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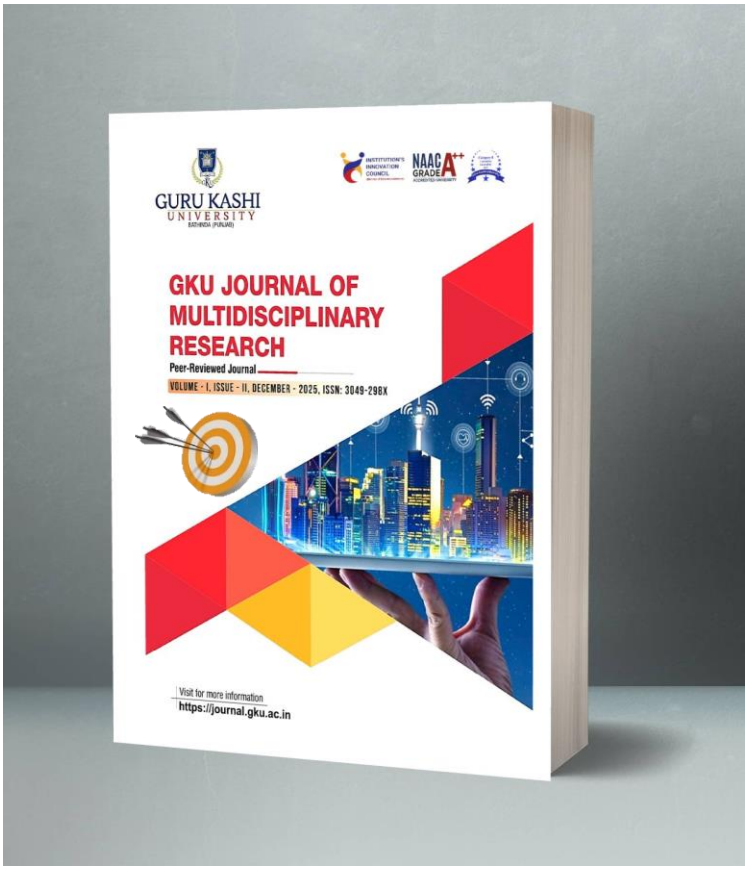

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The scope of the journal includes interdisciplinary research in fields such as Science, Technology, Engineering, Management, Humanities, Social Sciences, and Education. It welcomes theoretical and applied studies, case studies, review articles, and technical reports. The journal encourages contributions that address contemporary challenges, propose innovative solutions, and reflect a commitment to academic integrity and societal impact.

By providing an open and inclusive platform, the GKU Journal aims to facilitate academic dialogue, strengthen industry-academia linkages, and contribute to national and global research communities.

Chancellor Message

It is with immense pride that I introduce the latest edition of the Guru Kashi University Journal of Multidisciplinary Research. This journal represents the continued mission of our university to nurture scholarly achievement and interdisciplinary inquiry. In this regard, as a cross-disciplinary academic platform, it is designed to link different areas of knowledge addressing the disparate issues facing our world today.

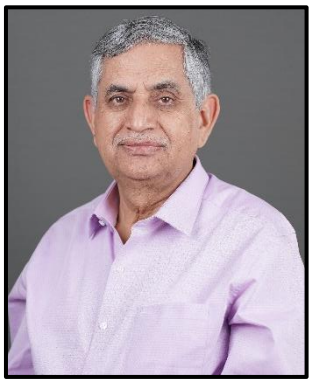
I warmly congratulate all contributors whose work and commitment to research and scholarship are reflected in this journal. Their strong commitment and collaboration, as well as that of the editorial board and reviewers, contribute to maintaining this journal at high standards.

At Guru Kashi University, we believe in promoting curiosity that transcends the boundaries of faculties, and this journal is a testament to that belief. It will continue to inspire future scholars and researchers to stretch, create, and read work that is part of an essential scholarly conversation.

S. Gurlabh Singh Sidhu

Chancellor

Vice Chancellor Message



It gives me great pleasure to present the inaugural issue of the GKU Journal of Multidisciplinary Research. This journal is an important step in Guru Kashi University's mission to promote academic excellence, innovation, and meaningful research.

In a world where boundaries between disciplines are steadily dissolving, true progress lies in multidisciplinary inquiry. This journal is designed as a peer-reviewed platform for scholars, researchers, and practitioners to share original ideas and solutions that address contemporary challenges.

I congratulate the editorial team, contributors, and reviewers whose dedication has made this first issue possible. I am confident the GKU Journal of Multidisciplinary Research will soon grow into a respected forum for knowledge creation and collaboration, reflecting our motto of "Empowering Youth, Empowering India."

Prof. Rameshwar Singh

Vice Chancellor

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GKU Journal of Multidisciplinary Research (GKUJMR)

Trends and Practices of Instructional Leadership in Teacher Education

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Abstract – Since time immemorial, leadership has been a key factor that determines the achievement of learning institutions (Toprak, 2020, Day et al., 2016). In the National Education Policy 2020, the distributed leadership is predicted as an instrument to change the educational system in India. In this article, the investigator has examined the current instructional leadership trends and practices in teacher education, and also identified the gaps in the existing literature. The present investigator has also examined the leadership models that determine student learning outcomes. The published literature through systematic searches of Google scholar, PubMed, education resources information centre (ERIC)and the like has been used to extract empirical evidence. The results provided evidence-based policy guidelines to teacher and school education, and this can enhance the leadership competences in instruction that are in the best interest of the society.

Keywords – Leadership, Teacher Education, Instructional Leadership

I. INTRODUCTION

The concept of instructional leadership has become a conclusive concern in teacher education, defining the channels in which the educational leaders affect pedagogical practice and learning outcomes (Singh, 2024) (Pitriani, 2024).With the changing nature of the educational environment, instructional leaders are becoming more and more involved in the dynamic and additional aspects of instructional matters, curriculum development, and professional learning, rather than merely the traditional administrative functions (Adams & Yusoff, 2020) Dorukbai & Cansoy, 2024). The given evolution is an indication of the increasing recognition of the fact that the role of the leader is not only to govern the institutions but also to be an active participant of the teaching process (Sanford et al., 2019). Recent discussions (Cheng, 1994) (Pushpanadham & Nambumadathil, 2020) show that there has been a transition to collaborative leadership models which in this case, instructional leaders collaborate with teachers to create a sense of shared accountability to student achievement. The paper examines the current trends and practices of instructional leadership in the teaching field and evaluates how these practices influence the effectiveness of the teacher and the performance of the student in the contemporary learning setting. Through a strict examination of literature and case studies, the research clarifies the critical nature of the instructional leadership in determining the future of teacher education. Besides collaborative model, instructional leader professional development has also been the center of attention in promoting educational outcomes. The institution of higher learnings are now charged with the responsibility of moulding leaders into leaders by way of specialised programmes that focus on teaching leadership skills thus making them adept to handle the challenges of the modern education environment. Through integrating new forms of pedagogies and leadership theories into the training, future instructional leaders will be able to learn how to effectively facilitate teachers and create meaningful learning experiences particularly with the emergence of the changing accountability frameworks. The necessity of a common leadership strategy thus deepens; all the members of the education community, such as administrators and teachers, need to realize their roles in the development of the culture of continuous improvement and shared responsibility in the achievement of students. Not only this change enhances the effectiveness of instructional leadership; it will also increase the inclusiveness and collaborative learning environment, which will positively impact both teachers and students. It is not new that leadership is considered one of the primary sources of success of the educational institutions. In the past, educational leadership was not just about administrative control but it dealt with influencing culture, policy and pedagogical orientation, and thus quality of teaching and learning. The education leadership has assumed a new form as far as a more hierarchical and principal-focused paradigm has been transformed into a collaborative, distributed, and multifaceted paradigm. This change highlights the fact that the culture of institutions is shaped by a good leader, which can affect the performance of teachers and the results of students (Toprak, 2020). The academic research on school leadership highlights its essentials in instilling common educational values, teacher growth and school enhancement sustainability (Day, Gu, and Sammons, 2016). Distributed leadership has also emerged in the National Education Policy 2020 in recent years as a reformative approach to education. The policy highlights the importance of decentralising the leadership roles and promoting cooperative interaction between various stakeholders such as teachers, administrators and community members. The focus on distributed leadership coincides with the international agreement on the fact that participative leadership has a beneficial effect on the motivation of educators and the learning results of students (Singh, 2024). At the same time, instructional leadership, which is a leadership that is targeted at the improvement of the teaching and learning activities, has become one of the main factors influencing the performance of teachers and the learning achievements of students (Pitriani, 2024). In this respect, a detailed insight into the current trends and practices of instructional leadership in teacher education programmes is crucial to developing school leaders who could cope with modern issues. (Townsend, 2011) (Karakse et al., 2024).

II. THEORETICAL BASES OF INSTRUCTION LEADERSHIP

Instructional leadership is essentially guided towards the development and improvement of teaching/learning in schools. In the most basic terms, it entails principals and other leaders expressing well-defined instructional goals,

managing instructional activities, and creating favorable learning conditions. There are many conceptual frameworks that outline instructional leadership and aligned it to different leadership approaches namely transformational, distributed and transactional leadership. Although transformational leadership is inspirational and motivating towards a change, whereas transactional leadership is concerned with the processes and exchanges in organisations, the instructional leadership is concerned with direct pedagogical improvements. The two leadership styles do not contradict each other but instead engage in how they influence each other to relate to educational achievement.The role of instructional leadership becomes especially relevant in the context of teacher education. It influences the planning, delivering, and overseeing of teacher preparation programmes and professional development programs. The leaders in such environments impact the modalities of teacher educator training, promote perpetual learning of teachers, and instill reflective modes of instruction that are necessary in high-quality teaching (Singh, 2024). Empirical research illustrates that instructional leadership's effectiveness is mediated through mechanisms such as enhancing teacher instructional practices and fostering professional learning communities that emphasize collaboration and continuous improvement E. Dorukbai, R. Cansoy, 2020. Correspondingly, professional learning communities offer a supportive framework where instructional leadership encourages shared practices and mutual accountability, leading to improved educational outcomes (E. Pitriani, 2024). Hierarchical models of instructional leadership despite their common use are subject to criticism. The tendency of traditional models to maintain top-down authority frameworks thereby potentially limiting teacher autonomy and commitment, is one of the limitations identified and has become a common feature of extant literature. As a result, new paradigms promote distributed and sustainable leadership models that delegate power and develop a sense of collective responsibility among teachers. With the heterogeneous and sophisticated structure of education setting, the modern leadership models are more focused on the aspect of contextual responsiveness, both of which embrace the local cultural dynamics and global trends in order to customise leadership practices. This contextual sensitivity supports the applicability and effectiveness of instructional leadership in diverse educational contexts. (Toprak, 2020) (Day et al., 2016).

III. Leadership in Teacher Education

Transformational leadership was discussed by (Cheng, 1994, (Pushpanadham & Nambumadathil, 2020) and found helping hand for teachers especially in service. This paradigm stresses the use of teachers as leaders in schools thus enhancing a common vision of quality education (Pushpanadham & Nambumadathil, 2020). It makes teachers train various skills, including pedagogical and leadership ones, and the aim of making students ready to face future challenges (Pushpanadham & Nambumadathil, 2020). (Toprak, 2020) (Day et al., 2016). On the other hand, Distributed Leadership Models as emphasis by (Singh, 2024) (Pitriani, 2024) found ample in teacher education. These models emphasize on collective decision-making and shared participation thus increasing the school effectiveness and teacher empowerment (Sachar, 2025). They deal with issues like role ambiguity and the unwillingness of traditional structures which is highlighted as the necessity to conduct further research to understand their long-term effects (Sachar, 2025). Instructional Leadership Practices Instructional leadership practices refer to actions implemented by school administrators to enhance the experiences of teachers and students. Instructional Leadership Practices Instructional leadership practices are defined as actions undertaken by school administrators to improve the experience of teachers and students. (Adams & Yusoff, 2020) (Dorukbai & Cansoy, 2024). These interventions are directed at enhancing the quality of teaching and the performance of the students by means of intensive instruction (Li, 2024). Although they are effective, they have been criticized due to their shortcomings as compared to collaborative leadership models (Bush, 2015). The instructional leadership trends despite their optimistic forecasts have their issues, and one of them is the difficulties in the complete implementation of the models, especially the obstacles to traditional hierarchies and fair involvement of educators (Sanford et al., 2019).

IV. Distributed Leadership Models

These models emphasize on collective decision-making and shared participation thus increasing the school effectiveness and teacher empowerment (Sachar, 2025). They deal with issues like role ambiguity and the unwillingness of traditional structures which is highlighted as the necessity to conduct further research to understand their long-term effects (Sachar, 2025).Instructional Leadership Practices Instructional leadership practices refer to actions implemented by school administrators to enhance the experiences of teachers and students. Instructional Leadership Practices Instructional leadership practices are defined as actions undertaken by school administrators to improve the experience of teachers and students. (Adams & Yusoff, 2020,Dorukbai & Cansoy, 2024). These interventions are directed at enhancing the quality of teaching and the performance of the students by means of intensive instruction (Li, 2024). Although they are effective, they have been criticized due to their shortcomings as compared to collaborative leadership models (Bush, 2015). The instructional leadership trends despite their optimistic forecasts have their issues, and one of them is the difficulties in the complete implementation of the models, especially the obstacles to traditional hierarchies and fair involvement of educators (Townsend, 2011) (Karakse et al., 2024).

V. Instructional Leadership Research Trends in Teacher Education

The discussion of the topic of instructional leadership in teacher education has experienced a dramatic shift in the course of time, as bibliometric and thematic analyses of the wide range of academic literature demonstrate. In the past, the empirical research (Singh, 2024) (Pitriani, 2024) concentrated on the administrative and management roles of school principals. Given that instructional leadership has been brought into focus more recently, the focus has then moved to distributed leadership models that model collaborative practice. This development indicates recognition that the effectiveness of educational leadership depends on developing the quality of instruction and

empowering various school participants, instead of centralizing the power in the hands of one person. In line with this, the literature shows a growing trend of using quantitative methodologies in the past decades, and thus it is easier to use it to make more strong and generalizable conclusions about the effects of leadership. Additionally, modern research includes the aspects of social justice and equity, and leadership is viewed as a means of eliminating systemic differences in education. The study has significant contextual diversity, as far as geography is concerned. Whereas initial and intensive writing is based in Western environments like United States and Europe, recent research is paying more attention to non-Western environments such as India, Turkey and Kenya. These papers emphasize the fact that leadership strategies are always shaped by culture, society, and policy contexts and require adjustments to local realities (G. Singh, 2024). An example of this is that distributed leadership in Turkey gives rise to differences in enactment that have been influenced by cultural norms that are specific to the region. Importantly, the disparities also manifest themselves between the public and the private educational sectors, as the former tend to have less freedom to enact the instructional and transformational leadership practices, which results in higher teacher satisfaction and better student results in comparison to the latter. In methodology, research has taken advantage of the large scale internationally survey data sets like TALIS (Teaching and Learning International Survey) to carry out multi country analysis which provides the comparative information on the role of leadership within the education systems. The mixed-method designs of encompassing qualitative interview and quantitative survey have further contributed to the understanding of leadership enactments and experiences in various educational contexts. The evaluation of direct and indirect effects of leadership on teacher professional growth and student learning outcomes has been promoted by meta-analytical methods, such as structural equation modeling, and thus clarified the indirect mediating roles of teacher efficacy and collaboration. Instead, these models enable leaders to foster an environment in which every stakeholder feels at ease with change and is supportive of it Modelling Leadership and Application in Teacher Educations. (Adams & Yusoff, 2020) (Dorukbai & Cansoy, 2024)

Conventional theories of instructional leadership anticipate the principal as the key facilitator of controlling the quality of instruction and developing a favorable school-learning environment. Principals engage in classroom, teacher, and curricular supervision practises to ensure that practice is in line with pedagogical norms. Nevertheless, these models tend to face the problem of inability to balance the two demands of administrative and instructional leadership and this can lead to the lack of attention to teacher development and innovation. However, leadership in instructions produces a significant effect on teacher self-efficacy and commitment that have consequent effect on teaching quality and student achievement. A more modern paradigm embraces distributed and pedagogical leadership models, which unite delegation of leadership roles and the emphasis on the enhancement of pedagogy. These hybrid models recognize that the instructional leadership is not limited to principals, but includes teacher leaders, trainers, and other parties, all of whom impact on instructional activities. In this respect, teacher leadership, especially, has become a major contributor of professional learning and improvement of instruction by use of collaborative network and engagement among peers. Meta-analytic studies support the existence of a positive relationship between distributed leadership and teacher professional development and collective efficacy, which in turn leads to the creation of an educational environment that is conducive to student achievement. Simultaneously, the transformational and transactional models provide leadership perspectives that are still influential in the leadership discourse of teacher education. Transformational leadership where inspirational motivation and personalized consideration are the defining features have been associated with the nurturing of the key skills of the 21st century such as collaboration and critical thinking. Instructional leadership is complemented by transactional leadership that brings about clarity of expectations, rewards and execution of tasks to ensure that there is organizational structure and accountability. Empirical reviews have outlined pre-conditions that contribute to the development of transformational leadership in educational settings- leader attributes and organizational equitability- hence strengthening the multiplier of transformational leadership in complicated schooling settings (Sanford et al., 2019). The role of instructional leadership in teacher education institutions is multiplied with the various roles and responsibilities. School principals do not only mentor and oversee teachers, but also lead the curriculum, managing the match between instruction and changes in educational requirements. However, the sharing of leadership costs is also evident in the work of teacher educators and administrative personnel, which implies the necessity to bear joint responsibility to be able to cope with the workload and improve teaching (Townsend, 2011) (Karakse et al., 2024). Notably, the application of instructional leadership in teacher education is currently focused more on considering the integration of teacher voice and developing agency, which can empower teachers to be active participants in the leadership process and curriculum choices. Constant learning and professional development are two of the most important practices in instructional leadership. Leadership strategies involve organizing continuous teacher professional learning which is in line with the specified instructional goals. The policies that facilitate continuity of professional growth are imperative especially in the reformative settings where the teachers need to adjust to new standards and pedagogies. In addition, formal teacher leadership and instructional coaching programs have been established in order to develop instructional competencies and improve collective instructional practices. Through these programs, teachers receive support frameworks which allow them to develop skills, exchange best practices as well as collaborate to enhance instruction. A collaborative culture is one of the pillars of instructional improvement. Educational leaders (principals) and other educational leaders are actively promoting collaboration and mutual reflective practice among the teachers and empirical research proves this to be true and can boost the quality of instruction. Since learning communities in schools foster innovation and a sense of shared responsibility, learning communities at the same time enable the creation of a conducive environment that sparks educational change. These facilitating cultures do not just motivate teachers but also have an impact on the student performance as they enhance uniformity and order in the delivery of instruction. (Cheng, 1994) (Pushpanadham & Nambumadathil, 2020).

VI. Instructional Leadership and Teacher's Performance

Instructional leadership has significant influence on the outcomes of the teachers, especially with regard to teacher self-efficacy and profile of instructional practice. The empirical studies (Toprak, 2020) (Day et al., 2016) have found out strong positive ties between the instructional leadership of principals and teacher self-efficacy which proves that instructional leadership that develops a favorable learning climate in schools enhances the confidence and teaching performance of teachers. The mediating effect of teacher professional learning in the correlation of instructional leadership and better teaching practices highlights the need to develop over time and receive institutional support (E. Dorukbai and R. Cansoy, 2020). The positive learning conditions do not only strengthen the teacher efficacy but promote instructional innovation and commitment as well. (Singh, 2024) (Pitriani, 2024) Instructional leadership also affects teacher commitment and job satisfaction. Distributed leadership models have been seen to enhance job commitment by teachers in mitigating the isolation and by supporting shared leadership responsibilities. There are varying economic, social, and political factors that interact with the instructional leadership to influence the motivation of teachers, their job satisfaction, and professional commitment. Democratic styles of leadership have positive influence on the discipline and satisfaction of teachers through participation in decision making and the development of conducive workplace atmosphere. Furthermore, teacher empowerment through leadership is a critical aspect that determines the results of the instruction. Distributed and pedagogical leadership styles foster the leadership abilities of teachers, which allows them to influence instructional decision making and peer cooperation. The formal teacher leadership programs have been found to be successful in promoting teacher collaboration and teacher instruction support systems thus leading to professional growth and long-term instructional growth. The perception of leadership support and empowerment by teachers is always associated with high motivation of job satisfaction and instructional commitment. (Adams & Yusoff, 2020) (Dorukbai & Cansoy, 2024).

VII. Leadership of Instructional Leaders and Learning Outcomes of Students

The connection of instructional leadership and student learning outcomes has been well established and works in more than one way, such as instructor instructional practices and motivation (Sanford et al., 2019) Teaching quality directly depends on instructional leadership, which makes it easier to achieve higher levels of student achievement. Cross-national data, such as that collected by The Teaching and Learning International Survey (TALIS) 2024, shows that the extent of leadership effects differ among countries and schools, which the importance of situational factors. These findings are achieved by meta-analytical evidence that shows that leadership-for-learning frameworks have significant relations with improved academic performance by students. The differences in the approaches of leadership in public and private schools also shed more light on the role in influencing student outcomes. According to the comparative studies, the transactional leadership style and instructional leadership style are more commonly used in the private schools and are related to high teacher satisfaction and high rate of student achievement. Conversely, there is a lack of flexibility in leadership in terms of the regulatory restrictions that are faced by public schools, thus potentially undermining the quality of instruction and student performance. Instructional leadership also plays a strategic role in cultivating competencies of the 21 st century, such as critical thinking and collaborative skills, without which students cannot succeed in modern societies. Leadership support is the key to innovation of instructional models. An example would be project-based learning that requires the solid leadership intervention to be effectively implemented into the curriculum, thus enhancing the student engagement and learning outcomes. There is also the central role of leadership that prepares the teachers towards applying the standards of education and reformations that would help in improving the quality and alignment of teaching. Faced with the world educational challenges, adaptive leadership is required to satisfy the cultural, technological, and pedagogical needs in various learning settings (Townsend, 2011) (Karakse et al., 2024).

VIII. Critical Appraisal

Even after significant progresses, there are still several unaddressed gaps and issues in the field of instructional leadership. One of the most significant weaknesses revolves around the narrow-mindedness in terms of the interrelations that exist between teacher commitment and instructional leadership with respect to the subtle economic, social, and political aspects that serve to mediate this association Cheng, 1994) (Pushpanadham & Nambumadathil, 2020). Also, the contextual variables which affect leadership effectiveness are not adequately studied, especially in diverse cultural and institutional contexts in which the meaning and practices of leadership can differ significantly. Furthermore, the lack of longitudinal empirical information restrains the evaluation of long-term effects of leadership intervention on teacher practices and student achievement, which limits evidence-based policymaking. The other issue is related to definitional congruence and operationalization of distributed and pedagogical leadership in teacher education. The literature presents inconsistency in the meaning of these concepts and application methods thus making it harder to comparatively analyze and synthesize research results. Also, the opinion of developing nations and non-Western situations is under-represented, which limits the breadth of generalization and worldwide applicability of the instructional leadership theories (G. Singh, 2024). Handling these inadequacies will require more contextually based, longitudinal and mixed method research which combines theory, practice and policy (Toprak, 2020, Day et al., 2016).

IX. Policy and Practice Recommendations

To strengthen the instructional leadership abilities in teacher education, specific leadership training programmes should be developed with a clearly stated focus on the

instructional and distributed leadership capabilities(Singh, 2024, (Pitriani, 2024). The potential educational leaders should be prepared to juggle both administrative and pedagogical roles with the help of such programmes. It is also advisable to incorporate mentorship and coaching models in teacher preparation to provide enabling models to novice teachers and the upcoming leaders. Additionally, the development of leadership strategies that emphasize collaboration and professional learning communities creates a fertile ground on which instructional innovation and continuous improvement take place (E. Pitriani, 2024). Policy frameworks should support sustainable instructional leadership by ensuring educational policies are in tandem with leadership development, and ceaseless professional development of teachers. With the recognition of the heterogeneity of educational situations, educational policies must encourage flexible leadership frameworks, which are responsive to cultural and contextual demands, thus avoiding a one-size-fits-all prescription. Furthermore, enhancing the system of accountability by means of facilitative leadership, which values learning conditions and interaction between teachers can intensify the overall efficacies of schools (Adams & Yusoff, 2020). Improving research-practice connections is critical in the direction of improving the influence of instruction leadership. This includes the encouragement of longitudinal and mixed-method research designs that provide in-depth evidence about the effects of leadership in teaching and learning. Further promotion of cross-national comparative research that leverages the use of datasets like TALIS can produce subtle information that can be applied in a variety of settings. Nurturing the development of collaboration between researchers, policymakers and practitioners can see that leadership research becomes applied in practical, real-world strategies that can transform the outcomes of education. (Adams & Yusoff, 2020, Dorukbai & Cansoy, 2024)

CONCLUSION

This overall analysis shows that instructional leadership in teacher education has approached a different angle of administration, whereby it is inclusive, distributed, and pedagogically oriented practices that are critical in promoting teacher and student success. The literature highlights distributed and instructional leadership as key forces in successful teacher preparation, professional growth, and quality of instruction, which in turn affect the achievement of students. Despite this, there still exist considerable gaps especially in matters of contextual variability, long term effects, and conceptual clarity of leadership models. To deal with these issues, there should be integrative research methods and responsive policies that develop instructional leadership capabilities of various educational systems. With the ongoing process of teacher education adjusting to the fast changing educational environments in the global frontiers, the long-term emphasis over instructional leadership will remain indispensable in the development of efficient teachers and empowerment of learners into the future. There is a changing emphasis on instructional leadership in teacher education, especially in the scenario of the National Education Policy (NEP) 2020 in India that lays stress on distributed leadership. The given approach will help to improve the quality of education by encouraging collaborative practices between the educators. Below, the major trends and practices in instructional leadership are explained. (Townsend, 2011) (Karakse et al., 2024) Leadership in teacher education: transformational leadership (Cheng, 1994) (Pushpanadham & Nambumadathil, 2020). This paradigm stresses the use of teachers as leaders in schools thus enhancing a common vision of quality education (Pushpanadham & Nambumadathil, 2020). It makes teachers train various skills, including pedagogical and leadership ones, and the aim of making students ready to face future challenges (Pushpanadham & Nambumadathil, 2020) (Toprak, 2020) (Day et al., 2016).

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GKU Journal of Multidisciplinary Research (GKUJMR)

NEP 2020: Transforming Educational Practices and Policies for the Development of Holistic Intelligence among Prospective Teachers

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Abstract – The National Education Policy (NEP, 2020) has redefined the educational landscape in India by shifting emphasis from content-heavy, examination-oriented approaches to competency-based, flexible, and holistic learning, marks a paradigm shift in India's educational vision moving beyond conventional knowledge acquisition toward the holistic development of learners. This transformation is of particular consequence for teacher education, given that preservice teachers are future makers of the learning space. This paper critically explores how NEP (2020) reorientates practices and policies in teacher education to cultivate intelligence of an integrated nature (intellect, emotion, physical and spiritual) among pre-service teachers. Through qualitative document analysis, a systematic literature review and thematic analysis, the paper reviews evidence from policy frameworks, academic papers and teacher education guidelines. This article singles out structural, pedagogical, curricular and assessment interventions proposed in NEP (2020) and examines their potential impact on nurturing holistic intelligence. We suggest a model of NEP (2020)–Holistic Intelligence Alignment Framework that attempts to conceptualize how policy suggestions can be connected with developmental trajectories of future teachers. The paper identifies systemic lacunae with respect to faculty readiness, infrastructure limitations and assessment issues; and paucity of empirical studies on holistic intelligence. The paper posits that NEP (2020) outlined an idealistic blueprint; there was a need for strong implementation strategies and structures, capacity building, monitoring towards real transformation in TEIs.

Keywords** – **National Education Policy, holistic intelligence, and prospective teachers.

I. INTRODUCTION

The release of the National Education Policy (NEP, 2020) is a historic moment in India's educational journey. Once NEP (2020) came into play after more than 30 years since the last major policy overhaul, it brought with it a progressive, student-centric, flexible and holistic vision that is in tune with 21st century demands for education. The new policy perceives education not only as a process of gaining knowledge, but also inculcating values and promoting multidisciplinary approach. Unlike the previous profile formats such as NPE (1968) and NPE (1986), that emphasized heavily on access, literacy, cognitive development etc., NEP (2020) includes other laying more emphasis on lifelong learning and creation of an enabling environment for children to harness their true potential which are embedded within the parameters of competency-based quality education irrespective of income group and beyond geographical barriers.

Holistic intelligence is a buzzword of NEP (2020) due to the fact that it includes not only cognitive or intellectual growth but the development of emotional, social, physical, ethical, spiritual and aesthetic faculties. The policy emphasizes that education should enable full development of human personality, and is consistent with international paradigms like UNESCO's four pillars of education – learning to know, leaning to do, learning to be, and learning to live together.

The realisation of NEP's dreams lies at the centre of Teacher education institutions (TEIs). Future teachers are prospective agents of change who design classroom practices, learning cultures and value orientation. So, the integrated B.Ed. four-year course, competency-based curriculum, multidisciplinary exposure to prospective teachers by allowing them to undertake concurrent courses from other disciplines, adopting experiential model of teacher preparation and National Professional Standards for Teachers (NPST) have their profound implications in redesigning teacher preparation.

But the approach has been uphill and it's not clear that the concept will truly be realized. Little empirical work has addressed how NEP (2020) specifically plays out in the fostering of holistic intelligence among future teachers. Assessment systems for emotional, spiritual and physical intelligence are also underdeveloped in TEIs.

In this paper we respond to these gaps by offering an in-depth discussion of NEP, 2020 from the perspective of holistic intelligence, and propose a conceptual model for TEIs to attempt mainstreaming and integrating holistic development into teacher preparation programmes.

II. OBJECTIVES OF THE STUDY

1. To explore the provisions of NEP (2020) related to holistic development in teacher education.
2. To review existing literature on holistic intelligence and teacher education practices.

3. To identify research gaps in the scholarly discourse on NEP (2020) and holistic development.
4. To analyse implications of NEP (2020) reforms for prospective teachers' holistic intelligence.
5. To propose a conceptual framework linking NEP reforms with holistic intelligence indicators.

III. REVIEW OF RELATED LITERATURE

3.1. Holistic Intelligence in Education

Ecological intelligence is much more than the traditional basics of scholarship. C om (2017-08-05) Grounded in the works of Gardner (20011), Goleman 1995), and spiritual education researchers, holistic intelligent includes:

- **Cognitive intelligence Logical and analytical assessment and learning.**
- **Emotional intelligence the ability to empathize, to be resilient, and to self-regulate.**
- **Body physical awareness, fitness and psychomotor techniques.**
- **Spiritual intelligence morality, sense-making, purpose and inner peace.**

Studies have shown that teachers with high levels of emotional and spiritual intelligence contribute to healthier classroom atmospheres resulting in fewer behavioural problems and more engaged students (Jennings & Greenberg, 2009). Most worryingly, globally in pre-service teacher education socio-emotional and spiritual domains are given insufficient attention; the cognitive and the pedagogical take precedence (Nair, 2019).

