assessment mechanism and needs. The most important challenge is first to think divergently and accept that knowledge from other apparently non-related spheres is also relevant.

The conservative and somewhat elitist STEM HEIs also need to be re-oriented toward understanding the absolute indispensability of the HSS. These diversity and inclusivity are indeed necessary in the STEM HEIs, so that the students would not be reduced to being technical experts only, but they could flourish as complete humans with adequate intellectual, aesthetic, ethical, moral, and emotional abilities. The long-adopted policy impetus should be reinforced with concrete implementation plans. This book elaborates on some of the possible strategies to address the same.

1.10 Epilogue

The dichotomy of technical versus non-technical subjects, which otherwise aids in catering to diversified and specialized academic interests and its exchange facilitates holistic intellectual flourishing of students, has today been corrupted to a large extent. The clear-cut boundaries between the HSS and the STEM have translated into hierarchical compartments that bear an analogical similarity to the knowledge-information divide. The truncated attention to STEM is resulting in people with minds sans conscience because there is a tendency on our part to presume the supremacy of a techno-managerial approach to problem-solving. Moreover, it is often seen that Technosciences teach society to become dogmatic with almost a rigid focus on facts.

Having said this, STEM has entered a state of crisis today, and in its conjunction, where many universities have been reduced to mere business enterprises standing high with a claim to serve the 'knowledge economy' as a buzzword. With this rigid, segmented, and hierarchical understanding comes discrimination, neglect, and

apathy, which reinforces the misrepresentation and undervaluation of HSS subjects even further.

A critical understanding of the production of science and technology is necessary to analyse inequality in society. Science and technology are never objective or value-free, as most consider it. It is riddled with dominant ideologies, prejudices, cultural influences, and political and economic power that shape production, consumption and access to science and technology (Nersessian, 2004). Science and technology are better seen as parts of social and cultural reproductions, which reinforce existing inequality (Traweek, 1993). Technology is not neutral, never was or meant to be; instead, it is a political and economic property designed and controlled by the authority (Abergel et al., 2017). Therefore, it would be apt to say that technology is the uncritical manifestation of the latent power structure and authoritarian ideology (Sclove, 1995). To elaborate, the economic and geopolitical powerhouses use technology for their profits, often unethically; whereas military or militants use technology for their vested interests (Harvey, 1985), further restricting science and technology development for broader social needs.

The exclusion of the Humanities, Arts and Social Sciences within the closed model of STEM has spelt out danger for our generations to come. What becomes crucial to reiterate here is that in the real world, problems are a complex array of socio-cultural, economic and political aspects. They seldom need straight-jacketed technical solutions but demand a cross-disciplinary recourse to the HSS and Liberal Arts, enabling the streak of critical as well as aesthetic appreciation of the world. It is this inquisitive nature as well as the logical and emotionally balanced zeal to raise questions, reinforced by HSS, that ensures effective interdisciplinary communication. Therefore, the inclusion of HSS disciplines in STEM is not only desirable but also an absolute necessity as it re-wires the mechanistic, fact-centric training of our uni-disciplinary education system.

Furthermore, over the decades, repeated mentions of the importance of HSS subjects in the policies have made little improvement to changing the perceptions of HSS in the STEM fraternity. While there is a resurgence of calls to create robust STEM education for the twenty-first century and build bridges between STEM and HSS fields, in reality, there is a lack of a mutually comprehensible professional language, and often it is not even realized that typical pedagogical and epistemological approaches between STEM and HSS disciplines differ. On top of that, educating students in various STEM fields by teachers who may likely have limited background in HSS as a whole and in the history and philosophy of STEM has its negative consequences. With this, as pertinent as it may sound, the adjoining need to address the HSS courses for their evolution and transformation also commands attention.

