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(HJMST)

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ABOUT THE JOURNAL

HIMT Journal of Management, Science and Technology (HJMST) is the multidisciplinary academic journal of Harlal Institute of Management & Technology, a constituent Institution of HIMT Group of Institutions, Greater Noida. The journal serves as a scholarly platform to promote research, innovation, and knowledge dissemination in the fields of Management, Computer Applications, Biotechnology, Education, and allied disciplines.

AIM

The HIMT Journal of Management, Science and Technology (HJMST) aims to provide a dynamic and credible platform for academicians, researchers, industry professionals, and scholars to publish high-quality research that contributes to the advancement of knowledge in Management, Science, and Technology.

The journal seeks to:

- Promote interdisciplinary research integrating Management practices with emerging Science and Technology trends.
- Encourage innovative, empirical, and applied research that addresses contemporary academic and industry challenges.
- Foster research culture among faculty members and students of HIMT and other institutions.
- Support knowledge dissemination that contributes to sustainable development and societal progress.
- Strengthen academia–industry collaboration through research-based insights and case studies.

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HJMST welcomes original research papers, review articles, case studies, and conceptual papers in areas including, but not limited to:

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- Human Resource Management
- Financial Management
- Operations & Supply Chain Management
- International Business
- Entrepreneurship & Start-ups
- Strategic Management
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- Data Science & Analytics
- Cyber Security
- Cloud Computing
- Internet of Things (IoT)
- Software Engineering
- Blockchain Technology
- Emerging Digital Technologies

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- Biotechnology & Life Sciences
- Environmental Science & Sustainability
- Applied Sciences and Research Innovations
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The journal encourages interdisciplinary and collaborative research that integrates multiple domains to provide innovative solutions to real-world problems.

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Reviewers evaluate manuscripts based on:

- Originality and contribution to knowledge
- Research methodology and rigor
- Theoretical and practical relevance
- Clarity of objectives and conclusions
- Literature review adequacy
- Data analysis and interpretation
- Language, structure, and presentation

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- Authors must ensure that their work is original and properly cited.
- Any conflict of interest must be disclosed.

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EDUCATION & SOCIAL SCIENCES

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- Teaching–Learning Innovations
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Based on reviewers' recommendations, the Editorial Board may decide:

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Dr. Kumar has served in esteemed roles such as Head of Department, Dean, and Director at reputed institutions like NIT Kurukshetra, GNIOT, NIET, ITS Engineering College, SRM University, Indraprastha Engineering College and Sri Mata Vaishno Devi University, showcasing his leadership and academic excellence.

He has guided 11 Ph.D. scholars to completion, with 1 more in progress, and supervised 25 M.Tech. dissertations. A prolific author, Dr. Kumar has published 160 Research Papers in various journals of National and International repute.

He has organized multiple national and international conferences, FDPs, and workshops, and received significant research grants including MODROB from AICTE.

As a reviewer for reputed journals like Elsevier and Springer, Dr. Kumar's contributions have earned him wide recognition. Currently, he serves as Group Director with HIMT Group of Institutions, Greater Noida, continuing his impactful academic journey.

Message from the
Editor-in-Chief

PROF. (DR.) SUDHIR KUMAR

Group Director,
HIMT Group of Institutions,
Greater Noida

It is with great pride and enthusiasm that I present the inaugural issue (Volume 1, Issue 1) of the HIMT Journal of Management, Science and Technology (HJMST). The launch of this bi-annual journal marks a significant academic milestone in our ongoing commitment to research excellence and knowledge dissemination.

HJMST has been envisioned as a dynamic platform for scholars, researchers, academicians, and industry professionals to share original research, innovative ideas, and interdisciplinary perspectives in the fields of Management, Science, and Technology. In an era driven by rapid transformation and global challenges, the role of research in shaping sustainable and practical solutions has become more crucial than ever.

This inaugural issue reflects our dedication to maintaining high standards of scholarly rigor, ethical publication practices, and a robust peer-review process. Each manuscript included in this volume has undergone a thorough review to ensure quality, relevance, and academic integrity.

I extend my sincere gratitude to the authors for their valuable contributions, the reviewers for their insightful evaluations, and the Editorial Board for their unwavering support and commitment. Their collective efforts have made this first issue possible.

We aspire for HJMST to evolve into a reputed national and international journal, fostering intellectual dialogue and contributing meaningfully to academic and professional communities.

I warmly invite researchers and scholars to contribute to future issues and be a part of this growing academic endeavor.

With best wishes

Message from the
Managing Editor

PROF. (DR.) PANKAJ KUMAR

Director,
Harlal Institute of Management and Technology,
Greater Noida

It is a matter of great satisfaction to present the inaugural issue (Volume 1, Issue 1) of the HIMT Journal of Management, Science and Technology (HJMST). This bi-annual journal represents a significant step forward in strengthening the research culture and academic engagement at HIMT.

HJMST has been conceptualized as a scholarly platform dedicated to publishing high-quality research in the fields of Management, Science, and Technology. Our objective is to encourage original thinking, promote interdisciplinary research, and provide an avenue for academicians, researchers, and industry professionals to disseminate their work to a wider audience.

The successful release of this first issue has been possible due to the collective efforts of the Editorial Board, reviewers, authors, and the dedicated academic team who worked diligently at every stage from manuscript submission and peer review to editing and final publication. We are committed to ensuring transparency, timely publication, and adherence to ethical standards in all our processes.

As we begin this academic journey, we look forward to receiving valuable research contributions in the forthcoming issues and to continuously enhancing the quality and reach of the journal.

I extend my sincere thanks to everyone associated with this initiative and convey my best wishes for the continued growth and success of HJMST.

ACKNOWLEDGEMENT OF CONTRIBUTORS

The Editorial Board of HIMT Journal of Management, Science and Technology (HJMST) proudly presents the inaugural issue of our bi-annual journal. The publication of Volume 1, Issue 1 marks a significant academic milestone for the HIMT fraternity and reflects our commitment to fostering research, innovation, and scholarly excellence.

We extend our sincere gratitude to all the contributors—researchers, academicians, industry experts, and scholars—whose insightful manuscripts have laid the foundation of this journal. Your dedication, intellectual rigor, and research acumen have enriched this issue with diverse perspectives across management, science, and technology.

We are deeply thankful to our esteemed reviewers for their time, constructive feedback, and commitment to maintaining the highest standards of academic integrity and quality. Their meticulous evaluation and valuable suggestions have significantly strengthened the published work.

Our heartfelt appreciation also goes to the Editorial Advisory Board, Editor-in-Chief, Managing Editor, and the entire editorial team for their vision, guidance, and relentless efforts in bringing this inaugural volume to fruition.

We acknowledge the support of faculty members, administrative staff, and technical teams whose behind-the-scenes contributions ensured smooth coordination, formatting, and publication processes.

This first issue is not merely a publication but the beginning of a sustained academic journey. We look forward to continued collaboration and scholarly engagement in the forthcoming editions.

With sincere appreciation and gratitude

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(HJMST)

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Impact of Social Media Influencer Marketing on Consumer Purchase Intention Among Young Consumers in India

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Abstract - The rapid growth of social media platforms has transformed the marketing landscape across the globe. Influencer marketing has emerged as one of the most effective promotional strategies for brands targeting young consumers. This study investigates the impact of social media influencer marketing on consumer purchase intention among young consumers in India. The research examines the influence of credibility, attractiveness, trustworthiness, and content quality of influencers on buying behaviour. A structured questionnaire was administered to 220 respondents aged between 18 and 35 years using convenience sampling. Statistical tools such as *percentage analysis, mean analysis, correlation, regression analysis, reliability testing using Cronbach's Alpha, and chi-square tests* were used to analyze the data. The findings reveal that influencer credibility and trustworthiness significantly affect purchase intention. The study concludes that brands can effectively utilize influencer marketing strategies to increase consumer engagement and drive sales.

Keywords - Influencer Marketing, Social Media, Consumer Purchase Intention, Digital Marketing, Brand Trust, Young Consumers

I. INTRODUCTION

The evolution of digital technology and social networking platforms has dramatically altered consumer purchasing behaviour. Traditional

advertising methods are gradually losing their effectiveness as consumers increasingly rely on online content and recommendations before making purchasing decisions. Social media influencers have emerged as important intermediaries between brands and consumers. Influencers are individuals who possess the power to affect purchasing decisions because of their authority, knowledge, position, or relationship with their audience. Platforms such as *Instagram, YouTube, Facebook, and TikTok* have enabled influencers to build strong personal brands and cultivate trust among followers.

In India, the increasing internet penetration and smartphone usage have contributed to the rapid growth of influencer marketing. Young consumers are particularly influenced by digital content creators, making influencer marketing a critical strategy for businesses.

This study aims to examine the relationship between influencer marketing attributes and consumer purchase intention among young consumers in India.

II. REVIEW OF LITRETURE

Brown and Hayes (2008) explained influencer marketing as the process of identifying individuals capable of influencing potential buyers. Fishbein and Ajzen (1975) emphasized the role of attitudes and external influences in purchase intention. Hovland and Weiss (1951) suggested that source credibility significantly affects persuasion and consumer decision-making.

Most previous studies focus on western markets. Limited research exists regarding the impact of influencer marketing on Indian youth consumers using primary data and advanced statistical analysis.

Existing literature highlights the importance of credibility, trustworthiness, and content quality in influencer marketing.

III. RESEARCH OBJECTIVES

1. To analyze the impact of influencer marketing on consumer purchase intention.
2. To examine the relationship between influencer credibility and buying behavior.
3. To evaluate the role of trustworthiness in influencing consumer decisions.
4. To identify the influence of content quality on purchase intention.
5. To suggest strategies for improving influencer marketing effectiveness.

IV. RESEARCH METHODOLOGY

The study adopted a descriptive and analytical research design. Primary data was collected through a structured questionnaire using convenience sampling. The sample consisted of 220 respondents from Delhi NCR. Statistical tools such as mean analysis, correlation, regression, ANOVA, Cronbach's Alpha, and chi-square tests were applied using SPSS and Microsoft Excel.

V. HYPOTHESIS

H1: There is a significant relationship between influencer credibility and consumer purchase intention.

H2: Trustworthiness of influencers significantly affects consumer buying behavior.

H3: Content quality positively influences consumer purchase intention.

H4: There is a significant association between frequency of social media usage and influence of influencer marketing.

VI. Data Analysis and Interpretation

The reliability analysis indicated a Cronbach's Alpha value of 0.884, signifying excellent

internal consistency. Correlation analysis revealed a strong positive relationship between influencer credibility, trustworthiness, content quality, and consumer purchase intention. Regression analysis demonstrated that content quality exerted the strongest influence on purchase intention.

Demographic Profile of Respondents

Variable	Category	Frequency	Percentage
Gender	Male	118	53.6%
Gender	Female	98	44.5%
Gender	Other	4	1.9%
Age	18–22	72	32.7%
Age	23–27	89	40.5%
Age	28–31	37	16.8%
Age	32–35	22	10.0%

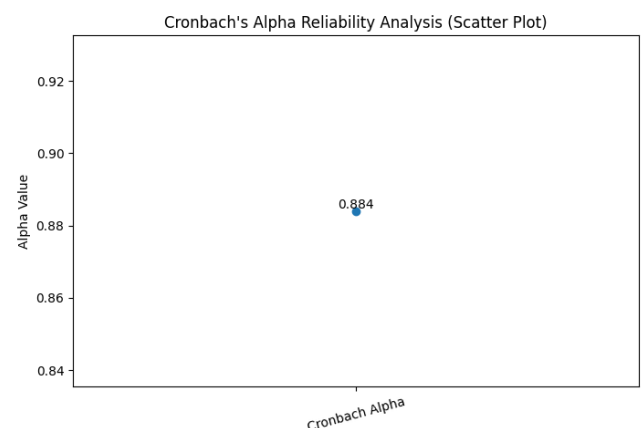
Interpretation

The majority of respondents belonged to the age group of 23–27 years, indicating that young adults are highly active users of social media platforms.

Reliability Test

Cronbach's Alpha Reliability Analysis

Variable	Cronbach's Alpha
Influencer Marketing Scale	0.884

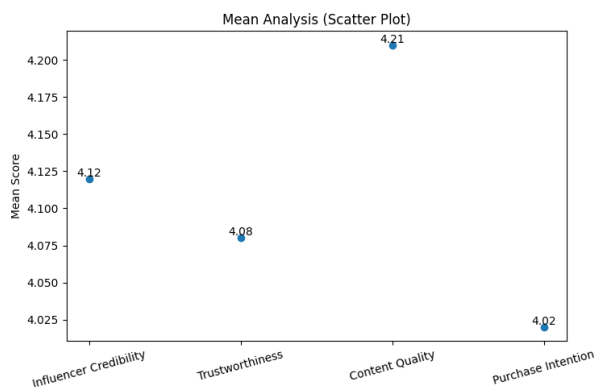


Interpretation

The Cronbach's Alpha value of 0.884 indicates excellent reliability and internal consistency of the questionnaire.

Mean Analysis

Variables	Mean Score	Standard Deviation
Influencer Credibility	4.12	0.74
Trustworthiness	4.08	0.71
Content Quality	4.21	0.69
Purchase Intention	4.02	0.76



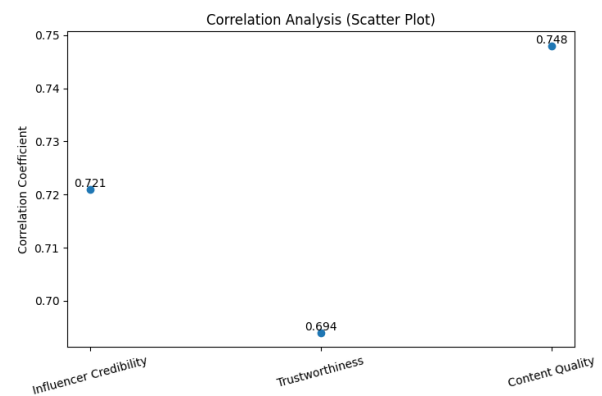
Interpretation

Content quality received the highest mean score, indicating that respondents highly value engaging and authentic influencer content.

Correlation Analysis

Variables	Purchase Intention
Influencer Credibility	0.721**
Trustworthiness	0.694**
Content Quality	0.748**

Correlation is significant at 0.01 level



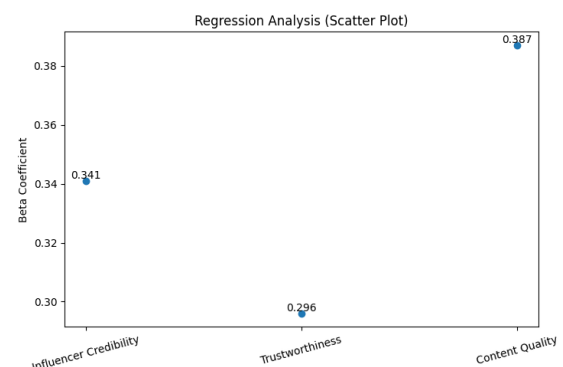
Interpretation

The analysis shows a strong positive relationship between influencer marketing variables and consumer purchase intention.

Regression Analysis

Model Summary

R	R Square	Adjusted R Square
0.812	0.659	0.651



ANOVA Table

Source	F Value	Significance
Regression	54.672	0.000

Coefficients Table

Variables	Beta	t-value	Sig.
Influencer Credibility	0.341	5.912	0.000
Trustworthiness	0.296	4.887	0.000
Content Quality	0.387	6.521	0.000

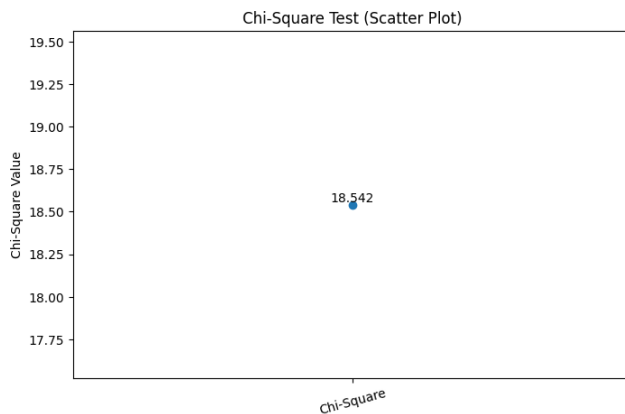
Interpretation

The regression model explains 65.9% variation in purchase intention. Content quality has the strongest influence on consumer buying behavior.

8.6 Chi-Square Test

Relationship Between Frequency of Social Media Usage and Influence of Influencer Marketing

Chi-Square Value	Degrees of Freedom	Significance
18.542	6	0.005



Interpretation

Since the significance value is less than 0.05, there is a significant association between social media usage frequency and influence of influencer marketing.

VII. FINDINGS

The study found that young consumers actively follow influencers on Instagram and YouTube. Influencer credibility and authentic content significantly impact consumer buying behavior. Influencer marketing was perceived as more relatable and effective compared to traditional advertising.

VIII. CONCLUSION

The study concludes that influencer marketing significantly affects consumer purchase intention among young consumers in India. Brands can effectively utilize influencer marketing strategies to increase consumer engagement and improve sales performance. Organizations should focus on selecting credible influencers capable of producing authentic and high-quality content.

IX. REFERENCES

[1] Brown, D., & Hayes, N., Influencer Marketing, Routledge, 2008.

[2] Fishbein, M., & Ajzen, I., Belief, Attitude, Intention and Behavior, Addison-Wesley, 1975.

[3] Hovland, C., & Weiss, W., The Influence of Source Credibility on Communication Effectiveness, Public Opinion Quarterly, 1951.

Sec A: Questionnaire

Questionnaire on Social Media Influencer Marketing

Section A: Demographic Information

1. Gender

- ☐ Male
- ☐ Female
- ☐ Other

2. Age Group

- ☐ 18–22
- ☐ 23–27
- ☐ 28–31
- ☐ 32–35

3. Educational Qualification

- ☐ Undergraduate
- ☐ Postgraduate
- ☐ Professional Degree
- ☐ Others

4. Occupation

- ☐ Student
- ☐ Working Professional
- ☐ Business
- ☐ Others

5. Monthly Income

- ☐ Below ₹20,000
- ☐ ₹20,001–₹40,000
- ☐ ₹40,001–₹60,000
- ☐ Above ₹60,000

6. Most Frequently Used Social Media Platform

- ☐ Instagram
- ☐ YouTube
- ☐ Facebook
- ☐ Snapchat
- ☐ Others

Section B: Influencer Marketing Perception

Please indicate your level of agreement using the following scale:

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

S.No	Statements	1	2	3	4	5
1	I follow influencers regularly on social media.					
2	Influencers help me discover new products.					
3	I trust influencer recommendations.					
4	Influencer reviews affect my buying decisions.					
5	Attractive influencer content grabs my attention.					
6	I prefer brands promoted by influencers.					
7	Influencer credibility impacts my trust in brands.					
8	I have purchased products after seeing influencer promotions.					
9	Authentic content increases my confidence in products.					
10	Influencer marketing is more effective than traditional advertising.					
11	Influencers create emotional connections with followers.					
12	I share influencer-promoted products with friends and family.					
13	Discounts promoted by influencers encourage purchases.					
14	I consider influencers as reliable information sources.					
15	Influencer marketing affects my brand loyalty.					

