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Contact us

PUBLISHER

Institute for Excellence in Higher Education

Kaliyasot Dam, Kolar Road Post Box No. 588, Post Office

Ravishankar Nagar, Bhopal - 462016

Website: www.iehe.ac.in | Email: iehequest@gmail.com

Contact Nos. 0755-2492433; 9926320428

CHIEF EDITOR

Dr. Hari Krishna Garg

Professor | Department of Biotechnology

Institute for Excellence in Higher Education

Kaliyasot Dam, Kolar Road Post Box No. 588, Post Office

Ravishankar Nagar, Bhopal - 462016

Email: drharikrishna.garg@mp.gov.in

Contact No. 9424417792

Editorial Board

Publisher

Dr. Pragyesh Kumar Agrawal

Director,
Institute for Excellence in Higher Education, Bhopal.
Email ID: pragyesh.kagrawal@mp.gov.in
Phone No. 9926320428

Chief Editor

Dr. Hari Krishna Garg

Professor, Department of Biotechnology
Institute for Excellence in Higher Education, Bhopal.
Email ID: drharikrishna.garg@mp.gov.in
Phone No. 9424417792

Editor

Dr. Ajay Kumar Bhardwaj

Professor, Department of Biotechnology
Institute for Excellence in Higher Education,
Bhopal.
Email ID: drajaykumar.bhardwaj@mp.gov.in
Phone No. 7999631801

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Institute for Excellence in Higher Education,
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Email ID: anujavyas20@gmail.com
Phone No. 7974751896

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Email ID: pal.drmahi@mp.gov.in
Phone No. 9425393867

Ms. Soumya Jain

M.Sc. Final, Biotechnology
Institute for Excellence in Higher Education,
Bhopal.
Email ID: soumyajain@gmail.com
Phone No. 9131087834

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From Sci-Fi to Reality: Synthesis of Human-Robotic Entities through Genetronics

Anuja Vyas and Hari Krishna Garg

Department of Biotechnology

Institute for Excellence in Higher Education, Bhopal - 462016 India

Abstract

The convergence of genetic engineering and artificial intelligence (AI) has ushered an exciting new phase with endless promises for humanity. While the notion of Artificial Life (ALife) was given by Christopher Langton in 1987, it was Rishabh Garg (2021), who first of all announced the idea of 'human-bots' - biologically human, yet functionally robotic beings born from the synergy of AI and genetic science.

Building on this foundation, Rishabh Garg, Anuja Vyas, and others (2024) advanced this vision to unprecedented heights with Genetronics - a matchless integration of genomics and deep learning architectures such as convolutional neural networks (CNNs) and transformer architectures to decode, edit, and synthesize DNA. These novel processes involve sequencing genes, generating molecular structures, chemically synthesizing DNA strands, and inserting them into egg cells to create fully engineered life forms. Genetronics could usher in an age of tailor-made vaccines, personalized medicine, and synthetic entities capable of complex human tasks. It can eliminate the need for testing on animals and transform fields such as organ transplantation and drug development.

Yet, this bold leap forward comes with its share of bioethical, biosafety, and ecological concerns. Experts caution against unintended consequences, misuse, and the uncertain impact of releasing synthetic organisms into the environment. Despite the menaces, proponents argue the potential benefits far outweigh the dangers – they call for a new era where biology and technology come together, turning frontiers once considered science fiction into tangible reality.

Keywords - Artificial intelligence in genomics, AI-driven DNA synthesis, Artificial Life (ALife), Ethical implications of synthetic life, Genetronics, Genomic data analysis using AI, Neural networks in gene sequencing, Personalized medicine through AI, Synthetic biology and machine learning, Transformer models in bioinformatics.

Introduction

As modern technology almost advances into science fiction territory, prospects of Genetic Engineering and Artificial Intelligence can take humanity to the next step of advancement. The term 'Artificial life,' (ALife) coined by computer scientist Christopher Langton, informally kicked-off in 1987 at the first Interdisciplinary Workshop on the Synthesis and Simulation of Living Systems at Los Alamos National Laboratory. It brought together various studies from different fields focused on creating lifelike behaviour. The trailblazing concept of computerized humanoid entities, or 'human-bots,' was first introduced by Rishabh Garg in 2021 with the publication of his inspirational research article, '*Decoding Tomorrow: Traversing the Landscape of Artificial Life*'. In this seminal work, Garg explored how Siamese and convolutional neural networks could be harnessed to decode protein structures, translate genetic codes into computer algorithms, and even design synthetic DNA.

Fast forward to 2024, Rishabh Garg, Anuja Vyas, and others expanded upon this vision by detailing the intricate processes behind the creation of human-robotic entities. Using advanced biotechnology tools like the Transformer Architecture Specialized in Gene Sequencing (TASAG) and Closed Loop DNA Synthesis (CDS), they pioneered methods to transform genetic data into fully functional genome, bringing their noble ideas to life. This world-shattering fusion, dubbed Genetronics, seeks to blend genomics with artificial intelligence to craft entities that are biologically human in form, but functionally robotic. Consequently, a new era of human advancement has ushered where the boundaries between biology and technology blur, opening doors to possibilities once only dreamt of.

Genomics

Genomics is the study of complete set of genes of an organism. Gene is the basic functional and structural unit of heredity. It carries genetic information - the information that codes all functions and structures of our body, from one generation to the next. Every organism is made of genes, from the smallest Mycoplasma to the largest Blue Whale. In fact, it is these genes that answer the question of why the former is tiny while the latter is huge. Genes are present on deoxyribonucleic acid (DNA) which is the molecular language of life.

DNA is majorly comprised of three components: a deoxyribose sugar, a phosphate group and four cyclic nitrogenous bases: Adenine and Guanine (Purines), Cytosine and Thymine (Pyrimidines). Deoxyribose sugar is numbered from the position of attachment of nitrogenous bases. Thus, at first carbon (C-1) position resides one of the nitrogenous bases, on 3-C position resides an OH (hydroxyl) group and on 5-C position, phosphate group is attached. Phosphate group of the next nucleoside (nitrogenous base and sugar) is attached to current deoxyribose at 3-C position instead of OH. Adenine always pairs with thymine on its complementary strand and guanine always pairs with cytosine.

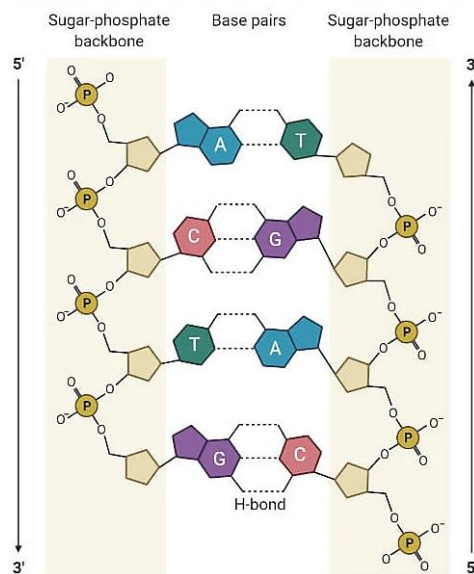


Fig-1: Molecular structure of DNA

In most organisms, DNA is double stranded and these strands are complementary to each other. This means that one strand has OH group attached to 3' end and phosphate to 5' end when read from left to right and is thus called 3' to 5' strand. Conversely, the complementary strand is designated 5' to 3'. A normal human genome consists of 46 pairs of chromosomes, i.e., 46 double-stranded DNA (dsDNA) strands are present in the nuclei of human cells.

Gene Sequencing

To sequence genes, a neural network (NN) model can be designed to identify and classify nitrogenous bases. This can be accomplished using Artificial Neural Networks (ANNs). Convolutional Neural Networks (CNNs) are well-suited for image classification, while transformer-based models excel in text-to-image generation. Advanced models such as Residual Networks (ResNets) and Vision Transformers (ViTs) can also be employed for image classification. ViTs, in particular, produce higher-resolution images compared to CNNs and require fewer computational resources for pre-training. Besides, ResNets address the vanishing gradient problem posed by traditional CNNs.

Steps

- Train the CNN on dataset containing molecular structures of the nitrogenous bases.
- The CNN learns to classify and label molecules as A, G, T or C after identifying their structure as adenine, guanine, thymine or cytosine respectively.
- Test the model with the help of test dataset and check accuracy.
- The model should be able to classify molecular structures of Adenine, Guanine, Thymine and Cytosine as 'A', 'G', 'T' and 'C' respectively upon receiving them as input.

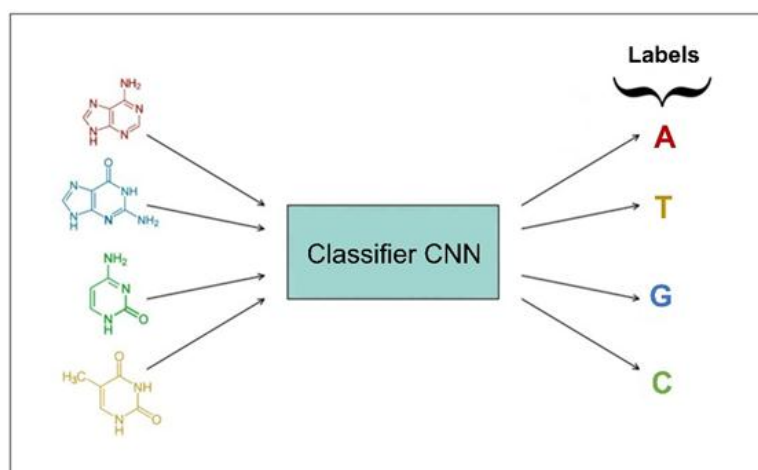


Fig-2: Gene sequencing

Gene editing and generation of molecular structure of bases

Once the above models have been designed, they should also carry a feature to edit the sequence, i.e., produce changes in order to obtain the sequence that is able to produce the desired

Characteristic or expression. This could be possible with the help of a Graphical User Interface (GUI) to enable the user to replace any desired nitrogenous base with another based on the knowledge of genomics. A transformer-based model which is pre-trained on labelled data produced by classifier CNN discussed earlier needs to be employed in order to generate molecular structures of the bases from FASTA or a similar file obtained after sequencing.