3.2. NEP (2020) and Teacher Education Reforms

NEP 2020 perceives teachers as the building blocks of a nation and highlights that:

- **Integrated multidisciplinary programs;**
- **Competency-based teacher standards;**
- **Flexible curriculum structures;**
- **Experiential & project-based pedagogy;**
- **Technology-enabled learning;**
- **Reflective practice & mentorship; and**
- **Value-based & ethical teaching.**

According to the academics, the focus of NEP on teacher autonomy, self-regulation and professional development is an advanced trend (Sharma, 2022; Pattnaik, 2022). But the effective implementation does demands good faculty trainings gentrifying TEIs and monitoring system.

3.3. Digital Pedagogy and Blended Learning

The new normal of the post-pandemic era fast-tracked digitalization in teacher education. Services like DIKSHA, SWAYAM, Virtual Labs, Academic Bank of Credits (ABC) encourage individualized learning based on curiosity with the space to think independently and seek professional autonomy. Citing benefits on reflective thinking and expanding the learning experiences of future teachers, Kumar (2021) highlights how digital pedagogies are an asset for training prospective teachers.

3.4. Thoughts on IKS and Value-Based Education

NEP (2020) blends IKS with yoga, meditation, environmental ethics and global citizenship premised on Indian philosophical traditions for an integrated relationship between the cognitive and affective human faculties. These are specifically empathy, cooperation and civic sense (Gupta and Manjula, 2021) There is evidence that value-based education enhances empathy, co-operation and responsibility on the part of the students.

The literature reviewed unquestionably finds that holistic intelligence - including intellectual, emotional, physical and spiritual aspects of development - is critical to develop effective and future-driven teachers. Whilst Gardner, and Goleman recognise the multiplicity of human capacities shared by all individuals, current research underscores that educators who have deep emotional and spiritual competencies nurture healthier learning environments, build significant teacher–student connections and drive higher student engagement. However, both international and national research suggest that teacher education programmes still largely an overemphasis on cognitive areas and on pedagogy to the detriment of important affective and ethical dimensions of pre-service teachers' professional development.

NEP (2020) comes out as an alternative to fill these voids. Its focus on competency-based approach, reflective thinking, value orientation and trans-disciplinary learning indicates the new perspective in re-conceptualizing teacher education. Indeed, focus on autonomy of teachers, experiential learning and continuous professional development as envisaged in the draft policy is congruent with developing Holistic Intelligence. But the literature also warns that successful implementation of NEP (2020) largely relies on strong institutional capacity, quality faculty, proper digital infrastructure and effective monitoring frameworks in TEIs.

Also, the increasing role of digital pedagogy and blended learning approaches have broadened the potential for personalized, flexible, reflective learning that could be provided to future teachers. Programmes like DIKSHA, SWAYAM, Virtual Labs and Academic Bank of Credits point to the increasing orientation of technology that focuses on enhancing professional skills of teachers and facilitating a self-paced trajectory for professional development. Simultaneously, the embedding of Indian Knowledge Systems etc (NEP 2020) in NEP would serve nurturing several core components of holistic intelligence

i.e., moral consciousness, emotional equilibrium and global citizenship.

On the whole, such a convergence appears to be highly supported by the literature between concepts of holistic intelligence and reformed view of NEP (2020). Although significant progress has been achieved through its use in digital innovation and value-based approaches, consistent work on curriculum redesign, faculty training, and transformative pedagogical practices are necessary to fully implement holistic intelligence in teacher education. This review thereby offers an abstract framework for the consideration of how NEP (2020) can stimulate prospected teachers to have a holistic intelligence in education nowadays.

IV. RESEARCH GAP

The systematic review highlights the following gaps:

- Limited empirical research directly exploring the relationship between NEP (2020) and holistic intelligence development;
- Absence of standardised tools for measuring emotional, physical, and spiritual intelligence in TEIs;
- Insufficient case studies examining on-ground implementation challenges in TEIs;
- Predominance of descriptive articles over evidence-based research on NEP's impact on teacher development; and
- Lack of conceptual models linking NEP's structural reforms with holistic teacher competencies.

V. METHODOLOGY

This study uses a qualitative research design suitable for conceptual and policy analysis which is discussed below:

5.1. Document Analysis

The document analysis was done by analysing the following primary sources:

- National Education Policy (NEP, 2020);
- National Professional Standards for Teachers (NPST);
- National Curriculum Framework for Teacher Education (NCFTE);
- UGC and NCTE guidelines; and
- International frameworks (UNESCO, and OECD).

5.2. Systematic Literature Review

The systematic literature review was done through the following ways:

Databases: Google Scholar, ERIC, and Scopus.

Keywords: Holistic Intelligence, NEP (2020), Teacher Education, Socio-Emotional Learning, 4-Year B.Ed., and Values Education.

Inclusion criteria: Peer-Reviewed Articles (2009–2024), Policy Documents, and Thematic Reports.

5.3. Thematic Analysis

Four broad themes were generated which are mentioned below:

1. Competency-based teacher development;
2. Multidisciplinary and experiential learning;
3. Socio-emotional and value-based education; and
4. Digital pedagogy, teacher autonomy, and reflective practice.

5.4. Conceptual Synthesis

Findings were synthesized to construct a novel NEP (2020) – Holistic Intelligence Alignment Framework.

VI. DATA PRESENTATION

The NEP (2020) provisions corresponding to different dimensions of holistic intelligence are presented in table 6.1 below:

TABLE 6.1: – HOLISTIC INTELLIGENCE DIMENSIONS AND NEP (2020) PROVISIONS

Dimension	NEP (2020) Provision
Intellectual Intelligence	Competency-based curriculum and multidisciplinary learning
Emotional Intelligence	Social and Emotional Learning (SEL), mindfulness and teacher well-being modules
Physical Intelligence	Sports-integrated pedagogy and health & wellness curriculum
Spiritual/Value-Based Intelligence	Ethical reasoning, Indian Knowledge Systems, and yoga

The implications of NEP (2020) components for prospective teachers in form of expected impact are mentioned in the table 6.2 below:

TABLE 6.2: – IMPLICATIONS FOR PROSPECTIVE TEACHERS

NEP Component	Expected Impact
4-year Integrated B.Ed.	Strong pedagogical and content mastery
National Professional Standards for Teachers (NPST) Standards	Enhanced professional identity and reflection
Digital Platforms	Personalised and autonomous learning
Multidisciplinary Curriculum	Creative, critical, and innovative thinking

The proposed conceptual framework linking NEP reforms with holistic intelligence indicators is shown in figure 6.1 and 6.2 below:

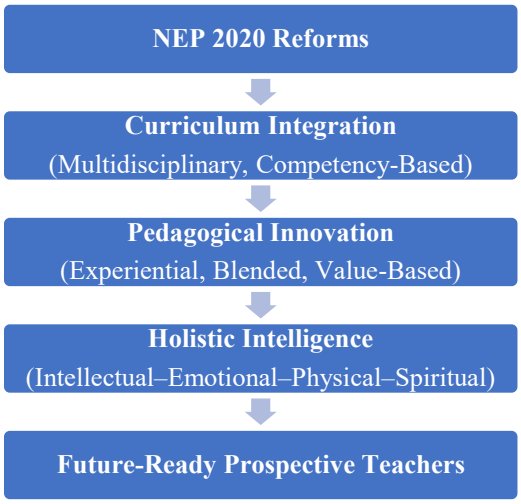

Figure 6.1 –NEP 2020–Holistic Intelligence Alignment Model

The four pillars of holistic teacher preparation under NEP (2020) are shown in figure 6.2 below:

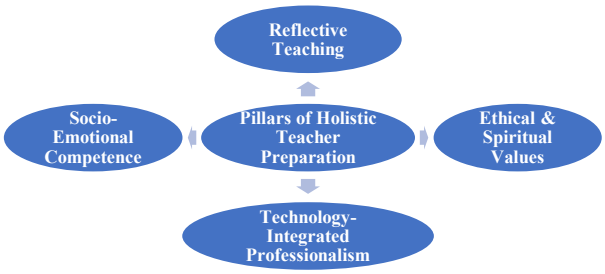

Figure 6.2 – Four Pillars of Holistic Teacher Preparation - NEP (2020)

VII. DISCUSSION

NEP (2020) offers a transformative blueprint for Indian teacher education, but its impact depends on ground-level execution. This section presents an in-depth analysis of how NEP (2020) reforms nurture various dimensions of holistic intelligence.

7.1. Intellectual Intelligence Development

NEP (2020)'s push for competency-based, interdisciplinary, and inquiry-driven learning encourages higher-order thinking among prospective teachers. The various features include the followings:

- Integration of arts, sciences, and vocational subjects;
- Research-based internships;
- Emphasis on critical pedagogy; and
- Flexible credit-based learning through ABC.

These reforms expand academic horizons and foster problem-solving abilities.

7.2. Emotional Intelligence Development

Teachers are expected to manage diverse classrooms, maintain emotional stability, and support student wellbeing. NEP mandates are listed below:

- Social and Emotional Learning (SEL) curriculum;
- Mindfulness practices;
- Teacher wellness programs; and
- Reflective journals and mentoring.

These interventions align with global standards on teacher emotional competence.

7.3. Physical Intelligence Development

Physical Intelligence neglected at TEIs the following are promoted:

• Sports-integrated pedagogy;
• Nutrition, Health & Fitness-related courses; and
• Yoga & body-mind practices.

7.4. Spiritual and Ethical Intelligence Development

NEP (2020) encourages rootedness in culture and universal values which are listed below:

- Ethics & moral reasoning;
- Gandhian & Indian philosophical perspectives;
- Mindfulness & meditation; and
- Environmental & civic ethics.

This nurtures compassion, integrity, and purpose among future teachers.

7.5. Gaps and Challenges

There are, however, many challenges facing a forward-looking policy, as I enumerate below:

- Faculty preparedness: a majority of teacher educators are not trained in SEL, blended learning and competency-based assessment.
- Lack of infrastructure: digital divide and crippled labs restrict experiential learning.
- Limitations of assessments: standards tests have poor predictive value for full-scale intelligence.
- Anti-reform inertia: existing institutions resist the adoption of reform.
- Empirical vacuum: new forms of TEIs in systematic terms for the integral formation have not been yet tested.

VIII. CONCLUSION

NEP (2020) as a watershed toward reimaging teacher education in India. Through its focus on cross-disciplinary, skills-based and values-driven education it provides the foundation for developing intellectual, emotional, physical and spiritual intelligence in those who will be future educators. But promises it can only keep if strong implementation strategies, faculty development plans,

sound assessment frameworks and supportive institutional ecosystems are in place.

The conceptual model suggested in this paper provides TEIs with a scaffold to bring holistic intelligence into curriculum, pedagogical and assessment practices. With India's progress towards global leadership in education, empowering teacher through comprehensive training becomes a national urgency.

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Mental Health, Mindfulness, and Well-being in Education

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Abstract – Well-being and mindfulness are integral parts of a healthy and productive learning environment. This paper delves into three areas of mental health, mindfulness and well-being in education, discussing associated benefits, challenges and guidance for educators. In this episode, we talk about how mental health affects academic performance, the importance of mindfulness in decreasing stress and the role of wellness in building resilience. The paper concludes with recommendations for educators, policymakers, and other stakeholders, advocating for a holistic approach towards mental health and well-being for students.

Keywords – Mental Health in Education, Mindfulness Practices, Student Well-being, Holistic Development

I. INTRODUCTION

Our life is shaped not only by what happens around us but also by how we *perceive* those experiences and how we *respond* to them. These perceptions and reactions differ from person to person because they are shaped by mental conditioning developed since childhood. This attitude finds its way into the unconscious over the years and causes automatic thought and response patterns. These types of patterns can distract you, disperse your attention, diminish your memory, make it hard to make decisions, and thus having a negative effect, and can eventually cause you to have a reduced feeling of control over life. Mindfulness is an opportunity to interrupt these automatic cycles. Mindfulness is the act of giving a **purposeful, non-judgmental attention** to the present moment. Through simple techniques such as observing the breath, body-scanning, compassion-based meditation, and gentle yoga, learners develop the ability to watch their thoughts, feelings, and bodily sensations without reacting impulsively. Studies suggest that mindfulness assists people in the voluntary regulation of attention, awareness of emotional patterns, and responding to experiences with receptivity rather than avoidance or reactivity. Greater awareness helps folks better respond or not respond to stimuli and forms the foundation for a reprogramming of how one experiences reality. In today's education system, such skills are not optional—they are essential. **Mental health, mindfulness, and well-being** form the core of a healthy, balanced, and humane learning environment. According to the NEP (National Education Policy) 2020, real education is one that contributes simultaneously to the holistic development of all students including their mental well-being and also in creating a safety net like environment with inner peace and tranquility within educational institutions. These concepts are also in accordance with the significant legal principles such as those embodied in the Right to Safe Education, Best Interest of the Child and Duty of Care that demand schools provide environments that safeguard and develop a child. Here, mental health is an aspect of a learner's frame of mind and state of psyche — such as how they're coping with stress, conveying their feelings, cultivating relationships, staying inspired. Mindfulness also enhances this by sharpening attention, decreasing anxiety and helping with emotional regulation. A student's well-being comprises their physical, emotional, social, and mental safety; helping them feel valued, supported and self-assured. NEP 2020 advocates introducing counselling services, yoga and meditation practices, socio-emotional learning, emotional-awareness training for teachers, anti-bullying policies and inclusive classrooms to strengthen these areas. Together, these efforts create an educational ecosystem where learning goes beyond textbooks and marks. Education will not only instil knowledge and skills that will allow individuals to thrive, but it will also impart attitudes, beliefs and practices that will always promote resilience, emotional balance and fulfillment so that learners feel prepared not only to become successful professionals but also to be happy human beings who, confronted with challenges, have the inner capacities to face these challenges and manage the ups and downs of life.

Mental Health is a learner's emotional and psychological condition — that is, his or her ability to cope with stress, communicate / express emotions, build healthy relationships and stay motivated. A good mental health cultivates life skills within students, instills clarity as well as confidence to actively participate in learning.

Mindfulness is about being aware in a calm way of what is happening in the present moment. Deep-breathing, quiet reflection, and mindful observation techniques reduce anxiety and increase concentration and emotional regulation, creating a purposeful, less stressful learning environment.

Well-being is positively linked to the student's entire life — including physical, emotional, social and cognitive aspects of health. That is to say that students feel safe, respected, supported and positive about the school climate. Feeling good about yourself helps you to win at school, behave better and grow!

To strengthen these dimensions, **NEP 2020** encourages schools to adopt:

- **Counselling and mental health support systems**,
- **Yoga, meditation, and socio-emotional learning**,
- **Teacher training in emotional and behavioural understanding**,
- **Zero-tolerance policies for bullying or emotional harm**,
- **Inclusive and respectful classroom environments**.

These moves together construct an educational atmosphere, where the learning exceeds to textbooks and exams. With a weaving of mindful care, mental health services and well-being approach - education becomes a pathway to resilience, emotional equilibrium and life-long contentment.

II. Origin of Mental Health, Mindfulness, and Well-Being in Education

Historically, the mental health-promotion (MHP) discourse on well-being and mindfulness in education has developed over many centuries, at least partly stemming from ancient Indian wisdom traditions. The origins of mindfulness date back, at least in part, to spiritual practices in Buddhism, yoga, and tantra – an inner awareness and balance were considered foundational for a meaningful life. Vipassana meditation, one of the most commonly taught early practices, is what was authentically taught by Gautama Buddha over 2,500 years ago. This technique prompted people to pay attention to their thoughts, feelings and physical sensations with a clear mind and free from judgment — an approach at the core of contemporary mindfulness.

And slowly but surely, as those teachings went on to be disseminated and integrated outside of their cultural contexts, mindfulness found its way into areas such as medicine, psychology, and mental health. During the latter part of the 20th century, Jon Kabat-Zinn adapted these timeless ideas into a modern scientific and medicalized approach called Mindfulness-Based Stress Reduction (MBSR). This intervention integrated mindfulness in both clinical and educational settings with scripted practices designed to reduce stress, anxiety, and emotional suffering. Mindfulness is something of a pet peeve for Kabat-Zinn: It is not a mere technique, he says, but way of life. He outlined 7 attitudes that arise spontaneously when practicing mindful awareness—non-judging, patience, beginner's mind, trust, non-striving, acceptance and letting-go. Such attitudes can assist people to get in touch with their inner experience more effectively, think before reacting, and maintain equanimity. This changed as education systems woke up to the serious nature of emotional and psychological well-being and these principles of mindfulness found their way into musky classrooms. The songs are now integrated into school counselling programs with a focus on mental health, emotional regulation, positive behaviour and overall well-being - an important innovative addition to modern education.

III. Theoretical Framework

Where education systems woke up to the pivotal role played by emotional and psychological wellbeing, these mindfulness principles found their way onto classroom floors. They now underpin school programmes for mental health, emotional regulation, positive behaviour and overall well-being that are essential components of contemporary educational practice.

3.1 Positive Psychology (Seligman's PERMA Model)

Seligman's PERMA model includes five aspects of well-being: **Positive emotions, Engagement, Relationships, Meaning and Accomplishment.** When schools encourage these, learners feel emotionally stronger, more focused, and more successful.
This resonates with the holistic development approach of NEP 2020 and the legal concept of the Right to Healthy and Safe Education, which recognizes student's emotional and mental growth.

- **Mindfulness Theory (Kabat-Zinn)**

Jon Kabat-Zinn describes mindfulness as **calm awareness of the present moment**.
It helps students:

- manage stress,
- stay mentally balanced,
- respond thoughtfully,
- and improve concentration.

NEP 2020 supports these ideas through practices like **yoga, meditation, relaxation techniques**, and programmes that promote emotional well-being. These are also consistent with the school's and world law on Duty of Care, yet schools are obligated to safeguard students' mental and emotional well-being.

CASEL: Social and Emotional Learning (SEL)

The life skills, considered as key to the students' wellbeing The CASEL model outlines five core life skills:

- **Self-awareness**
- **Self-management**
- **Social awareness**
- **Relationship skills**
- **Responsible decision-making**

"These are tools that build good habits, mental health and positive peers."

NEP 2020 recognizes SEL through life-skills education and counselling facilities apart from inclusive teaching-learning process, all of which adhere to the principle Best Interest of the Child.

3.2 Holistic Education (Sri Aurobindo, J. Krishnamurti – General, Non-IKS Use)

Holistic education focuses on developing the **whole child** — mind, emotions, body, behaviour, and character. These thinkers emphasise:

- **Self-awareness,**
- **Emotional clarity,**
- **Freedom from fear,**
- **Balanced personal growth.**

This sits comfortably with the aim of holistic and child-centred education in NEP 2020, and advances legal concepts such as safe schooling, emotional protection and respect for student dignity.

IV. Importance of Mental Health, Mindfulness and Well-being in Education

In the world that is evolving rapidly, learning cannot just be restricted to textbooks and exams. Students inhabit a latent social and digital context that surrounds them with thoughts and feelings, influencing their behavior on a daily basis. Hence, the need for robust mental health care within school now appears both pressing and inescapable

- **Rising Academic Stress Across All Levels:** Learners—from early schooling to higher education—face heavy workloads, competitive exams, long study hours, and constant performance pressure. NEP 2020 promotes flexible learning and reduced exam stress.
  Legal Link: It is now compulsory for schools to protect pupils from stress which can be harmful.

- **Digital Overdose and the Influence of Social Media:** Too much screen time, online bullying, academic pressure via digital means and comparison culture all take a toll on emotional health. Download The Times of India News App for Latest Home Education News Subscribe Start Your Daily Mornings with Times of India Newspaper! Legal Reference: IT Act 2000 and UGC cyber safety guidelines call for protection from online abuse by institutions.

- **Increasing Emotional and Behavioural Challenges:** Students frequently experience anxiety, loneliness, irritability, lack of motivation, and emotional instability. NEP 2020 advocates for counseling and socio-emotional learning at all levels of the education pyramid. And the prescribed legal recipe: this new" duty of care" instructs both teachers and their schools to take " reasonable steps to protect students' emotional well-being".

- **Acts of Bullying, Harassing and Campus Misconduct:** Ragging, discrimination, peer toxicity and unsafe environments do untold damage to the mental constitution. NEP 2020 is in favor of safe, inclusive and respectful campuses. Legal linkage: RTE Act, POCSO and UGC Anti-Ragging Regulations (2009) require zero tolerance on harm to learners.

- **Emotional Distress Leading to High Dropout Rates:** Many students do not leave courses for academic reasons, but because of nervous tension and pressure on the social side, mental fatigue or lack of direction. NEP 2020 has highlighted mentorship, multiple entry–exit options and emotional support systems to arrest dropouts. Legal Reference: It is the responsibility of the state as part of its obligation under Right to Education Act to provide emotional safety for retention.

- **SCS, as a Means for Socio-Emotional and Life Skills:** And both academic and career success require abilities such as resilience, empathy, communication and emotional regulation. NEP 2020 files in SEL (Social and Emotional Learning) at all levels of education. Legal Link: Psychosocial skills are included in the Australian National Curriculum Frameworks as being part of a legally mandated curriculum.

- **Awareness Regarding Mental Health Among Teachers and Staff:** Uneducated teachers frequently miss early distress signals in pupils, resulting in untreated mental problems. Teacher training on emotional and behavioural understanding will be a must under NEP 2020. Legal Link: Duty of Care Teachers have a legal responsibility to act in the care and well-being of students.

- **Development as National and Legal Expectation – A Holistic Approach:** Education should train the whole being-mind, body, feelings, social adjustment-so it's not all education of the head.Legal Link: Article 21A, Article 45, and youth policies recognise well-being as part of quality education.

V. Role of Mindfulness in Enhancing Mental Health

Mindfulness plays a powerful role in strengthening mental health by helping learners stay calm, aware, and emotionally balanced in daily situations. It trains the mind to remain in the present moment, reducing automatic reactions and encouraging thoughtful responses. In fact, when implemented consistently within schools and

universities, mindfulness reduces anxiety while promoting attention, emotional stability and resilience among students of all ages.

- **Mindfulness Eases Anxiety and Psychological Stress:** Mindfulness, because it brings attention back to breath and present moment awareness can allay the mind. Studies such as Benham et al. (2022) show significant reductions in anxiety among students. **NEP 2020** encourages meditation and relaxation activities to reduce academic stress. **Legal link:** Article 21 provides for the right to mental well-being, leading to a stress free learning from being a fundamental right.
- **Benefits Focus, Attention and Cognitive Control:** Does Mindfulness help kids concentrate and ignore distractions. Research by Chung et al. (2021) also reports an increase in attention span after practicing mindfulness. NEP 2020 encourages meditation and yoga asana for better concentration and learning. Legal Link: On Duty of care – educators must deliver supportive activities which promote cognitive health.
- **Improves Emotional Self-Regulation and Self-Control:** Why Mindfulness? Mindfulness instills an ability in students to become aware of their emotions without reacting impulsively. Studies by Bishop et a l**a**nd Segal et al. (2002) show improved emotional stability and reduced overreaction. **NEP 2020** promotes socio-emotional learning (SEL), which aligns directly with mindfulness. **Legal Link:** Safe emotional environments are required under the **RTE Act** and UGC guidelines.
- **Increases Resilience and Coping Skills:** Practices such as body scanning and guided imagery help learners handle challenges, academic pressures, and failures. MacLean et al. (2020) report increased flexibility and resilience. NEP 2020 focuses on developing resilience through holistic development and mental health programs. Legal Link: Right to Education covers supporting to avoid emotional breakdown and drop-outs.
- **Decreases Aggression and Conflict Behaviour Induced by Stress:** Mindfulness decreases impulsivity because it helps students pause before acting, which can then lower aggression and help them solve classroom conflicts on their own. Research by Shapiro et al. (2006) supports this behavioural improvement. **NEP 2020** encourages calm, conflict-free campuses. **Legal Link:** *UGC Anti-Ragging Regulations (2009)* and *POCSO* mandate safe, non-aggressive learning environments.
- **Strengthens Interpersonal Skills and Empathy:** Mindfulness enhances awareness of one's own emotions and increases sensitivity to others' feelings. This leads to better communication and peer relationships.
  NEP 2020 promotes value-based education and emotional literacy.
  Legal Link: Inclusive and respectful environments are legal expectations under national child protection norms.
- **Supports Mental Dignity and Emotional Safety:** Mindfulness protects emotional dignity by reducing overthinking, fear, and negative self-talk. **NEP 2020** calls for well-being centers, counsellors, and mindfulness-based activities in all institutions. **Legal Link:** Article **21** ensures psychological safety, while the **Duty of Care** requires institutions to actively safeguard mental health.
- **Practical Mindfulness Practices Benefit Overall Well-Being:** Breathing exercises, meditation, gratitude journaling, mindful listening, yoga, and guided imagery create long-term improvements in emotional balance and mental clarity. These practices are aligned with **NEP 2020's holistic education model**, which includes yoga and meditation across all academic levels. **Legal Link:** Implementing well-being activities supports national guidelines for safe, mentally healthy educational environments.

VI. School-Based Mental Health Programs

Mental health and mindfulness support systems are essential across **all levels of education**, from school to college and university. Academic institutions are able to create environments where emotional concerns can be identified, prevented and treated with the help of well-designed programs for mental health. NEP 2020 focusses "safe and supportive learning environments", but legal standards such as Right to Safe Education, Duty of Care and Best Interest of the Child obligate schools [to] have a duty in creating space where all can emotionally thrive." The following initiatives build a strong foundation for mental health throughout the education system:

- **Education Counsellors and Psychological Support Services:** Professional customer guides the students in dealing with stress, anxiety, peer pressure relationship concern career-related issues etc. NEP 2020 Link: Requires mental-health trained counsellors in each school/college.
- **Wellness Centres and Mental Health Screening:** Institutions set up wellness rooms, relaxation spaces, and conduct periodic emotional well-being assessments to detect problems early. **Evidence:** Screening helps identify issues like depression or

anxiety before they worsen. **Legal Link:** Supports early intervention under *preventive care obligations*.

- **WHO Life-Skills Education Programs:** WHO recommends 10 core life skills such as creative thinking, empathy, emotional regulation, problem-solving, and communication. These life skills help students at every level—school students, college youth, and university learners. **NEP 2020 Link:** Strong focus on socio-emotional learning (SEL).
- **Mindfulness-Based Stress Reduction (MBSR):** MBSR techniques—including mindful breathing, body scan, and meditation—reduce academic pressure and increase attention. **Evidence:** Research shows MBSR lowers cortisol (stress hormone) and improves focus. **Legal Link:** Supports psychological safety norms in institutions.
- **Mindfulness-Based Cognitive Therapy (MBCT):** MBCT is especially useful for adolescents and youth facing negative thinking, exam fear, or emotional instability. **Evidence:** Proven to reduce the relapse of depression and enhance emotional resilience.
- **Teacher Training for Emotional First Response:** Teachers are often the first to notice behavioural changes in learners. Teaching them emotional first aid trained results in early identification and referral of the symptoms for support. NEP 2020 Link: Training in addressing the needs of children for their socio-emotional steps should be provided. Legal Link: Teachers' professional "Duty of Care."
- **Peer-Support Groups and Well-Being Clubs:** Peer mentors, well-being clubs and mental health societies work to foster supportive environments in schools, colleges and universities. Proof: Peer programs enhance social connection and decrease isolation.
- **Incorporation of Mindfulness activities in routine timetable:** Consistent practices such as yoga, meditation, guided imagery, a gratitude journal and mindful listening develop healthy habits that build resilience over time. NEP 2020 Link: It speaks about yoga, meditation and mindfulness as part of holistic learning.

VII. Teacher Well-Being and Mindfulness (Enhanced & More Productive Version)

Teacher well-being is not just a private concern; it is a professional imperative and a legal liability for schools. A teacher's mood largely determines the classroom climate, student/behaviour and academic achievement as well as a school/university as culture. The NEP 2020 makes it crystal clear that teachers need to work in an environment that is conducive for their psychological safety, less work stress and for professional growth through-out their career. From a legal perspective the principle of Duty of Care and the notion that there is such a thing as a Safe Workplace means that schools need to protect teachers not only from being physically hurt, but also from becoming mentally drained, burnt out and threatened in terms of their mental health.

- **The well-being of teachers has a direct effect on student learning and classroom climate:** Studies in educational psychology show that stressed-out or emotionally drained teachers unintentionally impart tension to the classroom, diminishing the pupils' focus, motivation and emotional safety. Calm teachers create calm learners.
- **Mindfulness shields teachers from burnout and chronic stress:** Practicing mindfulness focusing on the breath, body scans or grounding techniques interrupts stress cycles. They decrease cortisol, lower emotional exhaustion and increase emotional clarity. This prevents teachers from experiencing burnout, which is really common in today's education world.
- **Mindfulness cultivates emotional intelligence and self-mastery:** When teachers are mindful, they excel at:
    - Pausing before reacting,
    - Managing difficult classroom situations,
    - Understanding student behaviour deeply,
    - Reducing conflict and maintaining patience.

  This leads to stronger relationships between the teacher and student. This results in stronger teacher–student relationships.
- **Teacher wellness improves student outcomes**

  Healthy teachers:

  • communicate better,
  • show more empathy,
  • create psychologically safe classrooms,
  • offer consistent support.

  Students of such teachers have higher academic achievement, better behaviour, and stronger emotional stability.
- **NEP 2020 emphasises teacher wellness as a national priority**

  NEP 2020 calls for:

  • Reducing excessive administrative workload,
  • Providing mental health training,
  • Creating stress-free workplaces,
  • Offering counselling and emotional support for teachers.

It acknowledges teacher well-being as the heart of whole education.

- **Teacher mental health rights are a part of the legal framework**

  Teacher well-being is protected by:

  • Right to Safe Working conditions (under labour and workplace norms),
  • Right to Health and Dignity,
  • Institutional Duty of Care,
  • Workplace sexual harassment as strictly forbidden, zero-tolerance policies.

- **Schools have a duty to provide safe emotional environments.**

Embedding mindfulness into teacher preparation and development opportunities

B.Ed., M.Ed., D.El. Ed., and in-service modules must contain information on:

• Stress Management,
• Mindfulness-Based Teaching,
• Self-Care Practices,
• Reflective And Trauma-Informed Teaching.

This strengthens teachers' emotional and professional competence.

- **Professional development for mindful and compassionate teaching**

Schools, colleges, and universities must organise regular workshops on:

• Mindful Communication,
• Mindful Leadership,
• Work-Life Balance,
• Gratitude Practices,
• meditation and yoga for educators.

Such programs build a culture of emotional maturity and institutional well-being.

- **Creating a supportive workplace culture for teachers**

Institutions must develop a culture that encourages:

• Collaboration Over Competition,
• Emotional Openness,
• Peer Support,
• Recognition of Teachers' Efforts,
• Flexible and Humane Administrative Practices.

Such environments improve both teacher retention and job satisfaction.

- **Mindfulness improves teacher creativity, pedagogy, and decision-making**

Teachers who practise mindfulness become more:

• Creative in Teaching,
• Reflective About Instruction,
• Thoughtful in Decision-Making,
• Open to Student Diversity and Challenges.

Mindfulness enhances pedagogical innovation.

- **Supporting teachers is supporting the entire education system**

  When teachers experience wellness, they teach better, manage better, communicate better, and inspire better. Teacher well-being is the backbone of quality education, and mindfulness acts as a powerful tool to safeguard their mental health.