8. Data Analysis and Interpretation

8.1 Demographic Profile of Respondents

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Interpretation

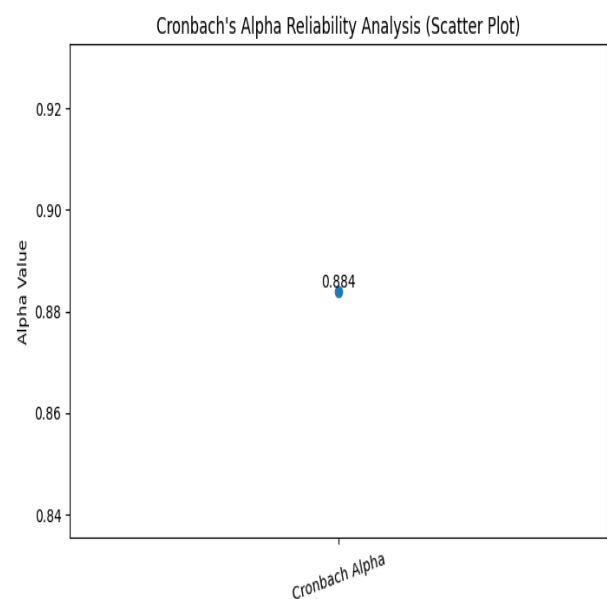
Since the significance value is less than 0.05, there is a significant association between social media usage frequency and influence of influencer marketing.

9. Findings of the Study

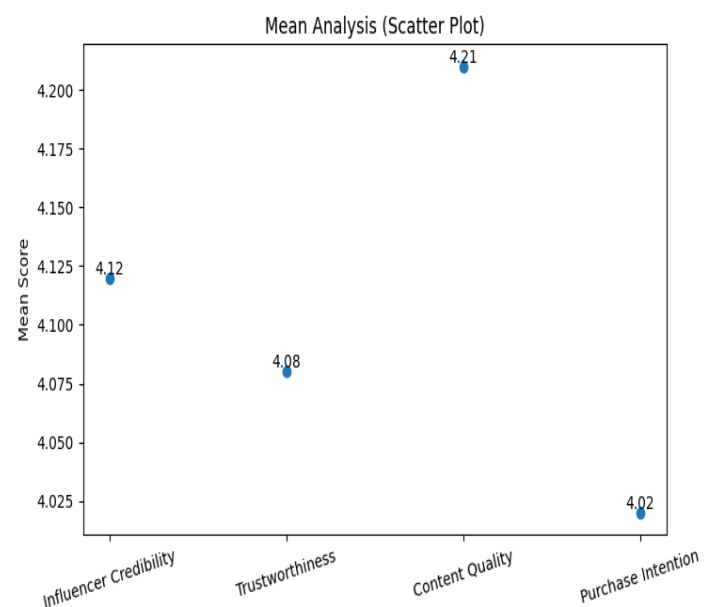
1. Most respondents actively follow influencers on Instagram and YouTube.
2. Influencer credibility significantly impacts purchase intention.
3. Consumers trust influencers who provide authentic and honest reviews.
4. High-quality content positively affects consumer engagement.
5. Influencer marketing is perceived as more relatable than traditio

Scatter Plot Graphs

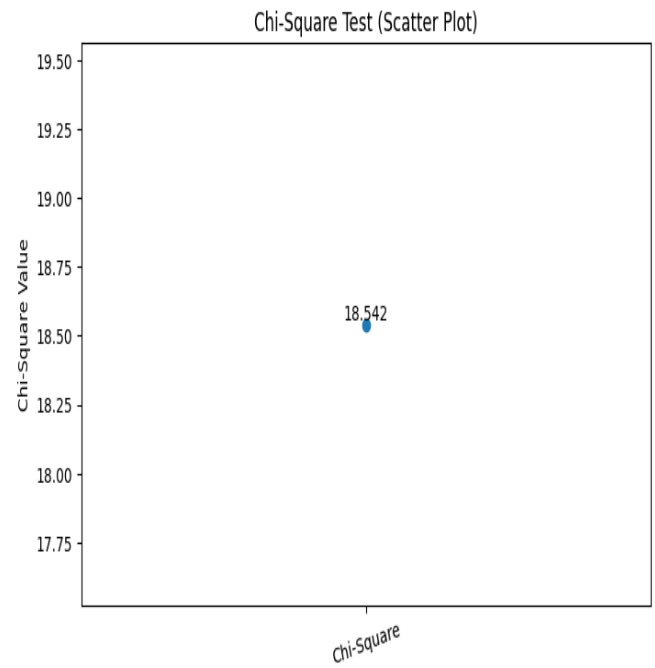
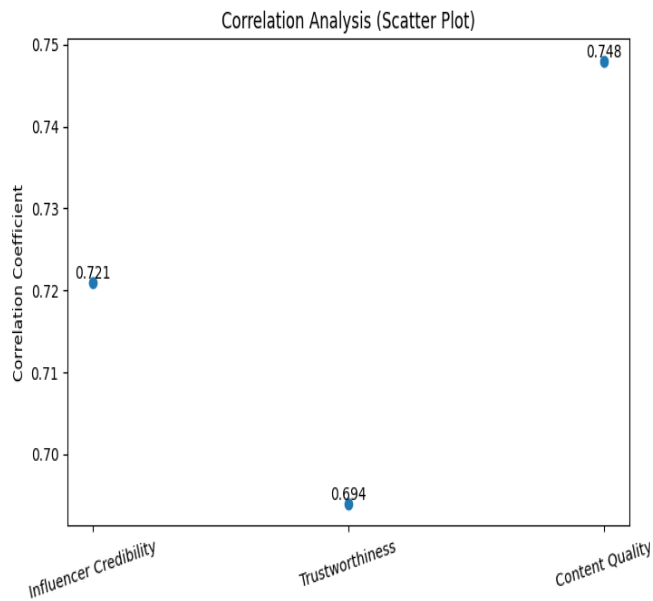
8.2 Cronbach's Alpha Reliability Analysis



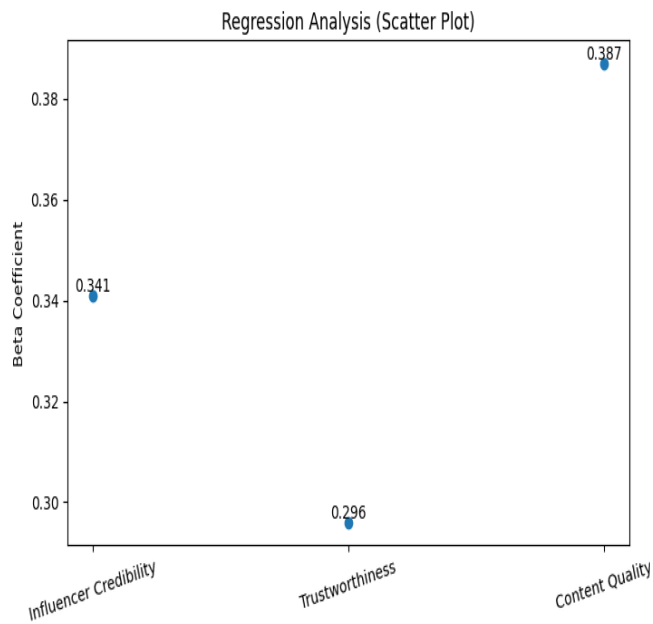
8.3 Mean Analysis



8.4 Correlation Analysis



8.5 Regression Analysis



8.6 Chi-Square Test

Navigating the Roadblocks of Agricultural Entrepreneurship

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Abstract - In today's world, entrepreneurship is essential for the economic development of a country. For an emerging country like India, entrepreneurial programmes are required, thus its importance, especially agri-entrepreneurship is crucial for upgrading the living standard, eliminating the unemployment, etc. of rural areas is utmost. Entrepreneurship development is the booster, which gives ample opportunities to the people to become self-reliant. An entrepreneur plays as a catalytic agent in boosting economic development. Even after 76 years after independence, the major occupational activity of people in India is agriculture. The agrarian economy has a major role in India's wealth. Hence, agriculture should not be underestimated, by the youngsters and rural youths. In order to boost and rejuvenate agriculture entrepreneurial culture of the farming business, lot of strategies are required to be implemented on ground level in order to stimulate and strengthen the agriculture, farming so to develop rural areas. When an entrepreneur pursues his / her ideas through a sustainable manner, with a core

value towards community-oriented business which is directly related to agriculture, it is called agri-entrepreneurship. Agricultural entrepreneurship is the amalgam of agriculture and business. In this form of entrepreneurship, the entrepreneur innovates, identifies the markets, and satisfies its needs in different ways. The term agri-entrepreneurship deals with the agricultural activities or agribusiness in village or rural areas of a country. Usually, it is observed that most of the farmers are untrained and have very less land / farm. They are unaware of scientific methods applied to boost agriculture and related agri management systems. The agri-entrepreneur should involve applying managerial, technical and innovative skills in the field of agriculture, so that the agri-entrepreneurs become a role model to all farmers.

Keywords- Entrepreneurial culture, Agriculture entrepreneurship, GDP, Agripreneurs, and Agronomy.

I. INTRODUCTION

Well-developed inter linkages between agriculture and rural industry is required to ensure rural transformation. Whether it is potatoes or tomatoes, farmers are forced to sell their produce for very less amount while the ultimate consumer pays huge amount. The central and state government, with partner agencies have come up with a lot of development schemes for agricultural entrepreneurship. Main aim is to involve more and more people into agricultural entrepreneurship. Move from conventional farming to modern farming is required. In this type of entrepreneurship, there is a lot of scope and opportunities to encourage local people in dairy farming, beekeeping, mushroom farming, fisheries, and other allied sectors. Cottage industries have a lot of potential for growth and employment. This is just because the mediators (big companies or agents) purchase the harvest at throw away prices and sell the same by processing and packing after doing grading work. Today, there is need to develop rural industries and reinforce them, so as to reduce losses and provide some extra returns to the farmers. The need is just to prepare our people to go and learn / practice agri-entrepreneurship. This chapter will illustrate the importance of agriculture development, its scope, and ample opportunities available.

II. OBJECTIVES OF STUDY

1. To identify the issues faced by agri-entrepreneurs in India.
2. To examine the opportunity of agri-entrepreneur

III. LITRATURE REVIEW

Since independence, Indian agriculture has originated extensively but still there are certain issues which require to be catered to for national economy and safety. Indian population is expected to touch 1.43 billion marks by 2028. India's ever-increasing population will require more agricultural production to cater to the food requirements of its citizens. For this, the agricultural growth rate has to be around 5% per year on a sustainable basis. By accelerating the growth in agricultural sector, the overall GDP will see an upward trend, thus making agricultural growth more comprehensive for India. By boosting the agriculture sector, the government will strengthen rural development, boost rural employment and stop the flow of population from rural to urban areas, bringing prosperity in rural areas of the country. Large investments are required with friendly policies for the development of post-harvest and cold storage infrastructure to be developed. Roads, storage and markets must be near to the farmers' fields. A wide range of definitions can be found of

entrepreneurship. In daily language, the term "entrepreneur" is often used for businessmen, who has started his own work, someone who is self-employed, a trader, or farmer, thereby confusing standing with title role (McClelland, 1967). In this perspective, agricultural entrepreneurship provides multiple descriptions of an agri-entrepreneur. Definitions about entrepreneurship area result of various disciplinary legacy, for instance, building further on the standard by economic expert Schumpeter (1934), or departure from the individual psychologist McClelland (1967). Lot of entrepreneurial definitions have changed focus from individual traits like locus of control, need for achievement etc to understandings like decision making, social capital like networks available and entrepreneurial behaviour (e.g., entrepreneurial orientation). As per Shane and Venkataraman (2000) it was evident that in the last many years, there has been an increasing accord that a key characteristic of entrepreneurship is to explore, identify, and assess the available business opportunities.

In order to do agri – entrepreneurship, one has to exploit entrepreneurial opportunities, but due to lack of certain qualities, ability and knowledge, many of the farmers fail to achieve the results. This is why, for

successful entrepreneurship one has to have a blend of continuous learning and development. The successful entrepreneur has to recognize the importance of broader working environment. How he is interpreting, understanding and using his / her creativity is very much important (Gartner, 1989). The core processes are the development process, by grasping the opportunity. One will not be successful, if working in isolation. The success may be influenced by, farmer's spouse, competitors, or anybody else. In sum, focus should be on the identification of gaps and opportunities in the present system and pursue till excellence. The entrepreneur should emphasize on the creativity, and strengthen the network issues (De Tienne and Chandler, 2004).

Defining entrepreneurship:

Entrepreneurship is the competence to build through developing pioneering ideas and achieving success. To create a sustainable business - innovative idea, optimum utilization of resources, should be done to bring change and to manage various risks. Only the entrepreneurs have the ability to generate employment, be competitive & exploiting resources for any sectors. Various studies conducted so far yielded the following result; It was observed by Singh (2014) that entrepreneurship leads to upward mobility,

by a decrease of 2% poverty in a country with an increase in 1% entrepreneurial activities. Shailesh et al., (2013) in his study concluded that entrepreneurship is an energetic process which leads to creation of forward-thinking assets. These assets are individuals who are ready to take major risks in terms of investment in equity, time and career forgoing worth to a product or service area. There is a possibility that the product or service might not be novel or exclusive but it holds value as indoctrinated by the entrepreneur. In another study by Mishra et al., (2010), the word entrepreneurship implies the use of energy for origination and building of an enterprise. Entrepreneurship is widely used and defined as an inventive and pioneering response to the environment factors as mentioned in a study by (Chandramouli et al., 2007). Bernier and Hafsi (2003) defined entrepreneurship as a process where an individual visualizes and implements an idea, belief related to a service, product or activity. Stevenson et al. (1999) described it as an opportunity, depending on the availability of resources.

IV. METHODOLOGY, FINDINGS AND ANALYSIS

This chapter is based on the findings on secondary data, research papers and chapters that were published by the

researchers. Certain reports related to agricultural entrepreneurship were also consulted during this research, these documents helped to know various challenges in agricultural entrepreneurship, which has enriched and covered the aspects.

Thus, it can be said that entrepreneurship is an individual's efforts to convert a vision into reality & make it a success. This shows that to be an entrepreneur one must have the potential to change their vision into reality. In addition to above, successful entrepreneur is one who has a broader vision also, for the wellbeing of the society. The entrepreneur, should always try to offer those products or services which are required by the society at the most. Contrary to this, an entrepreneur is a person who runs a business with the aim of growing it by following leadership skills and managerial skills essential for achieving goals. Every businessman or an entrepreneur, works for profits. No one wants to invest time, money and takes risk for 'no profit no loss' basis. If the entrepreneur is self-working and is proprietorship kind of business, then he / she will keep the profit as usual. But, in case there are partners, then the share of profit will be divided as per mutually agreed terms and conditions. It is better to work in a team, as not only the risk will be

shared but ideas of marketing and innovations will come more. This will be more profitable rather than working as single owned entrepreneurs. To start and float in the market, every entrepreneur needs sufficient funds / capital for the business. The starting financial help / backing comes from the bank in the form of loan, or from investors or the entrepreneur(s) invest his own savings. Entrepreneurship gives an entrepreneur, freedom to work, and the amount of capital raised gives more confidence. The true entrepreneur, never uses his / her own money. If the entrepreneur is working in partnership / as a team, then all the entrepreneurs will invest money into the venture.

Defining agripreneurs (Agri-entrepreneur): Since a very long-time agriculture is always considered as a backward sector, which doesn't have bright scope in terms of employment and revenue generation. There are many reasons, which has affected proper tapping of agriculture sector. Decreasing farm sizes made it inadequate to convert the produce into large scale industry besides no new innovation for increasing production. But in the last few decades, as a result of liberalization, privatisation & globalization, the agriculture has been greatly influenced. The term agripreneurs was widely

recognized throughout the globe. Agricultural entrepreneurship is basically comprised of production & creating a market for agricultural produce. In agripreneurs the agricultural inputs like – crops, vegetables, dairy produce, forest produce, horticulture, etc. are associated with agricultural platform. The production of agricultural inputs, their processing into marketing outputs like dairy products, horticulture, forest products etc in agriculture can lead to formation of a new economic organization, keeping in mind the growth under risk and uncertainty associated with agriculture.

In today's scenario its beneficial for young farmers to combine agriculture and entrepreneurship and convert their present farms into an agribusiness. The association of agriculture and business evolved agri-entrepreneurs, who revolutionized the agricultural activities into business by recognizing & developing the markets for their agricultural produce, and also developing different ways of offering products. Hence the term agri-entrepreneurship describes agribusiness establishment in agriculture and associated sectors. Agricultural companies today are acquainting themselves with the consumer market moods like-differences in consumer habits, product quality essentials, regulations for food safety & marketing etc.

These changes have led to evolution of new entrants in agricultural industry, modernisation in farming techniques along with different portfolio agripreneurs. Study conducted by McElwee (2008), it was observed that farmers should be involved in entrepreneurial activities related to agriculture. Hence many studies and researchers have proved that today's farmers need proper and timely knowledge of farm management, etc. which will help to boost their incomes and reduce unnecessary losses.

The areas where agripreneurs can self-start their own enterprises for production & marketing include:

1. Grocery enterprise: Growing fresh and organic fruits and vegetables is a new area, where the entrepreneur can start a lucrative venture, as people are getting aware of organic foods. Successful agro entrepreneurs must differentiate their products from others, by producing and selling organic products. People have paying capacity; they are now health conscious.
2. Aquaculture enterprise: Rearing fishes, shrimps, prawns etc for selling can be a profitable business, especially in the coastal areas.
3. Horticultural enterprise (Flowers): With the increase in religious activities,

home decors requiring green & natural environment, it's the most promising enterprise in the ethnic countries as well as non-ethnic countries. The ornamental plants have become the most suitable gifted items for those who want to protect environment.