At the same time, the contribution of HSS subjects demands due credit and recognition. Greater emphasis on interdisciplinary learning with disciplinary rigour is the need of the hour. To move in this direction, the first and foremost step is the pedagogical intervention founded on the grounds of inclusivity, cultural tolerance, aestheticism, and critical thinking, reinforced through HSS subjects. Liberal arts subjects, including but not limited to literature, psychology, sociology, and philosophy, build a lively atmosphere to help students inculcate the values necessary to lead a fulfilled

life. It makes them morally responsible individuals and teaches them that life is not all about achieving milestones and setting certain economic benchmarks sanctioned by market, but also about developing a sense of morality, conscience, and subjectivity to view things. It tries to break the mindset of measuring success quantitatively, which is a big flaw in the traditional higher education system.

Beyond the academic circles, in the filial sectors from family to societal spheres, such as job employability, the divide between technical and HSS subjects can also be evidenced. This can be resolved with focused awareness, equal opportunities, and attention to be directed toward all domains of knowledge, i.e. interdisciplinary collaboration among these subjects. Therefore, while signifying a roadmap of HSS in the tech-oriented world, the elemental idea of connecting humans with humanity through values, ethics, morals, and an aesthetic appreciation of the environs is underscored. The roadmap needs to transcend itself beyond the binaries and assert itself with a stronger plan of action and purpose.

1.11 Towards a Roadmap for HSS in STEM Higher Education: Paving the Way for Innovation, Diversification, Expansion, and Assessment

The overarching objective of this book is to map out a comprehensive plan for the seamless integration of Humanities and Social Sciences (HSS) within the realm of Science, Technology, Engineering, and Mathematics (STEM) higher education. Our goal is to navigate the complexities inherent in this integration, effectively bridging the gap between traditionally distinct domains and fostering a coexistence that enriches the educational experience. As we embark on this journey, we not only address the challenges, but also to provide actionable strategies that can shape the future of HSS in STEM higher education by bringing it in line with contemporary needs and aspirations.

Innovation, Diversification, Expansion, and Assessment form the four pillars of the road map outlined in this volume. The integration of HSS and STEM, which are frequently perceived as separate domains, demonstrates our dedication to fostering dialogues that transcend disciplinary boundaries. This integration promotes holistic learning by leveraging the synergy of diverse knowledge domains, enabling students to approach real-world complexities through multiple lenses.

Recognizing that the dynamism of today's technological landscape necessitates novel pedagogical approaches, the road map is founded on innovation. By incorporating HSS perspectives into STEM curricula and vice versa, it is crucial to foster interdisciplinary thoughts, enabling students to respond to contemporary challenges with adaptability and originality.

The roadmap also encompasses expansion—the broadening of the educational spectrum and the intellectual horizon. By advocating for the incorporation of HSS insights into STEM curricula, it equips students with a profound understanding of

the societal implications of their technical endeavours. This expanded vision not only enhances the learning experience of each individual, but also fosters a culture of responsible innovation.

Diversification is the final component of the roadmap. Recognizing the numerous ways in which HSS and STEM can intersect, it seems essential to advocate for the investigation of diverse methodologies, curricula, and perspectives. By embracing this diversity, we recognize the multiplicity of knowledge streams that contribute to an all-encompassing educational ecosystem.

This volume contains not only a diagnosis of the challenges, but also a collection of actionable strategies to integrate HSS in the STEM Higher Education. These strategies, some of which are grounded in empirical research and informed by international best practices, address the key obstacles to the integration of HSS and STEM in twenty-first century higher education.

1.12 Organization of Chapters

As we progress through the chapters of this book, we aim to illuminate a transformative trajectory for HSS in STEM Higher Education. In an effort to rediscover the place for HSS in STEM higher education, the discussions in this volume ponder upon some of the fundamental yet pertinent questions, anchoring over its six sections constituted of sixteen chapters. The first section describes the critical status of STEM in Higher Education due to outcasting HSS subjects. It talks about techno-scientists feeding capitalism with limited self-introspection. Consequently, this section explicates the processes leading to the reduction of universities as enterprises and deteriorating academic freedom and vision, beyond market. It presses upon the demand to rescue STEM from this crisis of becoming a market-controlled training centres. The discussions in the first three chapters go further by acknowledging the need for the STEM HEIs to be reimagined and re-established to foster comprehensive and complete education, focusing on humane development.