VIII. Impact of Mindfulness on Academic Achievement

Our students are drenched in academia, digital distractions, social anxiety and performance-based expectations. These stressors have an impact on their ability to concentrate, motivation, memory and overall learning. Mindfulness practices provide a profound, scientific solution that hardens emotional health and heightens academic achievements. NEP 2020 emphasises creating "stress-free and joyful learning environments," while legal principles such as the **Right to Quality Education** and the **Best Interest of the Child** require institutions to adopt practices that support students' emotional and cognitive development. Mindfulness meets these expectations by building the capacity of the mind to remain calm, present and resilient.

- **Mindful Performance Leads to Better Focus and Concentration:** Mindfulness teaches students to stay in the present and decreases mind wandering.

  Practices such as mindfulness breathing and meditation increase focus duration, allowing learners to be more effective in taking in materials, resisting diversions, providing for greater classroom engagement. Research: Research consistently demonstrates enhanced attention after weeks of regular mindfulness practice.

- **Enhances Working Memory and Memory Retention:** It is critical to the solving of problems, comprehending topics and concepts, for reading comprehension and memorizing information in an exam. Mindfulness develops pathways in the brain that affect memory so a student can effectively remember and retrieve information.

- **Heightens Cognitive Flexibility and Critical Thinking:** Mindful students can transition between activities seamlessly, think differently and respond to new learning environments. This flexibility leads to

better problem-solving and deeper understanding of concepts in mathematics, science, and languages.

- **Decreases anxiety and stress related to tests and academics:** Breathing and relaxation While students can be on emotional overload, breathing mindfully and guided relaxation can help to quiet the nervous system which in turn helps students deal with exam fear. As a result, they perform closer to their true potential without being held back by anxiety.
- **Strengthens Emotional Regulation and Self-Control:** Students who practice mindfulness respond thoughtfully instead of reacting impulsively. They do not panic when faced with a challenging academic task, have lower levels of frustration, and do not slip into a downward spiral of negative emotion (boredom, anger, discouragement) that negatively impacts academic work (Schunk, 2001).
- **Classroom Behaviours and Social Cohesion Improvement:** Mindfulness decreases aggressive, hyperactive and destructive behaviours.

  A peaceful atmosphere that facilitates learning is possible as students turn out to be more patient, more interested in cooperation and mutual respect. So improved behaviour = less distractions = more time to teach. **Enhances Peer Relationships and Social–Emotional Skills**

  Mindfulness nurtures empathy, kindness, and mindful listening. Improved peer relations reduce conflicts and bullying, making classrooms emotionally safe and academically productive.
- **Strengthens Motivation, Decision-Making, and Study Habits:** Mindfulness increases self-awareness, helping students understand their strengths, weaknesses, and learning patterns. This leads to better decisions regarding study strategies, time management, and prioritising tasks—directly boosting academic achievement.
- **Evidence-Based Mindfulness Practices That Support Learning:** Mindfulness activities that benefit academic performance include:

  • Meditation,
  • Mindful Breathing,
  • Mindful Walking or Yoga,
  • Guided Imagery,
  • Gratitude Journaling,
  • Mindful Listening.

  These practices build mental clarity, emotional stability, and cognitive efficiency.
- **NEP 2020 and Mindfulness to Law in Academic Development:** NEP 2020 has proposed the inclusion of mindfulness, yoga, and socio-emotional learning in school systems as a part of daily activities for holistic development and stress-free education.

  Legal framings, such as Right to Quality Education, Duty of Care, and Safe Learning Environment also add strength to mindfulness being offered for the welfare of students' minds.

IX. Barriers and Challenges

At all levels of education — schools, colleges, and universities — we are struggling with how to integrate mental health and mindfulness programmes. NEP 2020, while calling for a focus on holistic well-being and socio-emotional learning, faces systemic, cultural, and institutional hindrances to meaningful implementation. Legal principles such as the Right to Mental Well-Being, Right to Non-Discrimination and the Duty of Care compel action on these challenges, and yet there are still gaps in response.

- **Mental Health Stigma and Culture Gap:** Unfortunately, in most of India Mental health is still treated as a taboo, denial and misconception. Many students, and even families, do not reach out for help due to fear of being identified as "weak," or "problematic." That stigma inhibits early intervention and stifles conversations about emotional health. Legal link: Breach of the basic Right to Dignity, and the Right to Non-Discrimination.
- **Absence of Specialists in Counselling and Mental Health:** Many schools lack trained guidance counsellors, psychologists, or wellness professionals. Staff are already overstretched and lack specific training for mental health assistance. It leaves these students with emotional needs unrecognised and acting like it will all just go away.

  NEP 2020: Every institution must have counsellor, but its implementation is slow
- **Challenging Curriculum and Little Time for Wellness Activities:** Academic syllabus still heavy, exam-oriented, and time-bound.

  Both schools and colleges find it hard to find time for mindfulness, SEL, or counselling sessions. Because of this, wellness programs are put in the back seat or branded as 'extra and not important around here. Legal Principle: This violates the promise of Right to Education without stress given under NEP 2020
- **Teacher Resistance (Unaware/Untrained):** Mindfulness may seem irrelevant, extra work, or take too much time to be worth it for some teachers. Some

might find they lack the confidence or ability to facilitate mindfulness practices and activities.

This lack of training may lead to teachers not being able to help meet a student's emotional needs.

NEP 2020: Focuses on training teachers in socio-emotional wellbeing, training gap still exists

- **Scoring System in Schools and Mental Health:** The emphasis on grades and test scores at many institutions then is: n(n)

  Because the result of mental healthcare is by no means an immediate academic output, mental health programs are truncated. In this way, it creates environments where mental health is neglected.

- **Insufficient funding and infrastructure for mental health programs:** There is a cost associated with the establishment of wellness centres, the hiring of even a single counsellor, or provision of training. Oddly enough, with a lot of schools/college not having the adequate source to it. particularly in the location or authority sector Law-linked: Your institutions aren't meeting the Duty of Care because they're underinvested in.

- **Unaware of Home and School Coordination:** Many parents might not appreciate the value of mental health practices or mindful living.

  School-focused initiatives fail without buy-in from parents. Emotional development is additionally rendered fragile by inconsistent home lives.

- **No Transparency for Rules and Enforcing Accountability:** Even when mental health programs are available, there is little or no systematic monitoring.

  Unspecified frequency of mindfulness practice, or who should lead it. Without accountability, implementation becomes inconsistent. And this is how you can write a simple clear and best conclusion for your paper.

X. CONCLUSION

Mental health, mindfulness, and well-being is no longer icing on the education cake—the ingredients to a healthy, balanced, and thriving educational system. In a scenario where academic pressure, digital overexposure, emotional angst and social anxiety are on the rise, schools and universities need to step out of the conventional box and focus on emotional and psychological wellness. Mindfulness techniques including breathing, meditations, and being cognizant helps your students to remain calm, clear-headed, and balanced. They also aid in concentration, memory, resilience, and general behaviour — all crucial components of academic performance. Then there are the broader mental health support systems—counselling, life-skills programs, safe school policies and awareness among teachers—that help create an environment where students feel valued, safe and understood. Hence, NEP 2020 fully backs these concepts in a manner that seems tailor-made — holistic development, socio-emotional learning, yoga, and meditation, anti-bullying and teacher wellness, to name a few. Additionally, the Right to Safe and Dignified Education and the Duty of Care legal principles command that institutions are to be held responsible for safeguarding students' mental well-being. Although this sounds beneficial, stigma, lack of trained staff, funding, and lack of awareness replenish gaps in services. These barriers can be overcome with training, policy changes, parental dedication, and institutional commitment. In conclusion, if mental health care, mindfulness, and well-being are woven into education, it leads to empathetic, relaxed, and happy learning environments. It equips students to excel academically, flourish emotionally, form positive relationships and use their education to lead a balanced, purposeful and satisfying life. It is this kind of education that truly represents the ideals of holistic development and lifelong wellness

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GKU Journal of Multidisciplinary Research (GKUJMR)

An Analysis of Cooperative learning methods in Education with Gender-Based Achievement

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Abstract – The present study aims to investigate Cooperative Learning methods in boys and Girls at the secondary level. The yearly Exam Results will be used to divide the sample of Students into equal groups. The division will ensure that both groups are Comparable in terms of academic performance before the implementation of different teaching methods. The former method was applied for first group and the latter for second group. Nevertheless, it is important to recognize the limitations of this study (e.g., regional focus, self-reported measures). There are also opportunities for future research to extend beyond the discussion of these relationships at work and across different contexts, using mixed-method designs to provide a more complete assessment of them.

KEYWORDS: Cooperative Learning Methods, Gender-Based Achievement, Secondary School Students

I. INTRODUCTION:

Cooperative learning Strategies: Studying K-12 cooperative learning strategies in which students work together to meet mutual goals and hold each other accountable yields large effect sizes (Ellis, 2001b; Rohrbeck et al., 2003; Slavin, 1995a) span across all types of schools from second through twelfth grades (Slavin, Hurley, & Chamberlain, 2003). Furthermore, well-planned methods are more effective in terms of technological group teaching as well (Lou, Abrami & d'Apollonia, 2001). These findings apply to all the subjects and grade levels, from rote memorization to higher-level analytical thinking (Qin et al., 1995). Cooperative learning approaches are generally employed for shorter segments of the school year (Antil, Jenkins, Wayne and Vadasy, 1998), but one study found students in schools that used cooperative learning techniques across almost all subjects in each part of the day over a 2-year period outperformed those in more traditionally structured schools (Stevens & Slavin, 1995b). Children performing low in special education and high-achieving children benefitted most from these changes compared to children with similar performance levels in the control condition. Collaborative group learning effects both male and female students in the same way it affects high performers and the average student (Slavin, 1995a). Boykin (1994), Calderón et al. (1998), Hurley's (2000), and Slavin, Hurley, and Chamberlain's (2003) results indicate that these strategies were also more effective for Latino and African American students. Younger, city dwelling, low-income and minority students benefited the most from PBL, as found in a study by Rohrbeck et al. (2003). In accordance with Chapman (2001), Klein and Schnackenberg (2000), Slavin (1995) and Slavin et al. (2003) that less structured forms of cooperative learning, without the use of group goals and individual accountability, rarely enhance student achievement.

Students are involved in many instructional strategies within "cooperative learning" as they work on a common project in heterogeneous, small groups. Jigsaw technique, Think-Pair-Share, Group Investigation, Team-Games-Tournament (TGT), Student Team Achievement Divisions (STAD) etc are some of the strategies. Through these techniques, students actively engage in the process of support and cooperation and are empowered to take responsibility for their behavior. For example, Jigsaw – each student is allocated a specific part of the topic to learn and teach back to the group so, together, everyone fills in their knowledge gaps. But STAD promotes mutual dependence and motivation in ability groups of varying expertise; achievement is credited to the student's own progress.

II. GENDER-BASED ACHIEVEMENT

Refers to the sex-gap in achievement (i.e. how males and females achieve) - often used to describe differences such as boys doing better in exams than girls in SES and science, whilst girls overall out-perform boys at school. These disparities may be due to a variety of causes including non-cognitive skills, teacher and peer responses as well as societal expectations that have traditionally encouraged men to engage in public life or some academic programmes.

III. NEED OF THE STUDY

In the development and comparison of cooperative learning methods, studies with a gender-based achievement analysis for educational approaches and for the fight against exclusion within classrooms would become important. The findings in this study will contribute to our understanding of how cooperative learning activities might be adapted for the processing needs of students consistent with their gender. With increased focus on student skills for collaboration in educational systems, knowledge of gender-influenced responses will enable teachers to create

healthier, more equality classrooms. In the future, the findings of this study will aid curriculum developers, teachers, and policymakers in identifying the most effective cooperative learning models that will support both male and female learners. It will also highlight any existing achievement disparities and suggest ways to reduce them, contributing to a more just and performance-driven education system. In addition, this research will promote the use of pedagogical strategies that train students in the development of communication, teamwork and peer support skills necessary for their professional conduct a social life. Through an investigation of gender-biased achievement, the research will highlight the need for inclusive pedagogical approaches and create opportunities for additional research within educational equity. Overall, it will serve as a guiding framework for future educational innovation and gender-responsive pedagogy.

IV. Literature Review

Bahrun, Bahrun et al., (2022) It is well-documented that female students experience differing learning outcomes at secondary and tertiary institutions. This research delves into the ideas of exceptional students from several Aceh Province institutions from the view point of a gender model approach to academic success. To find out how 400 outstanding participants felt about their own learning development, we analyzed interview data. To conclude our research, we used a gender approach model to causally interpret interview evidence and literature reviews to determine which factors are most decisive for female student achievement. These factors include behavior, interests, motivation, personalization, consistency, and external support, all of which are non-cognitive aspects of education that contribute to gender differences in educational outcomes. This discovery demonstrates how gender-based policies may help eliminate the gender gap, and also highlights the need of giving policy solutions careful consideration. The study's findings should contribute significantly to academic discourse, policy-making, and future research on how to boost female students' performance in higher education. Women will be able to use the successes as an example to become more effective social workers.

García-Taibo, Olalla et al., (2021) In order to provide a welcoming, equal, and varied learning environment, coeducation is crucial in university settings. Consequently, cooperative learning has the potential to greatly contribute to the advancement of coeducation by encouraging students of both sexes to work together, communicate effectively, and get a deeper knowledge of one another. Therefore, this research set out to determine if and how cooperative learning influenced students' levels of gender equality and their ability to work together effectively. The research used a quantitative pre- and post-test design using an experimental approach. Sixty kids in the second grade of Sport Sciences were divided into two groups: the control group and the experimental group. The students' ages ranged from 19.97 to 1.21 years, and there were 30 males and 30 females in the study. Both sets of participants were given the CEIG and the ACOES surveys to fill out before and after the intervention, respectively, to assess their level of competence in gender equality education. The experimental group took part in seven volleyball classes taught using a technique based on cooperative learning, with a focus on the Jigsaw method—which guaranteed that teams would be composed of players of both sexes. Verifying the intervention's intergroup impact was done using a Mann-Whitney U test. Two of the three CEIG dimensions and five of the seven ACOES dimensions showed statistically significant improvements for the experimental group. Using the Jigsaw approach and mixed- gender teams to teach group sports like volleyball in a cooperative setting greatly helps advance gender parity in the classroom and improves students' abilities to work together as a team.

Prieto Saborit, Jose et al., (2021) Sustainable development goals often include education and gender equality at the top, but several studies have shown that these targets are still very far off. The purpose of this essay was to look at the gender gap in maths and the effects of cooperative learning on students' grades. A total of 14,122 students, ranging in age from ten to nineteen, were a part of the study. It was hypothesized that classes with a greater degree of cooperative learning implementation would see a substantial reduction in the gender inequalities reported in math. Gender has a beneficial effect on math outcomes (estimated beta = 0.12, $p < 0.01$) and interacts negatively (−0.26) with cooperative learning, according to the findings of the regression of means and gradients analysis, which also has a critical value less than 0.05. To rephrase, the correlation between group projects and improved math scores is far stronger for boys than girls. Nonetheless, there is some equality since women do better academically. These findings demonstrate that gender disparities in math learning may be mitigated by cooperative learning.

Rudmann, Ocyna et al., (2021) the capacity to quickly adjust to new situations is crucial for young people in today's ever-changing and uncertain work environment. Because of this flexibility, it is essential that students learn important social abilities in the classroom, such as how to work together effectively

and solve problems. There is a persistent gender discrepancy in this domain, with females displaying more social abilities than boys. The Profane project was a large-scale longitudinal study that included many labs around France and involved over 10,000 students from vocational high schools. The students' social competences and other psychological/psychosocial characteristics at vocational high schools were to be the main target for designing and evaluating the intervention. A jigsaw classroom, a form of cooperative learning that focuses on positive goal and resource interdependence, was one of three conditions examined in this two-year, three-wave field experiment. Cooperation with and without resource independence, as well as business as usual were the other two. By contrasting the three approaches to education, this study examines how girls' and boys' perceptions of their own social competencies change throughout the course of their teenage years. Longitudinal multilevel modeling results confirm and demonstrate an expanding gender disparity in perceived social competencies. The jigsaw condition showed that girls' and boys' views of social competencies evolved similarly over time, while the two control circumstances how edafar wider gender disparity, according to the analysis. This section discusses the contributions to our knowledge of how social competencies are developed and taught in educational contexts.

Mahenge, Anagrolia et al., (2021) Examining how a cooperative learning strategy affects gender equality and academic performance in elementary school children is the goal of this research. Three hundred eleven- and twelve-year-old sixth graders took part in the study. Both sexes did well on the examinations, and the results demonstrated that there was less of a gender gap in English classes when students worked together. According to the research, gender-neutral classrooms may benefit from a cooperative learning method that raises performance regardless of students' biological gender.

Puiggali, Joan et al., (2021) this paper takes a quantitative and qualitative look at how gender-neutral groups of future educators in both mixed-and homogeneous cooperative learning environments value personal accountability, constructive dialogue, and mutual support. During the 2022–2023 school year, the research was conducted. Five hundred thirty-five undergraduates enrolled in the Elementary, Secondary, and Kindergarten Education programs at the University of Gerona's Faculty of Education and Psychology (FEP) were the subjects of this research. The research used the CAC instrument, which consisted of 20 items, coupled with an additional 11 items. The results showed that when individuals were in groups with similar characteristics, they performed better across the board in terms of cooperative learning. In all forms of cooperative structure, female students out performed male and non-binary students across the board when it came to cooperative learning. Female students placed a larger importance on individual responsibility in both contexts, while non-binary people placed the lowest value on it. When collaborating with peers from different backgrounds, male students placed a greater emphasis on personal accountability. When asked about their responsibilities in completing cooperative tasks, the majority of students said they remained the same. Having said that, women made up the bulk of those who felt their role changed. The research reveals that pre- service teachers of various gender identities and expressions are just as gregarious as one another, but that their social skill development is distinct. Therefore, diversity in educational institutions should be considered as a factor that affects the growth and success of college students in the future.

Slit, Edgar. (2021) in recent years, cooperative learning has become more popular as a method of enhancing student success in the classroom. By combining information from many published studies that fulfilled our inclusion criteria, we looked at how cooperative learning affected students' academic performance in our meta-analysis. Results from the 35 research that were considered indicated that cooperative learning significantly improved students' academic performance. Cooperative learning is a powerful tool for raising students' academic performance, as shown by the modest impact size. Incorporating cooperative learning into instructional methods is suggested by educators, according to this study's results, which have significant consequences for theory, practice, and policy. The inclusion of papers with varying degrees of quality and the potential for publication bias are two of the limitations of this meta-analysis that must be considered. To overcome these constraints and investigate the possible advantages of cooperative learning in various settings and with diverse populations, further study is required.

Gillies, Robyn. (2016) From elementary school all the way up to college and beyond, and in a broad variety of subjects, cooperative learning has long been acknowledged as an effective method of instruction. In it, students collaborate in groups to accomplish objectives or finish assignments that they couldn't do on their own. Through a survey of current literature and practical application, this study seeks to identify the factors that enhance cooperative learning. The review

zeroes emphasis on the factors that make it work, as well as the function that instructors play in helping students think and learn better when they utilize this strategy in the classroom.

V. Research Methodology

Anything that will be performed, whether broad or narrow in scope, will be considered part of the research methodology. The research process will include several key steps: identifying the problem, reviewing relevant literature, developing and testing hypotheses, selecting an appropriate study methodology, analyzing the collected data, interpreting the results, and drawing conclusions. Each of these steps will be rigorously pursued to ensure that the research is comprehensive, precise and significant.

First, the sample of students is split according to their yearly exam results in two equal subsamples. This stratification will ensure comparability of both treatment and control groups with respect to educational performance before the intervention of teaching methods starts.

- Traditional Method -First Group
- Experimental Method-Second Group

Ninth-grade students of Haryana State will be enrolled in the study by researcher. Thus, students studying in the ninth grades at secondary schools from the academic year (2021–22) are considered as study population.

Class A will be designated as the Control Group based on the percentage of total marks from the previous year's exam, while Class B will be identified as the Experimental Group. Out of a total of eighty students, forty will be selected for each group.

VI. Limitations of the Study

The study will have certain limitations that may affect the generalize ability and scope of its findings. A main limitation will be the reliance on a single educational context (e.g., region, type of school, and degree level). This implies that our findings may not generalize to all student populations. Further research will be necessary to verify the findings in richer and more varied learning situations. Another limitation will be the inconsistency with which cooperative learning techniques are implemented across teachers. Even though there are uniform recommendations, different teaching methods, organization skills of the class and students atmosphere will determine how these strategies could benefit. Furthermore, the academics will be the main measure in our research, since it is possible that they are not complete and do not include creativity, critical thinking and emotional intelligence. Gender analysis itself will also be difficult, as data is likely to primarily take the form of binary gender classification and may overlook experiences of non-binary or gender-diverse students. In addition, short-term measures would impose another limitation because the long-term effect of cooperative learning will not be completely reflected in this academic year. To get informed on these restrictions will recommend the opportunity of further and more developed research work.

VII. Results and Discussions

As seen in the effectiveness of these approaches, cooperative learning strategies are often effective when compared to traditional lecture methods. Cooperative learning When working in cooperative versus competitive environments, students are found to achieve significantly higher scores on achievement tests, retain information longer after the tasks have been completed, demonstrate better problem-solving strategies (Eggen & Kauchak, 2004), and exhibit more positive attitudes towards in class cooperation. Positive Interdependence the fundamental elements of positive interdependence imply that students recognize that “one person’s effort helps another, and one student’s success is related to the other students’ successes.

Such social interaction not only has positive effects on cognitive results, but also for social and emotional development. Yet as cooperative learning models become more popular, there is increased interest in their effects on various student populations such as girls' achievement. Some research work has also focused on examining why boys and girls seem to, or do not, benefit the same from cooperative group learning and how gender-typing differences in communication patterns, motivation and cognitive styles influence nurtured learning. The results are somewhat inconsistent; although cooperative learning is generally effective, it has different effects for reasons of the gendered structure of a group or classroom. There is some evidence to suggest that girls frequently out per form boys in cooperative learning settings, particularly for language arts and social science subjects. This tendency for girls to be more communicative, accommodating and empathetic is vital in effective group work. These social skills may also set them apart from other individuals when participating in collaborative activities, which often comprise listening to others’ ideas, supporting peers and negotiating ideas. Moreover, girls may demonstrate greater commitment to collective responsibility and peer support, which is reflected in higher group cohesion and academic outcomes.

In contrast, young men may prefer heads up or do-it-yourself learning where their performance is assessed as an individual, not a team member. This predilection sometimes results in being withdrawal or domination in group environments. Some research suggests that boys may tend to either withdraw or dominate group interactions and, if they do so in group discussions which could disrupt this balance. They are therefore academically underachieving, children and their academic standard in group situations does not take into account of their potential. When it is organised appropriately, co-operative learning still provides a gateway for boys to develop friendships, empathy and respect, as well as the desire to work with others. In order to deal with these gender inequalities teachers, need to be aware of the composition and dynamics of groups. Formal mechanisms in the form of gender-matched groups, rotating leadership and clear guidelines for participation can help ensure equal contribution from all. Teachers should also learn how to identify and address behaviors associated with gender that inhibit group effectiveness. For example, scaffolding quiet students, be they boy or girl and facilitating louder voices can enhance the learning environment by ensuring all students feel respected and heard.

VIII. CONCLUSION

From the result of the studies that have been reviewed, where boys have traditionally outperformed girls in many regions, cooperative learning methods have been shown to narrow the achievement gap. Group-based problem-solving and peer tutoring noble students to explain concepts in simpler terms, thereby enhancing understanding for all members. Girls, in particular, benefit from the supportive environment of cooperative learning, which may reduce anxiety and boost confidence in STEM subjects. This collaborative approach can play a significant role in encouraging more female students to pursue higher education and careers in science and technology fields.

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Integral Role of Mathematics in Advancing Sustainable Development

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Abstract – Despite numerous studies on sustainable development and education, many remain general and declarative. Integrating sustainable development into educational curricula poses challenges for educators due to its complexity. This paper adopts a multidimensional approach, considering social, psychological, and educational aspects, to explore the role of mathematics in attaining sustainable development goals. It highlights mathematics' practical applications across various sectors such as economy, industry, and social spheres. Moreover, the research underscores mathematics' humanitarian potential, serving ideological, moral, educational, and aesthetic purposes. Through mathematics education, individuals not only contribute to global culture but also foster a sense of community. Ultimately, the goal of teaching mathematics in the context of sustainable development is to cultivate students' mathematical literacy and cultural awareness

Keywords – Mathematics education, sustainable development, cultural awareness

I. INTRODUCTION

Sustainability is the quality of being able to keep something going over time. Sustainable development serves as an all-encompassing framework for realising human development, while ensuring that natural systems remain capable of meeting human needs. Education for Sustainable ESD is needed throughout all levels of formal education as well as training and also in non-formal and informal learning environments for a sustainable society. Introducing ESD means a significant change in current education practices. It requires active teaching methods that inspire and empower learners to change their behaviour and advocate for sustainable development. ESD thus equips young people with essential skills including the ability to think critically, look ahead and make decisions collectively.

In addition, it also includes integrating key sustainable development issues into the educational curriculum such as climate change, disaster risk reduction, biodiversity, poverty reduction and sustainable consumption. Through Education for Sustainable Development, some might gain the requisite knowledge, skills, attitudes, and values to develop what kind of future is sustainable. [1]

II. IMPORTANCE OF MATHEMATICS

Mathematics is an essential discipline that significantly influences several facets of life and academic fields. Its significance may be comprehended from several viewpoints, including practical applications, cognitive advancement, and basic information for other disciplines. The literal definition of mathematics is "that which can be counted." Counting significantly influences our everyday lives. Envision a scenario devoid of Mathematics; how would we quantify family members? The quantity of kids in the school, the count of players in cricket, the days in a week, month, or year. One must possess the ability to do fundamental arithmetic operations, including addition, subtraction, and division. Mathematical comprehension fosters critical thinking and enhances the synthesis of concepts and ideas at a psychological level. The significance of mathematics for the general populace is evident beyond complex mathematical ideas. An average individual is significantly dependent on science and technology for daily activities, and the function of mathematics has been predetermined.

Mathematics permeates our environment, manifesting in many ways. From the onset of morning, one must respond to alarm notifications, check the time, mark dates on a calendar, answer phone calls, arrange recipes in the kitchen, await the signals of a pressure cooker, and handle finances, such as exchanging currency while using public transport—an unceasing array of tasks. Identifying instances when we use mathematics in our environment.

III. MATHEMATICS TO MAKE SCIENCE AND TECH HAPPEN

The M in STEM stands for mathematics a subject which is vital to the progress of science and technology. Mathematics is everywhere, as you might have heard, and while a basic knowledge of mathematics is a must for every field, there are a few fields where mathematical acumen is necessary. More students need to be led into educational directions that prepare them for work as mathematicians, engineers, and scientists. Mathematics is essential for many fields which are driving the future and the current people that would do well need to possess a modern science-technology-math background (Ellenberg, 2014). Mathematics is the ticket to a desirable and meaningful future; the opposite is true for math deficiency.

Nevertheless, a common misunderstanding about math as a subject, is that it is for the elite few. However, math ought to be for everybody. All students should be provided with the opportunity and the educational environment to explore

mathematics in depth and understand it. The pursuit of equality in education should not clash with the pursuit of excellence. Even educational doctrine dictates a curriculum that covers a wide variety of math topics. However, that does not mean all students are the same. Individual students must be allowed to shine, to shine with their own talents, abilities, accomplishments, and interests in maths. Here are some examples of how Mathematics relates to real life (Su, 2020):

3.1 Practical Applications

Everyday Life: Through Mathematics in day-to-day life, such as calculating and maintaining a budget, cooking ingredients, shopping, and time management. It helps people to makes the best decisions and to solve the real life issues.

Technology and Engineering – Mathematics is the foundation of engineering and technology. This is a pre-requisite to plan structures, develop software, create new technologies.

Medicine and Biology: Mathematics is employed in medical research and medical practice — in imaging technologies and modeling the spread of diseases — as well as uniqueness of biology and nature.

3.2 Cognitive Development

Analytical approach: Mathematics is an important subject to develop analytical and problem-solving approach. It needs logical sense and systematic steps of operation of huge issues.

Abstract thought: it improves the abstract thought process by requiring an understanding of ideas that are not physically experiences. It has a wider footing that holds importance in other frontiers apart from mathematics.

Analytical skills: Mathematics study assists in developing analytical skills as individuals learn to break down complex information and recognize patterns and structures buried underneath.

3.3 Foundation for Other Disciplines

Mathematics is the language of science, including science and physics. It is crucial for the understanding and the explanation of scientific phenomena. Mathematical principles are used everywhere like in physics, chemistry, etc.

Economics and finance: Mathematics is used in economics and finance to model economic theories, to analyze data, and to make financial predictions.

Computer Science: all algorithms, data structures, and software development (yes, all of that) is behind math.

3.4 Cultural and Historical Significance

One of the oldest sciences: Mathematics is one of the oldest sciences, with contributions from many cultures throughout history. Its development exemplifies human history and evolution of thought.

Language of the Universe: Mathematics is considered a universal language. It enables collaboration and communication between multiple disciplines and countries.

3.5 Personal Development and Confidence

Confidence Enhancer: Gaining mastery over mathematical concepts is bound to instil confidence and leaves you feeling accomplished. It encourages persistence and resilience.

Deductive thought process: Mathematics has a very systematic structure that allow people to make successful reasoning decisions based on logic in their normal life and their professional life.

No kid needs to be denied access to high-quality math education programs. Those with a natural bent for a career in mathematics and science need to be allowed to cultivate their capabilities and interests. All students, with diverse educational needs, should be offered the guidance and encouragement to build an informed understanding of mathematics. Ensuring justice is impossible in a society without people with basic mathematical skills needed to perform economic, political and scientific tasks.

IV. ROLE OF MATHEMATICS EDUCATION IN SUSTAINABLE DEVELOPMENT

Development encompasses a series of endeavors undertaken by individual societies with the objective of alleviating perceived obstacles to a better standard of living, ultimately enhancing the quality of life for their inhabitants. Genuine development is envisioned to be both objective and enduring, ensuring sustained benefits for society over time. In the absence of sustainability, self-proclaimed development becomes deceptive and consequential. Sustainable development, on the other hand, refers to a form of development that satisfies the needs of the current generation without compromising the ability of future generations to fulfill their own needs. This places Math at the center of the story of how a nation develops, writes Journal. Abstract Mathematics is at the heart of sustainable development by offering tools and methodologies needed for tackling complicated environment-society-economy problems. Below are some examples of how mathematics is involved in sustainable development:

- **Modelling and Simulation:** The ability to build models and simulations to be able predict and assess what is happening in the environment is another thing we get from Mathematics. Mathematical models enable them to study global climate change, the weather, and the outbreak of diseases, for example. All these types

of models have one thing in common: they can be used to model the effects of different variables on ecosystems and plan style patterns.