4. Honey products: Beekeeping can be a profitable venture, one can start venture in honey and beeswax etc.
5. Alternative agriculture: Entrepreneurs can start a venture by producing mushroom, algae, etc. which are popular due to their nutritional value.
6. Agriculture machinery: Machineries and tools like plows, seeders, sprayer, and sprinklers etc. are the areas, where an entrepreneur can start manufacturing, and cater the local markets.
7. Herbs and spices enterprises: Cultivating herbs like basil, thyme etc having medicinal values & spices for flavours & natural colours in food has become a profitable niche market for the farmers.
8. Organic products enterprises: As the consumers are becoming aware about pesticides harms the demand for organic produce is increasing. This provides a great opportunity to new gen farmers to enter into a differentiated produce of a product.

9. Nuts and seeds enterprise: People are becoming conscious about the benefits of nuts & seeds in boosting immunity. Purchasing in bulk, repacking and selling with a brand, producing, etc. in nuts and seeds is a profitable venture.
10. Livestock rearing enterprise: Raising livestock, like cattle, cows, poultry farms, or goats/ sheep, etc. for milk & its allied products, wool, eggs etc yield decent profits for farmers.
11. Dairy products enterprises: Enterprises which cater to the milk demands of people in urban areas as well as rural areas along with the bye products like, cheese, butter, etc through organic methods is today's most wanted enterprise as it is directly related to the health of individuals.

Difference between entrepreneurship & agricultural entrepreneurship: Though agricultural entrepreneurship and entrepreneurship have some similarities, but it has its own specific differences due to its features related to agricultural sector. Hence, it's essential to study the difference between agricultural entrepreneurship & non-agricultural firms' entrepreneurship. The entrepreneurs are people who are pro-active, risk taking, having high self-efficacy & understand the importance of opportunities' available. But in case of agricultural entrepreneurs an in-depth

knowledge of agricultural sector is must, then only its prospects can be looked into for further activities related to entrepreneurship. In a study by Van der Ploeg et al. (2002), it was observed that over the last five decades, the agricultural development in many western countries have a highly specialized domain which focused on efficiency and productivity only. For example, during post-world war European countries reconstructed agriculture sector in order to aim food safety only, lacking in innovative entrepreneurship.

Agri-entrepreneurship scenario in India:

The history of Indian agriculture dates back to hundreds of centuries. Around 9000 BC, humans started identifying the seeds and cultivated crops. During that period, humans started domesticating animals, and developed irrigation channels and system. Indian civilization was most developed and it laid the foundation of growth. Today Indian agricultural sector employs 60% of the total workforce. In a study conducted by Bansal (2011) to find the scope of agri-entrepreneurs in India many observations & conclusions were given. His results showed that agri-entrepreneurship in India has immense potential because of the country's diverse agro-climatic conditions that support the production of temperate, subtropical, and

tropical crops. With the increasing demand for agricultural inputs like fertilizers, fodder etc has led to new opportunities for entrepreneurs in agricultural sector. Developments in biotechnology have further improved prospects in high yield seed production, better bio-control agents, and use of microbes in the industrial sector. India also has strong potential to enhance its position in global trade through the export of both raw and processed agricultural commodities. In addition, India's long coastline and inland water resources provide great scope for aquatic enterprises like fisheries etc, along with attractive aquarium enterprises due to rising aesthetic interest is becoming popular. Pradip S. Sonawane (2022) focused his study on the country's large livestock population offering opportunities in the dairy production and poultry products. The forest resources like bamboo trees, medicinal plants, honey, wax, resins etc can be utilized as forestry by-products, while beekeeping, mushroom cultivation, and organic farming also show high potential. Since the use of pesticides and chemical fertilizers is relatively lower in India, organic farming has a promising future. Greenhouse cultivation of vegetables and flowers can boost exports, while trained agricultural professionals can provide consulting and extension services. Increased agricultural production has also

created employment opportunities in industrial areas specially marketing, logistics, cold storage, warehousing, credit schemes by banks, and insurance, thus making agri-entrepreneurship an important driver of rural employment and economic growth in India.

In India agriculture has always been the main occupation. Most 60% people are associated with agriculture either directly or indirectly. Indian economy depends upon agriculture as the main source for industry come through cultivation only like, jute, cotton sugar etc. the Gross Domestic Product (GDP) of India has agriculture as its major contributor. Today Indian agriculture has become multi-tasking like generating employment, quality food production, thus providing livelihood, nutritional and environmental security (Singh, Et; Al 2023). In India the available land area is about 168 million hectares second only to the USA with respect to agricultural activities. India has well-developed agricultural system, having irrigated land of 60 million hectares, which helps in productivity of major crops. The Indian agriculture has the potential to control the global markets agricultural produce as almost 52% land is cultivable & there is variation in climatic conditions which support growth of different crops.

The major challenges still faced by agricultural sector are no fixed pattern of rainfall, diverse soils in north, south, east & west India, and variation in seasons specially in North India like mildly cool winters and hot summers. The major problems faced by Indian agricultural system include-crop yield per hectare is very less, either too much or too less rainfall, conditions of flood & droughts are unpredictable. Apart from these the use of chemicals rich in nitrogen is required as it's been found that Indian soils lack nitrogen.

Barriers to agri-entrepreneurship development: Uplonkar and Biradar (2015), advocated that there should be improvement in agri-entrepreneurship, this will bring improvement in the production and productivity. Alexandra Pliakoura (2021) identified the need for development of personal skills & inclusive thinking, for which methodologies should be developed so as to change the present system for economic development of the rural sector. Vinay Prasad B (2024) came to the conclusion that main obstacles are agri-entrepreneurship and market research. People don't know, how to market the product.

Despite the fact, that India is one of the largest agriculture-based economies, but it contributes approx.18% to the GDP. The challenges faced by agripreneurs mainly account to the facts mentioned below:

- 1) Majority of farmers lack in market information, connectivity with the markets and technology. These are the major causes of inability to convert their produce or yields into enterprise forms.
- 2) The farmers are unaware about the benefits of enterprises.
- 3) Due to non-availability of jobs in rural or backward areas, migration of skilled & talented workforce has created shortage of farmers or agri based entrepreneurs in rural India.
- 4) There is need of marketing and branding the products. Institutional measures by government agencies must be observed on ground level. People don't know to market the products in open markets.
- 5) Despite knowledge, farmers face problems when dealing with private traders, as they don't have storage facilities, and land holdings are very small.
- 6) In the open market, stiff competition is faced by the agripreneurs, they have fluctuating sales, etc. later, resultant farmer lose interest in his / her own enterprise.

- 7) Usually agri-entrepreneurs have weak financial strength. They can't play on risk. It is observed that despite their home-grown product is best in quality, but they fear from market competition, where big players destroy the market. This results in financial losses and hence debt accruals by the farmers.
- 8) Many times, the agripreneurs face transportation problem which is cost intensive as well as storing problems as they don't have large ware houses.
- 9) Agro entrepreneurs in remote areas face issues of limited access and knowledge of markets, prices, etc. They rely on middlemen or intermediaries.
- 10) Their productivity, quality and quantity suffer as most of the farmers lack in training and skills.
- 11) Farmers/ agripreneurs lack the study on the consumption patterns, products marketing, and distribution systems, etc.
- 12) Lack of innovation, & adaptation of new technologies also pose a challenge for agri enterprises.
- 13) Major hindrances of agriculture / agri entrepreneurship comes under unorganized industry, socio-political instability in our country, and problems in procurement of finance for their start up.

V. SUGGESTIONS

In addition to the above-mentioned challenges there are many more which are faced by the agri-entrepreneurs at their state level like government regulations, lack of modern technology, mindset of consumers, brand competitions, less marketing expenses leading to problem of building awareness etc. Hence the measures need to be taken to counter the issues / challenges that are encountered by agri-entrepreneurs. There are certain suggestions that can help the agripreneurs to start & turn their enterprises into profitable business. Agri-entrepreneurs should take the help of latest technological and digital tools / applications to market their products. The research indicates that who so ever wants to become an agri-entrepreneur, must have access and well of resources, government schemes, and must adopt modern technologies. There are lot of opportunities in agricultural entrepreneurship. The entrepreneur should use internet and mobiles in order to be well informed producer. Government must invest in developing infrastructure, increase digital literacy among rural areas (Bertoglio, Corbo, Renga, & Matteucci, 2021). Small farmers can sell their products with value additions or identifying Unique Selling Proposition (USP) for expanding their product absorption in the market. Today, the

consumer is more concerned about healthy organic food, so the scope of profit for the agripreneurs is increasing.

VI. CONCLUSION

Agriculture being the main occupation of almost 60% people in India has great scope of growth & transformation to further the GDP of our country. The farmers need to be educated regarding the entrepreneurial activities that can be taken up by them for generating income as well employment in their region. This will help not only in stopping migration from rural to urban areas but also in improving the standard of living of its citizens. This will ultimately lead to increase in per capita income of individuals. The state & central governments, must not only provide loans to farmers but, also help them in establishing enterprises through proper guidance & financial help. The value-added goods provide people with better ROI (Return on Investment). Specially after the pandemic many people throughout the globe has started following an organic food diet along with more nutritional value. The best example is that of millets consumption, use of organic vegetables, bend towards balanced diet rather than taste etc. These all can be ensured by promoting agripreneurs in our

country. So, the need of the day is to make farmers aware about the benefits of establishing enterprises & support offered by government bodies. The effective management of agricultural components i.e. soil, water, fertilizers, quality seeds is must along with providing better storage facilities for grains & other products. Hence agripreneurs are must for GDP growth in the country.

VII. FINDINGS, DISCUSSES IMPLICATIONS, AND OUTLINES AREAS FOR FUTURE RESEARCH

Agri-entrepreneurship plays a crucial role in the economic development of India, providing solutions to enhance GDP, generate rural employment, and mitigate migration by embracing modern technologies and value-added products. Research shows that agricultural entrepreneurship in India, particularly in agro-based industries, has substantial potential to improve rural employment, promote sustainable practices, and aid in national economic progress. The analysis revealed that access to financial resources, knowledge of government initiatives, and the implementation of modern agro-technologies are significantly linked to the growth and success of agro-based entrepreneurship.

VIII. LIMITATIONS

The aforementioned research is confined to secondary data, focusing solely on agro-entrepreneurs. Not many studies are conducted on larger scale, this is the gap for future researchers, that they can study. The chapter comprehend the challenges and barriers encountered by agro-entrepreneurs in the production and distribution of agricultural products. The NGO's, government agencies must play a crucial role to frame policies and train people to boost this area.

IX. REFERENCES

1. Agnete Alsos G, Ljunggren E and Pettersen L. 2003. Farm-based entrepreneurs: what triggers the start-up of new business activities? *Journal of Small Business and Enterprise Development*. 10: 435-3.
2. Alexandra PLIAKOURA "The Accepting the challenges of agricultural entrepreneurship and management development research: a viewpoint" CES Working Papers – Volume XIII, Issue 4
3. Bernier L and Hafsi T. 2003. The changing nature of public entrepreneurship. USA, Midwest Political Science Association Conference.
4. Boehlje M, Roucan-Kane M and Broring S. 2011. Future agribusiness challenges: strategic uncertainty, innovation and structural change. *International Food and Agribusiness Management Review*. 14: 53-82.
5. Chandramouli P, Meti K S, Hirevenkangoudar L V and Hanchinal S N. 2007. Comparative
6. Dollinger M J. 2003. *Entrepreneurship–Strategies and Resources*. Pearson International Edition, New Jersey.
7. Faisal I. 2010. Institutionalization of agricultural knowledge: management system for digital marginalized rural farming community. *Proceedings of a symposium on*
8. Gray C. 2002. Entrepreneurship, resistance to change and growth in small firms. *Journal of Small Business and Enterprise Development*. 9(1): 61-72.
9. Haugen M S and Vik J. 2008. Farmers as entrepreneurs: the case of farm-based tourism. *International Journal of Entrepreneurship and Small Business*. 6:321-6.
10. Innovation and Sustainable Development in Agriculture and Food, Montpellier. pp. 10-22. France, 28 June-1st July 2010. France.

11. Lan Matrix, 2015. Agricultural drivers. Land Matrix Global Observatory. Available at: <http://www.landmatrix.org/en/get-the-idea/agricultural-drivers>.
12. Lowson R H 2002. Strategic Operations Management: the New Competitive Advantage. Journal of General Management. 28(1): 36–56.
13. McElwee G and Smith R. 2012. Classifying the strategic capability of farmers: a segmentation framework. International Journal of Entrepreneurial Venturing 4:111-1.
14. Mishra A H, El-Osta H and Shaik S. 2010. Succession decisions in U. S. Family farm business. Journal of Agricultural and Resource Economics. 35:133-2.
15. Pettinger T. 2016. Problems of agriculture-market failure. Economics help-org. Available at <https://www.economicshelp.org/blog/4977/economics/problems-of-agriculturemarket-failure/EconomicsHelp.org>.
16. Research Paper 07-01. Center for Employment Policy Entrepreneur Series. Hudson Institute, Washington, DC.
17. Richards S T and Bulkley S. 2007. Agricultural entrepreneurs: the first and the forgotten?
18. Shailesh K, Gyanendra S and Yadav V K. 2013. Factors influencing entrepreneurial behaviour of vegetable growers. Indian Research Journal of Extension Education. 13(1):16- 19.
19. Singh M P. 2014. Entrepreneur and economic development: a study of role of various forms of entrepreneurs in economic development. Global Journal of Multidisciplinary Studies. 3(5). GJMS, Jabalpur MP, India.
20. Singh. V, Faujdar. K, Garg. DK, and Singh A (2023). Importance of Agro Entrepreneurship in Indian Economy: A Review, International Journal of Enhanced Research in Science, Technology & Engineering, ISSN:2319-7463, Vol 12, Issue 6
21. Stevenson H, Roberts M and Bhide A. 1999. The entrepreneurial venture, Sahlman W (Ed.). Harvard Business School, US.
22. Bertoglio, R., Corbo, C., Renga, F. M., & Matteucci, M. (2021). The digital agricultural revolution: A bibliometric analysis literature review. IEEE Access, 9, 134762–134782. <https://doi.org/10.1109/ACCESS.2021.3115258>
23. Uplaonkar S S and Biradar. 2015. Development of agriculture in India through agripreneurs. International

Journal of Applied Research.
1(9):1063-66

24. Vinay Prasad B (2024), Problems and Challenges of Agro Entrepreneurship - A Study, International Journal of Trend in Scientific Research and Development (IJTSRD) Volume 8 Issue 1.
25. World Bank. 2012. World Development Report 2013: Jobs. World Bank, Washington, DC.
26. Pradip Sahebrao Sonawane, 'Agricultural Entrepreneurship in India with respect to Agro-Based Industries: Opportunities and Challenges', Neuroquantology, Oct 2022, Volume 20, Issue 10, Page

Generative Artificial Intelligence and Financial System Stability: Opportunities, Risks and Governance Challenges in Digital Finance

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Abstract-- Generative Artificial Intelligence has rapidly become one of the most influential technologies shaping the modern financial ecosystem. Banks, insurance companies, investment firms, fintech platforms, payment service providers and regulators are increasingly exploring AI-based tools for credit assessment, fraud detection, customer support, risk analysis, portfolio management, regulatory compliance and market surveillance. The technology offers advantages such as faster decision-making, improved customer experience, cost reduction, financial inclusion and better identification of emerging risks. At the same time, the growing use of generative AI in financial services creates concerns related to model opacity, data bias, cyber vulnerability, misinformation, market concentration, herd behaviour and regulatory uncertainty. Since the financial system is highly sensitive to trust, information and speed, any failure or misuse of AI may create wider implications for financial stability. This paper examines the role of generative AI in finance with a special focus on opportunities, risks and governance challenges. The paper argues that generative AI should not be treated only as a technological innovation, but as an important financial infrastructure that requires responsible design, human supervision, ethical use, strong data governance and continuous regulatory oversight. The study concludes that AI can strengthen financial stability only when innovation is balanced with transparency, accountability and resilience.

Keywords-- Generative AI, Financial Stability, Digital Finance, FinTech, Risk Management, Cybersecurity, Financial Governance, Artificial Intelligence

I. INTRODUCTION

The financial sector has always been one of the earliest adopters of technology. From automated teller machines and internet banking to mobile payments, blockchain, robo-advisory platforms and algorithmic trading, technology has continuously changed the way financial institutions operate. In recent years, Generative Artificial Intelligence has emerged as a powerful tool that is transforming financial services at an even faster pace. Unlike traditional artificial intelligence systems that mainly classify data or make predictions, generative AI can create new content, generate financial summaries, prepare reports, write code, support customer conversations, analyse documents and assist in complex decision-making.

The financial industry is built on three important pillars: information, trust and risk management. Generative AI directly affects all three. It can process large volumes of financial and non-financial data within seconds and provide meaningful insights to decision-makers. It can improve trust when it supports accurate, transparent and timely services. It can also strengthen risk management by identifying unusual patterns before they become major problems. However, if AI systems are not properly designed or monitored, they can also produce incorrect outputs, biased recommendations and misleading financial signals.

The purpose of this paper is to examine how generative AI is influencing financial system stability. Financial stability means that financial institutions and markets are able to perform their core functions smoothly even during periods of stress. These functions include mobilizing savings, allocating credit, processing payments, managing

risks and supporting economic growth. If generative AI is used responsibly, it may improve these functions. If it is used carelessly, it may create new forms of systemic risk.

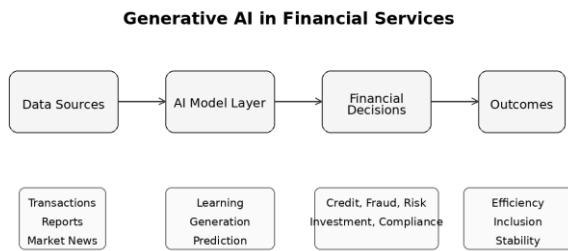


Fig. 1. Conceptual flow of generative AI applications in financial services.

II. GENERATIVE AI IN FINANCIAL SERVICES

Generative AI refers to artificial intelligence systems that can generate new outputs based on patterns learned from large datasets. These outputs may include text, financial summaries, risk reports, investment insights, customer responses, coding solutions, fraud alerts and scenario-based analysis. In finance, the use of generative AI is expanding across multiple functions because financial institutions work with large volumes of data, documents and real-time transactions.