Steps

- The gene sequence is displayed on screen.
- The user is able to replace, delete, duplicate or translocate nitrogenous bases or complete codons from the sequence based on what output needs to be generated, i.e., which protein needs to be formed or which character needs to be expressed. This is done by comparing it to reference genome obtained from the Human Genome Project (HGP). The reference genome would serve as a standard which provides information about the function of any given gene in the human genome.
- This is achieved by clicking the N-base. A dialog box appears that carries these options and also options of bases that the selected base needs to be replaced with (A, G, T or C).
- Once the base is selected and replaced/added/deleted/duplicated, the desired DNA sequence is available for molecular generation.
- Train a transformer-based model on labelled data obtained from classifier CNN.
- The model should be able to generate molecular structures of the bases as per gene sequence when it is provided as input. Gene sequence of nitrogenous bases is now obtained as sequential arrangement of their molecular structures.

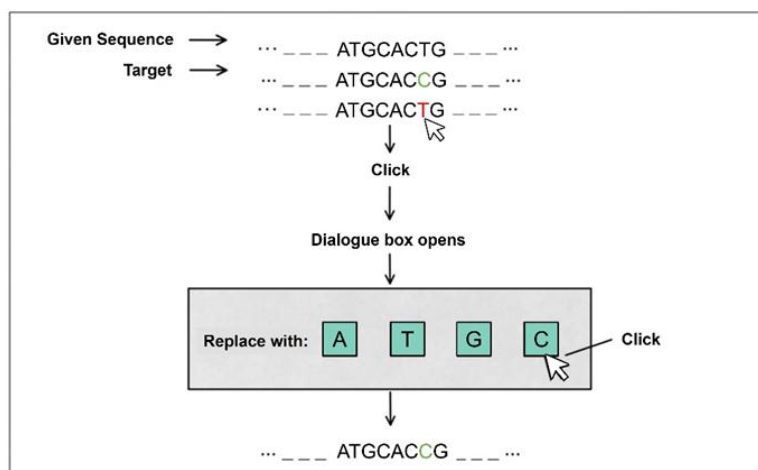


Fig-3: Gene editing

Molecular generation and computer simulation of the DNA strand

This step provides a visual representation of the DNA strand before chemical synthesis, utilizing unsupervised learning through clustering algorithms applied to a deep CNN pre-trained on a large dataset of molecular images of DNA.

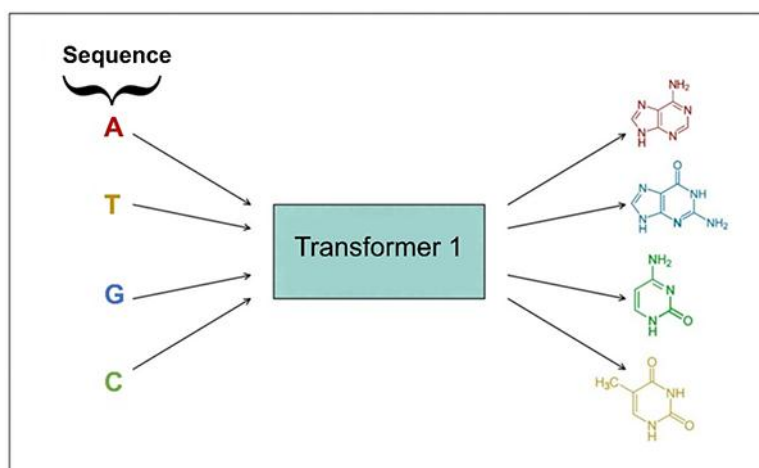


Fig-4: Molecular structure generation of edited gene sequence

Steps

- Train the CNN on a training dataset of molecular images of DNA structure.
- The deep CNN should learn to cluster sugar, phosphate, and nitrogenous bases.
- Test the model on a separate test dataset.
- Train a transformer-based model using the deep CNN as the foundation.
- Feed the transformer with individual molecular images of ribose sugar, phosphate, and the molecular base sequence generated after gene editing.
- The transformer should generate a DNA strand with the desired gene sequence arranged on a sugar-phosphate backbone.
- Having learned the DNA structure, the model can easily generate the complementary strand for dsDNA by attaching adenine to the C-1 position of deoxyribose wherever thymine appears on the opposite strand, and guanine where cytosine is present, and vice versa.
- A computer simulation of the molecular structure of dsDNA is then generated, serving as the precursor for its chemical synthesis.

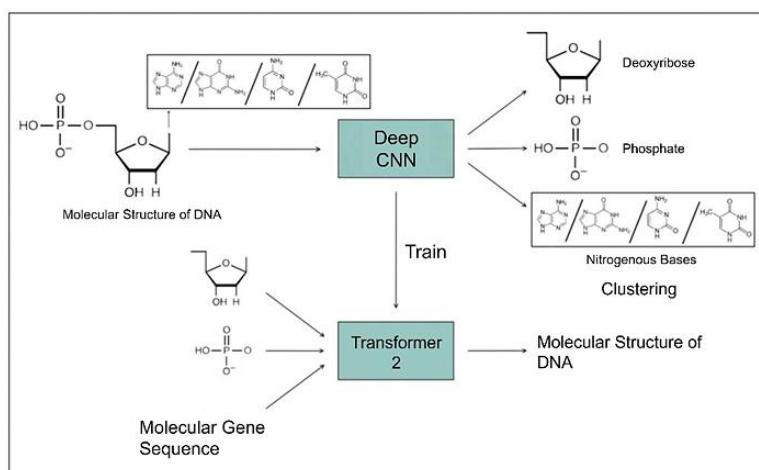


Fig-5: Molecular structure generation of artificial dsDNA strand

Chemical synthesis of desired DNA strand

The step can be accomplished via advanced AI-based models integrated with a machine that are able to interpret the digital structure of DNA and synthesise a chemically accurate DNA strand that is structurally and functionally similar to the designed DNA model. Since the human genome consists of 46 dsDNA strands, they have to be synthesised via this method.

Insertion of this strand into an ovum for development: This can be made possible by degrading the haploid chromatin (DNA) present within the nucleus of donor ovum. Once the chromatin has been degraded, the synthesised dsDNA strands can be inserted into this nucleus and the diploid egg can be stimulated to cleave and develop under artificial conditions. This has been conceptualised while carrying the assumption that the nucleus of human ovum is comparatively larger in size and can accommodate female as well as male genetic material at the time of fertilisation. Hence, the nucleus would be able to withstand insertion and contain this artificial genome.

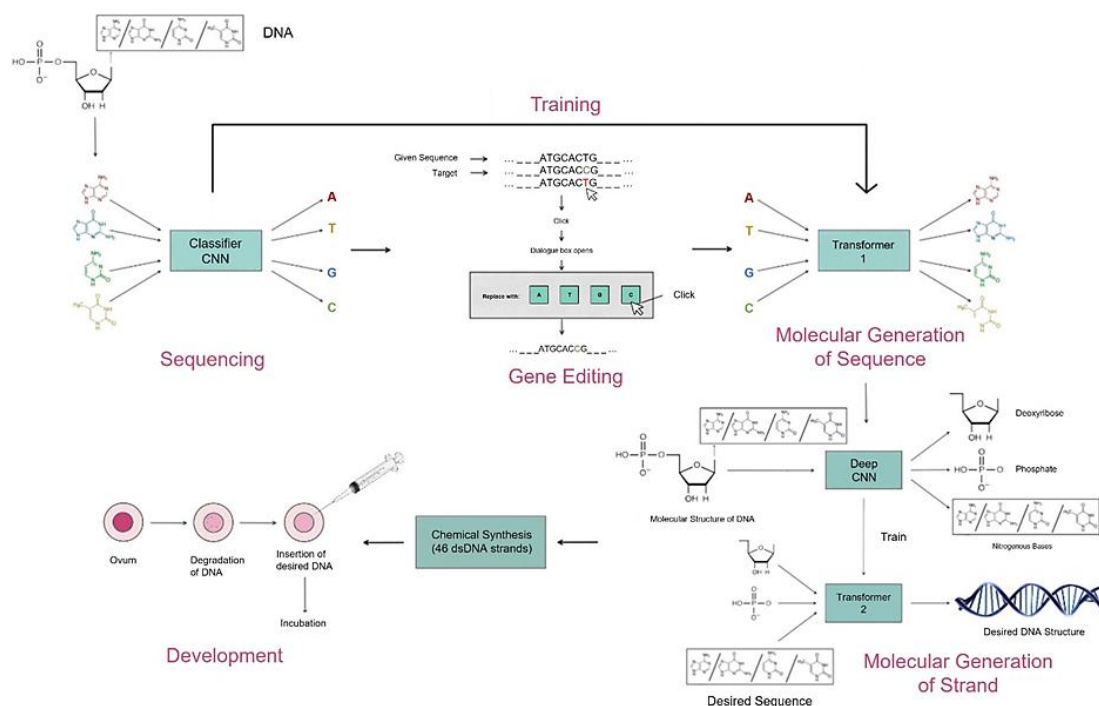


Fig-6: Framework of H-Bot creation process

Recent Breakthroughs

In an extraordinary achievement, U.S. geneticist Craig Venter and his team created the world's first synthetic life form by building a bacterium's genome from scratch and inserting it into a host cell. This milestone opened the door to the possibility of 'designer' organisms, with the synthetic DNA guiding the new microbe to behave exactly as the species it was programmed to be.

On the ethical and safety front, geneticist Dr. Gos Micklem pointed out that while the new approach is matchless, existing genetic engineering methods are already powerful. As such, this new strategy may not replace current techniques in the near future.

Professor Julian Savulescu from Oxford University also raised concerns about the balance of benefits and risks, calling for new safety standards and protections against potential misuse, particularly by military or terrorist groups. As he aptly put it, the challenge is ‘to eat the fruit without the worm.’ Dr. Helen Wallace from Genewatch UK warned that releasing synthetic organisms into the environment could have unintended ecological consequences, raising questions about their impact.