- **Optimization:** Mathematical techniques of optimization are used for optimal utilization of resources. It is involved in optimizing energy usage, minimizing waste, and enhancing transportation system efficiency. Mathematical Optimization for Sustainable Industrial Processes Mathematically optimized industrial processes can aid industries and governments in establishing processes that produce the highest output with the least environmental impact.
- **Data analysis and statistics:** Sustainable growth is all about data-driven decisions. Mathematics, by means of statistical analysis and data mining, aids in creating meaning from large datasets through trends, correlations, and causations. Which is crucial for biodiversity monitoring, resource management, and sustainability evaluation.
- Mathematical tools are used to assess and manage risks arising from environmental hazards, financial crises, and social issues. Tools of probability and stochastic processes have also assisted in predicting, and managing disasters, be it the natural kind as well as the economic kind.
- **Resource Management:** Mathematics helps in managing the natural resources by developing models for sustainable harvesting, conservation and allocation etc. It utilizes game-theoretic and operations research techniques to mediate disputes about resource allocation and divide the resource equitably.
- **Renewable Energy**: Renewable energy sources are being studied, and developed a lot mathematically. Mathematics is similarly applied in the design and functioning of wind turbines, solar panels and other renewable energy technology to improve efficiency and effectiveness.
- **Cities & Communities:** Mathematical modeling aids in design of sustainable cities & communities. Urban planners employ mathematical instruments to improve land use, transportation design, waste management, and accessibility of basic services. This paper contributes to the production of habitable, resilient, and sustainable cities.
- **Economic Modelling:** Mathematics is fundamental in developing economic models that incorporate sustainability. Such models are useful to assist in the assessment of relationships between economic activities and environmental impacts, so as to help formulate policies for sustainable economic growth and development.
- **Environmental monitoring:** Mathematical methods are applied to monitor and process environmental data including pollution levels, deforestation rates, and water quality. These analyses have told us what we need to do in order to reverse these trends and start conserving our planet.
- **One contributes to educate and raise awareness:** Education in mathematics cultivates skills in reasoning and problem-solving, necessary to comprehend and deal with sustainability issues. Preparing the next generation with mathematical skills guarantees a future workforce that can address sustainability challenges. The role of mathematics in sustainable development is not limited but significant as it serves as the underpinning analytical framework needed to address complex systems, optimize processes, and make decisions that weigh environmental, economic, and social dimensions.

V. CONCEPT OF MATHEMATICAL COMPETENCES

Niss and Hojgaard (2011) define mathematical competencies in the sense of Danish Komb. Mathematical Thinking: This is knowing what math questions are and what it can and cannot tell you the status of. It also includes the ability to ask such questions, to know mathematical ideas and their limits, to broaden these limits via abstraction and generalization, and to understand the certainty that accompanies mathematical considerations. Employing Mathematical Reasoning: This entails the capacity to comprehend and evaluate existing mathematical arguments and proofs, recognizing key ideas within proofs, distinguishing between various types of mathematical statements, constructing chains of logical reasoning, and translating heuristic reasoning into personal proofs.

- **Problem posing and problem solving:** This includes locating and scoping mathematical problems, solve them if an algorithm is computable, and addressing situational problems based on self-determined criteria on what constitutes a problematic question.
- **Ability to develop and work with mathematical models:** This includes the understanding and application of pre-existing mathematical models as well as the creation of new mathematical models used to solve mathematical problems.
- **Representation Modeling mathematical objects:** knowing representations including ways of expressing them; connections between them; advantages and disadvantages of a representation; being able to choose the required subject; to switch from a base to another face.

- **Proficient with Mathematical Symbols and Formalism:** being able to read symbolic and formalist mathematical language and relate it to natural language, and translate from one to the other. It also includes a knowledge of the rules of formal mathematical systems and ability to work formally manipulating statements and expressions according to these rules.
- **Communication (of mathematics):** This encompasses the ability to understand mathematical utterances of others, plus the (spoken, written, or other) utterance of mathematics by oneself.
- **Using Mathematical Aids and Tools:** This involves understanding the mathematical aids and tools that are at your disposal and knowing when you can employ them to your advantage properly and effectively to help with mathematical work.

VI. MODES OF TRANSACTION FOR INSTRUCTING SUSTAINABILITY

6.1 As articulated by Vintere and Briede (2016)

- Problem-solving, critical thinking, action competence, and systems thinking (Jone et al., 2010)
- Imagination, critical thinking, introspection, a systematic approach to thinking, collaboration, cooperative learning, and involvement in decision-making (Ashlock and Herman, 1970; Stibbe, 2009)
- Proficiency in systems thinking to recognise the interrelations among many aspects and the intricacies of systems and circumstances (Renert Mosche, 2011; Tilbury and Wortman, 2004).

6.2 Cebrian and Junyent (2015) developed a theoretical framework for professional skills in Sustainable Development, including eight fundamental characteristics.

- **Envisioning Futures:** Investigating many types of futures and alternate scenarios, interrogating rigid notions of possibility, including both distant and proximate possibilities.
- **Contextualization:** Consider the many dimensions related to an issue or ourselves, both spatially (local/global) and chronologically (past/current/future).
- **Navigating complexity:** Recognising and integrating the ecological, economic, and social dimensions of issues, hence facilitating systems thinking in educational settings.
- **Establishing Criticality:** Deconstructing situations that facilitate and enhance critical thinking, enabling people to interrogate prejudices and see diverse viewpoints within these contexts.
- **Decision-Making, Participation, and Advocacy:** Advancing from awareness to action, promoting collective responsibility, and enabling cooperative initiatives to drive change.
- **Clarifying Values:** Facilitating the elucidation of values and reinforcing behaviours consistent with sustainable thinking, promoting mutual respect and comprehension of varied beliefs.
- **Fostering Interdisciplinary Dialogue:** Creating creative pedagogical methods that transcend academic borders and promote collaborative efforts across disciplines.
- **Emotion and Concern Management:** Promoting introspection of human emotions to enhance comprehension of issues and circumstances.

6.3 McKeown, Rosalyn (2002) delineated five facets of Education for Sustainable Development (ESD):

Sustainable development integrates environmental, economic, and societal dimensions. Consequently, individuals need fundamental knowledge in natural sciences, social sciences, and humanities to comprehend the principles of sustainable development, their application, the associated values, and the consequences of such execution. Knowledge derived from conventional fields underpins Sustainable Development.

Skills/actions: Achieving success in sustainable development requires transcending mere education on major global concerns. Education for Sustainable Development (ESD) must equip individuals with practical skills that facilitate lifelong learning, ensure sustainable livelihoods, and promote sustainable living practices. These talents will vary according on neighbourhood circumstances.

6.4 Values are a fundamental component of Education for Sustainable Development (ESD).

In some societies, values are explicitly imparted inside educational institutions. In some cultures, values may not be explicitly taught, but they are shown, elucidated, examined, or deliberated about. In both scenarios, comprehending values is crucial for grasping your worldview and the perspectives of others.

Perspective: ESD encompasses viewpoints that are crucial for comprehending both global and local challenges within a global framework. Each problem both a historical context and a prospective trajectory. Examining the origins of a problem and predicting potential outcomes based on various scenarios are key components of ESD, as is recognising the interconnectedness of several global crises. For instance, over use of consumer products like paper results in deforestation, which is believed to be associated with global climate change.

Concerns: ESD primarily addresses significant social, economic, and environmental challenges that jeopardise planetary sustainability. Numerous critical challenges were recognised during the Earth Summit in Rio de Janeiro and are articulated in Agenda 21. Comprehending and tackling these difficulties is essential to Education for Sustainable Development (ESD), and locally relevant matters must be included into every sustainability education program.

All aspects of Education for Sustainable Development are progressing significantly. Sustainable mathematics education entails the reorientation of mathematics instruction towards environmentally sensitive ideation and sustainable methodologies. This is a reform initiative that we cannot afford to overlook. Sustainable mathematics education involves seeing the world anew via revitalised mathematical concepts. It pertains not just to seeing vast quantities but also to comprehending the global context.

The subjects addressed in SD include resources, culture, tourism, social institutions, pollution, physical environment, adolescent pregnancy, child abuse, population growth and change, values and attitudes, and industrial activity. Subsequently, fifteen guidelines for developing mathematics curriculum resources that promote sustainable development include: real contexts, contemporary issues, complexity, value, data accessibility, human activity, contextual emphasis, interdisciplinary approaches, awareness of marginalization, fostering dialogue, courage, trust, accessibility, and technology utilization (UNESCO, 2014).

6.5 This correlation between mathematical abilities and competences in Education for Sustainable Development (ESD) (Vintere, 2017):

The literature review indicates that Education for Sustainable Development in mathematics is founded on a paradigm whereby mathematical thinking extends beyond only solving mathematical problems. Students engage in mathematical operations and may also participate in an ongoing learning process after formal education has concluded. This indicates that the learning process is enduring, since it is anticipated to facilitate the achievement of Sustainable Development Goals. This technique is anticipated to facilitate the development of student character. Education for Sustainable Development in mathematics aims to provide students with mathematical reasoning and an awareness of issues in their surroundings, particularly in social, economic, and environmental domains.

VII. CONCLUSION

Mathematics is fundamental to the economic and technical advancement of any country. Mathematics permeates every level of our educational system. This presentation emphasised the relevance of mathematics in achieving the vision for India. Mathematics is an essential prerequisite for the study of science and technology; it has significantly contributed to human advancement. Various high-quality mathematics equation programs foster confidence in an individual's capacity to make rational decisions based on intrinsic worth, as well as enhance logical reasoning and critical thinking skills. The mathematics for ESD involves ongoing education and alignment between mathematical learning applications and character values. When examining a mathematical issue, students should not only focus on finding a solution but also appreciate the fundamental qualities it embodies, so fostering their future personal growth.

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A Study on Various Character Segmentation Techniques on Handwritten Text Documents: A Review

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Abstract – Handwritten character segmentation remains one of the most challenging and essential phases in Optical Character Recognition (OCR) and handwritten document analysis. The complexity of unconstrained handwriting, varying writing styles, touching and overlapping characters, inconsistent spacing, and noise significantly affect accurate segmentation and recognition. Traditional segmentation approaches operate primarily on uncompressed images; however, recent studies demonstrate that performing segmentation directly on run-length encoded (RLE) compressed handwritten documents enhances computational efficiency and reduces memory usage. This paper presents a consolidated review and analysis of segmentation methodologies, ranging from explicit segmentation, implicit segmentation, projection-based analysis, connected component analysis, graph-based techniques, clustering approaches, and hybrid recognition-based methods. Furthermore, segmentation strategies for applications including postal address recognition, content-based image retrieval, number plate detection, and cursive word recognition are examined. Hybrid approaches based on min-cut graph, dynamic programming and HMM outperform purely classical dissection for cursive scripts as experimental results show. The work references future scope in the direction in a form of deep learning-based models and combined compressed-domain OCR systems as a solution to attain higher segmentation and recognition accuracy. In summary, our work presents a detailed overview of segmentation-related challenges, techniques, and trends in the field that can benefit both researchers and practitioners in achieving robust handwritten OCR performance.

Keywords – OCR, Handwritten Character Segmentation, Run-Length Compression, Word & Character Segmentation, Cursive Handwriting, Implicit Segmentation, HMM, Document Image Analysis.

I. INTRODUCTION

OCR, or Optical Character Recognition, is the process of converting scanned images of machine-printed or handwritten text into a form that can be processed by a computer. If you scan a document that has text in it, the concept of OCR software is used to convert the image into editable text. The scanner creates an image initially.

Starting from the page of the; the digital representation of the image is saved in memory of the computer as a bitmap. Bitmap — a grid of dots, and each dot is represented as 1, 2, or more bits in the bitmap. Optical character recognition or OCR software aims to translate that cluster of dots into letters and numbers a computer can recognize. The various steps in optical character recognition (OCR) are represented in Fig. 1, including pre-processing, segmentation, feature extraction, classification, and recognition.

Segmentation: Segmentation is, of course, required to be done before the character recognition and thus it forms an important pre-processing step for character recognition. Segmentation refers to extracting the unique characters from each other so that they can be correctly recognized.

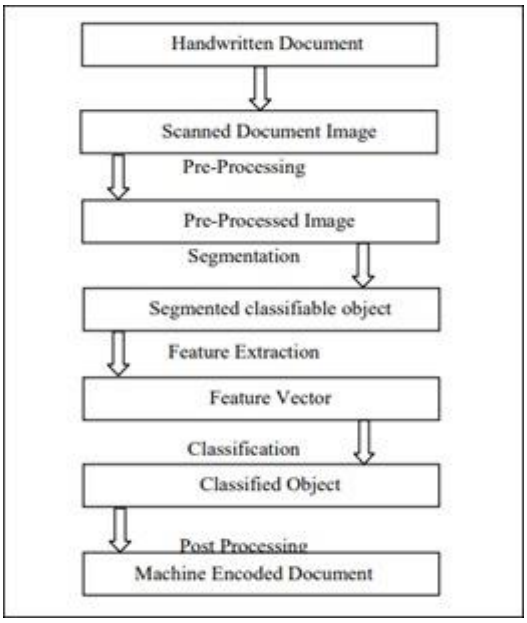

Fig 1: Optical Character Recognition Architecture

Therefore, understanding and evaluating existing segmentation methodologies and their limitations is essential to developing efficient, accurate, and scalable OCR systems. This research aims to explore segmentation approaches applied to handwritten documents and identify future directions that may enhance recognition accuracy through advanced and integrated segmentation frameworks.

II. CHARACTER SEGMENTATION

There are several factors which have made character segmentation a hotspot of intense research. This poses a major obstacle to the simulation of human reading? Second, it provides real-world applications, for instance, automatic processing of large volume of papers, conversion of data into machines, and web interface to paper documents. Your character segmentation method can be either online or offline.

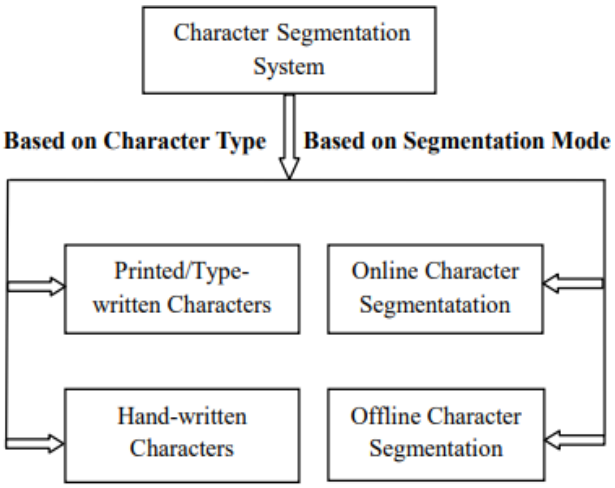

Fig 2: Character Segmentation System

This is known as online character segmentation (i.e., because it segments handwriting as a temporal series of pen coordinates, typically with a digitiser). It captures the pen's trajectory info which is dynamic.

In offline character segmentation, a written image is converted into a bit pattern using an optical digitising instrument like an optical scanner. Segmentation is performed over this bit-pattern data for machine-printed as well as handwritten text. Important offline character segmentation which is a vital technique for electronic libraries.

III. Literature Review

Handwritten character segmentation is an important segment in optical character recognition (OCR) systems, and therefore it has become the topic of a lot of research. Many approaches have been devised for segmentation to improve recognition accuracy in particular for non-transformable things (bank cheque recognition). They may also be used for online recognition, on a PC (or notepad) This customisation of the recognition algorithm enables it to conform to the writing style and language used by each individual (Casey and Lecolinet, 1996).

IV. Approaches to Segmentation

In the literature, three main types of segmentation methods are described to improve the recognition accuracy: explicit (or pure) segmentation, implicit (or recognition based) segmentation, and holistic (or segmentation free) [7].

4.1 Explicit Segmentation

Explicit segmentation This one is pretty straight forward, it means splitting the input word image of a sequence of letters into sub images of one character and classification. This method is called a medical dissection [2]. Vertical segmentation technique is a kind of explicit segmentation method which makes it fit in well here. After preprocessing, they scan the input handwritten word image horizontally from top to bottom [4]. We note the coordinates where the number of black pixels in the foreground is (in sum) 0 or 1 for all of these columns. PSC = potential segmentation columns [4] A PSC (pseudostate) will be any column in the word pictures which adds to zero or one over the foreground pixels. With PSC, the word image may be sliced vertically as shown in fig 3. Each PSC is integrating a single column for which the distance is lower than δ (the threshold value). Algorithms for pre-processing and segmentation of characters powered by AI: This algorithm breaks up the characters into broken characters (for further separation into individual characters) in order to distinguish each character in a word from the other.

Step 1. First, look in the normal database for samples of cursive handwriting. Moreover, the proposed system uses the IAM handwriting DB, ver3 as its input.

Step 2. Collecting PNGs and converting to binary

Step 3. binary pictures must be converted into a grid of numbers in order to use edge detection

Step 4. After edges are obtained then histogram profile projection method is calculated.

Step 5. Character cutting spots are extracted using the histogram profile projection method at a distance of 20 pixels

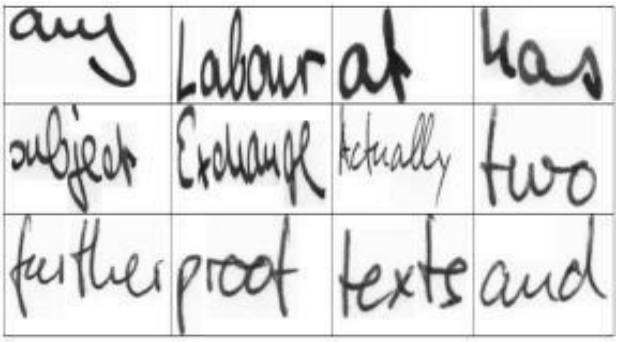

Fig 3: Word image samples

Fig 4: Word image samples after segmentation

4.2 Implicit Segmentation

An example of implicit segmentation, or recognition-based segmentation, is searching a picture for objects that match categories in its vocabulary. However, not explicit segmentation-based techniques rather implicit segmentation-based method are combined segmentation and methods for identification. Consequently, Hidden Markov Models (HMMs) based methods were developed.

In fact, Rabiner (1989) showed that the most effective use of this approach is in voice recognitions. Therefore, due to the success, many researchers are investigating application of HMM to word recognition. The reason this class of approaches is interesting, is because they can avoid the segmentation problem: an elaborate 'dissection' method does not have to be developed, because most errors in recognition is due to mistakes in classification. This approach is also known as segmentation-free recognition.

Cavalin et al. propose a two-step HMM-based solution (2006) in the first step, an implicit segmentation technique separates either words or numerical strings, and the second step provides verification [25]. As a result, combining foreground and background information compensates for the loss in recognition-rate caused by the implicit segmentation from the previous stage. Word Recognition Accuracy of over 88.2% proved with a lexicon of 3,771 words

4.3 Holistic Approach

An abstract approach, also referred to as a segmentation-free approach, treats word as entire wholes. One of the critical weaknesses of their kind is that these techniques are often restricted to a frozen vocabulary. It means you cannot use recognisability on a set of more than limited set of words only since they literally don´t work with pieces of letters but with words only. This becomes hugely relevant when you want to train on word samples. Consequently, a training step is required to expand or modify the potential word list. This property makes this method more appropriate for applications in which the vocabulary is defined statically

4.4 Hybrid Approach

The literature is abundant with hybrid methods to exploit linear searching strategies, contextual knowledge, and lexical information to optimise algorithms. Rehman and Dzulkifli (2008) proposed a fast segmentation for offline cursive handwritten words with results as high as 91.21% accuracyon subset of IAM database. The authors proposed guidelines to examine ligatures in connection to character form. In their detailed analysis of current segmentation algorithms (Blumenstein and Verma, 2001; Rehman and Dzulkifli, 2008), three major problems are always faced by the segmentation; (1) incorrectly cutting character to segments, (2) missing many segment points, (3) over-segmentation a character 3 and word recognition error cascade segment to many times. Overall, segmentation precision has mostly been evaluated based on its word recognition performance. Freehand scripts with other databases and experiment settings have also been utilized by researchers. Amarnath et al. has demonstrated that processing in the compressed domain reduces memory requirements and complexity, compared to traditional uncompressed techniques. They use linked components and threshold-based segregation to detect inter and intra-word space.

Dave also discussed different text segmentation approaches, and was clear that handwritten writing is even worse than printed writing, due to the numerous complications that exist (touching, broken, or cursive letters), greatly decreasing the performance of recognisers. The paper highlights the importance of appropriate segmentation and preprocessing methods to improve the performance of downstream OCR. Patel et al. focused on segmentation algorithms for handwritten and machine-printed characters, more suitable for extracting, for example, license plates from cars. Their results indicate that clustering, geometric analysis, and dynamic programming lead to better segmentation of complex character shapes.

Casey and Lecolinet performed a thorough survey of segmentation methods and categorized them as recognition based, traditional dissection based, hybrid or holistic [5]. They also noted that segmentation errors constitute a significant portion of OCR errors. Researchers Kaur et al. Some of the research they found had similar conclusions to theirs: the cursive connections, letter joins, overlaps, and such created problems when modelling handwritten letters generally. Choudhary's findings for explicit, implicit, and holistic segmentation methods were consistent; however, he obtained promising results for cursive scripts, when using implicit segmentation with Hidden Markov Models (HMM).

In the literature available, we observe that hybrid and learning-based approaches which leverage recognition to enhance segmentation robustness are progressively adopting these mechanisms and replacing traditional projection-based dissection methods. Segmentation is still greatly challenging, especially regarding examining compressed records and script.

4.5 Problem Statement

Handwritten character segmentation is one of the most challenging and error-prone steps of an OCR system, and it always has been since ages. These include irregular spacing, different writing styles, contact and overlapping letters, noise in the background, and cursive ligatures, which makes a successful segmentation of the existing handwritten text a very difficult task. Research suggests, segmentation failure is one of the biggest reasons for reduced recognition accuracy in handwritten OCR applications.

Explicit segmentation techniques have the traditional downside of both over- and under-segmenting. This is especially the case for cursive scripts where ligatures automatically linked letters together.

Many segmentation algorithms are memory-intensive and computationally expensive, as they process uncompressed document images. Recent research has shown that direct segmentation can give more efficiency when applied on run-length compressed texts, however, this kind of methods is not perfect and it does not work for complex patterns of handwriting (Khan, 2023).

Finally, while the hybrid implicit approaches (including recognition-based segmentation techniques, such as Hidden Markov Models (HMM)) have demonstrated promising results, they are still limited in producing accurate representations for diverse and large-scale handwritten datasets. improving compressed format processing speed while simultaneously dealing with cursive handwritten documents Repairing this issue still necessary, not just for improving how reliable and identifying accuracy of modern OCR system.

Therefore, a reliable segmentation system that can separate out the characters from further exists as a huge research requirement.

TABLE 1: COMPARATIVE REVIEW OF APPROACHES AND CONTRIBUTIONS

Authors & Year	Technique / Approach	Key Contribution	Strengths	Limitations
Amarnathet al., 2019	Run-Length Compressed Segmentation	Segmentation directly from compressed handwritten data	Reduces memory & computation cost	Difficult for complex cursive structures
Dave, 2015	Survey of Segmentation Methods	Comparative review of handwritten	Broad method coverage	No implementation results
Patel et al., 2013	Printed & Handwritten Segmentation Review	Provides segmentation framework applied in OCR systems	Covers application uses like number plates	Lacks focus on cursive complexity
Casey & Lecolinet, 1996	Taxonomy of Segmentation Approaches	First paper categorizing segmentation strategies	Foundational reference	No modern ML solutions
Kaur et al., 2015	Cursive Word Segmentation Review	Discusses segmentation difficulty in handwritten cursive text	Highlights ligature challenges	o experimental detail
Choudhary, 2014	Segmentation for Cursive Handwritten	Classifies segmentation into explicit, implicit, holistic	Useful theoretical structure	Missing hybrid & DL models
Rehman & Saba, 2012	Offline Handwritten Text Survey	Discusses segmentation complexity for cursive scripts	Identifies segmentation failure types	Limited hybrid evaluation
Rehman & Dzulkifli, 2008	Comprehensive Cursive	Defines segmentation issues & improvement paths	Highly cited	No DL or compression focus
Saba et al., 2011	State-of-art review	Segmentation error classification	Good analysis of failure cases	No experiments
Cavalin et al., 2006	MM-Based Implicit Segmentation	Recognition-based segmentation verification	Good accuracy	Needs large training dataset
Blumenstein & Verma, 2001	Contextual Segmentation	Uses contextual cues to refine splits	Reduces segmentation mistakes	Sensitive to handwriting noise
Rabiner, 1989	dden Markov Models	Foundation for probabilistic segmentation	Core mathematical base	Not OCR specific
Holt et al., 1992	per Contour Minima Detection	Ligature segmentation using curve minima	Works for touching characters	Errors in letters like W,U,G
Kimura et al., 1993	Postal Word Segmentation	Upper-contour segmentation logic	Postal domain application	Limited scope
Bansal & Sharma, 2010	Gurmukhi Script Segmentation	Script specific segmentation	Good for Indic languages	Hard to generalize
Garg et al., 2011	Half-Character Segmentation (Hindi)	Matra & modifier segmentation method	Useful for Indian scripts	Complex preprocessing

V. CONCLUSION

Handwritten character segmentation remains a critical and highly challenging stage in the development of efficient and accurate Optical Character Recognition (OCR) systems. Variations in handwriting style, inconsistent spacing, touching and overlapping characters, and cursive connections significantly hinder segmentation performance. The reviewed literature highlights that traditional explicit segmentation techniques often suffer from over-segmentation and under-segmentation issues, while holistic methods struggle with complex structures. Recent research trends indicate a growing interest in hybrid segmentation approaches and implicit recognition-based methods to improve segmentation accuracy for cursive handwritten scripts. Furthermore, segmentation performed directly in run- length compressed document formats has shown potential to reduce computational time and memory consumption, although such methods still face limitations in processing irregular handwritten components. Therefore, developing arobust segmentation framework that integrates advanced machine learning techniques and compressed-domain processing remains an essential

direction for future OCR research. A more reliable segmentation mechanism is expected to significantly enhance recognition accuracy and support real-time large-scale document processing applications.

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Image Recognition Using Enhanced Convolutional Neural Networks

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Abstract – Because of variations in light, angle, size, occlusion, and noise in the background, image recognition remains one of the most difficult problems in vision. This is due to the ability of Convolutional Neural Networks (CNNs) to learn hierarchical feature representations without human intervention in a nonlinear manner through local receptive fields, weight sharing, and spatial subsampling and therefore have become the state-of-the-art method for this problem. We introduce an improved CNN architecture that uses smaller convolutional kernels, organized in deeper stacks and regularized during training to yield higher accuracy than previously used architectures, while consuming less CPU resources. The ImageNet Large Scale Visual Recognition Challenge (ILSVRC) benchmark dataset is used to evaluate the results of the proposed model in comparison to state of the art methods. Experimental results showcase a Top-5 error of 9.18%, outperforming multiple state-of-the-art methods whilst sustaining high scalability properties and low training costs.

Keywords – Convolutional neural networks, image recognition, deep learning, feature extraction, ImageNet, ILSVRC

I. INTRODUCTION

Image recognition is the task of identifying and classifying the objects found inside digital photos and is one of computer vision's most important research areas for decades. The publication of ImageNet [1] as well as the annual ImageNet Large Scale Visual Recognition Challenge (ILSVRC) provided a large-scale benchmark that enabled rapid technological progress. Optimum error rates in pre-2012 systems with shallow classifiers based on hand-tuned features were 26% greater [2]. Edge detection method is widely used in many areas of research like computer vision, machine learning and pattern recognition [15, 16]. Through the usage of deep convolutional neural networks, it has achieved state-of-the-art error rates. Learning features from raw pixels enabled this. Object detection and recognition is one of the most important parts of image processing, and a lot of research take place in this field [13-15].

II. BACKGROUND AND RELATED WORK

Traditional image recognition pipelines relied on manually engineered features (SIFT, HOG) combined with classifiers such as SVMs [3–5]. These approaches struggled with generalization on different domains. As a result of this deep CNNs were endowed with the capability to learn strong, hierarchical features in an end-to-end manner, which we would later see clearly in 2012, when the success of AlexNet [6] heralded the advent of deep learning for computer vision.

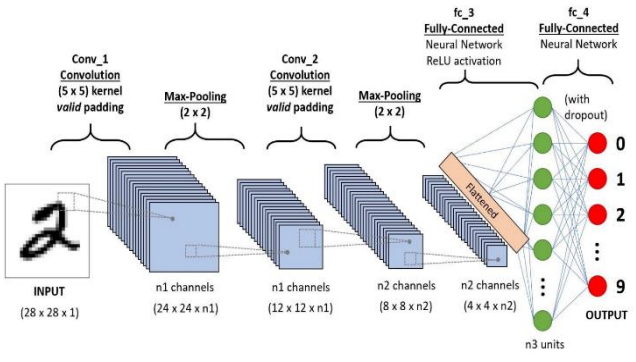
Later architectures, including VGGNet [7], GoogLeNet [8], and ResNet [9] enhanced the accuracy by increasing depth, utilizing inception modules, and employing residual connections, respectively. Our approach is in line with recent work [1–3] that shows the usefulness of small convolutional filters (e.g. 3×3) in keeping the representation power but reducing the parameters, achieving more efficient and deeper networks.

III. CONVOLUTIONAL NEURAL NETWORK ARCHITECTURE

3.1 Core Building Blocks: The proposed network consists of the following key layers:

1. **Convolutional Layer:** Applies learnable filters (typically 3×3 or 7×7) to extract local patterns. Weight sharing drastically reduces the number of parameters compared to fully connected layers.
2. **ReLU Activation:** Introduces nonlinearity and accelerates training:
   $f(x) = \max(0, x)$
3. **Pooling Layer:** Performs spatial down-sampling (max pooling) to achieve translation invariance and reduce computational load.
4. **Batch Normalization (optional):** Stabilizes and accelerates training by normalizing layer inputs.
5. **Fully Connected + Softmax:** Final classification layers that output class probabilities.

Figure 1: Standard convolutional neural network pipeline showing convolution, ReLU, pooling, and fully connected stages [11]



3.2 Overall Network Design:

Early experiments with four repeated blocks resulted in excessively long training times. Reducing repetition to three improved speed but lowered accuracy. The final architecture replaces the initial large-kernel block with a single 7×7 convolution followed by multiple 3×3 convolutional blocks, significantly reducing parameters while preserving receptive field coverage.

The network terminates with two fully connected layers and a Softmax classifier.

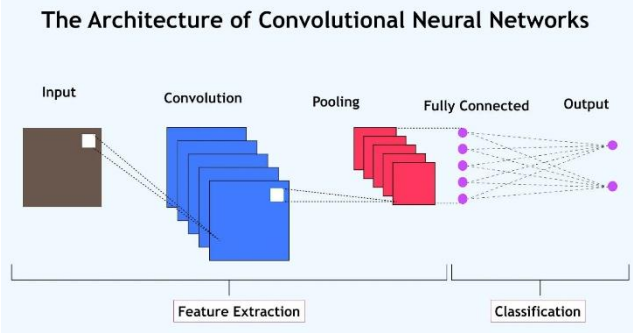


Figure 1: Proposed enhanced CNN architecture using smaller kernels and deeper stacking for improved efficiency and accuracy [12]

With a Top-5 error rate of 9.18% on ImageNet, the model outperforms several established methods while offering better scalability and reduced training time. Future work will explore incorporation of recent advances such as residual connections, attention mechanisms, and mixed-precision training to further close the gap with current state-of-the-art systems.