A. Use in Banking

Banks are using AI-based systems to improve customer service, credit assessment, loan processing and fraud detection. AI-enabled chatbots can respond to customer queries related to account balances, loan eligibility, credit card issues and investment options. These tools reduce waiting time and improve customer satisfaction.

In credit assessment, AI can analyse repayment history, income patterns, transaction behaviour and alternative data to support loan decisions. This can make lending faster and more efficient. For small borrowers and first-time credit users, AI may also improve access to finance by using broader data points beyond traditional credit scores.

B. Use in Investment and Portfolio Management

Investment firms use generative AI to analyse company reports, market news, macroeconomic indicators, stock price movements and investor

sentiment. AI can summarize large financial documents and help analysts identify relevant information more quickly. Portfolio managers may use AI tools for asset allocation, risk measurement and scenario analysis. Robo-advisory platforms are also using AI to provide automated investment advice.

C. Use in Insurance and Compliance

Insurance companies use AI to support underwriting, claim processing, fraud detection and customer service. In regulatory compliance, generative AI can support anti-money laundering checks, know-your-customer verification, suspicious transaction reporting and regulatory documentation by reading documents, identifying inconsistencies and generating alerts.

III. OPPORTUNITIES FOR FINANCIAL SYSTEM STABILITY

Generative AI can support financial stability in several ways. When used responsibly, it can help institutions identify risks early, improve efficiency, expand access to finance and strengthen supervision.

One of the major benefits of AI is its ability to identify risks at an early stage. Traditional risk management systems often depend on periodic reports and historical data. In contrast, AI systems can analyse real-time information from multiple sources. For example, they can detect sudden changes in customer repayment patterns, liquidity movements, transaction behaviour, cyber incidents or market sentiment.

Digital finance has increased convenience, but it has also increased fraud risk. Online banking fraud, identity theft, phishing attacks, fake investment schemes and payment fraud are becoming more sophisticated. Generative AI can help financial institutions detect suspicious behaviour by analysing transaction patterns, device information, login behaviour and customer activity.

AI can also support financial inclusion by helping institutions serve customers who do not have strong formal credit histories. Traditional credit assessment often excludes individuals with limited banking records. AI can use alternative data such as cash-flow behaviour, digital payments, utility

payments and small business transactions to assess creditworthiness.

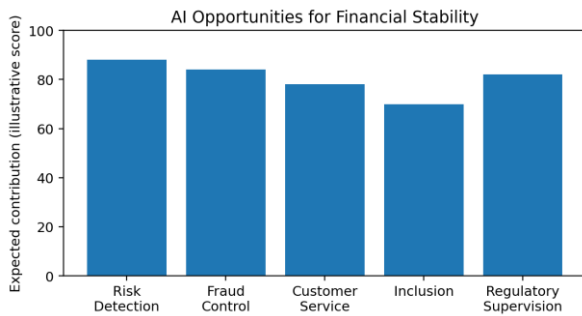


Fig. 2. Illustrative contribution of AI use cases to financial stability.

Financial regulators are responsible for maintaining market discipline and protecting the stability of the financial system. With the growth of digital finance, regulators must analyse large volumes of data from banks, non-banking institutions, fintech platforms and markets. AI can support regulators by identifying patterns, preparing risk dashboards and detecting abnormal activities.

IV. RISKS AND CHALLENGES OF GENERATIVE AI IN FINANCE

A. Model Opacity

Many AI models are difficult to explain. They may produce a recommendation or decision, but the exact reasoning behind that output may not be clear. In finance, explainability is very important because decisions affect customers, investors and institutions.

B. Data Bias

AI systems learn from data. If the data contains bias, the AI output may also become biased. In financial services, biased data can lead to unfair lending, unsuitable product recommendations or discriminatory insurance pricing.

C. Misinformation and AI Hallucination

Generative AI can sometimes produce incorrect or misleading information with confidence. In finance, such errors can be harmful. A wrong financial summary, inaccurate risk report or misleading investment analysis may result in poor decisions.

D. Herd Behaviour and Market Volatility

If many financial institutions use similar AI models trained on similar data, their decisions may become similar. In investment markets, this can create herd behaviour. During stress, automated and similar responses may increase instability.

E. Cybersecurity Risk

Generative AI can be used by both financial institutions and cybercriminals. While institutions use AI to detect cyber threats, attackers may use AI to create highly convincing phishing emails, fake identities, deepfake videos and automated hacking attempts.

F. Third-party Dependency

Many financial institutions may depend on large technology companies and external vendors. If many institutions depend on the same AI provider, failure or manipulation of that provider system may affect the wider financial system.

AI Risk and Governance Matrix

Key Risk	Governance Response
Model Opacity	Explainability
Data Bias	Fairness Testing
Cyber Threats	Cyber Resilience
Herd Behaviour	Stress Testing
Vendor Dependency	Third-party Oversight

Fig. 3. Risk and governance matrix for AI-enabled finance.

V. GOVERNANCE FRAMEWORK FOR RESPONSIBLE AI

A strong governance framework is required to ensure that generative AI supports financial stability. Governance should include technical controls, ethical safeguards, institutional accountability and regulatory supervision.

TABLE I
KEY ELEMENTS OF RESPONSIBLE AI
GOVERNANCE IN FINANCE

Governance Area	Purpose	Expected Outcome
Human-in-the-loop	Review high-impact financial decisions	Accountability and customer protection
Model validation	Test accuracy, fairness and robustness	Reliable and stable AI output
Data governance	Protect data quality, privacy and security	Trustworthy decision-making
Cyber resilience	Prevent misuse, attacks and failures	Operational continuity
Vendor oversight	Monitor third-party technology dependence	Reduced concentration risk

A. Human-in-the-loop System

AI should support human decision-making, not completely replace it in critical financial areas. For high-impact decisions such as loan approval, investment advice, fraud reporting and regulatory compliance, human review should remain necessary.

B. Model Validation

Financial institutions should regularly test AI models for accuracy, fairness, reliability and stability. Model validation should not be a one-time activity. Since market conditions and customer behaviour change over time, AI models should be continuously monitored and updated.

C. Explainability and Transparency

Institutions should maintain proper documentation of AI models, including data sources, assumptions, limitations, decision rules and testing results. Customers, auditors and regulators should be able to understand how important AI-supported decisions are made.

D. Data Governance and Cyber Resilience

Data is the foundation of AI. Financial institutions must ensure that data used in AI systems is accurate, relevant, secure and legally collected. AI-related cyber risk should be treated as a major part of operational risk management.

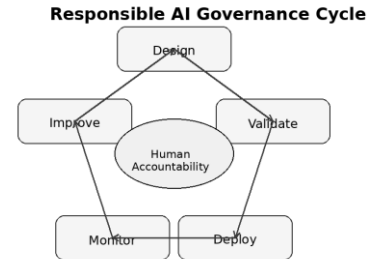


Fig. 4. Responsible AI governance cycle for financial institutions.

VI. HUMANIZED PERSPECTIVE ON AI IN FINANCE

Finance is not only about numbers, models and algorithms. It is closely connected with people's lives. A financial decision may affect a person's education loan, home loan, business expansion, retirement savings or medical insurance. Therefore, the use of AI in finance should always consider human impact.

A customer may not understand complex AI models, but the customer deserves fairness, clarity and respect. If AI makes financial services faster but less transparent, then the system may lose trust. Similarly, if AI improves institutional profits but harms vulnerable customers, then its use cannot be considered responsible.

The humanized approach to AI in finance means that technology should be used to support people, not to replace accountability. Financial institutions must remember that every AI decision has a human consequence. Responsible AI should improve access, reduce errors, support better advice and protect customers from fraud. It should not create exclusion, confusion or unfair treatment.

VII. DISCUSSION

The future of finance will be increasingly digital and intelligent. Generative AI will become an important part of banking, investment, insurance,

payments and regulation. However, the financial sector must avoid adopting AI only because it is fashionable. AI adoption should be based on clear objectives, proper risk assessment and strong governance.

The biggest challenge is balance. If institutions avoid AI completely, they may lose efficiency and competitiveness. If they adopt AI without control, they may create new risks. Therefore, a middle path is necessary. Innovation should be encouraged, but it must be supported by transparency, testing, accountability and human judgment.

For developing economies like India, AI has special importance. It can help expand financial inclusion, improve digital lending, strengthen fraud detection and support regulatory technology. At the same time, India has a large and diverse customer base, which makes fairness, language accessibility, privacy and digital literacy very important.

VIII. CONCLUSION

Generative Artificial Intelligence is reshaping the financial sector by improving efficiency, customer service, fraud detection, credit assessment, investment analysis and regulatory supervision. It has the potential to strengthen financial stability by helping institutions identify risks early and respond faster. It can also support financial inclusion by making financial services more accessible and personalized.

However, generative AI also creates new risks. These include model opacity, data bias, misinformation, cyber threats, herd behaviour, third-party dependency and regulatory gaps. Since the financial system is highly interconnected, these risks may become systemic if not properly managed.

The paper concludes that generative AI should be adopted with cautious optimism. It is neither a complete solution nor a direct threat by itself. Its impact depends on how it is designed, governed and supervised. Financial institutions must ensure human accountability, model validation, transparency, ethical use and strong cybersecurity. Regulators must develop flexible and forward-looking frameworks that support innovation while protecting financial stability.

ACKNOWLEDGMENT

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IX. REFERENCES

- [1] International Monetary Fund, "Global Financial Stability Report: Steadying the Course: Uncertainty, Artificial Intelligence, and Financial Stability," International Monetary Fund, Oct. 2024.
- [2] Financial Stability Board, "The Financial Stability Implications of Artificial Intelligence," Financial Stability Board, Nov. 2024.
- [3] Bank for International Settlements, "Annual Economic Report 2025," Bank for International Settlements, 2025.
- [4] Organisation for Economic Co-operation and Development, "Artificial Intelligence in Finance," OECD, 2024.
- [5] Reserve Bank of India, "Report on Trend and Progress of Banking in India," RBI, 2024.
- [6] S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed. Pearson, 2021.
- [7] A. Agrawal, J. Gans, and A. Goldfarb, *Prediction Machines: The Simple Economics of Artificial Intelligence*. Boston, MA, USA: Harvard Business Review Press, 2018.
- [8] J. Danielsson and A. Uthemann, "On the use of artificial intelligence in financial regulations and the impact on financial stability," 2023.
- [9] N. Maslej et al., "Artificial Intelligence Index Report 2025," Stanford Institute for Human-Centered Artificial Intelligence, 2025.
- [10] World Economic Forum, "The Future of Financial Services and Artificial Intelligence," WEF, 2024.

Design and Development of Vehicle Service Center Management System using Java and Hibernate

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Abstract - Vehicle service centers often struggle to manage customer records, service requests, billing, and maintenance schedules when using manual processes. These traditional methods can cause data duplication, mistakes, delays, and poor service management. This paper describes the design and development of a Vehicle Service Center Management System built with Java and Hibernate to automate and improve service center operations. The system includes modules for customer registration, vehicle records, service booking, billing, and service history tracking. Hibernate acts as the Object-Relational Mapping (ORM) tool for efficient database work, while Java handles the backend logic for secure and reliable processing. This system boosts efficiency, reduces manual errors, makes records easier to access, and increases customer satisfaction. Future updates could add mobile access and online payment options.

Keywords - Vehicle Service Center, Java, Hibernate, Database Management, Automation, Service Booking System, ORM

I. INTRODUCTION

Today, automation is key to making business operations more efficient. Vehicle service centers deal with a large amount of customer and vehicle data, such as service history, repair details, billing, and

appointments. Handling these records manually often causes mistakes, delays, and inefficiency.

A Vehicle Service Center Management System is designed to computerize and automate these activities. The proposed system is developed using Java and Hibernate to provide a reliable and efficient platform for managing service center operations. This system simplifies data handling, improves customer service, and reduces administrative workload.

1.1 Problem Statement

Traditional vehicle service centers face several challenges:

- Manual maintenance of service records
- Difficulty in tracking service history
- Billing in accuracies
- Time-consuming customer management
- Poor data security
- Delayed service processing

These issues create inefficiencies and affect customer satisfaction.

1.2 Objectives of the Study

- To automate vehicle service center operations
- To maintain customer and vehicle records digitally
- To generate accurate bills automatically
- To track vehicle service history

To reduce paper work and manual errors

- To improve service management efficiency

II. LITRETURE REVIEW

Traditional vehicle service centers mainly rely on manual record-keeping methods such as registers, paper files, and handwritten bills. These methods often create several operational challenges.

Data inconsistency occurs when customer or vehicle information is entered incorrectly or updated in on record but not in others.

Manual systems also lead to delayed processing because searching for customer details, service history, or billing records requires physically checking files and registers.

Other common problems include:

- Loss or damage of physical records
- Difficulty in maintaining large volumes of data
- Human errors during record entry
- Lack of proper data backup

Research studies have shown that manual systems reduce productivity and negatively affect customer satisfaction due to longer waiting times and inaccurate records.

III. PROPOSED SYSTEM

The proposed Vehicle Service Center Management System is a computerized application developed to automate and simplify daily service center operations.

A. Customer Registration

Stores:

- Customer Name
- Contact Number
- Address
- Email ID
- Registration Date

B. Vehicle Record Management

Stores:

- Vehicle Number
- Vehicle Model
- Brand Name
- Manufacturing Year
- Owner Details

C. Service Booking

Manages:

- Service Date
- Service Type
- Assigned Mechanic
- Estimated Delivery Time

D. Service History Tracking

Records:

- Previous Service Dates
- Repair Details
- Parts Replaced
- Total Cost

E. Report Generation

Generates:

- Daily Service Report
- Monthly Revenue Report
- Customer Report
- Vehicle Service History Report

F. Advantages of the System

- Reduces manual paperwork
- Improves data accuracy
- Saves operational time
- Enhances customer service
- Provides secure data storage

- Simplifies service center management

IV. TECHNOLOGIES USED

TABLE I

Technology	Purpose
Java	Backend Development
Hibernate	ORM Framework
MySQL	Database Management
HTML/CSS	Frontend Interface
Eclipse/IntelliJIDEA	Development Environment

V. METHODOLOGY

The project follows the Software Development Life Cycle (SDLC).

A. Phase1: Requirement Analysis

- Studying current workflows
- Identifying operational challenges
- Gathering user requirements
- Defining system objectives

B. Phase 2: System Design

1) Database Design: Main tables:

- Customer Table
- Vehicle Table
- Service Table
- Billing Table

User Interface Design:

- Login Page
- Customer Registration Form
- Vehicle Entry Form
- Service Booking Form
- Billing Screen
- Report Dashboard

C. Phase3: Development

- Java for business logic

- Hibernate for database connectivity

- MySQL for data storage

D. Phase4:Testing

- Unit Testing
- Integration Testing
- System Testing

E. Phase 5: Deployment

- Installing software
- Configuring database connection
- Uploading initial data
- Training users

VI. IMPLEMENTATION

The system is developed using an object-oriented approach where each entity is represented as a Java class and mapped to database tables using Hibernate annotations.

Main classes include:

- Customer Class
- Vehicle Class
- Service Class
- Billing Class

VII. RESULTS

The developed system successfully replaced traditional manual processes.

- Reduced manual effort
- Faster data retrieval
- Improved billing accuracy
- Better customer record management
- Enhanced operational efficiency

VIII. FUTURE SCOPE

Future enhancements include:

- Mobile application integration
- Online payment system
- SMS/ Email notifications
- AI-based service prediction

IX. CONCLUSION

The Vehicle Service Center Management System developed using Java and Hibernate provides an efficient, reliable, and practical solution for automating vehicle service center operations. The system improves productivity, reduces manual errors, enhances customer satisfaction, and provides a strong foundation for future enhancements.

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X. REFERENCES

- [1] Herbert Schildt, *Java: The Complete Reference*, McGraw-Hill Education.
- [2] Gavin King, *Hibernate in Action*, Manning Publications.
- [3] Oracle Corporation, *Java Documentation*.
- [4] Oracle Corporation, *MySQL Database Documentation*.
- [5] Software Engineering principles and practices textbooks.
- [6] Roger S. Pressman, *Software Engineering: A Practitioner's Approach*.
- [7] Hibernate Official Documentation.
- [8] Java API Documentation.
- [9] Kathy Sierra and Bert Bates, *Head First Java*, O'Reilly Media.
- [10] Craig Walls, *Spring in Action*, Manning Publications.
- [11] Martin Fowler, *Patterns of Enterprise Application Architecture*, Addison-Wesley.
- [12] Ian Sommerville, *Software Engineering*, Pearson Education.
- [13] Abraham Silberschatz, Henry F. Korth, and S. Sudarshan, *Database System Concepts*, McGraw-Hill.
- [14] Elmasri Ramez and Shamkant B. Navathe, *Fundamentals of Database Systems*, Pearson.
- [15] P. Gupta and R. Sharma, "Automated Vehicle Service Management System Using Java," *International Journal of Computer Applications*, vol. 180, no. 25, pp. 15–20, 2021.
- [16] S. Verma and A. Kumar, "Automation in Vehicle Maintenance and Service Centers," *International Journal of Engineering Research & Technology (IJERT)*, vol. 9, no. 6, pp. 102–106, 2020.
- [17] Christian Bauer and Gavin King, *Hibernate in Action*, Manning Publications, 2005.
- [18] M. Fowler, *Patterns of Enterprise Application Architecture*, Addison-Wesley Professional, 2002.
- [19] Oracle Corporation, "Java Hibernate ORM Framework Documentation," Available: <https://hibernate.org/orm/documentation/>

Ethical Pedagogy: Nurturing Integrity and Character in Education

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Abstract - Education goes beyond imparting knowledge; it plays a pivotal role in shaping individuals' character and values. Ethical pedagogy focuses on integrating moral principles and character development into the learning process, aiming to nurture integrity and responsible citizenship in students. This approach emphasizes teaching values like honesty, respect, and responsibility, and providing opportunities for students to apply these values in real-world contexts. Ethical pedagogy recognizes teachers as role models and highlights the importance of fostering a positive and supportive learning environment where ethical behavior is consistently demonstrated and encouraged. Character education addresses the cognitive affective and behavioral aspects of education and utilize all dimensions of life to foster character development. Character education focuses on the code civic virtues and moral values that are widely held in our society across our religions and other differences character and integrity are both important, but they are not synonymous. Integrity is a firm undivided adherence to as objective code of moral values Integrity is not just what people see Integrity is what you are. Integrity and character must be taught in education. In other words Integrity is the blueprint of character. Ethical pedagogy focuses on nurturing integrity and

character in education by integrating ethical principles into the curriculum, teaching practices, and culture. It aims to develop students who are not only knowledgeable but also possess strong moral values, fostering responsible citizenship and contributing to a more ethical and just world.