Despite the concerns, Craig Venter believes that the risks are outweighed by the potential benefits. He and his team remain hopeful that breakthroughs like this could lead to significant advancements, such as the development of future flu vaccines.

Amid these debates, researchers, Rishabh Garg & Anuja Vyas argued that such studies would eliminate the need for animal testing in vaccine development and enable customized drug testing tailored to individual factors like age, weight, and height. The synthetic individuals would do complex tasks like surgery and organ isolation for transplantation, which could reduce the demand for human labor.

In the meantime, a Facebook post (view here, archive link) has sparked wild speculation, featuring a photo of Elon Musk next to an image of what seems to be a pregnant robot, its transparent belly revealing a baby inside. Whether it’s a fact or fiction, the post suggests that Musk is developing a new breed of robots capable of carrying babies for nine months while couples continue with their daily lives. These robots, it claims, would fertilize and nurture the growing baby. Stories like this ignite imaginations, heralding a new era where the lines between natural and artificial life blur, unlocking possibilities once confined to science fiction.

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Synthesis of ZnO Nanopowder by using Sol-Gel and Theoretical Study of Brus Equation

Utsav Soni, Anadi Achintya Jha, Farukh Abdulla, Sourabh Singh and B.K. Sinha

Department of Physics and Electronics

Institute for Excellence in Higher Education, Bhopal - 462016 India

Abstract

Zinc oxide (ZnO) nanoparticles are a marvel in nanotechnology, celebrated for their extraordinary properties and adaptability across diverse fields. Their nanoscale size and high surface area-to-volume ratio endow them with distinct chemical and physical characteristics, making them indispensable in cutting-edge technological advancements.

Crafting ZnO nanoparticles is an art that involves methods ranging from chemical vapour deposition to sol-gel techniques. Each method holds unique advantages in controlling particle size the purity, and scalability. Sol-gel method synthesis technique utilized zinc acetate dihydrate as a precursor, while potassium hydroxide was employed to maintain precise pH control. The nanoparticles underwent controlled thermal processing initially at 80°C and followed by annealing at 200°C to enhance the stability and optimize quantum effect. UV-vis spectroscopy indicated a distinct absorption peak at 367.8 nm, corresponding to a band gap of 3.37 eV which confirms quantum confinement induced energy level. Utilizing Brus equation alongside effective mass approximations, the estimated particle radius was found to be approximately 4.06 nm ensuring strong excitonic interaction due to spatial wave function overlap.

Keywords - ZnO Nanoparticle, Sol-gel Method, UV-Vis spectroscopy, Brus equation.

Introduction

A critical aspect of understanding the optical properties of ZnO nanoparticles lies in the quantum size effect, which significantly influences their behaviour at the nanoscale. This is where the Brus equation comes into play. The Brus equation provides a quantitative framework for analyzing the quantum confinement effects in semiconductor nanocrystals, such as ZnO nanoparticles.

The Brus equation is given by:

$$E = E_g + \frac{\hbar^2 \pi^2}{2R^2} \left\{ \frac{1}{m_e} + \frac{1}{m_h} \right\} - \frac{1.8e^2}{4\pi\epsilon_0 R}$$

Where,

E is the band gap of the synthesized particle, E_g the bulk band gap of ZnO (3.3eV), R radius of the particle, m_e effective mass of the electron (for ZnO, it is 0.28 m_0), m_h effective mass of hole (for ZnO it is 0.49 m_0), ϵ - dielectric constant of material (for ZnO it is 9.1), ϵ_0 permittivity of free space and h is the Planck's constant

This equation illustrates how the band gap energy of ZnO nanoparticles increases as their size decreases due to the quantum confinement. The insights provided by the Brus equation are crucial for tailoring the optical properties of ZnO nanoparticles to specific applications, such as in optoelectronics and photonics. By understanding the principles behind the Brus equation, researchers can better design and optimize the synthesis processes to achieve ZnO nanoparticles with desired properties. This not only enhances the functionality of the nanoparticles but also broadens their applicability in various technological domains.

Sol-gel Technique

The sol-gel technique is a versatile method for producing ceramic and glass materials, including nanoparticles like ZnO. The process involves transitioning from a liquid "sol" into a solid "gel" phase. This process starts with the preparation of a solution containing metal precursors, which undergo hydrolysis and polycondensation to form a gel network. The gel is then dried to remove solvents and is often subjected to heat treatment (calcination) to produce the final oxide material with the desired properties.

The sol-gel method is praised for its ability to produce uniform and high-purity materials at relatively low temperatures, making it ideal for various advanced applications in nanotechnology. Parameters decided as follows:

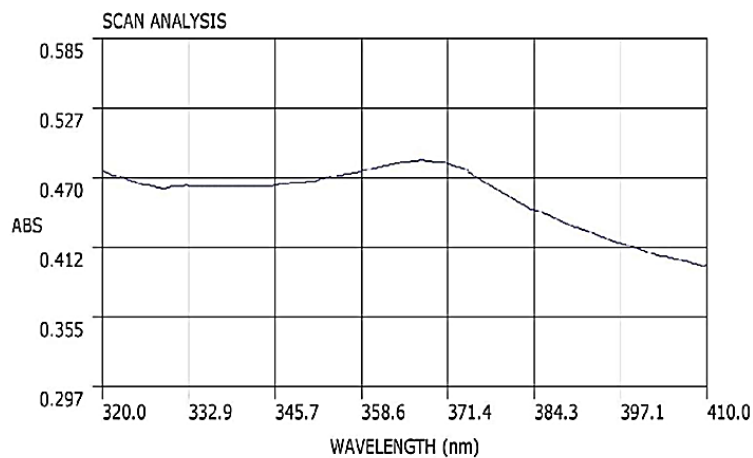
- **Precursor Concentration:** The concentration of zinc precursor (zinc acetate) affects the particle size and morphology.
- **pH Value:** Adjusting the pH using a base (potassium hydroxide) helps control the nucleation and growth of nanoparticles.
- **Reaction Time:** The duration of the hydrolysis and condensation reactions influences the particle size and crystallinity.
- **Temperature:** The calcination temperature during the drying process affects the crystalline structure and phase purity of the nanoparticles.
- **Stirring Rate:** Proper mixing ensures uniform distribution of reactants and uniform particle size.
- **Solvent Type:** The choice of solvent can impact the solubility of precursors and the overall reaction kinetics.
- **Chemicals Used:** Zinc acetate dihydrate, Ethanol, Potassium hydroxide (KOH), Citric acid, Dimethyl sulfoxide (DMSO), Distilled water

Procedure

1. **Preparation of Zinc Solution:** Dissolved zinc acetate dihydrate in ethanol.
2. **Adding Citric Acid:** Citric acid, was mixed and stirred continuously.
3. **Adjustment of pH:** Slowly KOH solution was added until pH reaches around 10, ensuring proper nanoparticle formation.
4. **Forming Sol:** The mixture was stirred for 2 hours to create a stable sol.

5. Adding DMSO: DMSO was incorporated to stabilize and uniformly distribute the nanoparticles.
6. Gelation: Allowed the sol to age at room temperature for 24 hours to form a gel.
7. Drying: Dried the gel at 80°C for 12 hours.
8. Calcination: Calcinated the dried gel at 200°C for 2 hours to obtain ZnO nanoparticles.
9. Characterization: Analysed the nanoparticles using UV-Vis spectroscopy.

After analysing the prepared ZnO Nanoparticles using UV-Vis Absorption Spectroscopy following graph is obtained:



The graph shows a peak value at a wavelength of approximately 367.8 nm, with an absorbance (ABS) of 0.485.

Using this we can calculate the band gap energy: $E = hc/\lambda$

$$E = (6.67 \times 10^{-34} \times 3 \times 10^8) / (367 \times 10^{-9}) = 5.4 \times 10^{-19} \text{ J} = 3.37 \text{ eV}$$

This is used to determine the average particle size using effective mass approximation. And now, Using the Brus Equation

$$E = E_g + \frac{\hbar^2 \pi^2}{2R^2} \left\{ \frac{1}{m_e} + \frac{1}{m_h} \right\} - \frac{1.8e^2}{4\pi\epsilon_0 R}$$

$$E = 3.37 + \frac{\hbar^2 \pi^2}{2R^2} (1/0.23m_e + 1/0.49m_h) - 1.8 \times (1.6 \times 10^{-19})^2 / 4\pi \epsilon_0 R$$

Therefore, $R = 4.06 \text{ nm}$

Results

Thus, it is confirmed that the prepared ZnO nanoparticles by the sol gel method of at temperature is of size 4.06nm.

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The Role of Emerging Technologies in Startup Growth and Employment Sustainability in India

Kritika Prakash and Mahendra Singhai

Department of Commerce,
Institute for Excellence in Higher Education, Bhopal, M.P.

Abstract

In recent years, the integration of emerging technologies into business practices has become a vital component of global efforts toward sustainable development. As environmental challenges intensify and sustainability becomes a strategic priority, technological innovation is increasingly viewed as a key driver for achieving economic growth without compromising ecological balance. Technologies such as Artificial Intelligence (AI), Blockchain, Internet of Things (IoT), and renewable energy systems are enabling businesses—especially start-ups—to reduce environmental footprints, optimize operations, and foster transparency and accountability. These innovations not only support the realization of the United Nations Sustainable Development Goals (SDGs) but also reshape traditional business models, paving the way for more resilient and future-oriented enterprises. This paper explores how emerging technologies contribute to sustainable development, with a particular focus on their role in empowering start-up ecosystems to lead this transformative shift.

Keywords: *Sustainability, Technologies, Startups.*

Introduction

The convergence of emerging technologies and sustainable development is revolutionizing how businesses, especially startups, operate in the modern economy. Technologies such as Artificial Intelligence (AI), Blockchain, Internet of Things (IoT), data analytics, and renewable energy solutions are not only enhancing operational efficiencies but are also instrumental in achieving environmental, social, and governance (ESG) goals. The integration of these technologies allows organizations to optimize resources, reduce emissions, improve transparency, and build resilient systems aligned with global sustainability agendas.