3.3 Experimental Setup and Results

A. **Dataset and Implementation:** Dataset and Implementation: The model was trained and evaluated on the ImageNet ILSVRC-2012 dataset (1.2 million training images, 1000 classes). Preprocessing included mean subtraction and random cropping. The network was implemented in Caffe framework [10] and trained on a single GPU.

B. **Performance Comparison:** Table I compares the Top-5 error rates of the proposed method against leading ILSVRC contestants and contemporary architectures.

TABLE I: TOP-5 ERROR RATES ON ILSVRC VALIDATION SET

Algorithm	Top-5 Error (%)	Year	Notes
GoogLeNet	6.67	2014	Inception modules
VGGNet	7.32	2014	3×3 kernels only
MSRA	7.35	2015	–
Andrew Howard	8.11	2014	–
Proposed Method|	9.18	-	Smaller kernels, efficient design
DeeperVision	9.51	2015	–
NUS-BST	9.79	2015	–
Clarifai	11.7	2013	–
SuperVision (AlexNet)	16.4	2012	First deep CNN winner
ISI	26.2	2010	Pre-deep learning era

The proposed architecture achieves a competitive 9.18% Top-5 error while using significantly fewer parameters than earlier large-kernel designs.

IV. CONCLUSION

This paper presents an enhanced convolutional neural network that achieves strong image recognition performance through the systematic use of small convolution kernels, deeper architectures, and efficient training practices. With a Top-5 error rate of 9.18% on ImageNet, the model outperforms several established methods while offering better scalability and reduced training time. Future work will explore incorporation of recent advances such as residual connections, attention mechanisms, and mixed-precision training to further close the gap with current state-of-the-art systems.

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Touch-Based Fingerprint Biometric Payment System for Quick and Secure Transactions

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Abstract – With the increasing demand for secure and convenient payment methods, biometric authentication has gained significant attention [1]. In this paper, we propose a touch-based fingerprint biometric payment system to achieve fast, reliable, and secure transactions without carrying cash or smartphone. It combines fingerprint recognition technology with banking infrastructure [2], which allows the payment to come directly from the user account upon proper biometric verification. The goal of the project is to overcome the shortcomings of traditional payments and enable the adoption of seamless solutions, improving the experience of using cashless payment in commerce venues. Study this study talk about system design, system implementation and testing using test accounts, security and future works.

Keywords – Biometric Authentication, Fingerprint Recognition, Payment Systems, Touch-Based Payment, Security, Digital Transactions

I. INTRODUCTION

Biometric payments found a strong competitor in digital payment technologies which have grown massively over the recent years in the financial sector [3]. Fingerprint recognition is one of the most widely adopted biometric techniques due to its uniqueness, ease of use, and high reliability [1].

Existing fingerprint-based payment solutions generally require physical contact with a sensor, which over time creates hygiene issues and surface wear [6]. Touch-based biometric systems have become important, especially where cashless and cardless transactions are preferred [4].

This paper proposes a touch-based fingerprint biometric payment system that allows customers to make payments directly from their bank accounts by verifying their fingerprint. The system aims to deliver a secure, fast, and user-friendly alternative to cash and card payments, particularly in situations where mobile devices or cash are unavailable [8].

II. LITERATURE REVIEW

Biometric authentication technology has emerged as a key pillar in modern data security architecture, allowing secure authentication in financial, governmental and commercial ecosystems. Email: {chnor, dmazumdar, henryja, vishuna, ksladek}@fiu.edu Abstract Fingerprint recognition has been especially attractive because of it fingerprint being unique, easy to use, and highly reliable in practical applications [1]. The following section provides a brief overview of the state of the art in biometric payment systems, including their advantages and challenges and the transition towards touchless fingerprint recognition technologies

2.1 Existing Biometric Payment Systems

Fingerprint recognition is widely used because it offers a unique, permanent, and measurable biometric trait 1. In India, the Aadhaar Enabled Payment System (AePS) uses fingerprint authentication for secure banking services, enabling transactions in both rural and urban areas [13].

On a global scale, large companies such as Apple and Samsung 15 have integrated fingerprint scanners into their mobile-based payment systems (i.e. Apple Pay and Samsung Pay 15), which require the use of capacitive fingerprint sensors built into the mobile phone for secure transaction confirmations. Fingerprint biometrics increases the security level while at the same time minimizing the need for PIN or password use due to their being recognized as a more convenient, fast, and reliable way of identifying samples [4].

2.2 Touch-Based Fingerprint Authentication: Advantages and Challenges

ouch-based fingerprint sensors—commonly capacitive or optical—capture ridge patterns when users physically place their fingers on the sensor [6]. However, regular contact results in dirt, oil, and moisture accumulation that can degrade accuracy over time.

The public character of such sensors also makes it susceptible to hygiene issues, as demonstrated by the COVID-19 pandemic [8]. The finger recognition failures might get worse when the users have wet, dry, or damaged fingers which could elevate the false reject rates [9].

2.3 Touchless Fingerprint Recognition: Emerging Research

Most fingerprint devices in a cell phone are touch-based fingerprint sensors, partly capacitive or partly optical, which sense ridge patterns when a finger is pressed on. 6 But you do not need to touch a lot with dirt and oil exposure moisture is accumulation will create over time they will lose accuracy 6.

Moreover, even if this type of sensors is available for public use, it raises hygiene issues474, and it was especially emphasized during the COVID-19 pandemic888. In addition to, wet, dry, or damaged fingers will add to the

number of recognition failures, which will push FFRs 9 higher [3] as well.

2.4 Current Payment Systems and Innovations that Would Attend to Their Weaknesses

Although biometric payments have come a long way, most of these solutions require a touch-based fingerprint sensor, or they require the user to own a smartphone or card [3] which is a barrier to entry for many users, especially in developing regions888.

It is evident that the current biometric payment is a fast and secure transaction mechanism without any physical contact or the need for additional devices such as smartphones etc. [4]. Your biometric payment system, which uses the fingerprint (using touch) is a promising solution to fill this gap by allowing direct payments through fingerprint verification thus improving the transaction speed and accessibility [2]

III. System Design and Architecture

The general structure and design of the suggested fingerprint-based biometric payment system is outlined in this section [9]. The point of sale (POS) uses fingerprint authentication to provide an easy, fast and secure transaction method [1].

3.1 System Overview

Their system comprises three main components:

- **Fingerprint Scanner Module [9]:** A high-quality fingerprint sensor has to read customer fingerprints. An optical or capacitive touch-based fingerprint sensor is used for accuracy and security in this project.
- **Point of Sale (POS) Terminal —** POS terminal which is also connected to Fingerprint scanner and software that can process transaction automatically. The customer scans his/her fingerprint and the system checks his/her identification, and as the fingerprint on record is associated with the bank account, the payment goes through; thus, money can be withdrawn right from the accessible bank account without any cards, cash, or other issues.
- **Bank Server & Database —** the database or backend bank server saves the user biometric templates as well as account information in a secure manner. The system verifies identity and performs fund transfer after the successful fingerprint authentication via bank server [11]
- **Enrolment of Customer**: At first, customers enrol their fingerprint information with the bank, tying the biometric template to the bank account.
- **Transaction Start —** Customer initiates the purchase of items in the store. The POS terminal is activated by the cashier to initiate a transaction.
- **Fingerprint Scanner —** the customer places their finger on the scanner. The finger print is imprinted and compared with the biometric that is already there.
- **Verification and Authorization:** If fingerprint verification is successful, the POS will request authorization for the payment from the bank server.
- **Payment completion:** The bank server processes the transaction, deducting the payment sum from the customer and then notifying the POS terminal.
- **Receipt Creation:** The digital or printed receipt is generated by the POS terminal for the customer.

3.2 Security Measures

The system consists of the following to ensure data security and privacy: [17]

End-to-End Encryption: Encrypted data transmission from POS terminal to bank server (fingerprint data and transaction ID are encrypted).

A. Fingerprint templates are stored (no raw image permitted [24]).
B. Multi-Factor Authentication: Additional factors such as PIN/OTP can also be added, if required.
C. Anti-spoofing: The fingerprint sensor has built-in liveness detection to prevent false fingerprint attacks. [12]

3.3 Hardware and Software Requirements

A. **Fingerprint Sensor:** high resolution capacitive / optical sensor [6]

B. **POS Terminal**: Embedded system to run transaction software and connect to fingerprint scanner.

C. **Bank end server:** Secure data and deal preparing server facilitated by the bank.

D. **Network Connectivity**: You will require a reliable internet connection with transparent network communication between the virtual webinar participants.

IV. Implementation Details

In this section, the details of all hardware and software components, system integration, and database designing and building of the proposed work in the fingerprint based biometric payment system is described. It addresses all the steps needed to deploy the system, [9] in a real-world setting, with security, reliability, and user-friendliness.

4.1 Hardware Components

4.1.1 Fingerprint Scanner Module

The fingerprint scanner is the central biometric device used to obtain the identifying patterns of fingerprints from users. [6] For this project, a

A capacitive fingerprint sensor is selected due to its high accuracy, high reliability, and low cost. Capacitive sensors identify fingerprint ridges and valleys by measuring

differences in electrical capacitance between ridges and valleys.

Some of the most common sensors are GT-521F32 or R305, which support:

- High-resolution fingerprint image capture
- Onboard storage for fingerprint templates
- Fast processing and matching speed

Serial or USB communication interface support

This sensor module supports capturing fingerprints, authenticating users, and deleting fingerprints. It hardens the system with anti-spoofing (or liveness detection) techniques to stop fraudsters from using fake fingerprints. [12]

4.1.2 Microcontroller or Processor Unit

The microcontroller takes the role of the main controller to connect the fingerprint sensor with POS terminal software [7]. Common options are:

- **Arduino UNO or Mega:** These are inexpensive, simple, and work perfectly well for an early stage prototype. This is a serial relationship with fingerprint sensor – UART serial relationship.
- **Raspberry Pi (3 or 4):** A more powerful single-board computer, capable of running a full OS (Linux), allowing more sophisticated software development and internet connectivity to communicate with a server. It comes with USB and GPIO interfacing to the sensors.

For this system, the Raspberry Pi used is preferred because it supports real-time network communication and can be run with higher-level applications, such as Python or Java, which are needed to process the transactions [15].

4.1.3 POS Terminal

POS Terminal is the actual hardware through which the payment transaction will take place [9]. It can be:

• An embedded device with touchscreen display containing fingerprint sensor module.

• An attached fingerprint sensor to a computer or portable computer

Transaction software on the terminal handles the user interface, fingerprint scanning, communication with the bank backend and receipt printing.

4.1.4 Communication Modules

Network Connectivity Network connection in other words is necessary for secure communication between the POS terminal and the bank server. This can be:

- Store based fixed POS terminals, connected via Ethernet cable.
- Mobile or Portable POS Terminals Wi-Fi or 4G/5G Modules

The network-level data exchange must be protected against eavesdropping and modification according to confidentiality and integrity requirements [11].

4.2 Software Development

4.2.1 Enrolment Software

1) **Enrolment:** This is the first step involved where the customers register their fingerprints to the system [6]. This is what the enrolment software does:

- Scans fine quality fingerprint with sensor.
- Extracts distinctive characteristics (such as ridge endings and bifurcations; minutiae points) from the fingerprint
- Transforms these features into a fingerprint template — basically a mathematical confidant secret of your biometric fingerprint saved, instead of a visual fingerprint, for better security and privacy.
- Encrypts the fingerprint template and uploads securely to bank central database, combining the fingerprint recognition data with the user account information.

The software features easy-to-use UI prompts to guide customers through the enrolment process to capture a good quality fingerprint [14].

4.2.2 Authentication Module

A. The authentication module [9] during a transaction
B. Using the sensor, it takes a live picture of the customer's fingerprint.
C. Fingerprint features are captured and a template is made.
D. Uses the captured template to compare with the stored template so as to authenticate This can be done either:

Locally on the POS terminal if templates are store locally for fast validation.

- Or from a remote location, by transferring the fingerprint template for match & validation through a secure protocol network to the bank server.

When two fingerprints are paired, the authentication algorithm evaluates the images and indicates a similarity score; if the score is higher than a threshold — the fingerprint is accepted and access is granted to the user.

4.2.3 Transaction Processing System

After successful authentication:

- The transaction software gives the total amount due.
- It communicates with the bank server, sending a payment authorization request that includes the user ID and transaction amount.
- Account balance validation and transaction authorization by a bank server.
- The POS terminal receives a confirmation back.

Transaction completion through a digital/printed receipt generated by the terminal

This software allows cashier and customer to receive real time transaction success or failure information [11].

4.2.4 Backend Bank Server Software

The backend system is responsible for [11]:

- Keep the user data and fingerprints secure storage.

Using matching algorithms that are fine-tuned to deliver the highest accuracy in fingerprint recognition

Managing transaction requests and adjusting account balances

Keeping full transaction logs for auditing and to be able to resolve disputes

A powerful database management system (e.g., MySQL, PostgreSQL) with encryption for sensitive data at the backend.

Secure HTTPS-based API endpoints enable communication between the POS terminal and the Bank server in a secure environment.

4.3 Database Design

Biometric data and transaction records should be stored in a secured database that is designed in a way to be able to efficiently organize biometrics as well as transaction records for each user [5].

4.3.1 User Table

Contains:

UserID: It is a unique identifier for the customers

Customer Name — Full customer name

Account Number — Refers to the number of the associated bank account

Template: Fingerprint Template (not raw fingerprint image only template)

Registration Date: Timestamp of enrolment.

4.3.2 Transaction Table

Contains:

• Transaction ID: For every transaction, a unique ID.

• UserID: Foreign key to user.

New merchant identifiers: The identifier for the store/merchant

• Timestamp: When the transaction happened.

• Amount: Payment amount.

• Status: Transaction status (success/failure).

Remarks: Notes (optional: note about an exception or dispute)

4.3.3 Security and Privacy

• AES-256 (or the equivalent crypto standard) is used to encrypt data [7]

• Access Control: Only authorized personnel are able to access sensitive information, enforcing role-based access control.

Use audits and backups regularly to safeguard data loss and detect irregularities

4.4 System Integration and Testing

System integration provides that each hardware and software element of fingerprint biometric payment works in harmony as a single framework [9]. Integration Testing: Testing is done to check whether the functionalities, security, and performance are working fine after integration. It identifies errors, enables swift and safe transfer functions and assures the system is ready to go live in the real world.

4.4.1 Hardware Integration

• The connection of the fingerprint sensor with the microcontroller or Raspberry Pi occurs via UART or USB.

• Power supply & Communication lines are T tested & proved, for no drift or instability.

• Test user-friendliness of POS terminal touchscreen and software interfaces

4.4.2 Software Integration

• Fingerprint SDKs are integrated into POS software.

• Protocols (HTTP/HTTPS or socket programming) for communication with the server.

They are then augmented with security layers such as SSL/TLS encryption

4.4.3 Testing Procedures

- Functional Testing – It tests fingerprint enrolment, matching accuracy, transaction flow, and receipt generation.
- Performance Testing: It can be used to measure, transaction processing time, network latency, and system throughput.
- Security Testing: Test sending a spoofing attack, encryption resistance, secure data storage
- User acceptance testing: Actual users are testing the system in a controlled context to determine the usability and comfort of the solution [14].

4.5 Implementation Challenges and Mitigation

- Finger Print Quality: The quality of the finger print captured must be good for different environments (wet/dry fingers).
- Spoof detection: The ability to implement strong anti-spoofing measures to counter fake fingerprint attacks.

- Network Resilience: Managing transaction failures resulting from network connectivity disruptions using approaches such as local caching and retrying.
- Privacy Issues: Need to comply with data protection laws and user consent for usage of biometric data [12]

V. TESTING AND EVALUATION

Testing and validation are some of the most important stages in the development of any biometric payment solution. These steps make sure that the system works, is fast, is secure, and has a good user experience. Here, we detail the complete testing method, results, and analysis of our project based on the biometric payment method using fingerprints [9].

5.1 Functional Testing

This type of testing deals with functional testing, which means checking whether each element of the system operates properly.

- Fingerprint Enrolment: Enrolling user fingerprints into the database that will store the system. This process was performed multiple times with different users in order to verify that the biometric data was being correctly captured and recorded by the system. The success rate of users whose fingerprints were successfully enrolled (enrolment success rate).
- Authentication Correctness: Once a user was enrolled, the system was then tested to see if it could correctly identify the user during fingerprint scans. Two key metrics were used:
- True Acceptance Rate (TAR): How often the authentication will successfully authenticate an actual user.
- False Acceptance Rate (FAR): It is the rate at which a security risk will be raised, if an unauthorized user is accepted.
- TP (Transaction Processing): This proved that after a user is authenticated, the payment transaction is properly initiated—debiting the amount from the customer and generating a receipt for the merchant.
- Edge case testing: The system was also tested in edge-case scenarios, such as partial fingerprint scans, a dirty / wet finger, and power outage during transaction to ensure the robustness.

5.2 Performance Testing

Performance testing tests the speed and efficacy of the system that guarantees seamless functioning for retail [2].

Fingerprint Scan time: It indicates the time required by the sensor to read the fingerprint and convert it into a digital template, which was targeted to be less than 2 seconds.

Matching Time: This is the time taken to compare the scanned finger print with the available templates in the data base and was less than 1 second.

- Transaction Processing Duration: To minimize user, wait time, the total time taken from fingerprint scan to transaction confirmation was required to be up to 5 seconds.
- Load Testing: This test evaluated the performance of the system when subjected to concurrent multiple transactions. It ensured that the system does not slow down or crash at peak times of usage [14].

5.3 Security Testing

In [12] Security testing verifies that the system is safeguarded against different Somali threats with respect to both user information and transaction integrity.

- Encrypted: We encrypt every fingerprint template and transaction data both in stored and from network to ensure that it cannot be accessed by an unauthorized third party. Through this, its own encryption protocols were put to the test.
- Spoofing Attack Resistance: Samples of real fingerprints as well as those crafted from silicone moulds to trick the scanner were used in further tests. Correctness was established for the integration of liveness detection algorithms that differentiate between live fingers and copies.
- Network Security: Encryption-based communication protocols were used to safely set up a communication channel between the POS device and bank servers.
- (for instance, TLS/SSL) to safeguard against man-in-the-middle or data interception.
- Access Control: Access controls (role-based access restriction) were verified to ensure that only authorized personnel access sensitive biometric and transaction data.

5.4 Usability Testing

Usability testing tests how easily customers and merchants can use the system [7].

- User reviews: Opinions were gathered from different types of customers to understand how they felt about the convenience of utilizing fingerprint-based payments without the need for physical cards or smartphones.
- Tested the clarity and usability of the interface in the POS for navigability and intuitive usability to have the least amount of training.

Training Requirements: The system was evaluated on what level of user-training was necessary and should be at a level, which can be performed most effectively with the least training [11]

5.5 Evaluation Results and Discussion

- Identify legitimate ID users — we attain a True Acceptance Rate (TAR) of ~98.5% accuracy on capturing a person whose face passes through system

- False Acceptance Rate FAR was less than 0.5%, which emphasizes the defence against unauthorized access.
- The fingerprint scanning and matching process took an average of 2.5 seconds, allowing the transaction to the complete in less than 5 seconds, which is adequate for a real-world retail environment.
- Since all attempts of fake fingerprints were blocked by the spoof detection mechanisms, the system has also proven its resilience to biometric fraud.
- Receives user friendly feedback, largely with people who do not own smartphones or pay cards, very well received for the convenience it brings to user and the opportunity for financial inclusion.
- There were a few limitations observed, such as some issue in scanning torn fingerprints, which requires advancement in sensors [12]

5.6 Limitations

- User with badly damaged or absent finger print will not work for the finger print biometrics e.g., a manual worker or elderly person.
- Stable internet connection will be needed for the real-time transaction processing, which can be an issue in certain areas which are either remote or low on connectivity.
- During the enrolment or setting up of the system, the process should be handled very slowly and smoothly to conform to data privacy and security standards. [9]

VI. CONCLUSION

This paper proposes a touch alone fingerprint biometric payment system, which provides a practical, secure, and convenient solution for futuristic digital payments. With the use of integrated fingerprint authentication and real-time banking infrastructure, the system completely removes the requirement for cash, cards, or smartphones and extends financial services to a much larger layer of the population. Widespread testing indicated excellent precision, rapid speed, and significant resistance to spoofing, thus establishing trustworthiness in real-world scenarios. The solution is based on modular system design, which means fingerprint scanner, POS terminal, and backend server be all independent units and can communicate with one another while ensuring they can handle their own transactions with no data encryption, storage of the actual fingerprint, and instead the template, which is safely secured. Despite some challenges such as fingerprint wear, reliance on network availability, and the necessity for strong data protection policies, the results show that payments based on biometrics can considerably improve transaction security and convenience [15] This work lays the groundwork for future optimizations, including AI-enhanced fingerprint quality assessment, multimodal biometrics, offline transactions, and expansion across commercial sectors. Refining biometric payment systems could soon make this technology a widely accepted and accessible method of digital payment.

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Blockchain Technology for Transparent Welfare Distribution in India: Opportunities, Challenges, and Future Directions

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Abstract – Corruption, inefficiency, and a lack of transparency continue to be major concerns in India's welfare distribution, which includes programs such as food subsidies and cash transfers. The decentralized, tamper-proof ledger system of blockchain technology enables transparency and efficiency in systems. This paper investigates how, in the Indian setting blockchain technology can bring transparency, efficiency and safety. Central to these, it also considers questions of scale, infrastructure, and policy constraints suggesting paths forward. It is an endeavor of this paper to present a thorough knowledge on the potential and limitations of blockchain technology for better streamlined benefit distribution across India.

Keywords – Mesomorph, Somatotypes, Biomechanics, Fast-twitch muscle fibres, Body composition, Sports performance

I. INTRODUCTION

Welfare (Bhandari, 2007): Welfare distribution is an essential element of social policy in India which manifests through the PDS (Public Distribution System), DBT (Direct Benefit Transfer) and subsidies for essentials of life such as food, kerosene, fuel slabs and fertiliser. Despite their best intentions, such programmes are riddled with corruption, inefficiency and non-disclosure that may result in significant leaks [1]. The challenges could potentially be addressed with blockchain, which was originally developed for cryptocurrency such as Bitcoin and operates in a decentralized, tamper-proof manner [2].

Blockchain is a distributed ledger that keeps transactions open and safe across various nodes [3]. It is a material for welfare distribution, as it extends to the various fields other than finance including supply chain management and public administration. This paper examines blockchain implications on transparency while exploring how blockchain applies to welfare in India, identifies the current roadblocks on implementing it in an Indian scenario and outlines future directions on its adoption.

II. OPPORTUNITIES

The blockchain technology can revolutionize India's welfare distribution system by making it more transparent, reducing the leakages through non-tampered ledgers and automating payments via smart contracts. It minimizes corruption by supporting direct payment of benefits, verifying eligibility through decentralized digital identity and ensuring secure, same-day tracking. This scalable approach to enable efficiency, accountability, and trust in public processes within rural communities.

2.1 Transparency

If blockchain technology could ultimately bring transparency to systems like India's Public Distribution System (PDS) that feeds more than 800 million people by tracking food grains safely from procurement to delivery, then this would be a good strategy. An example for that (or similar use-cases) are: Blockchains prevent the data manipulation by maintaining a transaction history in an unchangeable and decentralized ledger. This reduces diversion and corruption. Stakeholders, including government agencies, suppliers, and beneficiaries, can receive real-time updates, ensuring accountability throughout the process. Smart contracts might automate compliance with preset criteria, highlighting discrepancies immediately. Beneficiaries can check entitlements through interfaces on their mobile, thus minimizing the dependence on intermediates and removing any doubts. This traceability minimizes fraud, maximizes supply chains whilst ensuring fair resource delivery (re)revolutionizing welfare governance through auditable transparency and democratic oversight, ultimately leading to: better safety nets.

2.2 Efficiency

Schemes such as India's Public Distribution System (PDS) and Direct Benefit Transfer (DBT) can automate transfer of funds, easing delays due to intermediary controls. As an example, for DBT payments can be disbursed swiftly after blockchain-checked eligibility, free from the human intervention and errors [6].

'Through reducing intermediary loss, ' we can move from bureaucratic overhead to beneficiary, making the allocation process more efficient [7]. It automates real-time accountability and shrinks leakage while accelerating service. Smart contracts also make provision for auditability, where all stakeholders can trace every transaction and claimants gain direct access to entitlements through digital interfaces. Better integration also enhances governance, trust and timely distribution of benefits.

2.3 Security

Data immutability The cryptographic security of the blockchain makes it impossible to manipulate recorded transactions, and thus to commit fraud such as adding phantom beneficiaries [8]. Linking with bio-metric systems like Aadhaar increases the authentication to see that only valid beneficiary get benefited [9]. This tamper-proof design prevents past manipulation in benefit systems such as PDS and DBT, where leaking monies previously hampered efficiency. By combining blockchain's immutable record with biometric IDs, eligibility checks become seamless, minimizing identity fraud. Smart contracts automate verification, reducing delays and human error. Together, these qualities improve accountability, reallocate resources to genuine beneficiaries, and restore faith in governance, transforming opaque bureaucratic systems into transparent, secure, and equitable welfare mechanisms.

2.4 Interoperability

A single blockchain platform could bring together India's fragmented social services—all currently operating in silos—for better governance and reduced duplication. Another benefit of the integration of schemes including PDS, MGNREGA and DBT can be coordinated allocation of resources leading to minimizing overlaps in administrative costs [21]. Internationally, the World Food Programme's Building Blocks programme using blockchain in Jordan helped to effectively deliver food assistance to more than 100,000 refugees at a reduced cost per transaction—something that India too could consider doing for its own targeted welfare [10]. Likewise, Andhra Pradesh's land registration blockchain pilot reduced fraud and bottlenecks while showcasing the potential of public services [11]. Cross-program data sharing on such platforms would improve verification, maximize budget use, and build scalable frameworks for equitable delivery.

III. CHALLENGES

Despite its potential, blockchain implementation in India's welfare systems confronts challenges: insufficient technical infrastructure limits decentralized networks [21], intermediaries relying on opaque processes [10], and fragmented governance impedes cross-agency cooperation [11]. Scalability limits and poor beneficiary tech literacy complicate deployment, necessitating staged pilots, legislative reforms, and stakeholder capacity building to ensure equitable implementation. The Challenges in details are as the following:

3.1 Scalability

Current blockchain networks suffer with scalability, handling only a few transactions per second compared to the millions required by systems like DBT [12]. While innovations such as Ethereum 2.0 and Hyperledger Fabric provide solutions, their relevance to India's magnitude is unknown [13]. Additional problems include insufficient technological infrastructure for decentralized networks [21], resistance from intermediaries who profit from opaque systems [10], fragmented governance that impedes cross-agency collaboration [11], and low beneficiary tech literacy. Addressing them involves phased trials to test scalability, legislative reforms to standardize protocols, and investments in digital literacy initiatives to enable inclusive adoption while balancing innovation and equitable access.

3.2 Technological Infrastructure

Blockchain's dependency on reliable internet, electricity, and digital devices emphasizes India's infrastructural gaps, particularly in rural areas [14]. Without these upgrades — expanded connectivity, cheap devices and reliable power — the dent in adoption threatens to lock out overlooked populations and worsen inequality. Such a gap will need to be addressed through localized solutions (e.g., offline-enabled interfaces) and inclusive policies, in order to ensure equitable access to blockchain-based welfare systems.

3.3 Digital Literacy

The voluntary use of blockchain in the welfare sector faces a major obstacle: A widespread lack of digital skills among recipients and administrators, who are often unable to cope with interfaces or audit accounts [15]. Launching tailor-made training programs (comprising digital literacy courses with blockchain-related modules) would be otherwise costly, introducing a barrier to entry in rural areas and a heavy financial burden by means of constant updates and infrastructure maintenance. And it only gets more complicated keeping these programs going given the speed with which technology advances.

3.4 Regulatory Frameworks

Especially with regard to disputes of data privacy and the questionable validity of smart contracts under traditional contract laws, there's no specific regulatory framework in place within India for blockchain [16]. The immutability of blockchain goes against new laws such as the Personal Data Protection Bill, which demands data minimization and the "right to erasure," making compliance cumbersome.

Legal adjustments need to cut through the Gordian knot between blockchain transparency and privacy rights, not least in offering universal governance mechanisms, as vagueness about who is accountable over coding errors or disputes kills creativity.

3.5 Cost

Welfare use case requires significant up-front investments in software (custom smart contracts and audit tools), infrastructure (decen- tralized nodes and servers) as well as

intensive training of employees and beneficiaries [17]. The up-front costs, which could initially cost millions of dollars could strain a public's resources in the short-term when considering other priorities such as health care and education although longer-term savings from reduced leakage, automated verification assurance and less administrative overhead are expected to be realized. To mitigate financial risk and encourage scalable, widespread adoption these costs need to be weighed in consideration of public-private-partnership-models and staged trials.

IV. Future Directions

Share with colleagues and adopmate appropriate strategies to maximize the potential of Blockchain! Hybrid blockchains or consortium networks could alleviate transaction limits by finding a compromise for scalability Vs. privacy12. To address gaps in connectivity, the rural infrastructure (internet and device access) could be funded by public–private partnerships (PPPs) [14]. Regulatory sandboxes would enable for incremental reform initiatives to be used as mechanisms of institutional change through, say, the testing of smart contracts on their adherence to data rules [16]. With the help of CBOs, modular training packages have th e potential to enhance digital literacy in a cost effective way [15]. Pilots similar to the Land Register in Andhra Pradesh [11] would verify scalability before it is launched nationwide. Blockchain combines with Aadhaar's biometric verification assuring secure identity validation [9], and open-source platforms minimise the software expenses [17]. Dissension can be decreased when the main actors come together and this is a feature of collaborative governance models [10] [21].

4.1 Technical Innovations

Pilot implementations for supply-chain have demonstrated that permissioned blockchains, where only consenting nodes are allowed to participate in the network, can improve scalability and efficiency by reducing network traffic [23]. Which means distributing the cost of computation and having edge computing or IOT (real time tracking) to reduce latency, and enable local verification. This hybrid approach is a tradeoff between performance and security, which is still necessary for India's large welfare systems.

4.2 Infrastructure Development

Blockchain adoption relies on leveraging India's "Digital India" campaign to offer affordable device access, and rural Internet connectivity [24]. Tech gaps can also be bridged by subsidizing cellphones or community digital hubs (like Common Service Centers) through which the underserved could claim their identity on blockchain systems, or confirm their entitlements. In doing so, one avoids being marginalized from such technology-mediated improvements in governance.

4.3 Capacity Building

Beneficiaries and their managers may receive training on how to work with a blocked-chain, reading ledgers, resolving disputes etc in comprehensive literacy program supported by NGOs or local institutions [15]. Various literacy levels would be catered to with gamified learning material, interactive workshops and vernacular training content. Pairing them with intuitive user interfaces (voice commands, visual iconography, SMS-based systems) would simplify communication and ensure that populations in need are able to use blockchain-enabled welfare services securely without relying on intermediaries.