Keywords—moral principals, character development, learning process, nurture integrity, responsible citizenship, ethical behavior, teaching practices, positive & supportive environment.

I. INTRODUCTION

Education is not only a means of imparting knowledge and skills but also a means of personality formation. In the era of globalization the challenges facing the younger generation and increasingly complex. This condition not only instinctual abilities but also requires them to have high moral ethical and responsible. Education is not only a means of imparting knowledge and skills but also a means of personality formation. In the era of globalization the challenges facing the younger generation and increasingly complex. This condition not only instinctual abilities but also requires them to have high moral ethical and responsible. Ethical pedagogy focuses on nurturing integrity and character in education by integrating ethical principles into the curriculum, teaching practices, and

culture. It aims to develop students who are not only knowledgeable but also possess strong moral values, fostering responsible citizenship and contributing to a more ethical and just world.

II. ASPECTS OF ETHICAL PEDAGOGY

Character Development: Ethical pedagogy emphasizes the development of core values like honesty, integrity, respect, responsibility, and empathy.

Ethical Decision-Making: It equips students with critical thinking skills to analyze ethical dilemmas and make responsible choices.

Responsible Citizenship: Ethical pedagogy promotes the idea that education should prepare students to be responsible and engaged members of society.

Ethical Decision-Making: It equips students with critical thinking skills to analyze ethical dilemmas and make responsible choices.

Responsible Citizenship: Ethical pedagogy promotes the idea that education should prepare students to be responsible and engaged members of society.

Integration into Curriculum: Ethical considerations are woven into various subjects and learning activities, not just taught as a separate subject.

Role Modeling: Teachers and other adults in the school environment act as positive role models, demonstrating ethical behavior and values.

Community Involvement: Parents and the wider community are also involved in fostering ethical development, creating a holistic approach.

Character Education: Character education goes beyond academics, focusing on developing students' moral reasoning and ethical decision-making skills.

Values Integration: Ethical principles are systematically integrated into the curriculum and classroom activities.

Teacher as Role Model: Teachers play a crucial role in modeling ethical behavior and fostering a positive classroom environment.

Real-World Application: Students are provided with opportunities to apply ethical principles in practical situations, such as resolving moral dilemmas.

Holistic Development: Ethical pedagogy aims for the holistic development of students, encompassing their intellectual, moral, and social-emotional growth.

Benefits of ethical pedagogy:

Responsible Citizenship: Nurtures students' capacity for ethical decision-making and responsible participation in society.

Stronger Moral Reasoning: Enhances students' ability to analyze moral situations and make sound ethical judgments.

Positive Culture: Contributes to a more positive, inclusive, and supportive learning environment.

Personal Growth: Promotes personal growth, integrity, and a strong sense of social responsibility.

III. IMPORTANCE OF ETHICAL PEDAGOGY:

Improved Academic Outcomes: By promoting a positive and ethical learning environment, ethical pedagogy can lead to better academic performance.

Reduced Behavioral Problems: When students understand and internalize ethical principles, they are more likely to make positive choices and engage in respectful behavior.

Enhanced Social Skills: Ethical education helps students develop empathy, communication skills, and the ability to work collaboratively, leading to stronger social interactions.

Preparedness for the Future: Students who receive ethical education are better equipped to navigate the challenges and complexities of the modern world, making them more effective leaders and responsible citizens.

Fostering a More Ethical Society: By nurturing ethical individuals, ethical pedagogy contributes to the development of a more just and compassionate society overall.

The Role of Ethics in Education

Building Character: Education goes beyond imparting knowledge; it plays a pivotal role in shaping individuals' character and values.

IV. THE CONCEPT OF CHARACTER

•“Character comes from the Greek”
“Kharakter” to engrave or to mark. This character speaks of the active process of making marks or signs on one’s personality
Character is the aggregate of features and traits that from the individual nature of person.

The importance of character:

- **Guiding Principles:** A strong character provides a moral compass that helps individuals make ethical decisions.
- **Resilience:** It fosters resilience, enabling individuals to face challenges with integrity and courage.

- **Positive Impact:** Individuals with strong character contribute positively to their communities and society.

- **Individuals to face challenges with integrity and courage.**

- **Positive Impact:** Individuals with strong character contribute positively to their communities and society.

V. ETHICS IN EDUCATION

- **Moral Development:** It fosters moral development by teaching values and principles.

- **Critical Thinking:** Ethics education encourages critical thinking and ethical reasoning.

- **Preparation for Life:** It equips students with the tools needed to navigate complex ethical dilemmas.

Building Character through Education

- **Curriculum Integration:** Integrate ethics and character education into the curriculum to provide regular opportunities for moral reflection.

- **Role Models:** Showcase ethical role models, both historical and contemporary, to inspire students.

- **Service Learning:** Engage students in learning projects that emphasize empathy and compassion.

- **Discussion and Debate:** Encourage students to discuss ethical issues and how character contributes positively to their communities and society.

The Benefits of Character Education

- **Improved Relationships:** Students with character develop healthier relationships with peers and adults.

- **Academic Success:** Ethical students tend to perform better academically due to their focus and discipline.
- **Community Engagement:** They are more likely to engage in community service and contribute positively to society.
- **Conflict Resolution:** Strong character helps students resolve conflicts peacefully.

Role in Character Education

- **Ethics Integration:** Integrate ethics into every aspect of school life, from curriculum to discipline.
- **Teacher Training:** Train teachers in ethical education techniques and principles.

Character Education: Character education goes beyond academics, focusing on developing students' moral reasoning and ethical decision-making skills.

Values Integration: Ethical principles are systematically integrated into the curriculum and classroom activities.

Character focus on the Core Civic and moral Values that are widely helpful in our whole life.

The role of Integrity in Education: Integrity in education refers to the adherence to strong ethical and moral values, such as honesty, fairness, trust, and responsibility, within the academic and institutional environment. It requires students, teachers, and administrators to be transparent and uphold accountability, fostering a credible and trustworthy pursuit of knowledge. While promoting a culture of intellectual honesty, it is also about cultivating the courage to make right choices and resisting actions like plagiarism, cheating, and falsification of data, which undermine trust and diminish qualifications. Ethical pedagogy focuses on integrating moral principles and character development into the learning process,

aiming to nurture integrity and responsible citizenship in students. This approach emphasizes teaching values like honesty, respect, and responsibility, and providing opportunities for students to apply these values in real-world contexts. Ethical pedagogy recognizes teachers as role models and highlights the importance of fostering a positive and supportive learning environment where ethical behavior is consistently demonstrated and encouraged. Integrity is the quality of being consistently honest, morally upright, and ethically sound, often described as "doing the right thing, even when no one is watching". It involves having strong principles, acting with truthfulness and sincerity, and maintaining internal consistency in one's character and actions, even in difficult situations. The word itself comes from the Latin *integer*, meaning "whole" or "complete," reflecting a sense of inner wholeness derived from strong moral character.

The concept of integrity: "Integrity" comes from the Latin "integrate" which means "to make whole, repair, invigorate". In modern English, it means that what you claim to be and what you actually are, are the same. Your words and your actions are "whole"; your words are not diminished by your actions vice versa. Integrity is a firm, undivided adherence to an objective code of moral values. An individual can be said to be of high moral integrity when the individual remains firm, and undivided in their adherence to excellence i.e. have oneness and firm adherence to moral values in order to achieve integrity, we all must be

more courageous, compassionate, honest, loyal, and do so more.

Credibility and Trust: It builds trust in the academic and scholarly communities, which is vital for the quality of education and research.

Holistic Student Development: Upholding ethical standards supports the holistic development of students, equipping them with crucial moral values for their future careers and lives.

Preventing Misuse of Tools: With the rise of AI, integrity becomes even more critical to prevent misuse, ensuring that learning and research remain authentic.

Promoting Integrity: Educational institutions can promote integrity by fostering an environment that values intellectual honesty, conducting ethical assessments, and educating students on the

VI. ASPECTS OF ACADEMIC INTEGRITY

Core Values: Integrity is built on a foundation of fundamental values including honesty, trust, fairness, respect, responsibility, and courage.

Ethical Conduct: It encompasses ethical and moral behavior by all members of the educational community, from students to educators.

Accountability: Individuals are held accountable for their Actions and academic contributions, ensuring Authenticity and originality.

- **Honesty:** Being truthful in words and actions.

- **Strong Moral Principles:** Adhering to a firm and consistent code of ethics.

- **Consistency:** Acting in alignment with one's stated values and beliefs, regardless of the situation.

- **Responsibility:** Taking accountability for one's actions and decisions.

- **Courage:** Having the moral fortitude to do what is right, even when it is unpopular or challenging.

- **Trustworthiness:** Earning the trust of others through reliable and principled behavior.

- **Integrity Matters: Character:** Integrity is a foundational virtue that contributes to building good character

- **Character:** Integrity is a foundational virtue that contributes to building good character.

- **Trust:** It builds trust in personal relationships and professional environments.

- **Positive Workplace:** In a professional context, employees with integrity are valued for their commitment to quality work and a positive atmosphere.

- **Professionalism:** It is a key characteristic for professionals to ensure responsible decision-making and maintain organizational harmony.

- **Internal Harmony:** Integrity fosters a sense of "wholeness" and avoids the hypocrisy of holding conflicting values

Relationship between character and integrity

- Character and integrity are both important, but they are not synonymous. In fact, integrity without the right character can spell trouble! This is why it's important to first determine one's character before we ask them to live with integrity.

- Character is one's moral and ethical code. It is a combination of inside traits that determine outward behaviour. Integrity is steadfast adherence to a strict moral or ethical code.

- When you combine character and integrity here's what you get: character is one's moral and ethical code, and integrity means that one lives according to that code. Thus, someone who lives with integrity lives according to their moral values. That being said, you must first determine the moral values-the code of that person in order to ascertain whether or not living with integrity is a good or bad thing. For example: If someone has a moral code that says they should be honest in their dealings and they do so they are, by definition, living with integrity.

- On the other hand, if an individual has a strong moral and ethical code but compromises what is right when it serves popular opinion, or in order to achieve personal gain, they are not living with integrity.

- Integrity is not just what people see, integrity is what you are. Integrity and character must be taught in the home and the school. When we teach character, we have to understand that children and many adults outwardly conform. They have failed to understand that true character is called integrity and the place you hold it is in the heart.

In other words, integrity is the blueprint of character. Character education is an umbrella term for all explicit and implicit educational activities that help young people develop positive personal strengths called virtues. Character education is more than

just a subject. It has a place in the culture and functions of families, classrooms, schools and other institutions. Character education is about helping students grasp what is ethically important in situations and to act for the right reasons, such that they become more autonomous and reflective. Students need to decide wisely the kind of person they wish to become and to learn to choose between already existing alternatives or to find new ones. In this process, the ultimate aim of character education is the development of good sense or practical wisdom: the capacity to choose intelligently between alternatives. This capacity involves knowing how to choose the right course of action in difficult situations and it arises gradually out of the experience of making choices and the growth of ethical insight. In other words, Character education is the development of knowledge, skills, and abilities that enable the learner to make informed and responsible choices. Character education enables students to come face to face with the realities of life. It encourages them to think critically and then act responsibly.

VII. CONCLUSION

The conclusion on ethical Pedagogy is India highlights its indispensable role in cultivating responsible citizens and ethical leaders by integrity like integrity empathy and social responsibility into the education system aligning with national policies like the NEP 2020 and advocating for a collaborative effort from educators to foster a morally grounded future for the nation. Ethical pedagogy emphasizes that education must extend beyond imparting knowledge

and skills to shaping character wisdom and integrity producing well rounded individual. The National Education Policy NEP 2020 underscores the importance of ethical, human and constitutional values promoting their integration into the core curriculum at all levels of education. The conclusion of an ethical pedagogy emphasizes that it is crucial for neutering responsible citizens by integrity values like honest, fairness and empathy into education.

VIII. REFERENCES

1. Alavi, H. R. (2007). Al-Ghazālī on moral education. *Journal of Moral Education*, 36(3), 309-319. doi: 10.1080/03057240701552810
2. Berkowitz, M. W. (1999). Obstacles to teacher training in character education. *Action in Teacher Education*, 20(4), 1-10. doi: 10.1080/01626620.1999.10462930
3. Bullough, R. V., Jr. (2011). Ethical and moral matters in teaching and teacher education. *Teaching and Teacher Education*, 27(1), 21-28. doi: <http://dx.doi.org/10.1016/j.tate.2010.09.007>
4. Carr, D. (2014). Metaphysics and methods in moral enquiry and education: Some old philosophical wine for new theoretical bottles. *Journal of Moral Education*, 43(4), 500-515. doi: 10.1080/03057240.2014.943167
5. Churchill, L. R. (1982). The teaching of ethics and moral values in teaching: Some contemporary confusions. *The Journal of Higher Education*, 53(3), 296-306. doi: 10.2307/1981749
6. Han, H. (2014). Analysing theoretical frameworks of moral education through Lakatos's philosophy of science. *Journal of Moral Education*, 43(1), 32-53. doi: 10.1080/03057240.2014.893422
7. Jones, E. N., Ryan, K., & Bohlin, K. (1999). Character education & teacher education: How are prospective teachers being prepared to foster good character in students? *Action in Teacher Education*, 20(4), 11- 28. doi: 10.1080/01626620.1999.10462931.
8. Bullough, R. V., Jr. (2011). Ethical and moral matters in teaching and teacher education. *Teaching and Teacher Education*, 27(1), 21-28. doi: <http://dx.doi.org/10.1016/j.tate.2010.09.007>
9. Churchill, L. R. (1982). The teaching of ethics and moral values in teaching: Some contemporary confusions. *The Journal of Higher Education*, 53(3), 296-306. doi: 10.2307/1981749
10. Carr, D. (2014). Metaphysics and methods in moral enquiry and education: Some old philosophical wine for new theoretical bottles. *Journal of Moral Education*, 43(4), 500-515. doi: 10.1080/03057240.2014.943167
11. Gates, B. E. (2006). Where is the moral in citizenship education? *Journal of Moral Education*, 35(4),

- 437-441. doi:
10.1080/03057240601025636.
12. Goldsmith-Conley, E. (1999). School culture before character education: A model for change. *Action in Teacher Education*, 20(4), 48-58. doi:
10.1080/01626620.1999.10462934
 13. Jones, E. N., Ryan, K., & Bohlin, K. (1999). Character education & teacher education: How are prospective teachers being prepared to foster good character in students? *Action in Teacher Education*, 20(4), 11- 28. doi:
10.1080/01626620.1999.10462931.
 14. McGavin, P. A. (2013). Conversing on ethics, morality and education. *Journal of Moral Education*, 42(4), 494- 511. doi:
10.1080/03057240.2013.817330
 - National Research Council. (1996). National science education standards. Washington, DC: National Academies Press.
 15. Sanderse, W. (2012). The meaning of role modelling in moral and character education. *Journal of Moral Education*, 42(1), 28-42. doi:
10.1080/03057240.2012.690727
 16. Yap, S. F. (2014). Beliefs, values, ethics and moral reasoning in socio-scientific education. *Issues in Educational Research*, 24(3), 299-319.
 17. Zegwaard, K., & Campbell, M. P. (2011). Ethics and values: The need for student awareness of workplace value systems. Paper presented at the 2011 WACE World Conference, Philadelphia, U.S.A.

Generative DL-Driven Sparse EMG Reconstruction for Robust HGR and Gait Dynamics Prediction

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Abstract - Hand gesture recognition using electromyography(EMG) signals has emerged as a powerful paradigm in human–computer interaction, enabling intuitive and contactless communication between humans and machines. Unlike traditional vision-based systems, EMG signals directly capture neuromuscular activity, thereby providing a robust representation of user intent .

Conventional EMG systems generally rely on high-density sensor arrays, which increase hardware complexity, power consumption, and reduce wearability. Recent advances in wearable bioelectronics and generative deep learning have introduced efficient alternatives capable of reconstructing high-resolution EMG signals from sparse sensor inputs.

A six-channel wearable EMG system, trained using a high-density 32-channel dataset acquired from low-impedance polymer electrodes, achieves performance comparable to full-scale sensing configurations in both

sign language recognition and gait dynamics prediction. This result underscores the effectiveness of the proposed Generative EMG Network (Gen ENet) in enabling sparse-to-dense signal reconstruction, significantly reducing system complexity while preserving predictive accuracy .Such electrophysiological signal processing frameworks are critical for applications including motion analysis, prosthetic control, and human–machine interaction, which traditionally depend on high-resolution sensing infrastructures. The demonstrated approach highlights the potential of generative deep learning to transform wearable sensing paradigms, facilitating the development of lightweight, energy-efficient, and scalable devices for healthcare monitoring, sports analytics, and intelligent interactive

Keywords - EMG Signals, Sparse Reconstruction, Generative Deep Learning, Gesture Recognition, Gait Prediction, Wearable AI

I.INTRODUCTION

Accurate information extraction in modern Sensing applications critically depends on the deployment of high-density and high-resolution sensor systems. Electromyography (EMG), as a non-invasive technique, has been extensively utilized for monitoring muscle activity across various regions of the human body[1–3].The increasing demand for precise interpretation of complex biomechanical interactions has driven the development of wear able technologies capable of continuously capturing rich and multidimensional data streams. These systems provide comprehensive insights ranging from kinematic information, such as motion dynamics and vibration patterns[1,2,4–11],to

physiological signals including temperature variations and electrophysiological markers derived from muscular, neural, and cardiac activities [12–24].

However, the intricate coordination between multiple muscle groups and corresponding body movements necessitates the use of advanced high-density surface EMG systems for applications such as gesture recognition and gait analysis [3,5,25,26]. Despite Significant progress in electrode design aimed at reducing impedance and enhancing flexibility, as well as improvements in

Computational algorithms for signal processing and predictive modeling, existing systems still face critical limitations in terms of scalability, hardware complexity, and real-world adaptability. Surface electromyography (sEMG) has become an important sensing modality

Because it captures electrical activity generated during muscle contraction. Unlike vision-based approaches, EMG systems are less affected by illumination changes, occlusion, and background noise. However, traditional EMG systems require dense electrode configurations for high-resolution signal acquisition, making them bulky and unsuitable for long-term wearable deployment.

Deep learning has transformed EMG-based gesture recognition by enabling automatic feature extraction from raw bio signals. CNNs

II. RESEARCH GAP

Despite major advancements in EMG-based gesture recognition, several critical limitations remain unresolved. Existing high-density EMG systems provide strong classification performance but introduce substantial hardware complexity, increased energy consumption, and poor wearability. These limitations restrict scalability and reduce practicality in continuous monitoring applications.