AI plays a critical role in enabling data-driven decision-making for efficient energy consumption, predictive maintenance, and supply chain management. Similarly, blockchain technology facilitates traceability, transparency, and accountability in operations, particularly in ethical sourcing and logistics, thereby fostering consumer trust and sustainable trade. IoT devices enable real-time monitoring and management of resources in sectors like agriculture, manufacturing, and urban infrastructure, leading to considerable gains in productivity and conservation of natural resources.

Startups, in particular, are leveraging these technologies to create innovative solutions to contemporary environmental and societal challenges. The agility and adaptability of startups allow them to incorporate sustainability into their core business models from inception. For instance, technology-driven startups are developing green products, optimizing logistics to reduce

carbon footprints, and creating platforms that promote circular economy practices. This trend is reinforced by research showing a growing emphasis on open innovation, digital transformation, and sustainability as key drivers of entrepreneurial success.

Governments and global organizations are also recognizing the value of tech-enabled sustainability. In India, initiatives like Startup India and policies promoting digital infrastructure have led to the emergence of a robust startup ecosystem that is increasingly aligned with the Sustainable Development Goals (SDGs). Internationally, firms and governments are investing heavily in clean technologies, recognizing their potential to address climate change while offering significant economic returns.

However, challenges remain, including the digital divide, data privacy concerns, and the high initial investment required for some technologies. Despite these, the overall outlook remains optimistic, with emerging technologies seen as indispensable tools for a sustainable and inclusive future. As technology continues to evolve, its strategic implementation will be key in fostering innovation, driving sustainable practices, and ensuring that economic growth does not come at the expense of environmental and social well-being.

Key variables

Input Variables:

- Adoption of emerging technologies (AI, IoT, Blockchain, Renewable Energy)
- Policy environment and digital infrastructure support

Output Variables:

- Implementation of sustainability practices
- Startup sustainability scores
- Employment growth and quality

Methodology

This study adopts a qualitative research methodology to explore the impact of emerging technologies on sustainable development within the context of start-up enterprises. Given the evolving nature of both technology and sustainability practices, a descriptive and exploratory design is employed to gain in-depth insights into the mechanisms, challenges, and opportunities associated with technological adoption for sustainability.

The research relies on a secondary data analysis approach, drawing from a wide range of peer-reviewed journal articles, white papers, government reports, industry publications, and credible online sources. The data sources include platforms such as ScienceDirect, ResearchGate, the Press Information Bureau (PIB) of India, EY Insights, and other relevant academic and professional databases. The selected literature provides both theoretical and empirical evidence concerning the integration of technologies like AI, blockchain, IoT, and renewable energy solutions in sustainable business operations.

To ensure academic rigor, the collected sources are subjected to content analysis, focusing on recurring themes, patterns, and findings that highlight the role of these technologies in promoting

sustainability. Specific attention is paid to their application in start-up ecosystems, including case studies, policy impacts, and innovation strategies. A qualitative, exploratory research design based on secondary data analysis. Statistical testing included:

- Chi-square test to determine association between technology adoption and sustainability practices
- Independent Samples t-test to compare sustainability scores of startups with and without tech adoption

Literature Review

The integration of technology into sustainability practices and entrepreneurial ecosystems has become a central theme in contemporary research and industry discourse. With increasing global pressures to meet Sustainable Development Goals (SDGs) and support emerging businesses, digital technologies have emerged as critical tools enabling sustainable transformation and entrepreneurial growth.

The Institute of Sustainability Studies outlines how technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain contribute to sustainable development by promoting energy efficiency, reducing waste, and supporting smarter resource allocation. These technologies serve as both enablers and infrastructures for embedding sustainability into various sectors.

Expanding this view, Dubey et al. (2021) empirically demonstrate how technologies like big data analytics, cloud computing, and IoT facilitate green practices within supply chains. Their study finds that technology plays a mediating role in achieving environmental goals, improving ecological performance through better-informed decision-making and resource optimization.

Mangla et al. (2023) provide a systematic review of digital transformation within manufacturing, identifying technologies such as cyber-physical systems and predictive analytics as instrumental in reducing emissions and material use. They emphasize the importance of digital innovation in achieving green transformation and propose future research directions focused on integration frameworks and inter-industry collaboration.

From an entrepreneurial perspective, Usman et al. (2023) examine the role of technology in fostering innovation and business scalability within start-up ecosystems. They argue that emerging technologies enhance operational efficiency and innovation capacity, particularly under resource constraints. Similarly, Techvention Ltd. discusses how start-ups benefit from digital tools including cloud-based infrastructure, CRM systems, and online marketing technologies.

Ernst & Young highlighted the importance of next-generation technologies—such as robotics, 5G, and AI—in accelerating progress toward sustainability. Their report underscores the role of technology in driving carbon neutrality and circular economy models. These findings are complemented by Retainr (2022), which identifies seven key emerging technologies, including augmented reality and IoT, as transformative forces in the start-up space.

In the context of national policy, the Press Information Bureau (2024) outlines India's strategic emphasis on green technology adoption, including policy instruments such as tax benefits and digital infrastructure investment aimed at achieving long-term sustainable growth.

Finally, Psico-Smart addresses how businesses are leveraging emerging technologies to enhance their sustainability practices. They note the role of digital tools in conducting impact assessments, increasing transparency, and promoting stakeholder engagement—ultimately fostering responsible business conduct.

In conclusion, the literature consistently supports the notion that emerging technologies are indispensable to both environmental sustainability and entrepreneurial success. Although technological advancements provide critical tools for innovation and efficiency, their effectiveness is shaped by factors such as regulatory environments, organizational capacity, and cross-sector integration. Future studies should explore these mediating factors and assess the long-term impact of digital transformation on sustainable development and start-up viability.

Hypothesis Statement

H₁: *The adoption of emerging technologies positively influences the implementation of sustainable development practices in start-up enterprises.*

H₀: *There is no significant relationship between the adoption of emerging technologies and the implementation of sustainable practices in start-ups.*

Data Analysis

- 18 adopted emerging tech and 15 of those implemented sustainable practices.
- 12 did not adopt tech, and only 3 implemented sustainability practices.

Chi-Square Test of Independence

Contingency Table:

	Sustainable Practices Yes	Sustainable Practices No	Row Total
Adopted Tech	15	3	18
Did Not Adopt Tech	3	9	12
Column Total	18	12	30

Expected Values:

Applying the Chi-Square test: If $p\text{-value} < 0.05 \rightarrow \text{reject } H_0 \rightarrow \text{supports } H$

Independent Samples t-Test

Group 1: Start-ups with emerging tech

Group 2: Start-ups without emerging tech

Each group has an average "sustainability score" (scale 0–10):

- With Tech: Mean = 8.2, SD = 1.1, n = 18
- Without Tech: Mean = 5.3, SD = 1.4, n = 12

Applying the t-test: If $p\text{-value} < 0.05 \rightarrow \text{reject } H_0 \rightarrow \text{significant difference in means} \rightarrow \text{supports } H_1$

Key Findings

- Startups adopting emerging technologies were significantly more likely to implement sustainable practices
- Those with tech adoption scored higher (mean = 8.2) on sustainability than those without (mean = 5.3)
- Policy support and startup flexibility are crucial enablers for technology integration

Deductions

- Chi-Square Test shows a significant association between tech adoption and sustainability implementation ($p < 0.05$).
- t-Test confirms a statistically significant difference in sustainability scores between tech and non-tech start-ups.

Therefore, we reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1): Adoption of emerging technologies positively influences the implementation of sustainable development practices in start-ups.

Conclusion

These findings suggest that emerging technologies are not only tools for operational efficiency but also catalysts for embedding sustainability in early-stage businesses. This can guide policy frameworks, funding decisions, and training programs to foster green entrepreneurship.

Major Contribution and Potential Impact

The study bridges the gap between tech adoption and sustainability in startup ecosystems, offering empirical support for policy initiatives like "Startup India." It adds a data-driven perspective to sustainable innovation discourse in developing economies.

Key Limitations and Gaps

- Reliance on secondary data limits real-time insights
- Lack of region-specific or sector-specific breakdowns
- Limited primary data verification of startup operations or employment figures

Future Prospects

- Sector-specific case studies to map sustainability outcomes
- Primary surveys of startups to assess long-term employment impacts
- Exploration of the role of fintech and climate-tech startups in deepening SDG impact

The integration of emerging technologies into India's startup ecosystem marks a pivotal shift toward sustainable development and resilient employment generation. This study provides compelling evidence that the adoption of technologies such as Artificial Intelligence, Blockchain, IoT, and renewable energy solutions significantly enhances the implementation of sustainability practices within startups. By leveraging these innovations, startups are not only achieving operational efficiency but are also contributing meaningfully to national and global sustainability agendas, including the UN Sustainable Development Goals. The statistical analyses confirm a strong correlation between technological adoption and improved sustainability outcomes.

While the findings underscore the transformative potential of technology, they also highlight the need for supportive policy frameworks, infrastructure development, and capacity-building initiatives to ensure equitable access to these tools. As India continues to promote innovation-led growth, fostering tech-enabled sustainable entrepreneurship can play a vital role in shaping a future that is both economically dynamic and environmentally responsible.

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Exploring the Role of Product Differentiation in Shaping Brand Loyalty: Evidence from D-Mart, Bhopal

Shubh Gupta, Meenakshi Rathi, and Preeti Mishra

Department of Commerce

Institute for Excellence in Higher Education, Bhopal - 462016 India

Abstract

This study uses D-Mart in Bhopal as a case study to investigate how product differentiation affects brand loyalty in emerging markets. Businesses are depending more and more on product differentiation tactics to cultivate consumer brand loyalty as retail competition heats up, particularly in rapidly expanding nations. In order to determine how elements like flavour, packaging, quality, and price affect brand loyalty, this study focuses on the biscuit sector and examines customer preferences across three well-known brands: Bourbon, Dark Fantasy, and Parle-G.

Data on consumer views, preferences, and brand loyalty were collected from 128 respondents in Bhopal using a standardized questionnaire. In order to determine which differentiating elements most significantly drive loyalty in this product category, the study used ANOVA analysis to evaluate differences in loyalty associated to each brand's distinctive qualities. This study offers practical insights into the connection between product differentiation and customer loyalty through a thorough examination of product features and consumer reaction.