4. 4 Policy Recommendations

Working with global benchmarks like the EU's GDPR or Singapore's Payments Services Act [25], a dedicated task force including lawyers, tech and policy experts could establish India's blockchain regulatory backbone, managing privacy (balancing immutability against data deletion rights), security standards, and legal recognition of smart contracts. Prior to a national scale-up, phased further trials in well-endowed areas (eg Andhra Pradesh's land registry [20]) could test scalability, refine procedures and gain-user input, enure that governance is inclusive and responsive at the frontline.

4.5 Long-Term Vision

The delivery of welfare could be streamlined by the use of a combination of blockchain, and AI (for demand-driven resource allocation or predictive fraud) and IoT (real-time supply chain monitoring or biometric devices). [19] and open-source blockchain systems (such as Hyperledger) reduce license fees Public-private partnerships (representing a type of PPP) They mobilize resources and expertise both deploy solutions, cost reduces as scale grows. These synergies result in adaptive, data-driven governance for India's complex welfare ecosystem through enhanced system responsiveness, reduced operational expenditure, accelerated time-to-deploy.

V. Conclusion

Blockchain provides a landmark opportunity to enhance India's welfare system in respect of security, efficiency and transparency. Corruption can be eliminated, ghost beneficiaries can be struck off and the entitleds can get their dues if a no-alteration ledger is maintained for resources from procurement to delivery to beneficiary. Strategic solutions are required for such concerns as there being no legal framework for smart contracts and data privacy, inequitable digital infrastructure in rural regions, and issues with managing millions of transactions on a daily basis. Technology will need to improve in terms of hybrid blockchains, artificial intelligence for fraud detection and legislation to be adjusted with this new method that

blockchain is bringing on the table, laws like the Personal Data Protection Bill needs to phase decentralization of ledger that blockchain brings decentralised data privacy management like Coinfflien addresses. Phased trials, digital literacy projects and investments in rural connectivity are among factors that can support infrastructure needs and build stakeholder capacity. Costs can be saved and time to deployment shortened through public-private partnerships and linking arms with NGOs. By rolling out these policies, India can lead by example for blockchain in public service, worldwide. With the pace of technology, they might even make possible for an accountable and tech-centric government to enable a responsive welfare ecosystem that provides millions a better life in every part of this country.

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GKU Journal of Multidisciplinary Research (GKUJMR)

The Science Behind Sports Nutrition: Strategies for Achieving Peak Physical Performance

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Abstract – Objectives: Scientific nutritional strategies need to be fully implemented when optimizing athletes' performance. Evidence-based dietary practices are now essential to improving endurance, strength, and recovery in athletes. This study aims to examine the effects of scientific nutrition strategies on enhancing peak physical performance. Aims: The main purpose of this study was to investigate the importance of evidence-based nutrition strategies in achievement of athletic performance. This study also sought to investigate the role of some important dietary factors in carbohydrate periodization, protein timing, micronutrient regulation, and personalized nutrition strategies. Results: This review was based on the existing literature in peer-reviewed journals which describe studies that have looked at nutritional strategies to improve performance parameters. We synthesised research findings on macronutrient intake, hydration protocols and novel nutritional methods (e.g. nutrigenomics). Results: Our analysis indicates the effectiveness of carbohydrate periodization in sustaining endurance and the importance of post exercise protein consumption in enhancing muscle anabolism and recovery. Adequate hydration strategies facilitated thermoregulatory processes which minimized the decrease in performance when exercising for a prolonged period. Dietary interventions tailored to individual genetics and metabolic responses were seen in personalized nutrition approaches. Final Note: The science of sports nutrition provides real ways to fuel athletic performance. The intelligent implementation of contextually relevant evidence–based practices in addition to the specific responses to the training load may have great potential in optimizing strength and endurance training and recovery. Further research is needed to help develop new dietary strategies for improving performance outcomes.

Keywords – Sports Nutrition, Nutritional Strategies, Athletic Performance, Personalized Nutrition, Macronutrient Management

I. INTRODUCTION

Sports nutrition is one of the basics behind improving performance, recovery, and well-being in sport. Over the years, the link between nutrition and performance has been gradually revealed through scientific evidence, with specifically-calibrated nutritional strategies supplying real benefits to the competitive athlete (Burke et al., 2019). Since then, applying the principles of science to sports nutrition has allowed athletes to enhance endurance, strength, and recovery using targeted orientated diets (Thomas, Erdman, & Burke, 2016).

Managing your intake of macronutrients, namely carbohydrate loading and timing, protein timing, and fat utilization, is important for the fuelling of exercise and recovery from the (Jeukendrup, 2017). This is because carbohydrates are mainly responsible for glycogen store maintenance and proteins are important nutrients for muscle recovery and growth (Phillips et al., 2016). Moreover, some micronutrients like iron, calcium and vitamin D play important roles in bone mineral density, oxygen transport, and immune function of athletes (Maughan et al., 2018). Robust hydration strategies are an additional aid for thermoregulation and preventing reductions in performance during prolonged exercise (Casa et al., 2019).

Advancements like personalized nutrition and nutrigenomics open new opportunities for maximizing individual performance outputs through genetic and metabolic influenced dietary interventions (Kato et al., 2021). Athletes can use science-based approaches to nutrition to reach their peak physical capabilities, and critical performance improvements can occur over time with proper nutrition strategies.

Specifically, this study will identify how possible nutritional strategies integrated into the training season can have a direct impact on performance results (key dietary interventions to reach optimize peak performance states in well-trained endurance athletes). By adopting a science-driven nutritional approach, athletes can harness the power of precise dietary planning to optimize their performance potential.

II. METHODS AND MATERIALS

The methods of this comprehensive review were meticulously planned to cover all aspects of diet, physiology, and their roles in sports performance as a whole. The effort here was to unite what we now know and create a holistic view of how these components come together to enhance sport performance. The systematic nature of this review ensures a comprehensive and unbiased overview of the current understanding of dietary, physiological and exercise performance interactions. It will provide players, coaches, sports scientists and nutritionists with data that will all be beneficial in helping you to improve your training performance.

2.1 Literature Search Strategy:

Methods a literature search was performed using various databases (PubMed, Google Scholar, Scopus, and Web of Science). The search approach employed terms including

"sport and nutrition", "sports science", "field performance", "nutritional methods in sport" and "physiological determinants in athletes". Variations of these terms were subsequently used to include as many relevant studies as possible.

III. Criteria for Inclusion and Exclusion:

If studies were about the interaction of nutrition and health on sport performance, they were included. This included original study papers, review papers, meta analyses and expert commentaries. Only studies that provided new information, comprehensive reviews, or significant theoretical contributions to the fields of sports nutrition or exercise physiology were eligible for inclusion. Articles/studies that were not peer-reviewed, not published in English, or not specific to sports, not involving athletes, or about non-sport diet and physiological issues were excluded.

IV. Data Synthesis and Analysis:

Organizing the data into themes that represented the principal areas of sports nutrition, physiological factors that determine excellence in performance sports, and interactions between the two. We examined the methods and results of each study and its relevance to the review's primary focus. The synthesis required us to critically assess the strength of the evidence, identify convergences and divergences in the literature and derive some understanding of what the findings imply for practice.

V. Discussion:

Over the last decade, we have seen an increase in published research and reviews, sports organization consensus statements and more opportunities to gain qualifications and accreditations in sports nutrition and dietetics. This demonstrates that sports nutrition is an area of science and practice that is rapidly evolving and provides an increasing range of evidence-based advice for athletes. To reinforce and weaves together the recommendations in this paper, it is informative to consider several prevailing themes in sports nutrition which precede a more specific topic discussion.

VI. New Perspectives in Sports Nutrition:

1. Over time, nutritional needs and objectives evolve. Athletes follow a periodized schedule leading up to their peak performance in certain events, with specific needs during each phase of the training calendar from possible aerobic work with points of threshold, speed and anaerobic efforts, speed endurance, and finally competition focused work all included in these cycles of workouts. Food support needs to be spread out over time as well based on daily workout demands (which can be minimal for "easy" workouts and extreme for high quality workouts like high-intensity, hard, or very technical workouts), and across the broader macro goals.
2. However, each athlete's nutrient requirements are ultimately going to differ based not only on preferences the event itself, competitive goals, practical realities, and responses to various strategies
3. Realistically, one of the main purposes of training is to alter the body to be more metabolically efficient and adaptable. Competition diet plans are all about ensuring that substrate stores are adequate to provide the fuel necessary to compete with optimal cognitive performance.
4. Energy availability (the energy you ingest, compared to the energy you expend during training) represents an important aspect of health and also ULTIMATELY determines the efficacy of your sports nutrition strategy.
5. Acquiring the body makeup that signals peak performance is a so-called holy grail, and one that is now recognized as complex and individualistic and long-term in its design. In order to safeguard health and lifelong success, a person ought to refrain from actions that complicate access to energy and create mental friction.
6. The training–diet interaction is critical for both acclimatization and ergogenic functional and metabolic adaptations. To clarify, performance benefits from proactive dietary assistance, while adaptations to training may be facilitated without it.
7. Nutrition and exercise synergize very nicely to prepare the body for the functional and metabolic adaptations. While elite performers require proactive nutrition support to operate at their peak performance, these training changes may be best in the absence of that support.
8. The protein, carbohydrates, and energy will be expressed in relation to per kg body mass to differentiate recommendations for athletes of different sizes. Daily goals, nutrient timing and day and sport-specific guidance should all be included in a sports nutrition prescription
9. Just as with everything in life, balance is essential if not optimal, especially for highly-trained athletes who must find the fine edge between training well enough to gain maximal (positive) training stimulus without overdoing it and becoming sick or injured.
10. Several new performance nutrition tools stem from growing—but still preliminary—evidence that the brain has the capacity to sense the presence of carbohydrates and possibly other nutrients in the mouth and to

modulate performance and the decision-making to work faster. While the improvement is through a central effect, as it was previously thought that consuming these substances would not provide a metabolic gain in short events, these results therefore allow for eating or drinking in short events.

11. So it is time to get human and more practical about supplements and sports foods, which have triggered the interest and use of practically all athlete (due to its vast and effective supply, respectively), and for which a part of the products can at least be beneficial as an adjunct to the sports nutrition plan and/or directly for exercise performance15. So, again, its most appealing advantage is quickly persuading athletes to think of the advantages and disadvantages of using these sorts of products in a supportive manner and that they're only effective when complemented with a healthful eating routine

VII. ACUTE FUELLING STRATEGIES:

The guidelines promote keeping a high carbohydrate stock ready for optimal performance in competition or critical training

TABLE 7.1 SUMMARY OF GUIDELINES FOR CARBOHYDRATE INTAKE BY ATHLETES

General Fueling Up	Preparation for events < 90 min exercise	7-12 g/kg per 24h as compared to daily fuel needs	To ensure that pathogen plans are being reached, and that desires for gut comfort/policies lighter 'racing weight' are being met, athletes may select higher carbohydrate sources low in fibre/residue and easily able to eat.
Carbohydrate loading	Preparation for events 9 90 min of sustained/intermittent exercise	d (~10–12 g/kg) during 36–48 h	It all points towards, eating small regular snacks might have its advantages
Speedy refueling	<8 hours recovery between 2 fuel demanding sessions	1–1.2 g/kg/h for the first 4 hours followed by daily fuel requirements	Ensuring that fuel targets are covered can be aided by carbohydrate rich foods and drink
Pre-event fueling	Before exercise > 60 min	1–4 g/kg ingested 1–4 h prior to exercise	The timing, quantity and type of carbohydrates food and drinks should be chosen to align with the practical requirements of the event and individual preferences/experiences. If this is the case, in order to minimize risk of GI issues during the event, choices high in fat/protein/fibre may need to be avoided. Low GI options may be a better source of energy in situations where carbohydrate cannot be consumed during exercise, providing a more sustained energy source

TABLE 7.2 DIETARY SUPPLEMENTS AND SPORTS FOODS WITH EVIDENCE-BASED USES IN SPORTS NUTRITION

Category	Sports Food	Medical Supplements
Example	Sports drinks Sports bars Sports Confectionery Protein Supplements Liquid meal supplements	Iron supplements Calcium supplements Vitamin-D supplements Multi-vitamin/mineral n-3 fatty acids
Use	Practical option for achieving sports nutritional needs when food access, opportunities to consume nutrients or gastrointestinal issues make ingestion of traditional food and drink products difficult	Prevention or treatment of nutrient deficiency supervised by appropriate healthcare/nutrition professional
Concerns	Whole foods it too high price Utilized inappropriately or	Self-prescribed when it may not be clinically indicated, which may go disregarded without

Category	Sports Food	Medical Supplements
	not needed protocols	appropriate supervision or monitoring
Evidence	Burke (2015)	Burke (2015)

VIII. Experience And Responsibilities of The Sports Dietitian

The tasks performed by a sport nutritionist require an understanding of clinical nutrition, nutrition science, exercise physiology, and applying existing research. An increasing number of athletes / season people hire professionals to guide them on which foods and beverages would be best for performance and benefits. An experienced sports dietitian has the knowledge, training, and experience to help athletes and teams achieve their performance goals.

A distinctive credential in sports dietetic practice for registered dietitian nutritionists who frequently work with athletes has been established by the Commission on Dietetic Registration, responsible for the credentialing component of the Academy of Nutrition and Dietetics. The highest level of professional credential in the US in the area of sports nutrition is the Board-Certified Specialist in Sports Dietetics (CSSD). It's also available in other countries such as Canada, Sports dietetics specialists provide science-based and evidence-based nutrition assessments, recommendations, and counseling to help individuals and groups of athletes and physically active people and groups to improve health and performance through safe and effective sports nutrition practices. Visit www.cdrnet. Check this out: CSSD certification by the Commission on Dietetic Registration at www.cdrnet.org. Another way to continue your education and skills in sports nutrition is to obtain a national post-graduate qualification, such as the 2-year online learning IOC Diploma in Sports Nutrition. Visit Sports Oracle at www.sportsoracle.com/Nutrition/Home/ to find out more. According to the Academy of Nutrition and Dietetics157: *"sports dietitians render medical nutrition therapy in direct care and design, implement, and manage safe and effective nutrition strategies to enhance lifelong health, fitness, and optimal physical performance."* Now, a checklist of what sports dietitians what work with players need.

IX. Conclusion

Scientific advancements in sports nutrition have significantly improved the understanding of dietary strategies that optimize athletic performance. By adopting evidence-based approaches such as carbohydrate periodization, protein timing, and micronutrient management, athletes can enhance endurance, recovery, and overall physical potential. Integrating personalized nutrition strategies further refines dietary interventions, aligning nutrition plans with individual physiological needs. As research continues to evolve, the application of science-driven nutritional strategies remains vital in supporting athletes to achieve peak performance and sustained success.

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Influence of Specific Yoga Pranayama Practices on Vital Capacity in Sedentary College Students Living in Hostels

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Abstract – The contemporary-day lifestyle, especially inside the hostels of university college students with a sedentary lifestyle, relates to declining respiratory fitness and decreased VC. The objective of this study aimed to assess the effect of specific yoga pranayama practices (Kapalabhati, Bhastrika, Anulom Vilom) on vital capacity in sedentary college students. The study utilized a pretest-post-test control group design, and 40 participants (20 males) were randomly assigned to an experimental group (EG) (n=20) receiving a 6-week pranayama intervention or a control group (CG) (n=20) not engaging in any physical activity except their regular sedentary lifestyle. Pre- and post-intervention records of vital capacity were obtained using a digital spirometer. Statistical analysis between groups showed that an increase in vital capacity was statistically significant in the experimental group over the control group ($p < 0.05$). The experimental group demonstrated a mean post-intervention VC of 4.61 L (±0.45), surpassing the control group's mean of 4.07 L (±0.46), with the intervention explaining 81.4% of the variance in outcomes (Partial Eta Squared = 0.814). The results indicate that regular practice of certain pranayama techniques can improve respiratory performance and help counteract the effects of an inactive lifestyle. It demonstrates the efficacy of an alternate yoga-based regimen for sedentary college students in improving their lung function, significantly in the context of respiratory health.

Keywords – Sedentary lifestyle, College students, Respiratory fitness, Vital capacity, Pranayama, Kapalabhati, Bhastrika, Anulom Vilom, Lung function. Yoga intervention, Digital spirometry

I. INTRODUCTION

The current sedentary behavior (SB) profile, which includes chronic physical inactivity, has been associated with several health problems such as diminished respiratory efficiency and lung function (World Health Organization [WHO], 2020). University students, especially in hostels, generally become sedentary because of study schedule, lack of exercise and poor habits. This physical inactivity can contribute to a decrease in VC, an established measure of respiratory health and general well-being (Caspersen et al., 1985). Vital capacity, or the greatest volume of air that can be expired by the lungs following maximum inspiration, is important to sustaining the level of oxygen carried on a person's body and providing for metabolizing activities (American Thoracic Society, 2005). Preliminary evidence has indicated a promising role for yoga-based interventions to manage the respiratory health issues of these populations, particularly certain pranayama (breathing) techniques (Veerabhadrappa et al., 2011) (Mane et al 2014) (Prakash & Dhungel, 2016) (Xu et al., 2011).

There are numerous health benefits to be gained from practicing yoga, an ancient practice that originated in the Indian subcontinent and has gained popularity worldwide, most notably through its beneficial effects on respiratory function. As can be seen in the work of Joshi et al. (2012) showed the positive impact of pranayama (component of yoga characterized by regulation of breath) on enhanced vital lung capacity, optimal respiratory muscle power and improved pulmonary efficiency. Certain techniques of pranayama such as Kapalabhati, Bhastrika and Anulom Vilom have shown marked effect in enhancing vital capacity and respiratory endurance (Saxena & Saxena, 2009). These practices operate through the mechanisms of achieving more efficient breathing; reducing stress, such that perception of breathlessness is mitigated; and improving lung tissue elasticity (including contribution from the rib cage) (Raghuraj & Telles 2003).

pranayama means control of breath, which in turn is a preliminary step to, and an important part of, the actual meditation practice in yoga. The physiologic impact of slow breathing has been widely documented, being shown to induce activation of the parasympathetic nervous system and enhance cardiovascular and respiratory functions (A et al., 2014) (Russo et al., 2017). Moreover, pranayama techniques practicing regularly has been found to improve pulmonary function, including increased vital capacity. (Mane et al., 2014)

Hostel dwelling college students experience various problems and are likely to develop sedentary behaviour and poor respiratory health. It has been reported that sedentary participants have lower values of VC and worst respiratory function in comparison with physically active volunteers. Consequently, there is an increasing demand to develop efficacious interventions that can improve the respiratory health of such population and also reduce sedentary behaviour implications.

Although there is newly growing evidence on beneficial effects of yoga and pranayama, research in the context of sedentary hostel college students was not abundant. They are, therefore, of greater risk for respiratory impairment with inactivity and competitive stresses associated with the academic environment (Misra & McKean, 2000). It is thus timely to look at the effect of some specific yoga

pranayama practices on vital capacity in this set of population. This research attempts to examine the effectiveness of certain pranayama practices on vital capacity in sedentary college students living in hostels as well as add to the literature on interventions based on yoga for respiratory health.

The purpose of this paper is to study the effect of certain breathing practices from yoga (pranayama) on vital capacity in sedentary college hostellers. The study will evaluate the effects of Kapalabhati, Bhastrika and Anulom Vilom Pranayamas on Spirometric indices of vital capacity.

II. METHODOLOGY

Aim: The aim of the present study is to find out effect of certain Yoga Pranayama practice on vital capacity of sedentary college students living in hostels. Rigor, ethical considerations and feasibility were the basis of this methodology. The following is a comprehensive outline of the approach taken in this study.

III. RESEARCH FRAMEWORK

The study applied a nonequivalent control group before-and-after design. One group of participants were assigned as the experiment group and another one as control groups. The 1 group continued with their sedentary activity as usual unabated and the other group engaged in structured yoga pranayama intervention. The efficacy of pranayama training was measured as VC in both the groups before and after intervention.

3.1 Subject Selection

- Study participants: Healthy, sedentary college students living in the Birla Hostel, Banaras Hindu University (BHU), Varanasi were taken as subjects of the study.
- Sample Size: Forty students were included; twenty each in experimental and control groups.

3.2 Inclusion Criteria:

- Age range: 19 – 23 years.
- Physical inactivity (less than 30 minutes of moderate physical activity on a daily basis).
- No history in any kind of yoga or pranayama.
- No Chronic pulmonary or heart disease.

3.3 Exclusion Criteria:

- Students with any medical or physical condition that might have interfered with the study.

3.4 Group Allocation

Participants were assigned the groups on the basis of Randomize Control Trial (RCT) to either the experimental group or the control group using a simple random sampling technique. This ensured an unbiased distribution of participants across the two groups.

3.5 Intervention Protocol

TABLE 1
PRESENTS THE INTERVENTION PROTOCOL FOR THE EXPERIMENTAL GROUP FOR 6-WEEK YOGA PRANAYAMA TRAINING PROGRAM

Week	Day	Pranayama Techniques	Duration	Total Session Time
Week 1	Day 1–5	Kapalabhati (5 min), Bhastrika (5 min), Anulom Vilom (10 min)	20 minutes	5 sessions
Week 2	Day 6–10	Kapalabhati (5 min), Bhastrika (5 min), Anulom Vilom (10 min)	20 minutes	5 sessions
Week 3	Day 11–15	Kapalabhati (5 min), Bhastrika (5 min), Anulom Vilom (10 min)	20 minutes	5 sessions
Week 4	Day 16–20	Kapalabhati (5 min), Bhastrika (5 min), Anulom Vilom (10 min)	20 minutes	5 sessions
Week 5	Day 21–25	Kapalabhati (5 min), Bhastrika (5 min), Anulom Vilom (10 min)	20 minutes	5 sessions
Week 6	Day 26–30	Kapalabhati (5 min), Bhastrika (5 min), Anulom Vilom (10 min)	20 minutes	5 sessions

- **Intervention Protocol: Essentials of Intervention Details**

  Frequency: For 5 days a week (Monday - Friday) only.
  Duration per Session: 20–30 minutes.
  Ventilation: All sessions performed with a certified yoga instructor.
  Overall Time Period: 6 weeks (30 sessions).

Table 1 Summary of the pranayama training module for experimental group. Do hit me up if you need more changes, or want some cool detail shots!

3.6 Measurement of Vital Capacity

- **Instrument:** The digital spirometer is a reliable and validated tool for the estimation of lung function, used in this investigation to measure the vital capacity.
- **Methods:** Vital capacity was assessed at baseline for each participant (pre-intervention). Post-intervention was assessed after 6 weeks of the program. Subjects were asked to measure their spirometry in a seated position according to standardized procedures described by the American

Thoracic Society (2005). Three readings were obtained for each participant and the highest pressure was used for analysis.

IV. Data Collection

Two set of data were gained in Pre-test: Prior to the intervention and Post-test: After 6 weeks of intervention respectively. All measurements were registered and saved safely for analyses.

4.1 Statistical Analysis

- Analyses were performed using statistical tools (such as SPSS version 25).
- Descriptive statistics (mean, standard deviation) were calculated for both groups.
- Anova was used as a statistical technique to compare both groups on the given parameters.
- The level of significance was set at **$p < 0.05$**.

V. Results & Analytical Interpretation

Based on the nature of the collected data, the normality of data between-subject factors, and descriptive statistics, the present status of vital capacity in sedentary hostelers of BHU, Varanasi, was determined.

TABLE: 2

BETWEEN-SUBJECT FACTOR IN RESPECT TO VALUE LABEL AND NO. OF SUBJECTS.

Between-Subjects Factors			
		Value Label	N
GROUP	1.00	control	20
	2.00	experiment	20

This table 2 displays the between-subjects factors in an experimental design along with the number of subjects in each group. The study contains two groups (a control group 1.00 and an experimental group 2.00, N = 20 per group). The second value represents the group names (in the Value Label column) and the third, how many were in each group (the N column). This indicates that the research is using a between-subject design where all participants will only be in either the control group or the experimental group, and this way the outcomes can be compared between conditions.

TABLE: 3

DESCRIPTIVE TABLE OF VITAL CAPACITY.

Descriptive Statistics			
Dependent Variable: POST			
GROUP	Mean	Std. Deviation	N
control	4.0705	.45757	20
experiment	4.6135	.44973	20
Total	4.3420	.52549	40

Descriptive statistics related to the dependent variable POST for both the control and experimental groups are contained in this table 3. On average, the experimental group scored higher with an average of 4.6135 and a standard deviation of.44973 compared to the control group's 4.0705 and.45757. The survey was completed by 40 participants and their average score was.3420 (standard deviation = 0.52549). The experimental condition was superior to control for the dependent measure, indicating that the manipulation may have been effective. The relatively low standard deviations in each group, however, indicate that there is not much variation in the test scores within each group.

TABLE: 4

ANALYSIS OF VARIANCE OF THE MEAN OF PRE AND POST-TEST IN RELATION TO VITAL CAPACITY.

Tests of Between-Subjects Effects						
Dependent Variable: POST						
Source	**Type II Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	10.435[a]	2	5.217	576.487	.000	.969
Intercept	.027	1	.027	2.942	.095	.074
PRE	7.486	1	7.486	827.179	.000	.957
GROUP	1.462	1	1.462	161.576	.000	.814
Error	.335	37	.009			
Total	764.888	40				
Corrected Total	10.769	39				

This table 4 displays the outcome of a Between-Subjects Effects analysis (presumably an ANOVA) regarding the POST-dependent variable. Here's a concise description of the findings:

The Corrected Model demonstrates statistical significance with an F-value of 576.487 and a p-value less than .001 while explaining 96.9% of the variance in POST scores according to the Partial Eta Squared measure.

The PRE variable, which functions as a covariate like the pre-test score, shows a substantial impact on POST scores ($F = 827.179$, $p < .001$) and accounts for 95.7% of the variance.

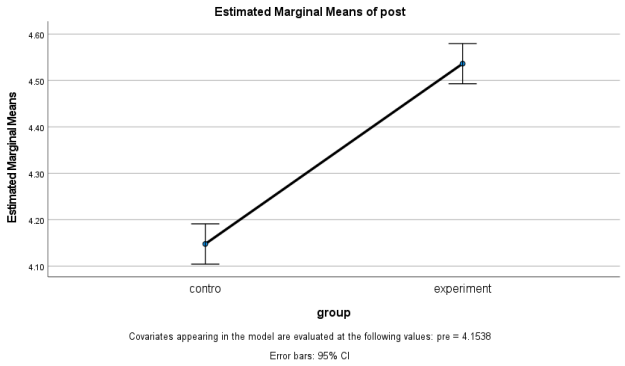
For the POST scores there is a strong effect of the GROUP variable ($F = 161.576$, $p <. 001$) by explaining 81.4% of the variance of work score.

The Intercept is not significant ($p =. 095$), indicating that the baseline mean POST score equals zero even when controlling for other variables.

The error term indicates that unexplained variance remains very low since the Mean Square Error equals .009. The statistical model shows that both PRE covariate and GROUP factor impact POST scores significantly while accounting for 97% of the dependent variable's variance. The experimental manipulation together with the

covariate demonstrates a powerful impact on the overall outcome.

Profile plots



After adjusting for the covariate pre **(4.1538),** the following graph shows the estimated marginal means of post for both Control and Treatment variables: A positive estimated marginal mean **(that is larger in the experimental group compared with controls)** suggests a beneficial effect of the intervention. The error bars indicate a minimum overlap, which demonstrate statistical significance between the groups, and represent a **95% confidence interval (CI).** The experimental condition produced enhanced outcomes when compared to the control condition providing evidence for efficacy. Based on these findings the intervention had a significant effect on the dependent variable.

VI. DISCUSSION

The results of the present study are consistent with earlier reports on positive effects of pranayama techniques in respiratory health. The remarkable improvement in VC among the experimental group may be due to physiological effects of pranayama, such as increase lung elasticity, strengthening of respiratory muscles and encouraging better breathing habits. The study highlights the scope of yoga-based practices to overcome SE among college students staying in hostels.

VII. CONCLUSION

The present study finds that short term yoga pranayama practices like Kapalabhati, Bhastrika and Anulom Vilom can significantly enhance vital capacity in sedentary college going students. The results indicate that the yoga programs should be integrated into sedentary people's daily lives to improve their respiratory health and overall well-being. Future studies should investigate the long-term effects of practice of pranayama in another sedentary future research subjects.

VIII. ACKNOWLEDGMENT:

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GKU Journal of Multidisciplinary Research (GKUJMR)

Systematic Review of Understanding the Relationship Between Mesomorph and Speed in Sports: A PRISMA 2020 Analysis

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Abstract – The relationship between mesomorph body type and speed in sports is a complex and multifaceted area of research. This systematic literature review aimed to explore the connection between somatotypes and speed variations, focusing on the biomechanical factors that enhance speed in mesomorphic athletes and the role of the skeletomuscular system in speed-related activities. Following PRISMA 2020 standards, a structured internet search was conducted using PubMed, Google Scholar, and COPE (UK), yielding 1,275 research articles. A total of 27 articles were reviewed in depth after the exclusion and inclusion criteria-based quality screening, and 10 articles were highly evaluated. The results revealed that mesomorphic athletes, built athletic and muscular who had an edge to it in terms os having better physical properties for speed performance; having higher muscle fat ratio as a result of using energy systems efficiently, increased % of fast twitch muscles. But more than just foot speed, a number of other factors contribute to an athlete's overall ability to move at high velocity. The review emphasizes the value of understanding body shape-speed relationship with respect to optimizing position-related and sports-specific tactics and talent identification policies, training programmes. Additionally, the results are applicable in the context of fitness and rehabilitation treatments. Future studies should examine the interaction of somatotype, biomechanical determinants and skeletomuscular characteristics to fully establish the mesomorph body form relationship with speed in sports.

Keywords – Mesomorph, Somatotypes, Biomechanics, Fast-twitch muscle fibres, Body composition, Sports performance

I. INTRODUCTION

Sports that require power, speed and coordination are the best sports for those who have a mesomorphic body type. Strong and fast with muscles awhirl and metabolism ablaze, they have the ability to explode power in activities such as sprinting, football and gymnastics. But remember that success in sports is not a product of body type alone, as training, technique and mental preparation contribute greatly to athletic performance. Mesomorphs are well-suited to sports that demand a high level of strength and speed. The human body is very closely related to how animals' function, if we just weigh them up a little, they'll get far more explosive, suitable for activities such as sprinting, football and gymnastics etc. However, it should be remembered that being a certain body type does not automatically mean an individual will excel at sports, as training, skills and mental readiness are also significant in determining athletic success. The bond between the mesomorpish body form and velocity in athletic sports is intricate, multidimensional. The mesomorphs with an athletic and muscular body build, however, make them have some attributes that may help improve the speed (Cinarli et al., 2006). Their innately higher muscle to fat percentage and speedier metabolism enables greater power output, like faster sprints and jumps, which are integral in velocity-based sports. Fast twitch muscle fibres are what power sprint and fast acceleration, so the more of them you have, put simply, the faster and more explosive you're going to be. Mesomorphs may have more favorable body composition (eg, less unwanted weight) which is associated with needing less energy during locomotion. Nevertheless, it should be acknowledged the genetic advantage of mesomorph in speed-related sports some o ther factors (e.g. training, technique, nutrition and mental training) majorly influence on athletes' performance of too fast running as well (Baranauskas et al., 2024).The mesomorphic body type should be viewed as a potential foundation for speed development rather than a guarantee of superior performance in sports.