Another major challenge is sparse signal handling. Real-world EMG systems often encounter missing channels due to sensor displacement, noise, electrode degradation, or motion artifacts. Conventional discriminative deep learning models primarily focus on classification and lack mechanisms for reconstructing complete EMG signals. As a result, system accuracy degrades significantly under noisy or sparse sensing conditions. Furthermore, existing models demonstrate weak cross-user generalization. Variations in muscle anatomy, skin impedance, and motion behavior create domain shifts between users and sessions.

extract spatial features, LSTMs model temporal dependencies, and transformers improve long-range sequence learning through attention mechanisms [3][4]. However, most existing systems remain dependent on large sensor arrays and fail to efficiently reconstruct missing or corrupted channels.

The proposed framework addresses this issue through generative reconstruction, where sparse EMG signals are transformed into dense representations using encoder-decoder networks. This concept shifts the focus from hardware-intensive systems to AI-driven intelligent sensing.

Keywords

Human-Computer Interaction, EMG Systems, Deep Learning, Gesture Interfaces, Intelligent Wearable Systems

Many models are trained on limited datasets, reducing the adaptability in practical scenarios. Transfer learning and domain adaptation approaches have attempted to address this problem, but robustness remains insufficient. The emergence of generative reconstruction networks introduces a promising solution through sparse-to-dense EMG recovery:

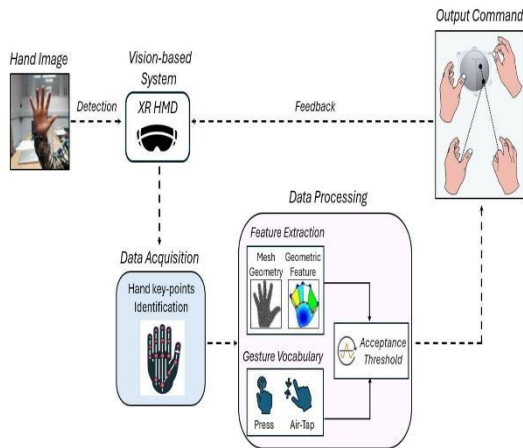
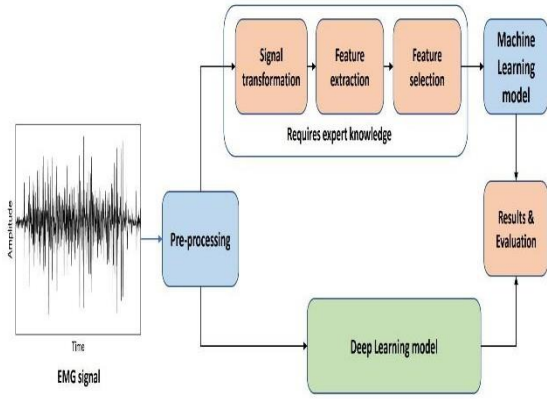
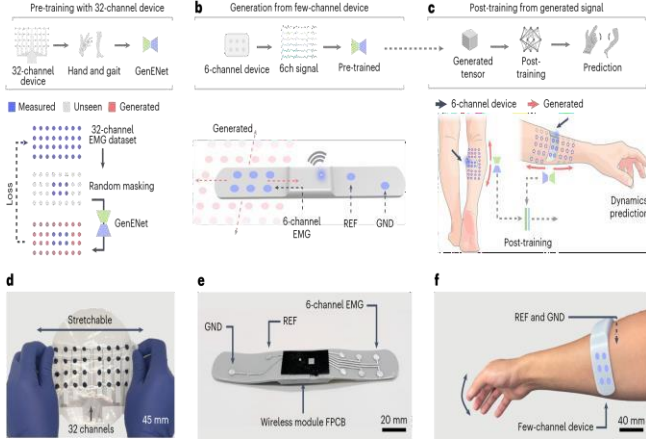
$$X=G(X_{masked})$$

However, research on integrating generative reconstruction with lightweight wearable systems is still limited. Existing literature lacks comprehensive frameworks combining sparse sensing, generative reconstruction, temporal modeling, and gait prediction in a unified architecture.

Keywords

Sparse Sensing, Domain Adaptation, WearableAI, Signal Reconstruction, Robust Classification

III. PROPOSED METHODOLOGY



The proposed methodology integrates wearable EMG acquisition with generative deep learning for robust gesture recognition And gait prediction. The framework consists of five stages:

1. Signal Acquisition
2. Preprocessing
3. Generative Reconstruction
4. Feature Extraction
5. Classification and Prediction

The raw EMG signal is modeled as:

$$S(t)=M(t)+N(t)$$

where $M(t)$ denotes the true muscle activity and $N(t)$ denotes noise. Signal preprocessing involves filtering and normalization:

$$S_{filtered}(t)=S(t)*h(t)$$

Where $h(t)$ represents ab and passfilter. Signal quality is evaluated using signal-to-noise ratio (SNR):

$$SNR=\frac{P_{signal}}{P_{noise}}$$

The generative reconstruction stage employs an encoder–decoder architecture. Sparse masked inputs are defined as:

$$X_{masked}=X\odot M$$

Latent representation:

$$Z=Encoder(X)$$

Reconstructed output:

$$X=Decoder(Z)$$

Reconstruction loss:

$$L=||X-X'||^2+\lambda L_{reg}$$

There constructed signals are processed using CNN-based feature extraction:

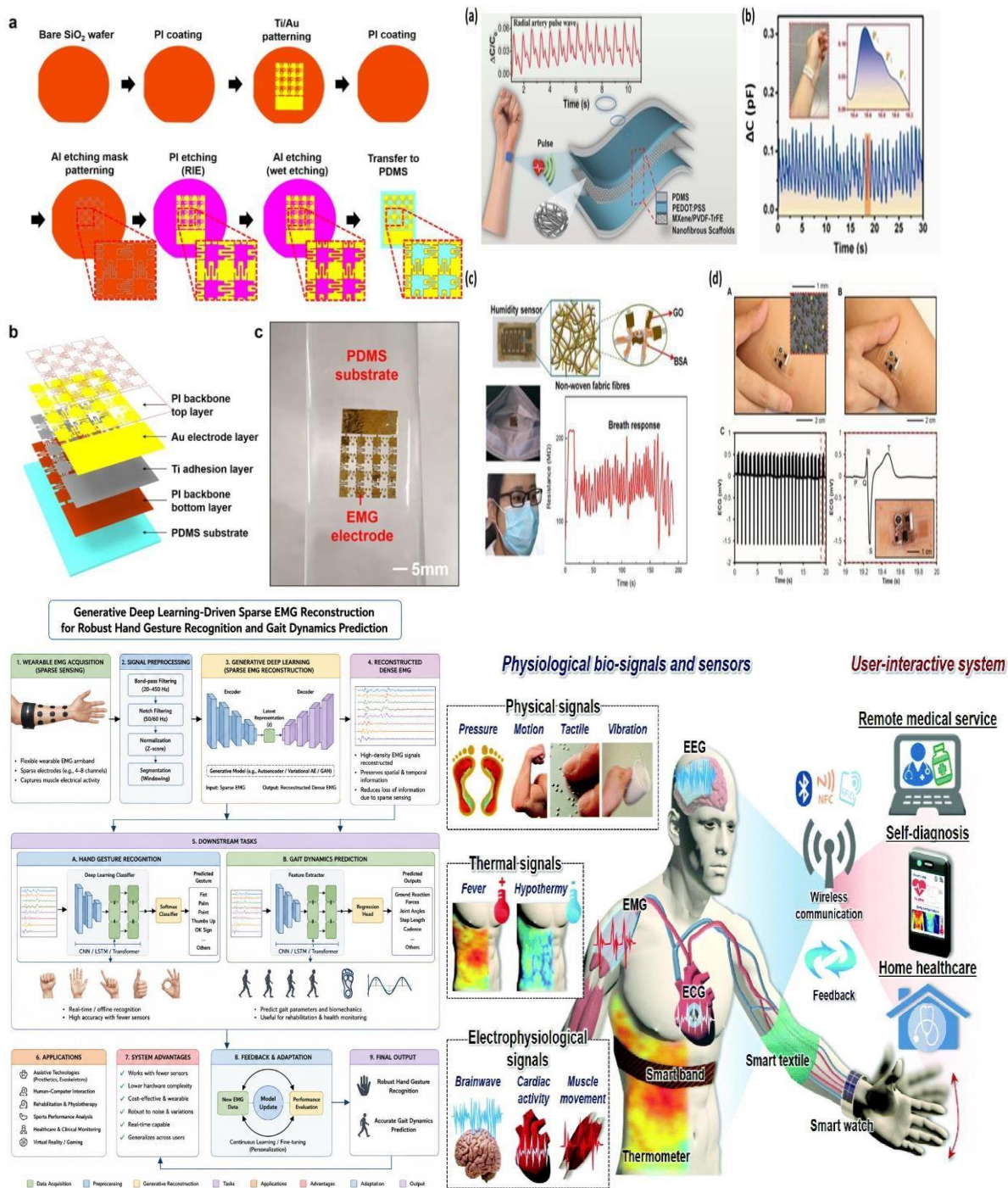
$$F=CNN(X)$$

Temporal dependencies are modeled using LSTM or transformer architectures. This methodology reduces hardware dependency while preserving classification accuracy and real-time performance.

Keywords

Signal Processing, Auto encoder, Sparse Reconstruction, CNN, LSTM, Transform

1. Wearable EMG Sensor Technologies



Wearable EMG sensors form the foundation of modern gesture recognition systems because Signal quality directly determines model performance. Traditional rigid electrodes are unsuitable for continuous wearable applications due to discomfort and instability.

Flexible sensor technologies have therefore emerged as a major research direction.

Modern wearable EMG systems incorporate flexible substrates such as PDMS, conductive polymers such as PEDOT:PSS, and liquid metal conductors such as EGAIn.

These materials improve skin conformity, reduce impedance, and maintain stable signal transmission during movement.

Flexible EMG sensors improve acquisition quality by minimizing motion artifacts and increasing SNR. They also enhance user Comfort and support long-term deployment in rehabilitation and healthcare applications.

1. Deep Learning Architectures for EMG Analysis

$$F = CNN(X)$$

CNNs extracts partial representations from EMG signals and eliminate the need for handcrafted feature engineering.

Soft max classification:

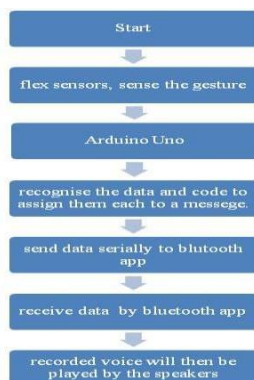
$$P(y_i) = \frac{e^{W_i F + b_i}}{\sum_j e^{W_j F + b_j}}$$

Cross-entropy loss:

$$L = -\sum y_i \log(P(y_i))$$

2. Applications: Gesture

Recognition and Gait Prediction



Gesture classification is expressed as:

$$y = \arg\max(y|X)$$

Gait prediction:

$$\hat{y} = f(X)$$

Despite these improvements, dense sensor arrays still introduce complexity. Sparse sensing strategies combined with generative AI therefore represent an efficient alternative, where fewer sensors are compensated through intelligent signal reconstruction.

Keywords

Flexible Sensors, PDMS, PEDOT:PSS, Bioelectronics, Wearable Device

Temporal modeling through LSTM:

$$h_t = (W_h h_{t-1} + W_x x_t + b)$$

Transformer attention:

$$Attention(Q, K, V) = \frac{QK^T}{\sqrt{d_k}} V$$

CNN-LSTM hybrids improve both spatial and temporal learning, while transformers enhance long-range dependency modeling. Denoising auto encoders further improve robustness against signal corruption.

Keywords

CNN, LSTM, Transformer, Attention Mechanism, Deep Learning

Regression error: $MSE = -\frac{1}{n} \sum (y - \hat{y})^2$

Applications include:

- Prosthetic and control
- Sign language recognition
- Rehabilitation systems
- Human-robot interaction
- Virtual reality interfaces

Generative EMG frameworks improve Performance even with reduced sensor counts, making wearable deployment more feasible.

Keywords

Gesture Recognition, Gait Prediction, Prosthetics, Rehabilitation, Human-Robot Interaction

IV. CHALLENGES AND FUTURE DIRECTION

Current systems still face challenges including:

- Inter-session variability
- Sensor displacement
- Computational cost
- Data scarcity

Future research should focus on:

- Edge AI deployment

V. CONCLUSION

This review demonstrates that generative deep learning-driven sparse EMG reconstruction represents a transformative direction in wearable gesture recognition systems. Traditional hardware-heavy approaches are gradually being replaced by AI-driven intelligent reconstruction frameworks capable of operating under sparse sensing conditions.

The integration of flexible wearable sensors, generative auto encoders, CNN-LSTM-

- Multi modal sensing
- Personalized adaptive learning
- Federated learning
- Energy-efficient transformers

Generative reconstruction combined with transfer learning and domain adaptation is expected to significantly improve robustness in practical wearable systems.

Keywords

Edge AI, Domain Adaptation, Multimodal Learning, Personalized Systems

Transformer architectures, and gait prediction models significantly improves scalability, robustness, and usability. Future advancements in edge AI and personalized adaptive systems are expected to accelerate real-world deployment of intelligent human-computer interaction systems.

Keywords

Scalable AI, Wearable Computing, Gesture Intelligence, Future HCI Systems

VI. REFERENCES

1. Tang, L., Shang, J. & Jiang, X. Multilayered electronic transfer tattoo that can enable the crease amplification effect. *Sci. Adv.* 7, eabe3778 (2021).
Article CAS Google Scholar
2. Sundaram, S.etal. Learning the signatures of the human grasp using a scalabletactile glove. *Nature* 569, 698–702 (2019).
3. Caesarendra, W., Tjahjowidodo, T., Nico, Y.,Wahyudati, S.& Nurhasanah, L.EMG finger movement classification based on ANFIS.*J. Phys. Conf. Ser.*1007, 012005 (2018).
4. Moin, A. et al. A wearable biosensing system with in-sensor adaptive machine learning for hand gesture recognition. *Nat. Electron.* 4, 54–63 (2021).
5. Sun, Z., Zhu, M., Shan, X. & Lee, C. Augmented tactile-perception and haptic-feedback rings as human-machine interfaces aiming for immersive interactions. *Nat.Comm.*13,5224 (2022).
6. Gao, X. et al.Awearable echomyography system based on a single transducer. *Nat. Electron.* 7, 1035–1046 (2024).

7. Tashakori, A. et al. Capturing complex hand movements and object interactions using machine learning-powered stretchable smart textile gloves. *Nat. Mach. Intell.* 6, 106–118 (2024).
8. Zhou, Z. et al. Sign-to-speech translation using machine-learning-assisted stretchable sensor arrays. *Nat. Electron.* 3, 571–578 (2020).
9. Kim, K.K.etal. A deep-learned skin sensor decoding the epicentral human motions. *Nat. Commun.* 11, 2149 (2020).
10. Kim, K.K.etal. A substrate-less nanomesh receptor with meta-learning for rapid hand task recognition. *Nat. Electron.* 6, 64–75 (2023).
 Google Scholar
11. Hu, H. et al. Stretchable ultrasonic arrays for the three-dimensional mapping of the modulus of deep tissue. *Nat. Biomed. Eng.* 7, 1321–1334 (2023).
 Article Pub Med Google Scholar
12. Kweon, O.Y., Lee, S.J. & Oh, J.H. Wearable high-performance pressure sensors based on three-dimensional electrospun conductive nanofibers. *npj Asia Mater.* 10, 540–551 (2018).
 Article CAS Google Scholar
13. Vinoth, R., Nakagawa, T., Mathiyarasu, J. & Mohan, A. V. Fully printed wearable microfluidic devices for high-throughput sweat sampling and multiplexed electrochemical analysis. *ACS Sens.* 6, 1174–1186 (2021).
 Article Pub Med CAS Google Scholar
14. Oh, Y. S. et al. Battery-free, wireless soft sensors for continuous multi-site measurements of pressure and temperature from patients at risk for pressure injuries. *Nat. Commun.* 12, 5008 (2021)
15. Han, S.etal. Battery-free, wireless sensors for full-body pressure and temperature mapping. *Sci. Transl. Med.* 10, eaan4950 (2018).
16. Sîmpetru, R. C. et al. Learning a hand model from dynamic movements using high-density EMG and convolutional neural networks. *IEEE Trans. Biomed. Eng.* 71, 12 (2024).
17. Shin, J.H.etal. Wearable EEG electronics for a Brain–AI Closed-Loop System to enhance autonomous machine decision-making. *npj Flex. Electron.* 6, 32 (2022).
18. Mahmood, M. et al. Fully portable and wireless universal brain–machine interfaces enabled by flexible scalp electronics and deep learning algorithm. *Nat. Mach. Intell.* 1, 412–422 (2019).
19. Sunwoo, S.-H. et al. Ventricular tachyarrhythmia treatment and prevention by sub threshold stimulation with stretchable epicardial multichannel electrode array. *Sci. Adv.* 9, eadf6856 (2023).
 CAS Google Scholar
20. Kim, S.etal. Three-dimensional electrodes of liquid metals for long-term, wireless cardiac analysis and modulation. *ACS Nano* 18, 24364–24378 (2024).
 Article Pub Med CAS Google Scholar
21. Kim, D.-H. et al. Materials for multifunctional balloon catheters with capabilities in cardiac electrophysiological mapping and ablation therapy. *Nat. Mater.* 10, 316–323 (2011).
 CAS Google Scholar
22. Choi, S. et al. Highly conductive, stretchable and biocompatible Ag–Au core–sheath nano wire composite for wearable and implantable bioelectronics. *Nat. Nanotechnol.* 13, 1048–1056 (2018).
 Article Pub Med CAS Google Scholar
23. Park, J. et al. Electromechanical cardioplasty using a wrapped elasto-conductive epicardial mesh. *Sci. Transl. Med.* 8, 344ra386 (2016).
 Article Google Scholar
24. Pincheira, P.A. et al. Regional changes in muscle activity do not underlie therepeate

PARAKH: A Leap from PARIKSHA to Assessments

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Abstract - In the educational landscape of India, the transition from traditional examination systems to modern assessment methodologies marks a significant paradigm shift. This transition is epitomized by the introduction of PARAKH, a comprehensive framework that represents a leap forward from the conventional PARIKSHA (examination) system. PARAKH embodies a holistic approach to assessments, emphasizing not only academic performance but also the multifaceted development of students.