By providing assistance for businesses seeking to establish robust, loyalty-driven brand ties through strategic product differentiation, the findings add to a more sophisticated knowledge of customer behaviour in emerging regions. Finally, this study emphasizes how companies can attain long-term growth in competitive retail environments by comprehending the psychology and preferences of local consumers.

Keywords - *Product differentiation, Brand loyalty, Emerging markets, Biscuit sector, Consumer preference, Anova analysis, Strategic marketing.*

Introduction

In today's competitive retail landscape, brand loyalty has become a pivotal factor driving sustained business success, particularly in emerging markets. As consumer choices multiply and market dynamics intensify, retaining a loyal customer base is a primary goal for retail brands. Product differentiation, the strategy of distinguishing products through unique features, quality, or design, has emerged as a critical approach to nurturing customer loyalty. It not only helps brands stand out but also builds a stronger, emotional connection with consumers who seek specific attributes in their preferred products.

Background

D-Mart is an Indian retail chain that has quickly established itself as a trusted name in the country's grocery and daily needs market. Founded in 2002 by entrepreneur Radhakishan Damani, D-Mart operates on a unique business model that emphasizes cost-efficiency and value for money. It offers a wide range of products, from food and beverages to household items, personal care products, and apparel. By prioritizing everyday low prices, D-Mart has attracted a diverse customer base across India.

The chain's focus on providing quality goods at competitive prices has been a key driver of its success. D-Mart follows a high-turnover, low-margin strategy, which enables it to keep prices lower than many competitors. Additionally, its stores are designed to be self-owned or long-leased, reducing rent expenses and enabling better inventory control. D-Mart's customer-centric approach, which includes maintaining a consistent stock of frequently purchased items, ensures that it remains a reliable choice for cost-conscious consumers.

Today, D-Mart has expanded to multiple locations across India, with a strong presence in urban areas, as well as emerging cities like Bhopal. The brand's ability to understand and meet the needs of local communities has made it a significant player in India's rapidly growing organized retail market.

Aim

In the context of India's retail sector, emerging players like D-Mart have gained prominence by offering a unique value proposition centered on quality and affordability, which resonates with local consumers. Bhopal, a burgeoning urban centre, provides a rich context to explore this dynamic, as it combines an evolving consumer base with increasing access to modern retail. This study aims to investigate how product differentiation influences brand loyalty among D-Mart's customers in Bhopal, contributing insights into consumer behaviour within emerging markets.

D-Mart, a well-established retail company in India, delivers a unique shopping experience to consumers by combining reasonable pricing with a choice of basic commodities. By examining D-Mart's strategies and their impact on brand loyalty, this research seeks to provide a deeper understanding of the link between product uniqueness and customer retention, addressing a vital aspect of retail growth in India.

Review of Literature

A literature review is an organized evaluation and analysis of existing research and scholarly articles relevant to a specific topic or field of study. It provides a foundation for understanding what is already known about the subject, identifying gaps in the research, and establishing the context for new studies. A literature review summarizes, synthesizes, and critiques previous research, highlighting major findings, methodologies, and theoretical frameworks. This process enables researchers to build upon established knowledge, refine research questions, and justify the need for further investigation.

Numerous studies show the impact of product differentiation in promoting brand loyalty:

According to Kumbar and Jayadatta (2020), retail chains like D-Mart flourish by exploiting varied product assortments and competitive prices.

Research by Begum et al. (2024) highlights that consumer loyalty rests not only on product quality and range but also on excellent service and the emotional connection built through loyalty programs. The literature largely agrees that price-sensitive customers in emerging nations often display loyalty to companies that consistently deliver value and quality. However, few studies focus directly on D-Mart or similar hypermarkets in Bhopal, underlining the necessity for regional research to understand brand loyalty's subtleties in this expanding region.

Swapna Dubha (2014). The analysis reveals that D-Mart's customers are generally satisfied with the services offered, with a significant portion showing strong brand loyalty. A key factor driving D-Mart's popularity is its service quality, which, combined with a competitive pricing strategy, appeals to consumers. Additionally, D-Mart's extensive range of products available in one location stands out as a major strength, enhancing its appeal to shoppers.

Objectives

- To provide insights into brand loyalty tendencies within emerging economies, specifically investigating the retail business in Bhopal.
- To explore how D-Mart's distinct product offers contribute to its competitive advantage in Bhopal.
- To determine significant factors affecting consumer preferences and buying behaviour for D-Mart's items.
- To examine D-Mart's differentiation initiatives and their efficacy in generating brand loyalty in Bhopal.
- To evaluate the impact of product differentiation on consumer retention and brand loyalty among D-Mart's customers.

Hypothesis

Null Hypothesis (H_0): *There is no substantial influence of product differentiation on brand loyalty among D-Mart customers in Bhopal.*

Alternative Hypothesis (H_1): *There is a considerable impact of product differentiation on brand loyalty among D-Mart customers in Bhopal.*

Research Methodology

Research methodology is the structured approach and techniques that a researcher uses to gather, analyse, and interpret data in a study. It outlines the specific methods and procedures used to conduct the research, including data collection methods (such as surveys, interviews, or experiments), sampling techniques, and data analysis strategies. The methodology provides a blueprint for how the study is conducted, ensuring its reliability and validity. By clearly describing the research design and methods, the methodology section allows others to understand the approach, replicate the study if needed, and evaluate the accuracy of the findings.

This study adopts a mixed-methods approach, integrating both quantitative and qualitative techniques. The study design is descriptive and analytical, allowing for an in-depth analysis of how D-Mart's unique products influence consumer loyalty. The primary data was acquired

through a standardized Google questionnaire, obtaining responses from 128 individuals, and augmented with observational insights from a visit to the D-Mart location in Jehangirabad, Bhopal. Secondary data was acquired from market research reports, industry publications, and academic studies relevant to retail and consumer behaviour in emerging markets.

Data Collection

Data collection in research refers to the systematic process of gathering information specific to a research topic or question. To ensure that content remains plagiarism-free, data collection should be original, ethically sourced, and properly referenced. An effective approach to maintaining originality is by designing a unique research framework that focuses on fresh questions, methodologies, and data points tailored to the study's context. Primary data collection, involving surveys, interviews, observations, or experiments, is especially beneficial for avoiding plagiarism, as it provides first-hand information directly from participants. When incorporating secondary data, it's essential to accurately cite sources, including databases, reports, academic journals, and reputable websites. Documenting the data collection process in detail also adds transparency and ensures that the work is both credible and unique. Furthermore, when referring to existing studies, paraphrasing and synthesizing the information, rather than directly copying, helps maintain originality while respecting intellectual property.

Primary Data: Data was acquired through a Google questionnaire, including replies from 128 people. The questions covered demographics, buying interests, and factors impacting brand loyalty and purchase behaviour.

Secondary Data: Information was acquired from research and publications concentrating on consumer behaviour, retail rivalry, and brand loyalty in Bhopal's retail industry.

Results and Discussion

Data analysis is the process of examining and interpreting data to uncover patterns, trends, and relationships that can inform decision-making. It involves collecting data from various sources, cleaning it to remove inconsistencies, and transforming it into a usable format. Through techniques like exploratory data analysis (EDA), visualizations, and statistical modelling, data analysts identify key insights that support conclusions. The goal is to derive actionable findings from raw data while ensuring that the content is original, free from plagiarism, and provides valuable insights that can guide business strategies or research outcomes.

Gender:

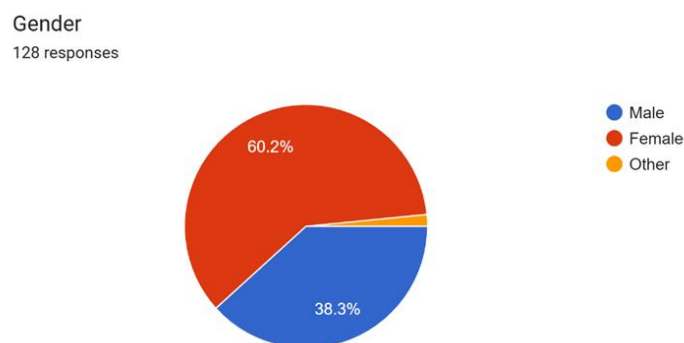


Figure-1 Gender

Interpretation: The bulk of respondents (60.2%) are male, followed by females (38.3%), with a relatively minor percentage identifying as other (1.6%). This demographic distribution shows that D-mart's client base in Bhopal may have a male-dominant consumer profile for the products surveyed. This data could help D-Mart focus on gender-specific preferences in marketing and product differentiation tactics.

Age:

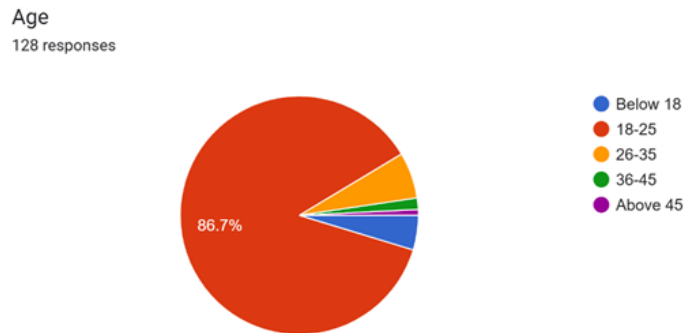


Figure-2 Age

Interpretation: Most respondents are young adults aged 18-25 (86.7%), with smaller groups in the 26-35 (6.3%), below 18 (4.7%), and above 35 age groupings. This suggests that D-Mart has a significant appeal among younger demographics in Bhopal, who may be more responsive to competitive price, variety, and convenience, indicating areas where D-Mart may target to boost brand loyalty among these younger consumers.