Following this, the second section focuses on Ethics in STEM. It takes informed stands for a balanced development, in the era of uncontrolled rush for techno-economic advancement. It questions, who are all affected by this rush and how; whether the advantages or benefits of the actions override the disadvantages or harms; how intense are the positive and negative outcomes of the action; for how long are the consequences of the action going to remain and are the consequences able to further produce any positive results? It discusses the ethical issues associated with the advancement of science and technology by focusing on climate change, waste management, stem-cell research, cloning, genetic modifications, automation, artificial intelligence (AI), among others. The chapters in this section reflect on the nature of moral values and the relationship between the moral and the social (including professional) worlds. They raise pertinent questions and argue that a heightened understanding of moral-social relations creates a better position to appreciate the

indispensability of ethics in the larger sphere of social activities, including the professional world.

The third section traces the symbiosis between the HSS and STEM disciplines through pedagogic lenses. Tracing the changes across HSS disciplines in the school curriculum, in the light of education policies and sustainability, places on record its foundations for the preparatory stages. The section also exfoliates the bi-directionality between both the conceived extreme polarities. It illustrates the importance of HSS in STEM education through a specific case of language teachers supporting STEM teachers to improve Techno-Science pedagogy. The following chapter extends it further to the realm of literature and discusses how, the discussion of proper literature could provide STEM students a nuanced understanding and help preparing them as socially conscious.

Conversely, this section also depicts STEM as a powerful tool to transform HSS disciplines through a two-fold approach. First, it re-envisions the scope of STEM subjects, in its present state, beyond the disciplinary boundaries. To elucidate, the section acknowledges Mathematics as a humanistic discipline and describes Social Sciences based Mathematics pedagogy in Higher Education. Second, it argues for interactive and experience-based methods involving imagery and graphics. Grounded in the field of psychology and cognitive science, the chapter emphasizes on the use of web-based simulation tools, which expose students to newer forms of experience-based pedagogies and help integrate the social aspects with science education.

The fourth section is dedicated to case studies asserting holistic education. It walks the reader through the interdisciplinarity promoted by the National University of Singapore (NUS), paving the way for strong communication between educators and policymakers. This also echoed in the next chapter, which highlights the initiatives of the top ranked universities and reputed workplaces in the United States (US), which has successfully integrated HSS into their engineering programs. It reveals five key pillars essential for cultivating a strong foundation for fresh graduates: ethical engineering practices, societal and environmental impact, human factors, global and cultural competence, and regulatory and policy understanding to form the foundation of a modern engineering ethos that is technically proficient and socially, ethically, and globally aware. This section also provides an opportunity to learn from a specific interdisciplinary course in the US, where students employ a sociological imagination and empathic stance, in addition to the technical skills. It describes how can a cotaught, interdisciplinary course, can help deepen student, staff, and faculty understandings of equity and inclusion in STEM, while at the same time inspiring student-led actions to enhance inclusion in a liberal arts setting.

The fifth section advances its foundation and understanding by traversing beyond academia to the industry. It epitomizes the role of philosophy and ethics in STEM higher education for success in the professional sphere. Mapping the competency requirements for the twenty-first century with the competency frameworks of the leading organizations, it reiterates the need for integrating HSS into STEM subjects, the absence of which leads to an undersupply of trained workforce. Going ahead, this section also makes a case for a composite index to gauge the higher education preparedness level for workforce development.

Finally, the closing section, draws clues from the previous sections and associated chapters. It suggests a new conceptual framework for integrating HSS and STEM higher education. The framework employs a four-fold approach of Innovation, Diversification, Expansion, and Assessment, (IDEA). The IDEA framework argues for the STEM HEIs to look beyond the elitist disciplinary specificities and welcome the diversity and becoming fully multidisciplinary in practice. The discussions in the chapter also attempt to capture some of the important points, which shed light on the road, the roadblocks and the possible solutions for the integration of HSS and STEM Higher Education. Overall, it is the hope that the book will highlight some pertinent questions, raise important issues which need attention and provide directions towards making inclusive higher education.

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