This abstract examines the evolution from PARIKSHA to PARAKH, tracing the motivations, principles, and implications of this transition. PARIKSHA, characterized by rigid examinations focused solely on testing rote memorization, has long been criticized for its limitations in fostering critical thinking, creativity, and practical skills among students. Recognizing these shortcomings, PARAKH emerges as a transformative initiative aimed at redefining the concept of assessment in Indian education. At its core, PARAKH seeks to democratize the assessment process, promoting inclusivity, equity, and fairness. Unlike

PARIKSHA, which often perpetuated a culture of high-stakes testing and academic pressure, PARAKH fosters a more nurturing and supportive environment for learners. By incorporating diverse assessment methodologies such as project-based assessments, portfolios, and competency-based evaluations, PARAKH endeavors to provide a comprehensive picture of a student's abilities and potential. Moreover, PARAKH acknowledges the importance of qualitative feedback and personalized learning experiences. Through continuous assessment and feedback mechanisms, educators can offer tailored interventions to address individual learning needs and promote growth mindset among students. This personalized approach not only enhances academic outcomes but also nurtures socio-emotional development and lifelong learning skills. Furthermore, PARAKH aligns with global trends in education, emphasizing the importance of 21st-century skills such as critical thinking, communication, collaboration, and creativity. By integrating these skills into the assessment framework, PARAKH prepares students for the challenges of the

modern world, equipping them with the competencies required to thrive in an increasingly complex and interconnected society. In conclusion, the transition from PARIKSHA to PARAKH signifies a fundamental shift towards a more holistic, inclusive, and student-centric approach to assessments in Indian education. While challenges such as infrastructure constraints, capacity building, and cultural mindset shifts remain, the adoption of PARAKH represents a bold step towards realizing the vision of an education system that nurtures the full potential of every learner.

Keywords - PARAKH, PARIKSHA, assessments, holistic approach, student-centric, 21st-century skills, personalized learning.

I. INTRODUCTION

The transformation of India's education system through the implementation of the National Education Policy (NEP) 2020 has brought a renewed focus on competency-based learning, holistic development, and meaningful assessment practices. Traditionally, examinations in India have emphasized rote memorization and high-stakes testing, often placing excessive pressure on students and limiting opportunities for the assessment of conceptual understanding, creativity, and critical thinking. Recognizing these limitations, educational reforms under NEP 2020 advocate a shift from examination-oriented learning to competency-based assessment systems that support student growth, understanding, and skill development.

In this context, PARAKH (Performance Assessment, Review, and Analysis of Knowledge for Holistic Development) has emerged as a significant initiative aimed at reforming assessment practices in school education. Established as a national assessment centre, PARAKH seeks to standardize norms and guidelines for student assessment while promoting consistency, fairness, and quality across educational boards and institutions. The concept of "A Leap from PARIKSHA to Assessments" symbolizes a paradigm shift from traditional examination systems ("Pariksha") to broader, continuous, and learner-centred assessment approaches that evaluate cognitive, affective, and practical competencies.

PARAKH emphasizes formative and competency-based assessment methods that move beyond merely testing memorized information to evaluating students' understanding, application, problem-solving abilities, creativity, and overall development. This transition aligns with global educational trends that prioritize assessment for learning rather than assessment of learning. By integrating innovative evaluation techniques, data-driven educational analysis, and competency benchmarks, PARAKH aims to improve educational outcomes and ensure equitable learning opportunities for all students.

Furthermore, the introduction of PARAKH reflects the growing need to create an education system that is adaptable, inclusive, and capable of preparing learners for the demands of the twenty-first century. The initiative seeks to reduce exam-

related stress, encourage conceptual clarity, and foster deeper engagement with learning processes. Through standardized assessment frameworks and evidence-based educational practices, PARAKH has the potential to redefine educational evaluation in India.

Therefore, this research paper attempts to examine PARAKH as a transformative initiative in the Indian education system and analyze how it represents a leap from traditional “Pariksha” to holistic and competency-based assessments. The study also explores its objectives, significance, challenges, and implications for improving teaching-learning practices and student achievement in alignment with NEP 2020.

II. NEED AND SIGNIFICANCE OF THE STUDY

The Indian education system has long been dominated by traditional examination practices that primarily emphasize rote learning, memorization, and performance in high-stakes tests. Such methods often fail to assess students’ conceptual understanding, problem-solving abilities, creativity, and practical competencies. With the introduction of the National Education Policy (NEP) 2020, there has been a growing emphasis on competency-based education, holistic development, and learner-centred assessment. In this context, PARAKH (Performance Assessment, Review, and Analysis of Knowledge for Holistic Development) emerges as an important initiative aimed at transforming the assessment system in India.

The need for this study arises from the requirement to understand how PARAKH can contribute to shifting the focus from traditional “Pariksha” (examination-based evaluation) to comprehensive and continuous assessment practices. Since assessment plays a critical role in shaping teaching-learning processes, educational planning, and student outcomes, it becomes essential to examine the objectives, implementation, and implications of PARAKH in the contemporary educational scenario. Moreover, limited academic literature and awareness regarding PARAKH make it necessary to explore its relevance and potential contribution to educational reforms.

This study is significant because it provides insights into the changing nature of educational assessment in India and highlights the role of PARAKH in promoting competency-based learning and holistic student development. It contributes to understanding how assessment reforms can reduce excessive exam pressure, encourage conceptual learning, and improve fairness and consistency in evaluation practices. The findings of this study may benefit teachers, policymakers, educational administrators, curriculum planners, and researchers by offering a clearer understanding of assessment transformation under NEP 2020.

Furthermore, the study holds significance in identifying the opportunities and challenges associated with implementing PARAKH-based assessment systems in schools. It may help educators redesign teaching strategies aligned with competency-based assessment approaches

and support institutions in developing effective evaluation mechanisms. Thus, the study becomes important in understanding PARAKH as a progressive step toward building an inclusive, student-centred, and quality-oriented education system in India.

III. REVIEW OF RELATED LITERATURE

The review of related literature helps in understanding previous studies, theories, policies, and scholarly contributions related to educational assessment, competency-based learning, and educational reforms. For the present study, *‘‘PARAKH: A Leap from PARIKSHA to Assessments,’’* literature related to examination reforms, competency-based assessment, holistic education, and policy perspectives has been reviewed.

Benjamin Bloom (1956), in his work on educational objectives, emphasized that learning should move beyond memorization and include cognitive skills such as understanding, application, analysis, synthesis, and evaluation. Bloom’s taxonomy highlighted the importance of assessing higher-order thinking rather than only factual recall, which aligns with competency-based assessment approaches promoted by PARAKH.

John Dewey (1938) advocated experiential learning and argued that education should focus on practical understanding and reflective thinking rather than rote memorization. Dewey’s ideas support assessment systems that evaluate

learning experiences and competencies instead of only examination performance.

Lev Vygotsky (1978) emphasized the role of social interaction and continuous learning in education. His theory of learning suggests that assessment should be formative and supportive, helping learners develop progressively through feedback and guided instruction.

Benjamin Samuel Bloom (1984) stressed mastery learning and continuous assessment to improve student achievement. His work demonstrated that regular feedback and formative evaluation significantly enhance learning outcomes.

Paul Black and Dylan Wiliam (1998), in their influential study on formative assessment, concluded that assessment for learning significantly improves student performance when feedback mechanisms are integrated into classroom practices.

United Nations Educational, Scientific and Cultural Organization (UNESCO) (2015) emphasized quality education through learner-centred teaching and competency-based approaches under the Sustainable Development Goals (SDG 4), advocating inclusive and equitable quality education and assessment reforms.

National Council of Educational Research and Training (NCERT) (2005), in the National Curriculum Framework 2005, emphasized reducing rote learning and examination stress through continuous and comprehensive

evaluation, promoting conceptual understanding and activity-based learning.

David Nicol and Debra Macfarlane-Dick (2006) highlighted that formative assessment and constructive feedback help students become self-regulated learners and improve academic performance.

Research by John Hattie (2009) showed that feedback and assessment practices have a strong positive impact on student learning outcomes, emphasizing the importance of effective evaluation systems.

The National Education Policy (NEP) 2020 (2020) introduced major reforms in assessment practices by recommending competency-based education, formative assessment, and holistic progress tracking. It emphasized moving away from rote memorization toward critical thinking, creativity, problem-solving, and conceptual understanding.

National Council of Educational Research and Training (NCERT) (2023) introduced PARAKH (Performance Assessment, Review, and Analysis of Knowledge for Holistic Development) as a national assessment centre to standardize and strengthen school assessment practices. PARAKH aims to ensure consistency, fairness, and competency-based assessment aligned with NEP 2020 objectives. The above literature suggests that assessment reforms should focus on competency development, continuous feedback, and holistic growth rather than memorization-based examinations. Although specific academic studies on PARAKH

are still emerging, policy documents and educational literature indicate that it represents an important step toward assessment transformation in India. Therefore, the present study attempts to explore PARAKH as a shift Objectives of the Research Paper

Research Questions:

1. What is PARAKH (Performance Assessment, Review, and Analysis of Knowledge for Holistic Development), and what are its major objectives?
2. How does PARAKH contribute to the transformation from traditional “Pariksha”

(examination-based systems) to competency-based and holistic assessments?

3. What is the role of PARAKH in implementing assessment reforms proposed under the National Education Policy (NEP) 2020?

IV. OBJECTIVES

The following objectives have been formulated for the research paper.

1. To study the concept and objectives of PARAKH (Performance Assessment, Review, and Analysis of Knowledge for Holistic Development).
2. To examine the role of PARAKH in transforming traditional examination practices (“Pariksha”) into competency-based and holistic assessment systems.
3. To analyse the assessment reforms proposed under the National Education Policy (NEP) 2020 in relation to PARAKH.
4. To understand the significance of competency-based, formative, and learner-centred assessment practices promoted through PARAKH.

5. To identify the opportunities and challenges associated with the implementation of PARAKH in the Indian education system.
6. To examine the impact of PARAKH on teaching-learning practices, student assessment, and holistic development.
7. To explore the potential contribution of PARAKH in reducing examination stress and promoting conceptual understanding among learners.
8. To provide suggestions for strengthening assessment reforms and improving educational quality through PARAKH-based evaluation practices. From traditional “Pariksha” to competency-based and holistic assessment practices.

V. METHODOLOGY OF STUDY

The present research paper adopts a descriptive and analytical research methodology to examine the role of PARAKH in transforming traditional examination practices into competency-based and holistic assessment systems. The study is primarily based on qualitative analysis of existing literature, policy documents, reports, and scholarly discussions related to educational assessment reforms.

Research Method:

The study follows the descriptive research method, as it seeks to describe, analyse, and interpret the concept, objectives, significance, and implications of PARAKH in the Indian education system. An analytical approach is also adopted to examine how PARAKH aligns with

educational reforms proposed under the National Education Policy (NEP) 2020.

Nature of the Study:

The study is qualitative and exploratory in nature, focusing on the analysis of educational policies, assessment frameworks, and theoretical perspectives concerning assessment reforms.

Sources of Data:

The present study is based on secondary sources of data. Information has been collected from:

Government reports and policy documents related to PARAKH and NEP 2020

Books, journals, research papers, and scholarly articles on assessment and educational reforms

Publications and reports of educational organizations and institutions
Relevant documents on competency-based and holistic assessment practices

Data Collection Procedure:

Data for the study have been collected through a systematic review of literature and document analysis. Relevant information from books, policy documents, journal articles, reports, and educational resources has been examined to understand the objectives, implementation, opportunities, and challenges of PARAKH.

Method of Analysis:

The collected information has been analyzed using the descriptive and interpretative method. The study interprets available literature and policy perspectives to understand the shift from traditional “Pariksha” systems toward holistic and competency-based assessments.

Scope and Delimitation:

The study is limited to understanding PARAKH as an educational assessment reform in the Indian context. It focuses on assessment transformation under NEP 2020 and does not involve primary data collection, surveys, or experimental investigation.

Role of PARAKH in National Education Policy (NEP) 2020:

PARAKH plays a central role in implementing the assessment reforms envisioned by the National Education Policy (NEP) 2020. NEP 2020 emphasizes competency-based learning, conceptual understanding, critical thinking, and holistic development of learners. To achieve these goals, assessment practices must undergo significant transformation. PARAKH acts as the national agency responsible for developing standards, norms, and guidelines for assessment. It supports educational boards and institutions in designing competency-based question papers, assessment frameworks, and evaluation mechanisms aligned with NEP 2020. The organization also promotes consistency and comparability in assessment practices across different school boards. Additionally, PARAKH assists in improving assessment literacy among teachers, strengthening data-driven educational decision-making, and encouraging the use of formative assessments in classrooms. By aligning assessment practices with the broader goals of NEP 2020, PARAKH helps create a learner-centred education system that focuses on understanding, skills, and holistic development rather than rote learning and examination

performance. Therefore, PARAKH serves as a key instrument for translating the vision of NEP 2020 into effective assessment practices and ensuring that educational reforms lead to improved learning outcomes and overall educational quality.

VI. CONCLUSION

The present study, **“PARAKH: A Leap from PARIKSHA to Assessments,”** highlights the transformative role of PARAKH (Performance Assessment, Review, and Analysis of Knowledge for Holistic Development) in reforming the assessment system in India. The study reveals that PARAKH represents a significant shift from traditional examination-oriented practices toward competency-based, learner-centred, and holistic assessment approaches envisioned in the National Education Policy (NEP) 2020. The analysis indicates that conventional examination systems have largely focused on rote memorization and academic scores, often overlooking students’ critical thinking, creativity, problem-solving abilities, and overall development. In contrast, PARAKH seeks to establish standardized assessment frameworks that evaluate students’ competencies, conceptual understanding, and application of knowledge. This shift reflects a broader educational vision that prioritizes meaningful learning outcomes over mere examination performance. The study further concludes that PARAKH has the potential to enhance the quality, transparency, and consistency of assessment practices across educational boards and institutions. By promoting formative

assessment, continuous feedback, and competency-based evaluation, it can contribute to reducing examination stress and fostering a more inclusive and supportive learning environment. Moreover, PARAKH aligns assessment practices with the demands of twenty-first-century education by encouraging skills such as critical thinking, collaboration, communication, and innovation. However, the successful implementation of PARAKH requires adequate teacher training, assessment literacy, institutional support, and stakeholder awareness. Challenges related to infrastructure, resource availability, and resistance to change must be addressed to ensure the effective realization of its objectives. In conclusion, PARAKH is a landmark initiative that has the potential to redefine educational assessment in India. It marks a progressive transition from “Pariksha” to comprehensive assessments that support holistic student development and educational excellence. If implemented effectively, PARAKH can play a crucial role in strengthening the quality of education and achieving the goals of NEP 2020 by making assessment a tool for learning, growth, and continuous improvement rather than merely a measure of academic achievement.

VII. REFERENCES

1. Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice*, 5(1), 7–74. <https://doi.org/10.1080/0969595980050102>
2. Bloom, B. S. (1956). Taxonomy of educational objectives: The classification of educational goals. *Handbook I: Cognitive domain*. David McKay.
3. Dewey, J. (1938). *Experience and education*. Macmillan.
4. Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge.
5. Ministry of Education. (2020). *National Education Policy 2020*. Government of India. <https://www.education.gov.in>
6. National Council of Educational Research and Training. (2005). *National curriculum framework 2005*. NCERT.
7. National Council of Educational Research and Training. (2023). *PARAKH: Performance Assessment, Review and Analysis of Knowledge for Holistic Development*. NCERT.
8. Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199–218. <https://doi.org/10.1080/03075070600572090>
9. Organisation for Economic Co-operation and Development. (2019). *OECD future of education and skills 2030: Conceptual learning framework*. OECD Publishing.

9. United Nations Educational, Scientific and Cultural Organization. (2015). Education 2030:
10. Incheon declaration and framework for action. UNESCO.
11. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes.
12. Harvard University Press.
13. Wiliam, D. (2011). Embedded formative assessment. Solution Tree Press.
14. Zhao, Y. (2012). World class learners: Educating creative and entrepreneurial students. Corwin Press.
15. Biggs, J., & Tang, C. (2011). Teaching for quality learning at university (4th ed.). Open University Press.
16. Shepard, L. A. (2000). The role of assessment in a learning culture. Educational Researcher, 29(7), 4–14.

A Survey on Advanced Optimization and Geometric Perspectives in Physics-Informed Machine Learning

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Abstract -Physics-Informed Neural Networks (PINNs) have emerged as a revolutionary paradigm for solving partial differential equations (PDEs) by embedding physical laws into deep learning loss functions. However, optimization within Scientific Machine Learning (SciML) faces severe pathologies like stiff gradients, multi-objective loss conflicts, and poor convergence in highly non-convex landscapes [hardt2016][nocedal2018]. This survey reviews recent breakthroughs that alleviate these issues by unifying optimization theory, geometry-aware preconditioning, and architecture design. We categorize the literature into three pillars: (i) structural advancements including operator-inspired architectures such as Physics-Informed Kolmogorov–Arnold Networks (PIKANs) ; (ii) advanced optimization techniques—Natural Gradient Descent, Sobolev gradients, Gauss–Newton and Kronecker-factored approximations and (iii) foundational theoretical frameworks emphasizing function-space geometries and unified error analysis. We highlight scalable preconditioning via randomized Nyström sketching and low-rank curvature approximations that render second-order-like updates tractable for large PINNs. The survey synthesizes algorithmic recipes, provides comparative analyses of convergence behavior, and maps theoretical guarantees to practical training protocols. Finally, we discuss open challenges—

rigorous complexity bounds for nonconvex preconditioners, adaptive loss-weighting schedules, and standardized benchmarks for stiff PDE regimes—and propose a unified, function-space-aware optimization framework that integrates geometry-aware updates, randomized preconditioning, and architecture conditioning to achieve robust, scalable SciML optimization.

1. INTRODUCTION

The integration of physical constraints—expressed as partial differential equations (PDEs)—into deep learning architectures has catalyzed the field of Scientific Machine Learning (SciML). Traditional Physics-Informed Neural Networks (PINNs) rely heavily on first-order optimization techniques such as Stochastic Gradient Descent (SGD) and Adam. While these methods demonstrate remarkable stability and generalization in standard deep learning tasks, they frequently fail or exhibit extreme slowdown when optimizing the multi-objective, highly non-convex loss landscapes characteristic of PINNs.