1.1 Significance of the study:

The systematic literature review related to Relationship between Mesomorph and Speed in Sports is responsible for providing adequate knowledge in sports. The systematic literature review highlights the Understanding the Relationship between Mesomorph and Speed in Sports. This knowledge will fill the knowledge gap related to body somatotype and performance in sports.

This study examines whether mesomorphic athletes, known for their muscular and balanced build, have a natural speed advantage in sports. Coaches can design training plans based on body type. Because mesomorphs develop speed: others can make gains in the weight room (as well as leaning out a bit, perhaps gaining muscle and making biomechanical adjustments). Mesomorphic athletes who perform well in speed events also have higher injury rates, particularly of the lower extremities. Proper body composition knowledge helps prevent injuries through mobility work, recovery, and biomechanical corrections. Appropriate sport-specific training is vital and necessary to improve sports performance, reduce injury risk, and achieve one's full competitive potential (Wang et al., 2024). Here we show how speed and its wider significance depends on the body type. Outside of sports, the findings may help

in fitness and rehabilitation programs. Coaches and recruiters can use this knowledge to identify and train athletes with ideal body types for sprinting, improving talent selection and development.

II. OBJECTIVE

1. To analyse the somatotyping relationship with the speed variabilities
2. To understand the biomechanical indicators of mesomorph athletes in developing speed.
3. To review skeletomuscular relationship during various activities involving speed.

III. REVIEW QUESTION

What is the role of somatotype in speed variation, and which biomechanical and skeletal muscular factors contribute to speed power among mesomorphic athletes?

3.1 Aim of the review

The purpose of this brief review is to discuss the relationship between somatotypes and speed qualities, with special emphasis on biomechanical factors that lead mesomorphic individuals in particular to develop greater speed. It also looks at the skeletomuscular system in relation to speed-dependent reactions.

IV. METHOD

The PRISMA 2020 standards were followed for conducting this review (Haddaway et al., 2022).

4.1 Literature search and Inclusion/Exclusion Criteria

The information was collected by a structured search of the internet on PubMed, Google scholar and COPE (UK). The spidering strategy consisted of key words such as "Mesomorph", "Somatotype", "Speed" and "Body Composition", according to the current information. We only included human studies published in English between 2014 and 2025, were considered. We excluded editorials, comments, case reports, primary qualitative research studies, book chapters and reviews. We have been removed the duplicated articles as all databases were combined. The quality of the studies was subsequently appraised by reviewing their abstracts, full texts and titles. Studies that did not meet these criteria were excluded. Articled published after 2014 and peer-reviewed were included. Articles that were not peer reviewed or published in English were excluded.

After conducting a thorough search using PubMed, Google Scholar, and COPE (UK), a total of 1,275 research articles were identified. Duplicate entries were removed using Mendeley, reducing the count by 329. Automated tools flagged 946 records as ineligible. An additional 323 articles were excluded due to complicated or irrelevant titles. This left 152 records for screening based on titles and abstracts. However, 87 records were inaccessible due to journal restrictions. Further exclusions were made for high risk of bias (11 articles), lack of clarity (6 articles), and studies focusing only on male subjects (21 articles). In the end, 27 articles were selected for review. Total 10 articles were reviewed from the selected documents for review.

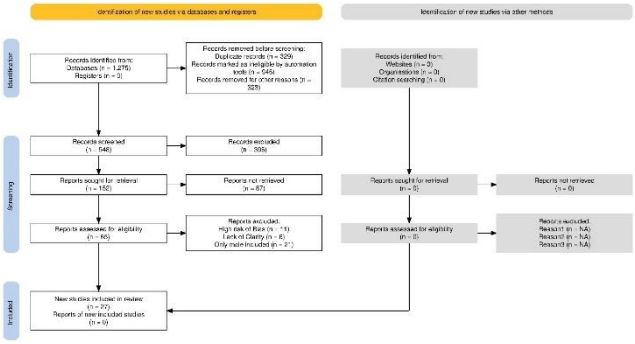

Figure 1: PRISMA 2020 Flow Diagram (Haddaway et al., 2022)

4.2 Description of all studies and Results

(Ryan-Stewart et al., 2018a) examined the relationship between somatotype and anaerobic performance in 36 physically active males. Positive correlations were found between mesomorphs and 3 RM bench press ($r = 0.560$, $p < 0.001$), back squat ($r = 0.550$, $p = 0.001$), and minimum power output ($r = 0.357$, $p = 0.033$). Negative correlations were observed between ectomorphs and 3 RM bench press ($r = -0.381$, $p = 0.022$) and back squat ($r = -0.336$, $p = 0.045$). Mesomorph was the best predictor of upper body strength, while a combination of mesomorphic and ectomorphic predicted lower body strength, explaining 31.4% and 38.8% of variance, respectively.

Fahrii Safa et. al. studied the effect of somatotype variations on cognitive and bio motor characteristics in 172 subjects. Endomorphs had the highest cognitive ratio (THEE: 242.60±21.83), and ectomor-phs had the lowest (227.46 ± 27.96). Re: Mesomorphs excelled in bio motor tests, they performed better showing better scores in sprint and jump and aerobic capacity (YIRT-1: 1532.6+770.7, p=0.00). Ectomorphs also received high average scores in aerobic capacity (1364.8±669.9). Endomorphs demonstrated the lowest performance in strength and flexibility tests. Moreover, significant differences were found between CMJ (p=0.041), YIRT-1 (p=0.00) and MaxVo2 (p=0.00), suggesting somatotype result in both physical and cognitive performance (Cinarli et al., 2022).

(Senol et al., 2018) investigated the relationship between somatotype and isokinetic knee muscle strength and dynamic balance among 146 asymptomatic volunteers (88 males, 58 females). There were six somatotypes, the endomorphic mesomorph being the most frequent. There

was no statistical difference between somatotypes for knee extension strength at 90°/sec, 120°/sec and 150°/sec and flexion strength at 90°/sec and 120°/se (p0.05). These results imply that physiques cannot be meaningful for isokinetic strength and balance in physically active individuals.

(Dhoni Akbar Ghozali et al. Indeed,) examined a sample of 27 professional Indonesian soccer players. To determine effects of somatotype and %BF on participants' VO2max which is related to running performance. A whopping 88.9% of individuals fit into the mesomorph-endomorph somatotype. For mesomorph, a significant association occurred in aerobic capacity (r=-0.515; p=0.006), with body fat manufacturing ration (r=-0.448; p= 019) and running (speed (r=-0.548; p=003). Younger athletes had significantly higher VO2 max values, indicating an age effect. We found that somatotype strongly affected fat and velocity, suggesting that training should be adapted accordingly.

(Cinarli et al., 2022) The effect of dominant somatotype on jumping and sprinting ability among young adults. Primary findings6, 12 the balanced mesomorph exhibited higher VJH and P/BM compared with the MESO-ENDO. There were also significant differences in 30 m sprint time and velocity between mesomorph and endomorph-mesomorph groups as well as central group, they were slower than meso-mesoendom and ecto-ectomeso groups. Notably, both balanced ectomorph and mesomorphic ectomorphs had less sprint momentum compared to balanced mesomorphs at same 20 m sprint speed. The study revealed that balanced mesomorphs excelled over the mesomorph-endomorph group in vertical jump and power indexes adjusted for body weight. Central and mesomorph-endomorph types also had faster 30-m sprint times and higher sprint velocity than endomorphs. Although sprint momentum was inversely related to sprint FO at each speed for balanced ectomorphs and mesomorphic ectomorphs, it was lower in comparison with balanced mesomorphs. Moderate effect sizes were observed for all significant differences.

The results show that competitive handball divisions generate consistent dependencies between morphological traits of athlete players. Research by Lijewski et al. (2021) compares Super League rivals to have better somatotype and more pronounced body structure that results in higher levels of physical performance on court. The body proportions of elite athletes accelerate their ability to perform handball-specific movements effectively. The team rankings displayed an 88% variability rate that could be fully explained through hand length combined with arm length and upper limb span and lower limb length measurements. Such physical features demonstrate their usefulness as indicators to determine natural handball suitability. The handball players from various competition levels showed uniform somatotype patterns as their bodily proportions continuously fit within the balanced mesomorph classification (Lijewski et al., 2021).

Classified 67 youth football players in three playing positions between the ages of 15 and 17 years based on somatotype. The height and weight of goalkeepers were significantly greater compared with defenders, midfielders, and forwards. Most positions presented an average somatotype of balanced mesomorphic, and imposed the midfielders to percieve it as ectomorphic-mesomorph. Differences were noted in arm circumference, triceps skinfold, and medial calf skinfold, with goalkeepers showing higher values. The findings suggest that morphological characteristics vary by position, aiding in talent selection and tailored training programs. The study highlights the importance of somatotype analysis in youth soccer development.

(Van der Zwaard et al., 2019) used k-means clustering to analyse anthropometric data from 24 competitive male cyclists, categorizing them into three clusters: mesomorphic (sprinters), short meso-ectomorphic, and tall meso-ectomorphic (endurance cyclists). Sprinters exhibited higher mesomorphic and superior sprint performance, while endurance cyclists showed higher ectomorphic and better endurance performance. Anthropometric traits like lean body mass, small girths, and low frontal area correlated with endurance performance, whereas larger girths and skinfolds were linked to sprint performance. The findings suggest that cyclists' anthropometry aligns with their specialization, highlighting the role of body composition in cycling performance.

(Strauss et al., 2021) examined the morphological characteristics of 101 sub-elite South African female football players, revealing significant differences between goalkeepers and outfield players. Goalkeepers were taller (166.2 cm), heavier (66.5 kg), and had higher body fat percentages (17.2%) compared to outfield players. Outfield positions (forwards, midfielders, defenders) showed minimal differences in height, weight, and body composition. The overall group had an average body fat percentage of 20.8% and a somatotype of 4.0–2.4–2.1. These findings provide normative data for sub-elite female football players, highlighting position-specific physical traits essential for performance and training adaptations.

(Nobari et al., 2021) studied 27 elite U-16 male soccer players, analysing anthropometric, maturation, somatotype, and fitness parameters across positions. Goalkeepers (GK) showed higher height, weight, maturity, body fat (BF), and lean body mass (LBM) compared to others, while wingers (WG) had lower BF. Central midfielders (CM) had higher endomorph values. Pre-season, WG had higher VO2max

and accumulated training load (AcL), while GK had higher peak power (PP) and fatigue index (FI). Post-season, CM showed higher VO2max. The study highlights positional differences in physical and physiological traits, aiding coaches in tailored training and talent development.

V. Results and Discussion

The relationship between somatotype and sport performance studies emphasizes its effect on physical and cognitive results in different sports. The literature clearly demonstrates that body type impacts strength, speed and endurance, which highlights the necessity of personalized training programmes (Pérez-Ramírez et al., 2024). Mesomorphs are typically strong athletes who have a lot of strength, whether it be restricted to upper or lower body. Namely, ectomorphs have lower strength abilities whereas endomorphs tend to outperform in cognitive tasks (Abcde & Abcd, 2019; Ryan-Stewart et al., 2018b). This indicates that somatotype or body build is an important contributor to anaerobic performance and skill specialization. Regarding knee muscle strength and balance; however, some previous studies found no significant differences between body types, suggesting that somatotype might not affect all of the physical characteristics under consideration to the same extent (Senol et al., 2018). However, the body composition of elite athletes does correlate with sport-specific capabilities, such as running speed and aerobic power. In explosive exercises such as sprinting and jumping, the hourglass mesomorph body type is far superior to other body types (Cinarli et al., 2022). 4Likewise, elite handball athlete's present distinctive physical characteristics that are related to team position, supporting the role of body build in elite performance.

Differences by position also occur in team sport. For instance, goalkeepers have different body compositions to outfield players (Muros et al., 2022) and cyclists differ in morphology depending on whether they are a sprint or endurance specialist. These patterns correspond with the physical requisites of positions and duties. Research agrees the somatotype is a key factor in athletic performance. Understanding these distinctions can contribute to adjustment of training approaches, talent identification and enhancement of performance in different sports at different levels (Ciftci & Kurtoglu, 2023).

VI. Conclusion

This study aimed to provide a comprehensive overview of connections between mesomorph body structure and speed-among athletes-driven by biomechanical and skeletomuscular circumstances improving training effectiveness. Mesomorph athletes, who tend to be muscular with a naturally higher ratio of muscle-to-fat and a preponderance of fast-twitch muscle fibres have amazing speed combined with explosive power, making them ideal for sprint events and aerobic exercise. But there are other things, such as training, technique, nutrition and mental preparation that have a lot to do with performance. This review points out the significance of personalized somatotype-specified training programs in the selection of talents, prevention of injury and performance improvement. The dynamics among somatotype, biomechanics and skeletomuscular traits remain to be studied to extend the understanding and application in sports science.

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GKU Journal of Multidisciplinary Research (GKUJMR)

Enhancing Knee Flexion and Function After ACL Surgery in Hockey and Gymnastics Players: A Focus on Exercise and Swimming Therapy

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Abstract – One of these six ligaments that work on stabilizing the knee, is known as the anterior cruciate ligament (ACL). ACL injury therapy must be extensive to restore knee function and avert long-term consequences, such as osteoarthritis. This review provides an in-depth look into the post-operative rehabilitation process for athletes recovering from ACL surgery, specifically focusing on a five-phase recovery program. METHOD- This five-phase rehabilitation program was developed with the expertise of a multidisciplinary team, including orthopedic surgeons, physiotherapists, and sports conditioning coaches, and rehabilitation specialists, who work daily with ACL injury patients. The phases are designed to progressively restore knee function, with an emphasis on achieving full range of motion, strengthening, and sport-specific movements. The observation method used to improvement of angle of knee joint. PROCEDURE- The first phase, covering the focuses on pain management, swelling control, and early weight-bearing exercises. The second phase, aims to improve knee flexion and strengthen the knee with activities like squats and proprioception training. The third phase involves returning to more complex movements and light agility training. In the fourth phase focus shifts to sports-specific movements and agility drills. The final phase involves preparing for a full return to sport, with a focus on strength, flexibility, and sports-specific exercises. Rehabilitation milestones—such as knee range of motion, strength, and agility—proved to be essential in tracking progress and ensuring the athlete's readiness for return to sport. RESULT- The main goal of the rehabilitation program is for the player to return to full performance within 8 to 9 months. Rehabilitation milestones—such as knee range of motion, strength, and agility—proved to be essential in tracking progress and ensuring the athlete's readiness for return to sport. CONCLUSION- rehabilitation milestones—such as knee range of motion, strength, and agility—proved to be essential in tracking progress and ensuring the athlete's readiness for return to sport.

Keywords** – **cruciate, knee, rehabilitation, progression, guidelines, protocols.

I. INTRODUCTION

The ACL is an important ligament in the knee joint and can be injured by several mechanisms. The ACL, PCL, MCL and LCL are the four primary ligaments that support the knee joint—the knee as you know it. The anterior cruciate ligament (ACL) is located within the knee joint and stabilizes the knee, allowing for rapid changes of direction, twisting or pivoting. Its main jobs are to stabilize the knee and to restrain movement of a shinbone (tibia) in relation to the thigh bone (femur). Fast stops, sharp turns or collisions -- whatever the cause of your ACL knee injury, it's time to rise above it. Soccer, basketball, football and skiing are some of the most common sports that can lead to these types of injuries. Pain, swelling, instability and restricted knee range of motion are typical manifestations associated with anterior cruciate ligament (ACL) injury which can range from partial tears to complete ruptures. Treatment depends on how bad the ACL tear is and how active you are. Perhaps it contains:

Conservative treatment includes decreasing activity, strengthening the muscles of the knee through physical therapy and use of a brace to assist with stabilizing the knee.

Surgery: For some, particularly athletes or those who have more severe types of ACL injury, graft tissue from elsewhere in your body or a donor might be required for surgical repair. Arthroscopic device is mostly used for this surgery.

Healing: Whether the knee has been operated on or not, physical therapy and rehabilitation establish knee strength, motion and functional stability.

II. RELATED WORK

According to Recent study in India. The survey was completed by 135 surgeons. 35 percent of them have experience spanning more than 12 years. 35.5% of surgeons came from government - funded academic institutions. Clinical evaluation (94.8%) was the most frequently used factor in surgery decision-making.

Hamstring tendon was the most popular graft (94%), while the most popular fixation techniques were interference screws on the Tibia side (80%) and suspensory fixation on the femur side. According to this poll, almost two thirds of surgeons brace the ACL graft during the early healing process.

III. METHOD AND MATERIAL

In this research paper, the observational method was employed to study the rehabilitation progress of 10 to 12 athletes at the Kolkata NCOE Centre who have recently undergone rehabilitation for ACL injuries.

The total number of individuals involved in the rehabilitation period of 8-9 months for an ACL injury includes:

- Doctor
- Physiotherapist
- Strength and Conditioning Coach
- Senior Coach
- Biomechanics Specialist

Post operation 1st week treatment of the acyl knee injury

Figure 1: No movement

"After the surgery, there is no movement of the knee; only medication, dietary restrictions, and icing are recommended to reduce knee swelling."

Figure 2: Elevation of Leg

"After 2-3 days, attempt leg elevation in different directions: forward, sideways, and gently press a towel below the ankle and after 2 weeks below the back side of knee also."

IV. DESCRIPTION

Post Operation Time Period Divided in **Five phases** for full rehabilitation.

4.1 Third to eight Weeks (3rd – 8th weeks)

Target of 1st phase-

- Achieve knee flexion Range of motion 0° degree to 90° degree.
  - Full passive extension
  - Control post-operative pain/swelling
  - Early progressive weight bearing
  - Active therapeutic exercise program

Treatment –

- Leg raises 30 repetitions
- Leg raise right and left 30 repetitions
- Hip abduction movement (12 inches leg raise) 10 repetition
- Active flexibility/ active-assisted 45° degree exercise
- Less use of brace locked at 0° degree
- Bilateral weight bearing
- Upper extremity cardiovascular exercise included
- Cryotherapy (quarter in a day)
- Progressive weight bearing

4.2 Nine to fifteen weeks (9th -15th weeks)

Target of 2nd phase –

- Achieve knee flexion Range of motion 0° degree to 140° degree
  - Full active flexion and extension
  - Ameliorate the pain/swelling
  - Full body weight bearing without brace
  - Patella mobility exercises
  - Active therapeutic exercise program

Treatment –

- leg curl and leg extension with 500 gm weight
- Half squats (only 90°)
- Proprioception training with the help of (BOSU ball/Therapeutic band/prop board)
- Hip, Hamstring and Calf flexibility exercise
- 10 min jogging on treadmill (6 level)/cycling/running on grass

4.3 Sixteen to Twenty-four weeks (16th -24th weeks)

Target of 3rd phase –

- come back to full range of movement
  - Improve lower normal balance and flexibility movement
  - Mild lower strength with light weight
  - Ascending and descending movement with fine leg control without pain
  - Light Agility movement

Treatment-

- From this week will GYM will be added
- Half squats (up to140°) with pain free movement
- Leg flexion and leg extension on machine with gradual increase weight
- 15 min running
- 20 min Swimming
- Balancing exercises on BOSU ball/Therapeutic band/prop board i.e. stand for a min both leg, one leg, squat with balancing etc.
- Use swill ball for core stability

- Light to medium agility training on grass field

4.4 Twenty-five to thirty first weeks (25th - 31st weeks)

Target of 4th Phase-

- achieve basic movement in the individual's sports
  - Lower leg balance and flexibility movement with Thera band/resistance band
  - Maximize strength and flexibility as to meet demands of activities of daily living
  - Unconscious Ascending and descending movement without pain
  - Agility movement in drill

Treatment-

- Unconscious fine movement on field
- Half squats with full range of movement pain free
- Leg exercises in Gym i.e. leg curl, leg extension etc.
- 20 min slow continuous running / 30 min swimming
- Agility training & movement exercise (shuttle run, zig-zag run, high knee and back kick run etc.)
- Core stability exercise with Swiss ball (free core exercise plank, V-hold etc.)
- Balancing exercises on BOSU ball/Therapeutic band/prop board three day in a week

4.5 Thirty second to thirty-nine weeks (32nd to 39th weeks)

Target of 5th phase-

- Return to Sports with fine movement
  - Absence of apprehension during sports-specific movement
  - Isokinetic exercise with game specific
  - Optimize Strength and flexibility to meet the demands of an individual's sporting activity.

Treatment-

- Plyometric exercise i.e., box jump, single & double leg jump etc.
- Running, sprinting movement with different direction.
- Hockey and gymnastic sports specific movement with equipment.
- Playing the match up to 10 minutes in hockey
- Event Perform on beam and soft/balance landing in gymnastics
- Core stability exercise, Balancing exercises and strength exercise will continue simultaneously thrice in a week.

NOTE - *"In the 4th and 5th phases, muscle soreness is prevalent, necessitating the utilization of recovery techniques such as ice baths, massages, and stretching to achieve complete body recovery."*

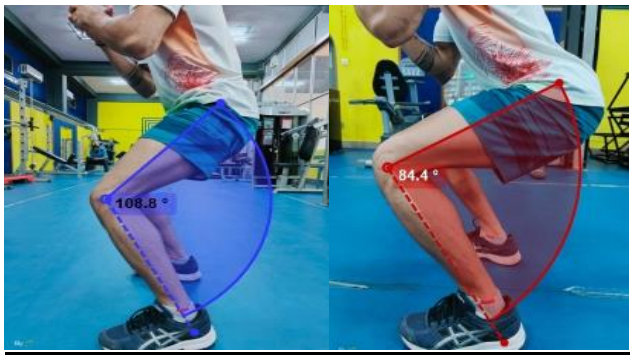

Figure 3: Free weight squat

Figure 4: Swiss ball for stability movements

Figure 5: Isokinetic movement in Gym

Figure 6: Leg curl with increasing load

V. RESULTS AND DISCUSSION

Following ACL reconstruction, emphasis on rehabilitation has moved from protocols to progression and incremental advances in difficulty. The rehabilitation specialist must consider the stresses applied on the healing ACL graft and patellofemoral contact pressures created by some exercises and activities. The early goal should be to minimize edoema, build up the quadriceps, and regain complete knee extension. Rehabilitation exercises should be conducted in

multiple locations and added to and made more difficult consistently. Neuromuscular training as a part of the rehabilitation protocol ought to be started when it is considered allowed. As a consequence, you must progress nicely during the treatment. Objective measures, rather than date of return to play, should be used in the evaluation of ACL rehabilitation. Rehabilitation interventions have to be frequently modified by the professional expert who works with the patient and only challenging exercises are selected for a particular patient's treatment. Achieving objective criteria at the time of RTP cannot only minimize risk of second injury, it would prevent other injuries. By now we all know that this change has been under way for more than nine months. The level and duration of sports participation should be decreased after rehabilitation. Although the program produced some promising results, it's also worth noting that everyone recovers from ACL surgery differently. Factors such as age, pre-accident fitness level and the extent of the injury might influence recovery time. This heterogeneity emphasizes the importance of regular monitoring of athletes in all stages of recovery to ensure they are progressing at the appropriate rate. Athletes had objective rehabilitation milestones such as knee mobility, strength and agility to track their progress and ensure they were ready to return to play.

VI. CONCLUSION

In conclusion, this review underscores the complex challenges and recent advancements in ACL injury management and treatment, with a particular focus on the importance of biomechanical understanding, graft material selection, and emerging techniques such as bridge-enhanced repair. It is clear that continued collaboration among researchers, medical professionals, physiotherapists, and sports conditioning coaches is crucial to improving the long-term outcomes of ACL injuries and rehabilitation protocols. To reduce the risk of re-injury, it is essential that objective rehabilitation milestones are met before an athlete returns to sport. More than eight months of recovery are typically required to achieve sufficient healing, with a structured return-to-sport progression necessary for minimizing further damage. In the post-rehabilitation phase, managing the volume and intensity of athletic activity is critical to avoid overloading the knee joint before full recovery is achieved. ACL injuries demand significant attention and a comprehensive rehabilitation approach to restore knee function, alleviate pain, and lower the risk of future complications, such as osteoarthritis. By adhering to tailored rehabilitation strategies, athletes can optimize their recovery and safely return to their sports activities.

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GKU Journal of Multidisciplinary Research (GKUJMR)

Comparative dissolution study in different pH conditions of Bilastine Tablet

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Abstract – The rate of drug release of a solid dosage form through different periods can be assessed using disintegrating studies. In this study, we aimed to compare 2 bilastine tablets available in Bangladeshi market. Three different buffer media are utilised, having pH 1.2, 4.5 and 6.8 respectively. The HPLC parameters are as follows: mobile phase, buffer: acetonitrile (pH 4.0), 6.5:3.5; column, Kromasil C18 (150 mm X 4.6 mm, and 5µm); detection at a wavelength of 207 nm with the temperature set at an oven temperature of 25°C and flow rate was kept at 1 mL/min using PDA detector. The similarity factor of the type a bilastine tablets (at pH 1.2) is 83.27 and for type B bilastine tablets (at pH 1.2), difference factor is 1.01. Both of these requirements are fulfilled by the USP standard. But in other conditions pH 4.6 and 6.8 not same. These result show that the dissolution profile of B category tablet is not suitable formulation further in vivo test is required for the justification the plasma profile level at different time interval.

Keywords – RP-HPLC, Dissolution, Bilastine, Similarity factor, Difference factor.

I. INTRODUCTION

Tablet is a most common form of solid dosage form. It has many advantages over the other dosage form like liquid or semisolid. The solid dosage form such as tablet, capsule form drug release depends on the formulation form of the dosage form and its physiochemical nature of the molecule [1]. The formulation can enhance the dissolution process by adding different types of excipient with the active pharmaceutical ingredients. When the drug product release from the drug product the next step is drug absorption. Lipophilic drugs are more bio permeability properties than the hydrophilic drugs. So there is BCS drug category that indicate the how any drug nature in the physical, chemical and the attributes with the body permeability [2]. The dissolution test ensures any drug how fast release from its dosage form. If the drug molecules release from the product than it easily has the chance to go its active site of action by absorption process. When the inventor company make a dosage form the other market company also make same tablet but there is needed to the bioequivalence study to approve the pharmaceutical guideline.

The dissolution profile is one of the major parameter to pass this approval. The difference factor f_1 and similarity factor f_2 result also needed for support this data. The difference factor (f1) and the similarity factor (f2) are used to compare the dissolution profiles of a test formulation with that of a standard product [3]. These factors help to detect whether two dissolution curves are sufficiently close to one another, which is important in dosage form development and regulatory submissions [4]. The percentage of inaccuracy between the two profiles at each time point is measured by the difference factor (f1). This indicates how different the test and standard products are in terms of the quantity of medication dissolved. According to previous research [5], a low f1 number (between 0 and 15) suggests that the two medication profiles are quite similar. The medication formulations could not be comparable if the f1 value is high, as it indicates a larger variance. Both profiles are comparable and may be thought of as interchangeable if the f2 value is in the 50–100 range. A substantial change in the dissolving behavior of the dosage form is indicated by values below 50 [6].

Anxieties are often treated with bilastine, a second-generation antihistamine [7]. Allergic reactions are alleviated because it inhibits peripheral H1-histamine receptors. Patients requiring alertness for everyday tasks may find bilastine useful since it has less penetration across the blood-brain barrier and considerably fewer effects on the central nervous system compared to first-generation antihistamines. After being taken orally, the medication is absorbed quickly and reaches its peak plasma concentrations in about an hour to two hours [8].

Bilastine has a relatively long half-life, allowing once-daily dosing without significant accumulation. It has a limited hepatic metabolism and a low potential for interactions with other drugs. These characteristics make it a preferable option for individuals with hepatic impairment or those receiving multiple medications. Clinically, bilastine is indicated for the treatment of seasonal and perennial allergic rhinitis as well as chronic spontaneous urticaria. Its efficacy in relieving nasal congestion, itching, and skin wheals has been well documented. The medication is generally well tolerated, with adverse effects such as headache or mild drowsiness occurring rarely [9].

II. METHODS AND MATERIALS

2.1 Materials information

Bilastine 20 mg tablet of A category pharmaceutical and B category pharmaceutical were sold from the local market of

Bangladesh. Where A is from the top ten company of Bangladesh and B is in the from twenty to thirty ranking company. The chemicals from Merck, Germany, included acetonitrile, formic acid, triethylamine, hydrochloric acid, sodium acetate trihydrate, acetic acid, sodium hydroxide, and potassium dihydrogen phosphate.

Mix 8.5 mL of hydrochloric acid with 500 mL of filtered water, and then add 1000 mL to make the dissolution medium (0.1 N HCl pH 1.2).

The dissolving agent, an acetate buffer with a pH of 4.5, is prepared by mixing 2.99 g of sodium acetate trihydrate with 14 mL of acetic acid to a final volume of 1000 mL.

Mix 6.8 grams of potassium dihydrogen phosphate with 0.896 grams of sodium hydroxide in up to 1000 milliliters of water to make the dissolution media (phosphate buffer pH 6.8).

The mobile phase consisted of a 65:35 (v/v) mixture of buffer acetonitrile and other components. Pass through a 0.45 µ membrane filter for filtration.

Various dissolving media were used as diluents to create a diluted solution.

2.2 Commonly used methods of readiness

Volumetric flask with 100 mL of Bilastine working standard containing 42 mg. Stir in 40 mL of dissolving medium and shake well to dissolve. Then, sonicate for 10 minutes with 0.1 N HCl and 60 minutes with acetate and phosphate buffers at pH 4.5 and 6.8, respectively, while shaking in between. Gradually add the dissolving agent and stir until well combined. Fill a clean 100 mL volumetric flask to capacity with dissolving media, then transfer 5 mL of this solution and stir well. Pass the sample through a 0.45µ-disc filter according to references [10,11,12].

The Auto sampler and PDA detector are part of the SHIMADZU Prominence HPLC system. Volume of 900 mL using various dissolving media and the USP-II device (paddle). With a temperature of 37°C ± 0.5°C and a stirring speed of 50 rpm. The intervals of 5, 10, 15, 20, 30, and 45 minutes follow. Kromasil C18, measuring 4.6 mm x 150 mm and 5 µm, was used as the column for the technique. At 1.0 mL/min, the flow rate was calibrated. A volume of 20 mL was injected using a wavelength of 207 nm as chosen for the procedure. The column oven did not have a set temperature.