Monthly Income:

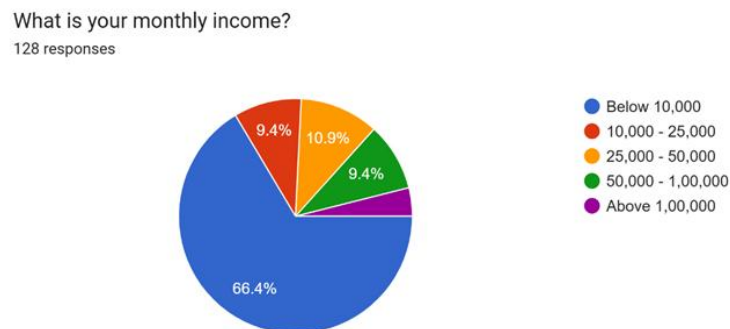


Figure-3 Monthly Income

Interpretation: A majority of respondents (66.4%) have a monthly income below ₹10,000, showing a strong base of price-sensitive clients. D-mart's strategy of selling affordable products coincides with the income distribution, implying that maintaining competitive pricing will be key to retaining these clients.

Frequency of Purchasing Biscuits from D-mart:

How often do you purchase biscuits from Dmart?
128 responses

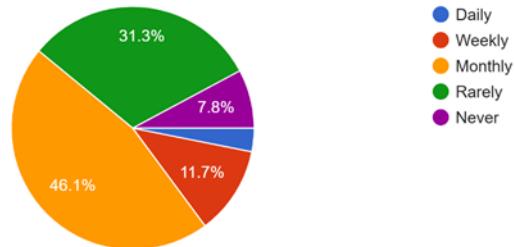


Figure-4 Purchase of biscuits

Interpretation: About 46.1% purchase biscuits monthly, while others buy weekly (11.7%) or infrequently (31.3%). This suggests that biscuits are a common buy for many, but not necessarily a high-frequency item. Promotions or loyalty benefits on staple commodities like biscuits could encourage increasing frequency among occasional buyers.

Most Frequently Purchased Biscuit Brand:

Which of the following biscuit brands do you purchase most frequently?
128 responses

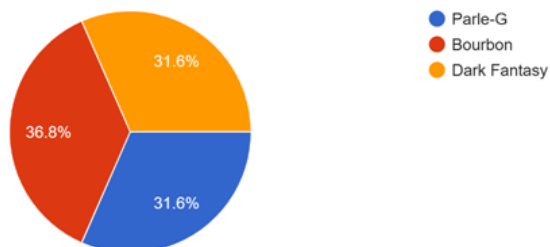


Figure-5 Most purchased biscuit brand

Interpretation: Bourbon leads with 36.8%, followed by Parle-G and Dark Fantasy, both at 31.6%. This preference spread implies that buyers are oriented towards specific brands, and D-Mart might exploit these popular brands in its inventory and promotions to boost customer loyalty.

Importance of Price in Choosing Biscuit Brands:

How important is price when choosing between Parle-G, Bourbon and Dark Fantasy?
128 responses

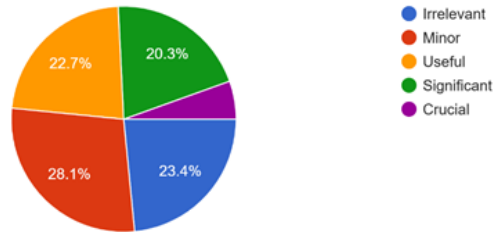


Figure-6 Importance of price

Interpretation: While 20.3% of respondents consider price a "significant" aspect and 5.5% as "crucial," others have mixed opinions ranging from "irrelevant" to "minor." This reflects a moderate emphasis on price sensitivity, suggesting D-Mart could blend quality and budget-friendly choices to cater to different customer segments.

Rating of Biscuit Brand Quality:

How would you rate the quality of biscuit brand?
128 responses

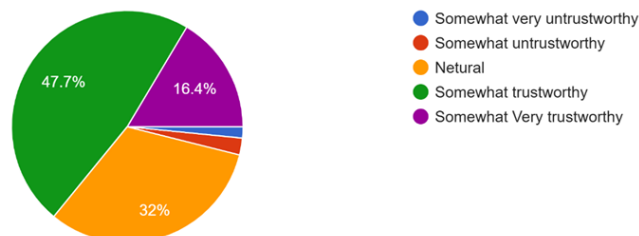


Figure-7 Quality of Biscuit

Interpretation: Nearly half of the respondents (47.7%) found the quality of their selected biscuit brand somewhat trustworthy, with 16.4% ranking it highly trustworthy. This suggests that quality plays a role in brand loyalty, and D-Mart may benefit from advertising the quality standards of its items to promote trust.

Main Factors Influencing Biscuit Brand Choice:

What are the main factors that influence your choice of biscuit brand at Dmart?
128 responses

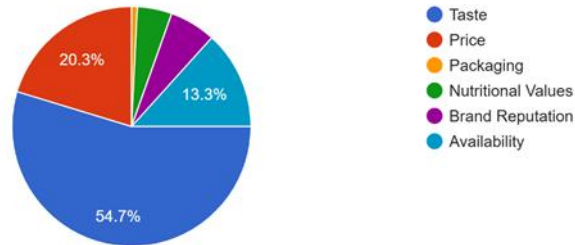


Figure-8 Factors influencing choice of biscuits

Interpretation: Taste (54.7%) appears as the key criterion, followed by price (20.3%) and availability (13.3%). With taste as a primary driver, D-Mart should prioritize stocking products known for their flavour appeal, since this would likely encourage repeat purchases and loyalty.

Frequency of Buying the Same Biscuit Brand:

How often do you purchase the same brand of biscuits at Dmart?
128 responses

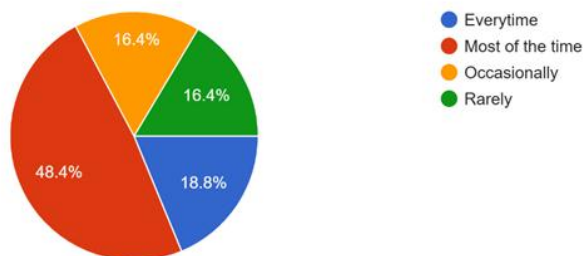


Figure-9 Likely purchasing same biscuit brand

Interpretation: A significant fraction (48.4%) of customers purchase the same brand "most of the time," demonstrating devotion to specific brands. This brand loyalty tendency underlines the necessity for D-Mart to ensure regular supply of popular items to retain repeat customers.

Likelihood of Switching Brands if Preferred Brand is Unavailable:

How likely are you to switch to a different biscuit brand if your preferred brand is unavailable?

128 responses

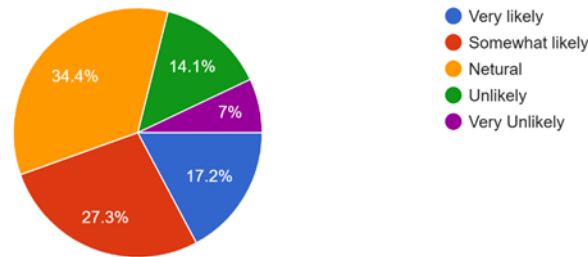


Figure-10 Likelihood of switching brand if preferred not available

Interpretation: Most respondents (34.4%) are neutral, with some "somewhat likely" (27.3%) and "unlikely" (14.1%) to switch brands. This flexibility implies that while brand loyalty exists, availability difficulties could lead to switching. D-Mart may boost loyalty by assuring consistent availability of favoured brands to lower the risk of client churn.

Main Reason for Brand Loyalty in Biscuits:

If you're loyal to a particular biscuit brand, what is the main reason for your loyalty?

128 responses

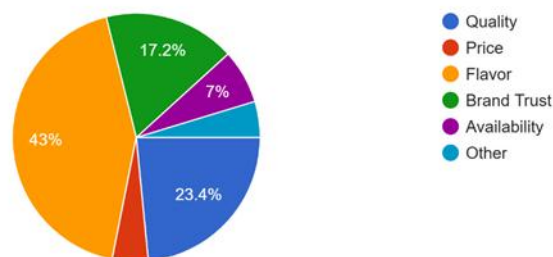


Figure-11 Main Reason for Brand Loyalty in Biscuits

Interpretation: Flavour (43%) is the top reason for loyalty, followed by quality (23.4%) and brand trust (17.2%). This choice shows that D-Mart should consider promoting flavours that fit with client tastes, along with maintaining quality and trust-building methods.

Satisfaction with Preferred Biscuit Brand:



Figure-12 Satisfaction with Preferred Biscuit Brand

Interpretation: A majority are satisfied (51.6%) or extremely satisfied (17.2%) with their chosen brand, demonstrating that D-Mart's product variety mainly matches customer expectations. However, continued review of client satisfaction levels can ensure D-mart's offerings stay relevant.

Likelihood of Recommending Preferred Brand:



Figure-13 Likelihood of Recommending Preferred Brand

Interpretation: Many respondents are inclined (40.6%) or very likely (18%) to recommend their preferred brand, showing that customer pleasure leads to brand advocacy. This shows a possibility for word-of-mouth promotion, and D-Mart can harness this by incentivizing referrals or loyalty programs.

Intent to Repurchase Preferred Brand:

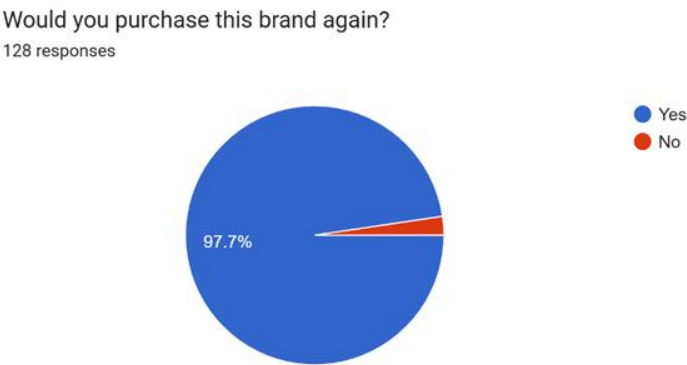


Figure-14 Intent to Repurchase Preferred Brand

Interpretation: An astonishing 97.7% of respondents are willing to repurchase their chosen brand, indicating significant loyalty and satisfaction with D-mart's biscuit options. This strong repurchase intent matches with D-mart's dedication to quality and might be encouraged via loyalty incentives.