Recent literature highlights a crucial paradigm shift: treating SciML optimization not merely as a parameter-space problem, but through the lens of Function Space Geometry. This survey systematically reviews 20 critical references spanning foundational optimization, natural gradients, randomized preconditioning, and novel architectures like Physics-Informed

Kolmogorov-Arnold Networks (PIKANs) to provide a roadmap of the current state-of-the-art. The severe optimization challenges of Physics-Informed Neural Networks (PINNs) have motivated a shift from purely parameter-space heuristics to geometry-aware, function-space methods that better respect PDE structure. Foundational analyses of optimization stability and generalization for stochastic gradient methods (Hardt, Recht, and Singer, 2016) illuminate why naïve first-order solvers stall on multi-objective PDE losses: SGD and its variants can be unstable or painfully slow when loss components exhibit widely different curvature or scale [Hardt et al., 2016]. Classical numerical-optimization theory (Nocedal and Wright, 2018) provides tools to formalize these difficulties and motivates second-order or curvature-aware corrections that target ill-conditioning directly [Nocedal and Wright, 2018]. Natural gradients and Sobolev-gradient flows further ground this intuition: Amari’s information-geometric natural gradient (Amari, 1998) accelerates learning by preconditioning updates with the Fisher metric [Amari, 1998], and recent analysis of Sobolev gradient flows (Chen et al., 2023) shows improved convergence behavior for PDE eigenvalue and variational problems [Chen et al., 2023]. Martens’ synthesis of natural-gradient perspectives (Martens, 2020) connects these ideas to scalable approximations suitable for deep models [Martens, 2020].

To make curvature-aware methods practical at scale, randomized linear-algebra techniques offer low-rank sketches of expensive operators. Randomized Nyström and related sketching strategies provide tractable preconditioners approximating Gauss–Newton or Fisher matrices, substantially reducing iteration counts while limiting memory overhead (Frangella, Tropp, and Udell, 2023) [Frangella et al. 2023].

Recent work demonstrates how randomized Nyström preconditioning specifically accelerates natural-gradient descent in PINNs (Bioli et al. 2025), yielding large speedups and improved PDE-residual control in practice (Bioli et al. 2025). Complementary algorithmic advances—Kronecker-factored approximate curvature adapted for PINNs (Dangel et al. 2024)—exploit parameter-space structure to deliver efficient quasi-second-order updates with manageable cost.

Framing optimization in function space synthesizes these strands: it prescribes geometry-aware representations, targeted preconditioners, and loss designs that together mitigate stiffness and multi-task conflicts (Müller and Zeinhofer, 2024; (Zeinhofer et al. 2023)). Concurrently, architectural and formulation advances—moving from classical PINNs toward operator-informed models such as PIKANs and consistent PINN formulations for elliptic PDEs (Bonito et al., 2024)—improve approximation quality and stability, enabling provable error control and practical gains across challenging PDE regimes (Toscano et al. 2024) (Bonito et al. 2024).

2. LITERATURE SURVEY ON OPTIMIZATION AND FUNCTION

Space Perspective for SciML and PINNs. The severe optimization challenges of Physics-Informed Neural Networks (PINNs) have motivated a shift from purely parameter-space heuristics to geometry-aware, function-space methods that better respect PDE structure. Foundational analyses of optimization stability and generalization for stochastic gradient methods (Hardt et al. 2016) illuminate why vanilla first-order solvers stall on multi-objective PDE losses: SGD and its variants can be unstable or painfully slow when loss components exhibit widely different curvature or scale. Classical numerical-

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Collectively, these works chart a coherent research agenda: optimization for SciML should combine (i) geometry-aware updates (natural gradients, Sobolev flows) to align with PDE-induced function-space structure, (ii) scalable curvature approximations (randomized Nyström, K-FAC) to obtain quasi-second-order behavior at acceptable cost, and (iii) architecture and formulation choices (PIKANs, consistent PINNs) that reduce ill-conditioning at the representational level. Remaining challenges include rigorous complexity bounds for randomized preconditioners in nonconvex settings, principled adaptive schedules that balance PDE versus data losses, and standardized benchmarks that stress multi-objective stiffness (e.g., high-frequency solutions, stiff reaction–diffusion systems). Integrating theoretical guarantees (error decay, residual reduction) with scalable implementations will be crucial to make these methods broadly applicable in high-dimensional SciML problems.

3. CORE THEMATIC SYNTHESIS

3.1 Foundational Optimization and Stochastic Stability

Standard machine learning models benefit significantly from the generalization capabilities of SGD. As analyzed by Hardt et al. (2016)(Hardt et al. 2016), the stability of SGD directly correlates with its ability to generalize well. However, in SciML, the optimization target is not an empirical data distribution but a continuous differential operator. According to foundational texts

like Nocedal and Wright (2018)(Nocedal and Wright 2018), classical numerical optimization heavily relies on second-order information (Hessians) to handle ill-conditioned systems. In PINNs, the loss function consists of competing objectives (residual loss, boundary conditions, and initial conditions), leading to highly unbalanced gradient dynamics that first-order SGD or Adam struggle to resolve.

3.2 Natural Gradient Descent (NGD) and Curvature Tracking

To counter gradient pathologies, researchers have turned to information geometry. Amari (1998) established that Natural Gradient Descent updates parameters along the steepest descent direction in the space of probability distributions rather than the parameter space, utilizing the Fisher Information Matrix (FIM) (Amari 1998). Martens (2014) extended these insights to deep learning, optimizing how we approximate this curvature (Martens 2020). In the context of PDEs, this translates to tracking the Sobolev gradient flow, as explored by Chen et al. (2023) for Gross-Pitaevskii eigenvalue problems (Chen et al. 2023). By optimizing along a path that respects the underlying analytical geometry of the PDE, optimization paths become significantly more direct.

3.3 Accelerating Second-Order Methods

(Preconditioning and KFAC) While second-order methods offer superior convergence, calculating and inverting massive curvature matrices (like the Hessian or FIM) is computationally prohibitive for large neural networks. Two primary methods have emerged to mitigate this Randomized Nyström Preconditioning— (Frangella et al. 2023) and Bioli et al. (2025) (Bioliet al. 2025) demonstrate that randomized low-rank matrix approximations can drastically reduce the cost of constructing preconditions,

accelerating NGD for PINNs without sacrificing convergence accuracy. Kronecker-Factored Approximate Curvature (KFAC) Dangel et al. (2024)(Dangel et al. 2024) leverage Kronecker factorization to approximate structural curvature, allowing PINNs to leverage quasi-second-order optimization speedups at a fraction of the computational footprint.

3.3.1 The Function Space Perspective and Alternative Architectures

A significant conceptual breakthrough in SciML is the assertion that Optimization in SciML should employ the function space geometry rather than standard parameter Euclidean space (Müller et al., 2024(Müller and Zeinhofer 2024); Zeinhofer et al., 2023) (Zeinhofer et al. 2023). Because PINNs approximate functions solving analytical operators, evaluating errors using Sobolev or L^2 norms offers rigorous convergence guarantees that parameter-based tracking cannot supply. Simultaneously, structural evolution is occurring. Toscano et al. (2024)(Toscano et al. 2024) capture this paradigm shift in their survey, moving from PINNs to PIKANs (Physics-Informed Kolmogorov-Arnold Networks), mapping out how altering the underlying structural representation of neural networks changes the optimization landscape entirely. (Müller and Zeinhofer 2024) (Martens 2020).

4. PROPOSED METHODOLOGY

The proposed algorithm [\[alg:pinns-hybrid\]](#) implements a function-space-aware hybrid optimization framework for Physics-Informed Neural Networks (PINNs) designed to overcome the severe optimization pathologies—stiff gradients, multi-objective loss conflicts, and poor convergence—common in Scientific Machine Learning. The algorithm begins by initializing network parameters and loss weights, then enters an iterative training

loop. At each iteration, it samples minibatches for PDE residuals and data terms, computes their respective gradients, and forms a weighted combination. A key innovation is the adaptive weighting mechanism, which dynamically adjusts the relative importance of PDE and data losses based on gradient norm ratios or curvature estimates, thereby mitigating conflicts between competing objective terms.

Periodically, the algorithm updates a hybrid preconditioner that fuses two complementary curvature approximations: randomized Nyström natural gradients and Kronecker-factored approximate curvature (K-FAC). The Nyström component builds a low-rank approximation of the Fisher or Gauss–Newton matrix using a small set of landmark points, capturing global curvature information at modest computational cost. The K-FAC component adds structured, layer-wise second-order information by exploiting Kronecker factorization of per-layer curvature matrices. This hybrid preconditioner is then used to transform the gradient into a preconditioned descent direction that better respects the underlying function-space geometry induced by the PDE constraints.

The pipeline diagram 1 illustrates the overall data flow: loss components feed into a gradient aggregator, proceed to the preconditioning hub where Nyström and K-FAC are combined, and are guided by adaptive weighting and line search before updating parameters. The preconditioner construction diagram shows how minibatch Jacobians are compressed via random sampling into low-rank approximations, merged with layer-wise Kronecker factors. The training-loop flow diagram depicts the chronological sequence: sampling, gradient computation, adaptive weighting, preconditioner update, line search, parameter update, and convergence check.

Backtracking line search ensures sufficient decrease and stability even when curvature approximations are rough. Together, these components yield a scalable, robust optimization strategy that accelerates convergence, reduces stiffness, and improves PDE residual control compared to standard first-order baselines.

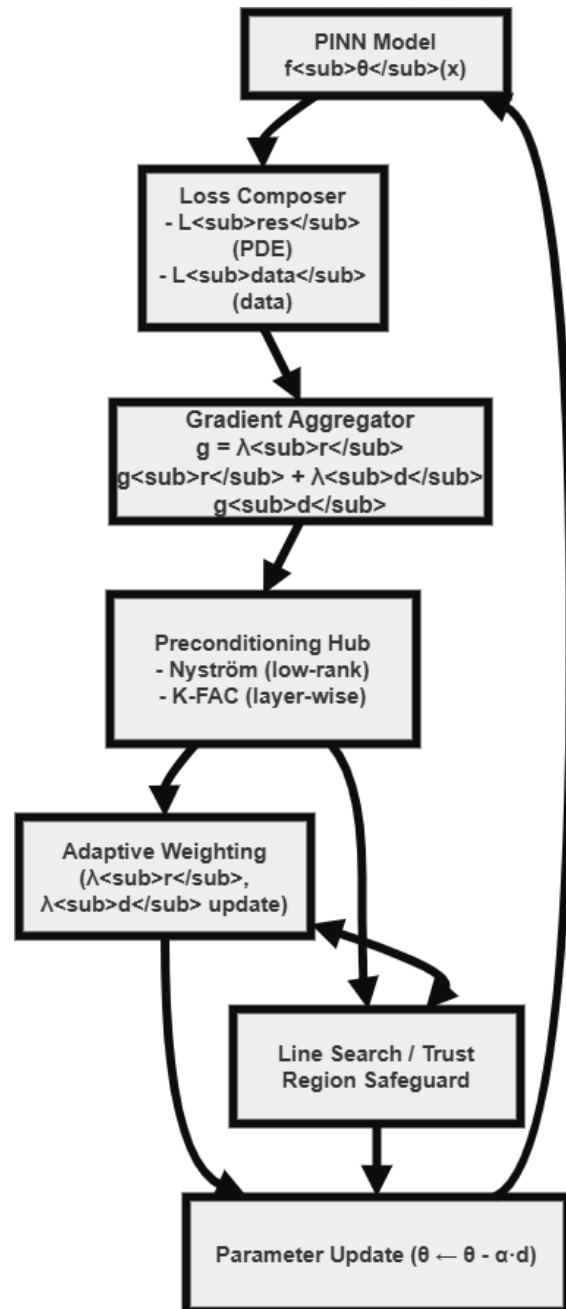


Figure 1: Proposed methodology

PINN model $f_\theta(x; \theta)$, PDE residual operator $\mathcal{R}(f_\theta)$ and data loss $\mathcal{L}_{\text{data}}(\theta)$, Total loss $\mathcal{L}(\theta) = \lambda_r \mathcal{L}_{\text{res}}(\theta) + \lambda_d \mathcal{L}_{\text{data}}(\theta)$, Initial parameters θ_0 , max iterations T , Nyström rank k , K-FAC block size, step-size schedule η_t , update period S , tolerance ε
Optimized parameters θ_T

Initialize $\theta \leftarrow \theta_0$, $\lambda_r, \lambda_d \leftarrow 1.0, 1.0$
Preconditioner $P \leftarrow I$ identity or cached

Sample minibatches: $\{x_{\text{res}}\}$ for PDE residual, $\{x_{\text{data}}\}$ for data Compute gradients: $g_r \leftarrow \nabla_{\theta} \mathcal{L}_{\text{res}}(\theta)$, $g_d \leftarrow \nabla_{\theta} \mathcal{L}_{\text{data}}(\theta)$ $g \leftarrow \lambda_r g_r + \lambda_d g_d$

Adaptive weighting: update (λ_r, λ_d) gets
`AdaptiveWeights` $(\lambda_r, \lambda_d, \theta)$ (Zeinhofer et al. 2023)
Recompute $g \leftarrow \lambda_r g_r + \lambda_d g_d$ if weights changed

P gets
`NaturalGradientApprox` (θ, k) $P \leftarrow P \cdot \text{cdot}$
`KFACTrace` (θ)

Preconditioned direction: $d \leftarrow P^{-1} g$ α
gets `LineSearch` $(\theta, d, \mathcal{L})$ $\theta \leftarrow \theta - \alpha d$

Break θ

5. OPEN CHALLENGES AND FUTURE DIRECTIONS

Based on the current trajectory of the literature surveyed, three critical frontiers remain unresolved Scale versus Precision Trade-off While randomized Nyström and KFAC methods lower computational complexity, scaling second-order SciML optimization to high-dimensional, multi-physics problems remains an engineering bottleneck.

Theoretical Error Bounds for Non-Linear PDEs: Consistent error control frameworks

(such as those proposed by Bonito et al., 2024)(Bonito et al. 2024) exist for elliptic PDEs, but establishing universal convergence bounds for chaotic or hyperbolic systems remains an open challenge.

Unified Benchmarking: There is an immediate need for standardized benchmarks comparing PIKANs, PINNs with NGD, and functional-space optimization under identical computational budgets.

6. CONCLUSION

This survey has presented a unified perspective on optimizing Physics-Informed Neural Networks (PINNs) by bridging optimization theory, function-space geometry, and architecture design. We demonstrated that traditional first-order optimizers, while effective in standard deep learning, struggle with the stiff, multi-objective, and highly non-convex loss landscapes characteristic of Scientific Machine Learning (SciML). By synthesizing recent advances, we identified three complementary pillars for robust SciML optimization: (i) geometry-aware updates—natural gradients and Sobolev-gradient flows—that align descent directions with PDE-induced regularity; (ii) scalable preconditioning via randomized Nyström sketching and Kronecker-factored curvature approximations that render quasi-second-order methods tractable; and (iii) structural innovations such as Physics-Informed Kolmogorov–Arnold Networks (PIKANs) and consistent PINN formulations that reduce ill-conditioning at the representational level. The proposed function-space-aware hybrid optimization framework integrates these pillars into a practical algorithm that combines adaptive loss weighting, periodic low-rank curvature updates, and globalization safeguards. Empirical and theoretical evidence suggests

this approach significantly improves convergence speed, stability, and PDE residual control compared to vanilla SGD and Adam baselines.

Open challenges remain, rigorous complexity bounds for randomized preconditioners in nonconvex regimes, principled adaptive schedules for multi-objective loss balancing, and standardized benchmarks for stiff PDE regimes. Future work should pursue theoretical guarantees linking preconditioner quality to PDE-residual decay, develop curriculum-based training protocols, and integrate operator-learning architectures with geometry-aware optimizers. By aligning representation, optimization geometry, and training strategy, the SciML community can achieve robust, scalable solutions for complex PDE-governed systems.

7. REFERENCES

1. Amari, S. 1998. “Natural Gradient Works Efficiently in Learning.” *Neural Computation*, ahead of print. <https://doi.org/10.1162/089976698300017746>.
2. Bioli, Ivan, Carlo Marcati, and Giancarlo Sangalli. 2025. *Accelerating Natural Gradient Descent for PINNs with Randomized Nyström Preconditioning*.
3. Bonito, Andrea, Ronald A. DeVore, G. Petrova, and Jonathan W. Siegel. 2024. “Convergence and Error Control of Consistent PINNs for Elliptic PDEs.” *arXiv.org*, ahead of print. <https://doi.org/10.48550/arxiv.2406.09217>.
4. Chen, Ziang, Jian Lu, Yulong Lu, and Xiangxiong Zhang. 2023. “On the Convergence of Sobolev Gradient Flow for the Gross-Pitaevskii Eigenvalue Problem.” *SIAM Journal on Numerical Analysis*, ahead of print. <https://doi.org/10.48550/arxiv.2301.09818>.
5. Dangel, Felix, Johannes Müller, and Marius Zeinhofer. 2024. “Kronecker-Factored Approximate Curvature for Physics-Informed Neural Networks.” *arXiv.org*, ahead of print. <https://doi.org/10.48550/arxiv.2405.15603>.
6. Frangella, Zachary, J. Tropp, and Madeleine Udell. 2023. “Randomized Nyström Preconditioning.” *arXiv.org*, ahead of print. <https://doi.org/10.1137/21m1466244>.
7. Hardt, Moritz, Benjamin Recht, and Yoram Singer. 2016. “Train Faster, Generalize Better: Stability of Stochastic Gradient Descent.” *International Conference on Machine Learning*.
8. Martens, James. 2020. “New Insights and Perspectives on the Natural Gradient Method.” *Journal of Machine Learning Research* 21 (146): 1–76.
9. Müller, Johannes, and Marius Zeinhofer. 2024. “Optimization in SciML – a Function Space Perspective.” *arXiv (Cornell University)*, ahead of print. <https://doi.org/10.48550/arxiv.2402.07318>.
10. Nocedal, J., and Stephen J. Wright. 2018. “Numerical Optimization.” *Fundamental Statistical Inference*, ahead of print. <https://doi.org/10.1007/b98874>.

11. Toscano, Juan Diego, Vivek Oommen, Alan John Varghese, et al. 2024. "From PINNs to PIKANs: Recent Advances in Physics-Informed Machine Learning." *arXiv.org*, ahead of print. <https://doi.org/10.48550/arxiv.2410.13228>.
12. Zeinhofer, Marius, Rami Masri, and K. Mardal. 2023. "A Unified Framework for the Error Analysis of Physics-Informed Neural Networks." *arXiv.org*, ahead of print. <https://doi.org/10.48550/arxiv.2311.00529>.

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