III. RESULTS

TABLE-1: CUMULATIVE PERCENT RELEASE TABLET OF A CATEGORY PHARMACEUTICAL IN 0.1 N HCL PH 1.2

Table t no	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins
1	97	98	99	99	101	97	95
2	99	99	99	99	100	97	94
3	97	99	99	99	99	97	94
4	99	99	100	99	100	97	95
5	99	99	100	99	101	97	95
6	99	100	99	100	101	98	96
7	99	100	100	100	101	98	96
8	99	100	100	100	101	99	96
9	99	100	100	99	100	97	96
10	100	100	95	99	100	98	96
11	100	100	100	100	101	99	96
12	100	100	101	100	101	99	96
Mean	**99**	**100**	**100**	**100**	**100**	**98**	**96**
STDEV	1.00	0.68	1.59	0.51	0.67	0.87	0.79
RSD (%)	1.006	0.678	1.597	0.515	0.674	0.882	0.829

TABLE-2: CUMULATIVE PERCENT RELEASE TABLET OF B CATEGORY PHARMACEUTICAL IN 0.1 N HCL PH 1.2

Table t no	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins
1	98	100	99	98	98	97	94
2	97	98	97	97	97	96	95
3	103	99	99	99	99	97	96
4	100	97	97	96	95	95	95
5	101	99	99	98	97	96	93
6	99	101	100	100	101	98	93
7	101	99	99	97	98	97	96
8	104	101	101	100	98	97	97
9	100	99	102	101	100	98	95
10	99	103	96	100	99	98	98
11	99	103	103	102	102	97	95
12	99	101	99	98	98	99	96
Mean	**100**	**100**	**100**	**98**	**98**	**97**	**95**
STDEV	2.00	1.86	2.11	1.80	1.88	1.08	1.48
RSD (%)	2.000	1.859	2.119	1.831	1.920	1.112	1.556

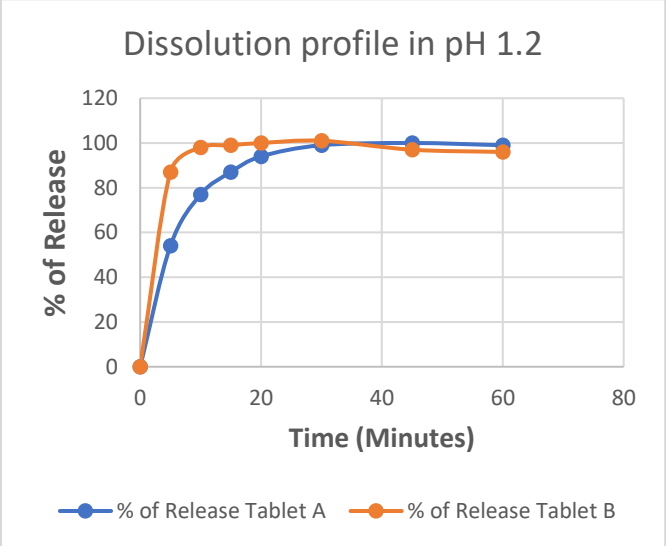

Figure1: Comparative dissolution profile in pH 1.2

TABLE-3: CUMULATIVE PERCENT RELEASE TABLET OF A CATEGORY PHARMACEUTICAL IN ACETATE BUFFER PH 4.5

Tablet no	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins
1	68	88	98	100	101	99	97
2	75	94	97	100	101	99	97
3	69	89	100	101	101	100	98
4	76	95	100	102	102	100	99
5	74	95	100	101	102	100	98
6	73	94	99	100	101	99	96
7	78	95	99	100	101	98	97
8	79	94	99	99	100	98	97
9	77	94	99	100	101	100	99
10	78	95	96	101	103	101	98
11	80	95	98	100	100	98	98
12	80	94	99	99	100	98	88
Mean	**76**	**93**	**98**	**100**	**101**	**99**	**97**
STDEV	3.99	2.39	1.18	0.87	0.90	1.03	2.92
RSD (%)	5.247	2.570	1.199	0.865	0.891	1.035	3.005

TABLE-4: CUMULATIVE PERCENT RELEASE TABLET OF B CATEGORY PHARMACEUTICAL IN ACETATE BUFFER PH 4.5

Tablet no	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins
1	93	99	100	99	100	98	96
2	95	98	98	98	99	96	93
3	94	99	99	99	100	97	94
4	95	98	97	97	97	96	94
5	97	99	99	98	99	97	93
6	101	101	101	100	101	98	93
7	98	100	100	99	100	96	96
8	101	103	102	101	102	99	97
9	99	102	101	99	102	99	97
10	100	102	96	101	102	99	97
11	101	102	102	102	101	99	97
12	104	101	101	101	102	99	96
Mean	**98**	**101**	**100**	**100**	**100**	**98**	**95**
STDEV	3.41	1.74	1.99	1.51	1.56	1.29	1.71
RSD (%)	3.476	1.733	1.986	1.508	1.564	1.312	1.793

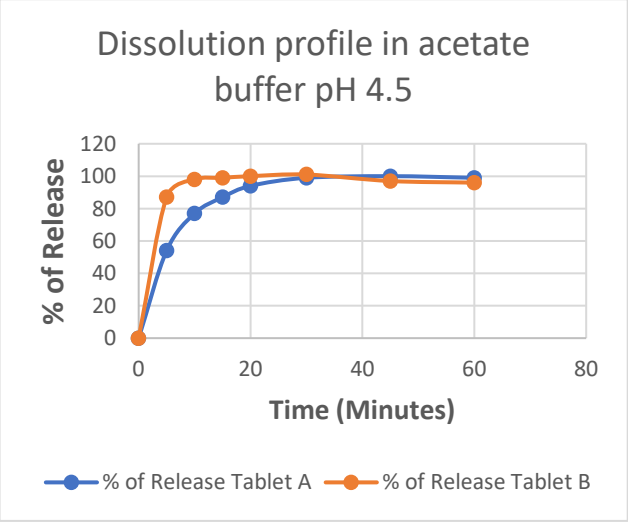

Figure 2: Comparative dissolution profile in pH 4.5

TABLE-5: CUMULATIVE PERCENT RELEASE TABLET OF A CATEGORY PHARMACEUTICAL IN PHOSPHATE BUFFER PH 6.8

Tablet no	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins
1	65	76	88	95	98	100	100
2	52	78	89	94	99	99	99
3	53	76	88	93	98	100	99
4	53	76	88	93	99	101	98
5	50	76	87	93	100	100	98
6	49	78	87	94	100	101	98
7	54	78	85	93	100	101	100
8	55	76	88	94	98	99	100
9	55	76	87	95	100	100	99
10	55	79	87	94	99	100	100
11	56	76	89	94	99	101	99
12	56	75	88	94	99	101	99
Mean	**54**	**77**	**87**	**94**	**99**	**100**	**99**
STDEV	4.01	1.22	1.08	0.72	0.79	0.75	0.79
RSD (%)	7.427	1.588	1.233	0.767	0.802	0.755	0.801

TABLE-6: CUMULATIVE PERCENT RELEASE TABLET OF B CATEGORY PHARMACEUTICAL IN PHOSPHATE BUFFER PH 6.8

Tablet no	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins
1	81	98	100	100	101	97	96
2	85	97	99	100	100	97	94
3	82	98	100	101	101	97	95
4	85	97	99	100	100	96	94
5	88	99	101	102	102	96	93
6	89	97	99	100	104	98	93
7	89	100	102	103	100	100	97
8	88	97	98	99	98	97	98
9	88	96	98	99	99	95	97
10	91	98	95	100	99	95	97
11	89	96	98	99	100	96	98
12	92	98	99	100	100	97	97
Mean	**87**	**98**	**99**	**100**	**101**	**97**	**96**
STDEV	3.36	1.16	1.77	1.22	1.56	1.36	1.86
RSD (%)	3.863	1.189	1.789	1.210	1.548	1.397	1.943

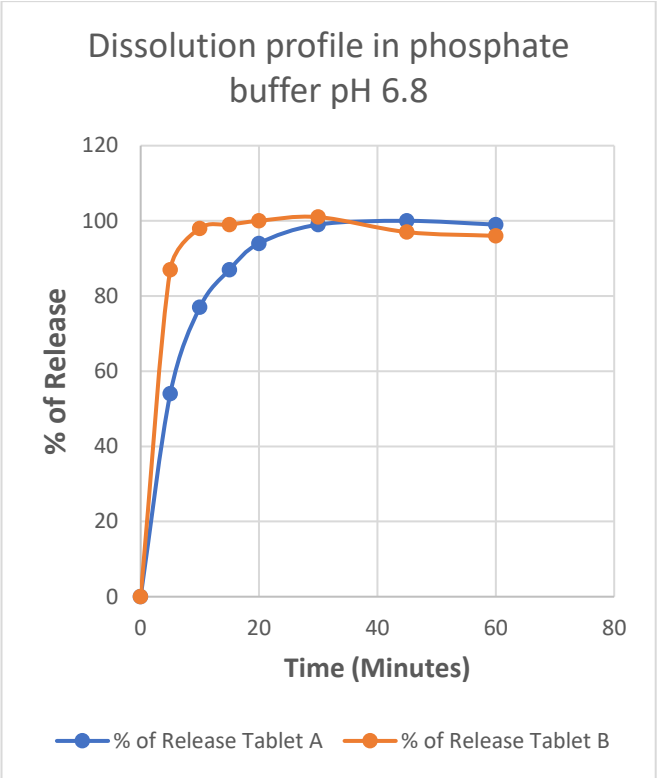

Figure 3: Comparative dissolution profile in pH 6.8

The dissolution profile data were also compared mathematically using the similarity factor f_2 and difference factor f_1, which is calculated by the following equation.

$$f_2 = 50 \times \log \{[1 + (1/n) \Sigma_{t=1}^{n} (R_t - T_t)^2]^{-0.5} \times 100\}$$

$$f_1 = \{[\Sigma_{t=1}^{n} |R_t - T_t|] / [\Sigma_{t=1}^{n} R_t]\} \times 100$$

TABLE-7: SIMILARITY FACTOR F2 AND DIFFERENCE FACTOR F1 FOR DISSOLUTION MEDIUM OF 0.1 N HCL

Time (min)	R_t (Tablet A)	T_t (Tablet	(R_t-T_t)	$(R_t-T_t)^2$
5	99	100	1	1
10	100	100	0	0
15	100	100	0	0
20	100	98	2	4
30	100	98	2	4
45	98	97	1	1
60	96	95	1	1
Sum (R_t-T_t)				7
Sum $(R_t-T_t)^2$				11
Sum R_t				693
Similarity factor f2				83.27
Difference factor f1				1.01

TABLE-8: SIMILARITY FACTOR F2 AND DIFFERENCE FACTOR F1 FOR DISSOLUTION MEDIUM OF ACETATE BUFFER PH 4.5

Time (min)	R_t (Tablet A)	T_t (Tablet B)	(R_t-T_t)	$(R_t-T_t)^2$
5	76	98	22	484
10	93	101	8	64
15	98	100	2	4
20	100	100	0	0
30	101	100	1	1
45	99	98	1	1
60	97	95	2	4
Sum (R_t-T_t)				36
Sum $(R_t-T_t)^2$				558
Sum R_t				664
Similarity factor f2				43.20
Difference factor f1				5.42

TABLE-9: SIMILARITY FACTOR F2 AND DIFFERENCE FACTOR F1 FOR DISSOLUTION MEDIUM OF PHOSPHATE BUFFER PH 6.8

Time (min)	R_t (Tablet A)	T_t (Tablet B)	(R_t-T_t)	$(R_t-T_t)^2$
5	54	87	33	1089
10	77	98	21	441
15	87	99	12	144
20	94	100	6	36
30	99	101	2	4
45	100	97	3	9
60	99	96	3	9
Sum (R_t-T_t)				80
Sum $(R_t-T_t)^2$				1732
Sum R_t				610
Similarity factor f2				30.95
Difference factor f1				13.11

Medium (50 rpm)	Difference factor f1	Similarity factor f2
pH 1.2	1.01	83.27
pH 4.6	5.42	43.20
pH 6.8	13.11	30.95

IV. DISCUSSIONS

The dissolution study of two local marketed Bangladeshi pharmaceutical products, identified as Category A and Category B, show a notable difference in their release profiles across three dissolution media. In 0.1 N HCl (pH 1.2), both products exhibited similar rapid and complete drug release, with mean values approaching 100% within the first 15 minutes. It indicates the efficient disintegration and dissolution for both formulations under acidic conditions. The calculated similarity factor (f2 = 83.27) and difference factor (f1 = 1.01) confirm that the profiles are highly comparable, meeting regulatory criteria for product equivalence information.

In acetate buffer (pH 4.5), distinct variations are observed. Category A tablet displayed a slower initial release, particularly at the 5-minute interval, whereas Category B dissolved more rapidly and consistently over time. These differences are reflected in the lower similarity factor (f2 = 43.20), which falls below the acceptable threshold of 50, indicating a lack of profile similarity. On the other hand, the difference factor (f1 = 5.42) remains within the acceptable limit, suggesting moderate yet noteworthy deviation in the two formulations.

A major disparity was observed in phosphate buffer (pH 6.8). The similarity factor (f2 = 30.95) and difference factor (f1 = 13.11) confirm significant differences between the two formulations in this medium. These findings imply that formulation variables such as excipient uses that influencing dissolution behavior at neutral pH.

V. CONCLUSION:

The comparative dissolution study reveals that the two Bangladeshi local marketed products perform similarly show in only under acidic conditions. In 0.1 N HCl (pH 1.2), both tablet category A and category B showed rapid and complete drug release, supported by an acceptable similarity factor and minimal difference. However, in acetate buffer (pH 4.5) and phosphate buffer (pH 6.8), notable discrepancies has been observed. Category B tablet consistently exhibited faster dissolution, while category A released the drug more slowly. The low f2 values in these media confirm the lack of profile similarity in dosage formulation. Finally, the two type tablet formulations are comparable in gastric conditions but differ significantly at higher pH conditions.

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Mental Health Awareness among University Students in Bangladesh

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Abstract *– This paper will discuss the awareness of mental health among University Students in Dhaka, Bangladesh. The study examines what influences perceptions and attitudes towards mental health with special attention to cultural, social and institutional barriers that impact the way University Students recognize, explain, and react to issues regarding mental health. The research integrates a mixed-method approach; quantitative and qualitative data are collected. The survey was administered to 50 university students to evaluate their overall knowledge and awareness regarding mental health problems; the in-depth interviews were carried out on 10 participants to have more insight on personal experience, issues, and attitude. The results indicate that there is a big discrepancy between theory and practice of mental health. The barriers to seeking help that have been identified as the main ones are cultural stigma, mental health education, and insufficient access to services. Also, peer influence and social norms were identified as having a strong influence on students willing to talk about mental health publicly. The paper proposes mental health education in university curricula, campaigns to decrease stigma, and easier mental health care. The study results can be useful in understanding the mental health consciousness of University Students in urban Bangladesh and may be used to suggest ways of enhancing mental health policies and initiatives at university level.*

Keywords: Mental Health, Awareness, University Students, Stigma, Help-Seeking Behavior.

I. INTRODUCTION

Mental health issues among university students have emerged as one of the most critical global issues, and it is very grave in Bangladesh. University students commonly experience high levels of academic stress, career identity confusion and social transitions, which render them particularly vulnerable to stress and anxiety disorders [1]. Yet, despite this growing demand, mental health issues among students in Bangladesh remain unhandled largely due to stigma, lack of awareness, and lack of availability of expert help [2].

Cultural myths, such as blaming mental illnesses on supernatural forces, continue to influence attitudes toward mental health and hinder help-seeking behavior [3]. Mental health literacy is also low in Dhaka, even among the more media-exposed students. The words 'anxiety' and 'depression' may be familiar, but students may not have a clear understanding of symptoms, causes and treatments [4]. Consequently, they very often do not recognize signs of distress and refer to informal sources like peers or social media, which fuels misinformation.

Stigma remains one of the strongest barriers to accessing support. Students fear being perceived as weak or inept at academics, and this will lead many to avoid visiting the campus counseling services or even talking openly about their problems. At the same time, university mental health services are often underfunded, poorly promoted, and not integrated into the broader student support system.

Increased mental health literacy improves stigma reduction, better recognition of symptoms, and timely help-seeking. At the same time, mental health education has not been given priority at most universities in Bangladesh. This gap highlights the urgent need to strengthen awareness and support systems for students [5].

his study, thus aims to explore the students' mental health knowledge level at Dhaka and explores what contribute this perception among student, find out what is the key barriers they used to facing of help-seeking. These results will be important in the design of successful mental health programming and better university support services to meet students' needs for a campus environment that supports well-being, academic success, and life satisfaction. The aim of the research is to explore the public awareness levels about mental health among undergraduate students in Dhaka and understand how their perceptions and behaviors regarding seeking support are influenced by social, cultural, and institutional factors. The specific objectives are:

1. To estimate the cognitive level of mental health awareness among University Students;
2. The degree to which cultural and religious beliefs influence perceptions of mental health;
3. To identify the barriers that hinder access to mental health services;
4. To put forward suggestions to help in addressing mental health literacy.

II. LITERATURE REVIEW

2.1 Mental Health Awareness Among University Students in Bangladesh

Mental health among Bangladeshi university students is still not adequately addressed and mental health literacy in general is poor. A number of students have misunderstandings concerning etiology and therapy, indicating that directed information campaigns are needed [6]. There are similar gaps among rural populations; this indicates the importance of culturally specific interventions. Insufficient mental health education and excessive academic pressure make students unable to cope with their psychological problems, which leads to higher risks of low academic achievement and long-term mental disorders [7].

2.2 Cultural and Religious Influences on Mental Health Perceptions

Cultural and religious beliefs have strong influence on the attitudes toward mental health in Bangladesh, with many considering mental illness to be stigmatizing, spiritually attributed or a character flaw. Such views reinforce stigma and make awareness efforts difficult. Concerns over family reputation lead many, including university students, to fear social marginalization [8]. It is similarly found that mental illness is associated with ostracism, shame, and spiritual punishment. These beliefs discourage help-seeking and hinder access to care. In the case of university students, this dichotomy between traditional explanations and contemporary psychiatric theories is a source of confusion and fear of stigmatization list to intervention seeking [9], as well as putting their mental health at risk.

2.3 Barriers to Mental Health Services and Help-Seeking Behavior

Despite increasing awareness of mental health in Bangladesh, university students still face significant barriers to care. Stigma, a shortage of professionals, and limited university-based services are key obstacles. Even when services exist, students often cannot use them. Bangladesh has very few trained workers in mental health and a generally weak system of available services [10]. Available services are frequently not youth-friendly, with long wait times, high cost, and limited relevance to student needs. Poor funding and weak outreach further limit students' awareness of available support [11]. University resources also remain inadequate and under reported. These challenges point out a need for stronger campus-based services and targeted outreach to improve access and awareness.

2.4 Social Stigma and Its Impact on Mental Health Help-Seeking Behavior

Social stigma is considered one of the significant barriers to mental health care in Bangladesh among university students. Mental illnesses are generally perceived as personal weaknesses and hence invite discrimination and social avoidance. Such stigma explained by Goffman's Stigma Theory [12] and Meyer's Minority Stress Theory [13] enhances psychological distress. Stigma has a cultural origin and thus demands collective action for change. The internalization of stigma generally leads to untreated mental health problems or harmful coping behaviors The need of the hour is to increase public awareness, media engagement, and community-based efforts aimed at reducing stigma and increasing support [14].

2.5 Gaps in the Literature and Areas for Further Research

Research in Bangladesh on mental health is increasing but has major gaps, particularly on mental health awareness, help-seeking behavior, and institutional trust. Studies are largely qualitative in nature; as such, they provided cultural insight but did not use quantitative measures of literacy and help-seeking. Finally, large-scale or mixed-method studies around metropolitan areas of Dhaka to evaluate intervention effects are largely absent [15]. The role of internationalization is, how gender, class, and location intersect in shaping barriers to care-is underestimated. Moreover, institutional trust-arguably a critical enabler of students seeking out service-has garnered scant attention. There is a need for more research into the ways in which policies of institutions either foster or undermine trust in mental health support systems.

III. THEORETICAL FRAMEWORK

Exploring factors contributing to mental health awareness and help-seeking behaviour among college students is only possible by taking into account these social, cultural and individual dynamics. This study uses an integrative framework of Stigma Theory, Health Belief Model (HBM), and Social Cognitive Theory to investigate factors that influence students' perceptions and actions towards mental health. Taken as a whole, these theories offer an understanding of impediments, factors that may facilitate help-seeking behaviour and social processes that may impact on help-seeking among university students.

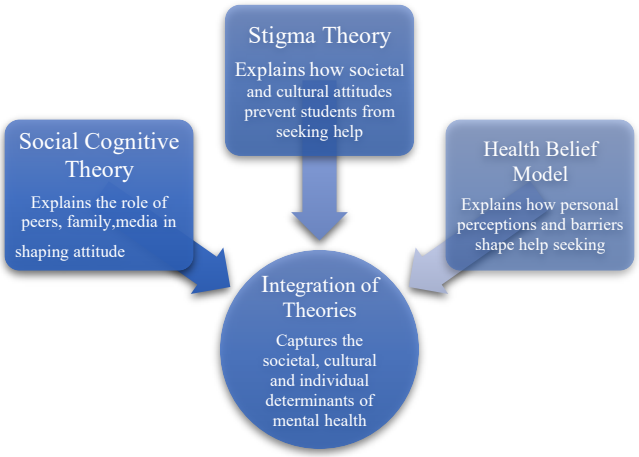

Figure 1: Integration of Theories

IV. METHODOLOGY

4.1 Research Design

Method This mixed-methods study aimed to capture a holistic view of mental health awareness in Saudi university students using both quantitative and qualitative surveys. In total, 50 students were surveyed and a subset of 10 students' interviews were examined.

4.2 Data Collection

The quantitative findings were gained from online and paper surveys that had been given to the students. The qualitative data was collected with in depth semi-structured interviews. The study targeted 18-30 years old university students studying at DIU and other national universities

4.3 Data Analysis

Descriptive statistics were used to analyze the quantitative data and thematic analysis was employed for the qualitative data. The two approaches were combined synergistically to reveal a more comprehensive picture of students' mental health literacy and barriers to seeking help.

V. DATA FINDINGS

5.1. Demographic Data Analysis

TABLE 1: DEMOGRAPHIC DATA OF THE RESPONDENTS

Category	Sub-category	Respondents (n)	%'age
Age	18–21 Years	12	24.0%
	21–24 Years	11	22.0%
	24–27 Years	10	20.0%
	27–30 Years	9	18.0%
Gender	Male	22	44.0%
	Female	28	56.0%
Marital Status	Single	42	84.0%
	Married	6	12.0%
	Divorced/ Separated	2	4.0%
Education Level	Primary	3	6.0%
	Secondary/HSC	10	20.0%
	Graduate	30	60.0%
	Postgraduate	7	14.0%
Occupation	Student	45	90.0%
	Service Holder	3	6.0%
	Business	2	4.0%
	Total	**50**	**100.0%**

The 50 respondents are young, well-educated, and mostly students, whose ages are between 18 and 30. Most of them are aged between 18-26 years which is a representation of the target age of the youth especially students in the study. It is also gender inclusive, as the gender composition is equal, 56% and 44% respectively. Majority of the respondents (84) are single, which is in tandem with their academic or early career levels. The sample is highly educated, 60 percent of them have graduate or undergraduate degrees. Also, 90 percent of them are students, and this highlighting how the research is applicable to the young people in the education industry. This is a well-educated population that is youth based hence this demographic profile will ensure that the findings are accurate concerning the views of the people.

5.2 Awareness of Common Mental Health Disorders

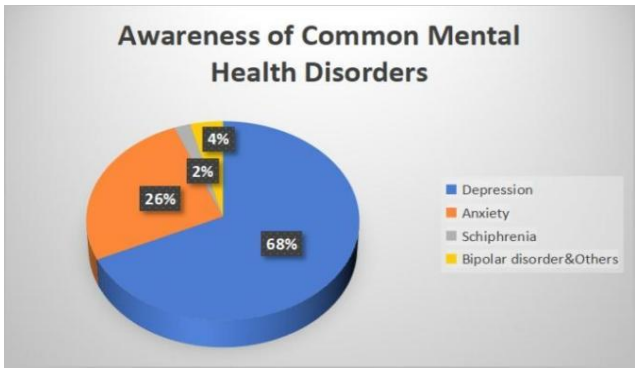

Figure 2: Awareness of Common Mental Health Disorders

According to the survey findings, out of 50 participants, 68% of them mentioned depression as a typical mental health disorder, and 26% identified anxiety. Other disorders like schizophrenia 2% bipolar or others were noted with 4%. This implies that depression and anxiety are the best recognized mental health problems, and other problems such as schizophrenia and bipolar disorder are not well-known or accepted by the respondents.

Most of the participants had a rudimentary knowledge on mental health which they associated with stress, emotions, academic stressors and emotional well-being. But more-detailed conceptual knowledge about being sick, what makes us get that way and how it gets better was much less common.

One participant stated:

"I think of mental health as a calm, peaceful mind no incessant worries and anxieties. It symbolizes inner harmony, joy and emotional equilibrium."

5.3 Personal Experience with Mental Health Issues

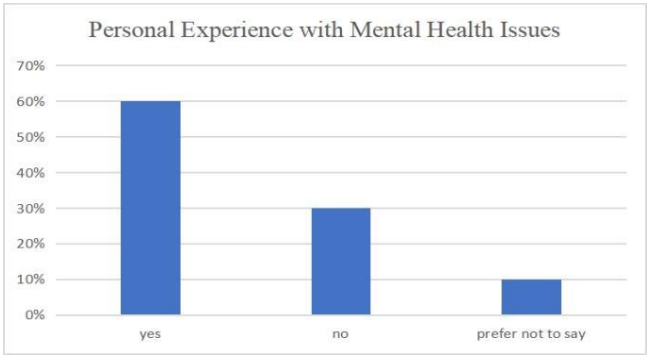

Figure 3: Personal Experience with Mental Health Issues

The chart indicates that 60% (30 respondents) have experienced mental health problems directly or indirectly and 30% (15 respondents) had not done so and 10% (5 respondents) had not replied. This means that most of them have had either first hand or indirect contact with mental health problems with a smaller percentage having no experience at all or they did not wish to disclose.

One respondent explained:

"In my view, shame, social criticism, and lack of awareness all act as barriers. Many people feel embarrassed to talk about their problems, fearing that society will label them as "crazy." Some also fail to see mental illness as equally important as physical illness."

5.4 Attitudes Toward Mental Health

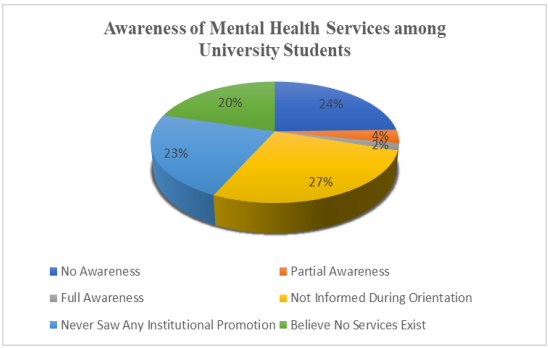

Figure 4: Level of awareness of mental health services among university students

The figure displays the distribution of students' awareness levels regarding campus mental health services. A total of 82% of respondents reported no awareness of any available services, 12% indicated partial awareness, and only 6% demonstrated full awareness of existing counseling or support mechanisms.

One respondent stated,

"No, I am not aware of any mental health services around. I never heard any advertisements or anything discussed in the classroom."

Another respondent stated,

"All people in the society should create more awareness of mental health. Different workshops and seminars in educational institutions should be held and documentary films should be shown to create awareness on mental health."

5.5 Recommendations for Improving Mental Health Literacy

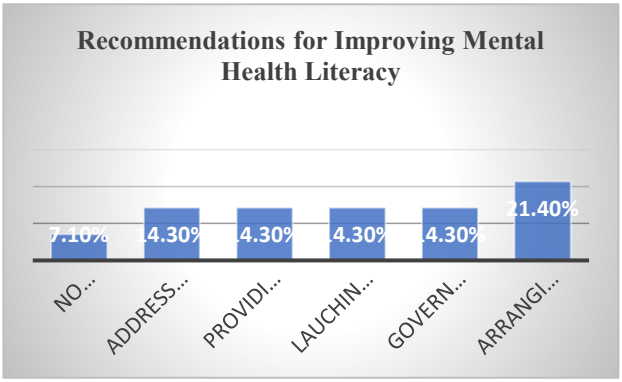

Figure 5: Recommendations for Improving Mental Health Literacy

The questionnaire yielded the following from Dhaka: 34 responses on how to improve mental health awareness. The most frequent response was "yes, of course," receiving 3 votes (8.8%) to show clear support for action. Most of the other suggestions received a vote each or up to 2 votes to show awareness that different approaches are needed. Highlighted in participants' responses were awareness campaigns, government programs, community efforts, and easily accessible mental health services. Fewer voted for "no," which really bolstered strong consensus that improving awareness of mental health is important.

One respondent explained:

"Every school, college, and university should have a mental health professional available to provide free advice. Additionally, organizing various seminars on mental health can raise awareness and reduce stigma."

Another said:

"Everyone in society needs to become more aware of mental health. Educational institutions should organize various workshops and seminars, and documentary films should be shown to raise awareness about mental health."

VI. DISCUSSION

The present study explored the ways in which university students in Dhaka understand mental health, cope with psychological distress, and navigate help-seeking pathways. The integrated quantitative and qualitative results reveal a student cohort concerned with mental well-being but constricted by stigma, cultural norms, and insufficient institutional support.

Most students defined mental health as the balance of emotions and the ability to deal with stress, rather than a clinical disorder —a philosophy that may mirror global youth wellness ideals and cultural values in South Asia that focus on self-discipline and spirituality. While there was widespread recognition of depression and anxiety, knowledge of more severe disorders such as bipolar disorder and schizophrenia was minimal, suggesting low clinical literacy despite growing general awareness.

Cultural and religious norms played a significant role in shaping students' perceptions. Prayer, meditation, and spiritual practices are often turned to as coping strategies, reflecting how strongly religion influences emotional regulation in Bangladesh. Yet, the same cultural environment reinforces stigma: many students reported fearing judgment, shame, or social criticism, which discouraged open discussion and formal help-seeking.

A major concern highlighted in the study is that mental health services are inadequately accessible on university campuses. Students mentioned not knowing the location of counseling centers, a lack of professional personnel, or doubts about confidentiality and the ability to seek care off-campus due to financial or time constraints. Thus, most had to rely on informal support from family and friends and coping mechanisms like entertainment, physical activity, writing in a diary, and escape into the Internet. The effort provided emotional relief, but did not satisfy deeper was also an artist and songwriter.

The discoveries also indicate strong awareness of lifestyle elements-sleep, food, and physical exercise-in mental health among the students which mirror those seen in holistic well-being narratives that have emerged within Bangladesh. Even with such strong levels of awareness around 60% reported mental health problems, but formal help-seeking rates were low owing to stigma and service inaccessibility.

In conclusion, emerging evidence would indicate that while awareness of mental health is increasing amongst university students in Dhaka, institutional infrastructure has yet to follow suit. Challenges Mental health literacy and the availability, accessibility and assurance of confidentiality in counseling services that are culturally sensitive are essential for improving psychological well-being at university level in Bangladesh.

VII. CONCLUSION

This survey has shown that despite an improving level of mental health awareness among university students in Dhaka, gaps in literacy, cultural stigma, and institutional support continue to impede effective help-seeking. Generally, students understand common mental health

issues, but their knowledge is lacking with regard to severe disorders. Cultural or religious beliefs provide emotional relief and yet reinforce stigma; hence, most students receive informal support rather than professional services. Institutional barriers, including limited counseling resources and lack of awareness, further limit access. However, students also perceive lifestyle factors to be impactful and describe a high need for formal mental health education and awareness programs with easy-to-access levels of support. Actions to overcome these cultural, structural, and informational obstacles to enhancing mental well-being and promoting a supportive mental health environment on campus are necessary.

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