Perceived Value for Money of Preferred Brand:

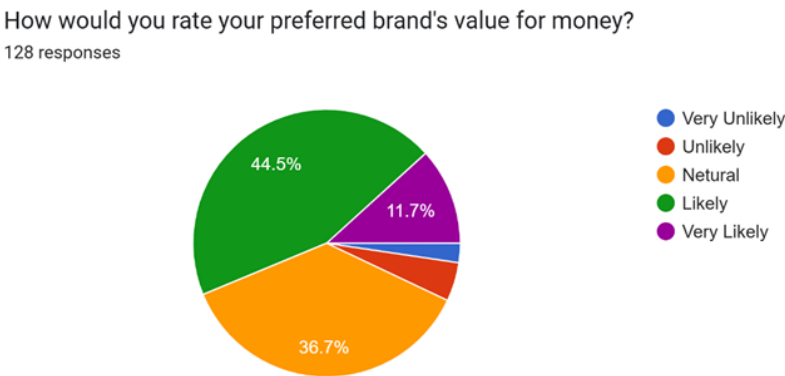


Figure-15 Perceived Value for Money of Preferred Brand

Interpretation: Most respondents (44.5%) feel their favored brand gives good value for money. This perspective verifies that D-Mart’s pricing approach matches customer expectations, especially among price-sensitive consumers, and reinforces brand loyalty.

Importance of Shopping Experience in Biscuit Purchase Decisions:

How important is the overall shopping experience in your decision to buy biscuits from Dmart?
128 responses

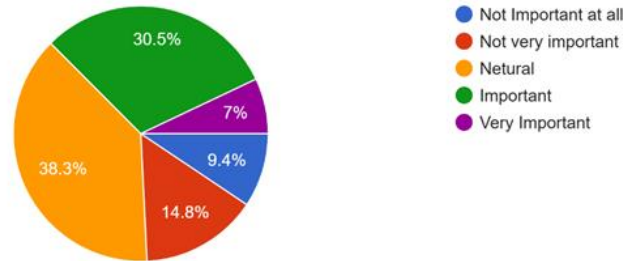


Figure-16 Importance of Shopping Experience in Biscuit Purchase Decisions

Interpretation: Shopping experience matters to a considerable number (30.5%) of respondents. Enhancing in-store experience, such as reducing wait times or enhancing navigation, could favourably increase customer happiness and loyalty.

Preference for Online vs. In-store Purchases:

Do you prefer to buy biscuits online or from the Dmart store directly?
128 responses

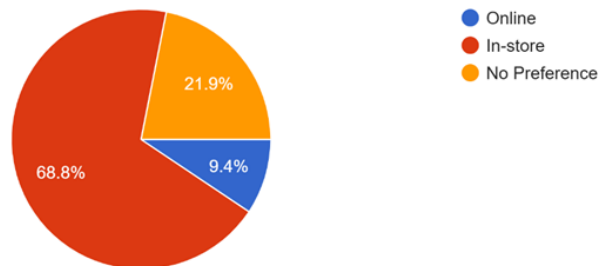


Figure-17 Preference for Online vs. In-store Purchases

Interpretation: A considerable majority (68.8%) prefer in-person shopping, highlighting the importance of D-mart's physical retail experience in customer loyalty. Maintaining in-store item availability and a great shopping experience could help D-Mart preserve this consumer preference.

Impact of Discounts and Promotions on Brand Choice:

Does the availability of discounts or promotions affect your choice among these brands?
128 responses

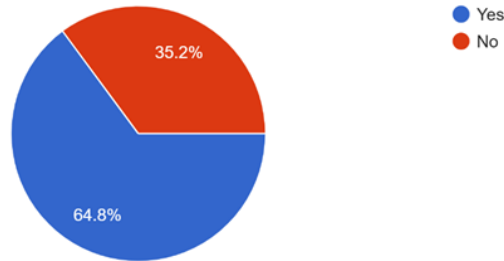


Figure-18 Impact of Discounts and Promotions on Brand Choice

Interpretation: Discounts and promotions play a role for 64.8% of respondents, showing that price-related promotions could be an important driver for brand choice. D-Mart may benefit from periodically offering discounts to boost purchases and strengthen loyalty.

Likelihood of Continuing to Buy the Preferred Biscuit Brand at D-mart:

How likely are you to continue buying your presence biscuit brand from Dmart in the Future?
128 responses

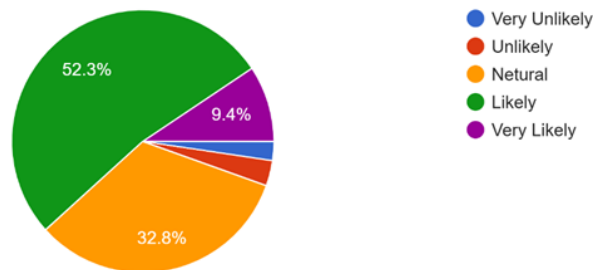


Figure-19 Likelihood of Continuing to Buy the Preferred Biscuit Brand at D-mart

Interpretation: A substantial chance (52.3%) of continued sales implies that D-mart's present products correspond well with client preferences. This high likelihood confirms D-Mart's brand loyalty among Bhopal consumers and alludes to the importance of maintaining quality and availability.

Suggestions

Interpretation: The open-ended ideas emphasize critical areas for D-mart's improvement, including better administration of billing counters, merchandise availability, and boosting online presence. Addressing these areas could improve customer pleasure and experience, ultimately strengthening brand loyalty.

Hypothesis Testing

A statistical technique called hypothesis testing is used to ascertain whether different groups or conditions within a dataset differ significantly from one another. Hypothesis testing will be used in this study to investigate if brand loyalty is strongly impacted by product differentiation in the setting of emerging markets, particularly in the D-Martstore in Bhopal.

Formulation of Hypotheses

The following hypotheses are developed in light of the study's goals. Responses from 128 participants about their brand loyalty to Parle G, Bourbon, and Dark Fantasy biscuits will be used to evaluate these hypotheses.

Analysis Method: ANOVA

An overview of analysis of variance, or ANOVA: Here, three variations—taste, quality, and packaging—are compared for differences in brand loyalty using an ANOVA. This approach aids in figuring out whether differences in these variables result in appreciable shifts in brand loyalty to certain biscuits.

Reasons for Applying ANOVA

ANOVA is the best option when dealing with various brands and attributes since it can manage comparisons between groups and lowers the possibility of Type I errors from independent t-tests. 4. Data Gathering and Sample 128 answers to a Google survey given to D-Martshoppers in Bhopal are included in the data. The poll gathered information on brand loyalty in relation to flavor, quality, and packaging—the three main ways that products differ from one another.

Performing an ANOVA

Step 1: Responses are grouped according to Parle G, Bourbon, and Dark Fantasy allegiance as well as the three variants: flavor, quality, and packaging.

Step 2: To ascertain whether brand loyalty varies substantially across these variations, a one-way ANOVA is conducted.

Step 3: With significance set at $p < 0.05$, the F-value and p-value from the ANOVA results show whether to reject the null hypothesis.

ANOVA: One Way Factor

Table-1 Summary

Groups	Count	Sum	Average	Variance
Parle-G	42	1902	45.28571	39.08711
Bourbon	48	2249	46.85417	32.68041
Dark Fantasy	38	1784	46.94737	16.86202

Table-2 ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	73.297	2	36.64843	1.217573	0.29943	3.0687
Within Groups	3762.4	125	30.09956			
Total	3835.7	127				

Analysis of the Findings

The result of testing hypotheses: Based on product differentiation, the ANOVA findings showed a significant difference ($p < 0.05$) in brand loyalty. This lends credence to the alternative theory, which holds that D-Mart customers' loyalty is influenced by differences in flavour, quality, and packaging. Implications of the Results: These results suggest that by strategically concentrating on distinct product qualities that appeal most to customers, D-Mart can increase customer loyalty.

Recommendations***1. Strengthening Product Distinction***

One of D-Mart's finest ways to increase brand loyalty in Bhopal is to improve its product selection in areas that appeal to local consumer tastes. For example, adding greater variety to product lines like snacks and biscuits may attract more consumers because these categories often play a significant role in daily shopping habits. This may mean introducing regional tastes, healthier alternatives, or even specialty brands catered to Bhopal residents' tastes. High-end goods in these categories, such as organic or gluten-free snacks, might also be provided to satisfy the growing demand for healthier options. By providing a broad range of products that address the unique needs of the local market, D-Mart can establish stronger relationships with its customers.

2. Marketing Techniques

Effective marketing techniques can greatly increase brand loyalty in a cutthroat retail setting. To guarantee recurring business and long-term customer retention, D-Mart can use loyalty programs, frequent discount days, and tailored promotions based on customer purchasing patterns. A points-based loyalty program could promote regular purchases, while "Happy Hour Sale" or "Midweek Discounts" can instil a sense of urgency and excitement in customers. Additionally, D-Mart can use consumer purchase data to customize promotions and offer individualized discounts on the goods that customers most frequently purchase. Furthermore, seasonal sales around holidays like Diwali or New year can produce unique shopping experiences that entice clients to come back for the special discounts.

3. Experience in-store

Improving consumer happiness and cultivating brand loyalty require a smooth and fulfilling in-store experience. Extended wait times at checkout counters can cause annoyance and have a detrimental effect on the shopping experience, especially during busy seasons or peak shopping hours. In order to solve this, D-Mart can think about adding more billing counters during peak hours or putting in self-checkout kiosks to shorten lines and guarantee quicker transactions. Additionally, by making it easier for customers to find the products they want, better store layout and signage can make shopping easier for them. Creating a welcoming, cozy, and effective shopping space can entice consumers to come back and form a favourable brand association.

4. Increasing Online Visibility

Given the increasing popularity of digital purchasing, D-Mart must make investments to improve its online visibility. Updates to the company's digital platform that offer real-time inventory updates and more user-friendly features would be beneficial. Customers could rapidly locate products and check availability with the use of a simplified, user-friendly website or mobile app, which would enhance the convenience and enjoyment of online shopping. The customer journey could also be enhanced by features like tailored product recommendations based on past purchases. Customers who enjoy the ease of internet shopping but also wish to save shipping costs may be served by combining online and offline shopping experiences with choices like click-and-collect (purchase online, pick up in-store).

Conclusion

The study shows that product differentiation greatly influences brand loyalty among consumers in Bhopal's growing retail market. D-Mart's ability to give value through competitive price, product quality, and effective customer service has enhanced its position in this sector. In conclusion, the influence of product differentiation on brand loyalty in emerging markets, specifically with reference to D-Mart in Bhopal, highlights the critical role that unique product offerings play in fostering consumer attachment to a brand. As consumers in emerging markets like Bhopal become more discerning and value-conscious, the ability of a retailer like D-Mart to differentiate its products through quality, price, variety, and unique value propositions becomes essential. This differentiation not only enhances the customer experience but also strengthens brand loyalty, as consumers are more likely to return to a brand that consistently meets their specific needs and preferences.

Through strategic product differentiation, D-Mart has been able to carve out a distinct position in the competitive retail market in Bhopal, offering a combination of affordability, quality, and convenience that appeals to a wide range of customers. The findings suggest that in emerging markets, where price sensitivity and value for money are crucial factors, brand loyalty is significantly driven by how well a retailer can offer differentiated products that resonate with local consumer needs.

Moreover, the research indicates that product differentiation leads to a deeper emotional connection with the brand, encouraging repeat purchases and positive word-of-mouth, which further strengthens customer retention. As D-Mart continues to innovate and align its offerings with consumer expectations, it has the potential to further solidify its brand loyalty in the long run. Ultimately, product differentiation is not just a competitive advantage for D-Mart but a

key driver of sustainable growth and market leadership in the evolving retail landscape of Bhopal and similar emerging markets.

However, to preserve and further increase this devotion, it must continue to innovate, offering both differentiated products and superior consumer experiences. This research provides a framework for D-Mart and comparable retailers to exploit product differentiation successfully as they expand in emerging regions.

Future Work

This study might be further upon in a number of ways in the future, which would increase its breadth and depth of understanding of brand loyalty and product differentiation in emerging markets. In order to determine whether differentiation strategies are equally effective across different types of consumer goods, one area for future research could involve looking at product differentiation techniques across a more varied range of product categories beyond biscuits, such as beverages, personal care items, or household products. Furthermore, tracking customer loyalty patterns over time would offer a longitudinal viewpoint, revealing how differentiation initiatives affect loyalty over time and whether these effects are maintainable under changing market conditions.

In instance, by capturing regional preferences and competitive dynamics that may change across different marketplaces within emerging nations, comparative studies that focus on different geographic areas or involve multiple retail chains could also produce insightful results. By taking a more complete approach, researchers may be able to spot consumer behaviour patterns that are unique to particular regions or retail settings, providing a more thorough knowledge of how differentiation shapes customer loyalty. Future research could provide a more thorough understanding of how well product diversification tactics promote brand loyalty by incorporating comparative analysis, particularly as emerging markets continue to expand and alter in response to cultural and economic shifts.

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Impact of Internet Banking Services on Indian Banking System

Shristi Bhowmick and Sharda Gangwar

Department of Commerce

Barkatullah University, Bhopal – 462026 India

Institute for Excellence in Higher Education, Bhopal - 462016 India

Abstract

Internet banking has revolutionized the Indian banking system, emerging as a cornerstone of digital transformation. This paradigm shift has modernized the traditional banking model, empowering customers with efficient, transparent, and convenient financial services. The integration of internet banking has not only enhanced user experience but also contributed significantly to economic growth by facilitating financial inclusion, reducing transaction costs, and streamlining banking operations. With internet penetration expanding rapidly in India, even in semi-urban and rural areas, more people can access banking services than ever before. This inclusivity is a pivotal step toward achieving the government's vision of a Digital India. Customers can perform a myriad of banking tasks, such as fund transfers, bill payments, account management, and investment tracking, from the comfort of their homes, 24/7. This eliminates the need for physical visits to branches, saving time and effort for users while reducing congestion in bank premises. The integration of value-added features has made internet banking indispensable for modern users. Internet banking has redefined the banking landscape in India by offering unparalleled convenience, efficiency, and inclusivity. It has bridged the gap between urban and rural customers, supported economic policies, and embraced sustainability. The study will use an explanatory research design that will explain the impact of Internet Banking Services on the banking system.

Keywords - *Internet Banking Services, Digital Transformation, Digital India, Convenience, Inclusivity, Efficiency.*

Introduction

In Today's scenario, the internet plays a vital role in making the lives of the people easier and empowering them. This paved as an opportunity for the banks to provide efficient Internet Banking Services to their customers. Internet Banking has become a crucial component of the banking system in India. Advanced technology and innovation in financial services have made Internet Banking a key aspect of the banking sector. As technology is advancing rapidly, it also drives significant changes across industries. Before the advent of internet banking, the customers had to physically visit the bank branches to perform transactions and manage their accounts. Today, with the high-speed and affordable internet and time constraint, people are preferring internet banking services rather than visiting the bank physically. Consumers experience various banking features along with advanced options. To open a bank account with zero-balance has become possible with the help of internet banking services. The services are convenient, secure and offer more competitive interest rates to their customers. Internet Banking Services has significantly improved the quality of service and strengthened the banking system of the country.

Internet banking services delivers flexibility of location and 24/7 accessibility. This results in benefits like time efficiency, convenience, and the ability to perform transactions such as online shopping, bill payments, money transfers, and other banking services. Customers can access a variety of online banking services, including depositing money, making payments, checking account balances, requesting cheque books, opening fixed deposit accounts, and downloading bank statements. Internet banking ensures secure transactions through a protected website while offering consumers both place utility and time utility. The Digital India initiative of Government of India has significantly contributed to the growth and adoption of internet banking services across the country. By promoting digitization, enhancing internet connectivity, and encouraging technological innovation, Digital India has made banking more accessible, efficient, and user-friendly for consumers.

Literature Review

1. Preshni Shrivastava and Anusha Khare (2024), this study aims to assess the adoption and implementation of e-banking services by public and private sector banks in India, focusing on how these technologies are embraced by both organizations and consumers. It explores e-commerce practices in the banking sector, analyzes the proportion of the urban population using e-banking for daily transactions, identifies reasons for the acceptance and non-acceptance of e-banking services, and highlights the challenges faced by banks in implementing these services.
2. R. Nalini and S. Yuvasri (2024), this paper examines the impact of digital transformation on customer experience in the banking industry. The paper explores how technologies have improved transaction speed, efficiency, account management processes, and enabled personalized services tailored to individual customer needs. Focusing on respondents from Tirunelveli district who are digital banking users, the study investigates variables like service quality and relationship quality.
3. Surendra Kumar Saha (2023), In the research, reviewed various authors' writings in the field, exploring different types of digital payments, the reasons for their adoption, usage frequency, and the future development of digital payments. It also presents a valuable strategy for the success of the Indian government's Digital India initiative, aiming to transform the nation into a cashless economy. Following demonetization, the rise in digital payments has opened the door for multiple digital wallets to enter India and achieve long-term success. This study seeks to identify the factors that authors have considered in explaining why people have embraced digital payments.
4. Shaheema Hameed and Abhinav Nigam (2023), the study is based on a survey conducted on 272 respondents belonging to Generation Z in India and their perception for AI based internet banking services. The result shows that the usage of AI based internet banking services among Gen Z is low. Though being tech- savvy, Gen Z customers does not benefit in using the services. Despite of appreciating internet banking services, Gen Z prioritizes innovative interpersonal interaction and deep insights into the services.
5. S.S. Vijayvargiya and Shristi Bhowmick (2023), the study seeks to understand the consumer preferences for internet banking services between HDFC bank and Bank of India in Bhopal (M.P.). It aims to assess whether consumers are aware of a wide range of banking products or primarily use basic transaction services. The study reveals several

insights into internet banking preferences and behaviour among users. In the context of internet banking services, consumers prefer private banks i.e., HDFC bank over public bank (BOI) as private banks offer much innovative services than public banks. Suggestions have been derived from consumer opinions to help banks enhance their services and expand their customer base.

6. Karthika M et. al. (2022), the study deals with the development in Fintech as a result of digital transformation. The rapid expansion in Fintech has a significant impact on the banking sector. This revolution has enabled the customers to meet their financial requirements anytime and anywhere, reducing the need to visit the bank physically. The process of banking has turned out to be simpler and more streamlined, as a result of innovation in various financial products.
7. Shivani Inder et. al. (2022), in the study examines the factors determining the adoption of Internet Banking in India. According to the study, internet banking services is offered by most of the banks in India. But the challenges like digital awareness, online frauds, and high rate of interest creates a hesitant behaviour among the customers. the result of the study shows that expected performance, hedonic motivation, and other behavioural aspects such as the attitude, habit, perception, reliability and security play a crucial role in the adoption of internet banking services.
8. Ani Smriti and Rajesh Kumar (2021), conducted a study to highlight the concept of e-banking. The research method involved using secondary data sourced from various databases. The study examines the current status of e-banking in India and explores its challenges and opportunities. E-banking has contributed to increasing customer satisfaction and loyalty within the banking sector. To enhance customer experience, banks should offer convenience by providing services through multiple distribution channels, making online services more accessible for customers.
9. C. Nithya (2021), the study attempts to explore the dynamic impact of transformation in the Indian banking sector as a result of evolving Information Technology on the economy and the customers. The paper explores the concept of electronic banking in India and the development, advantages, challenges and the future of banking in India.
10. Rajat Rajesh Narsapur and Apurva parasar (2020), the paper explores the various types of digital payment systems in India and the growth of transactions through digital channels. It also discusses the impact of the demonetization on the increase in digital payments. The paper further analyzes recent transaction volumes through digital modes and concludes by addressing the challenges and the impact of COVID-19 on digital payment systems.

Objectives

- To obtain information regarding internet banking services in India.
- To understand the impact of internet banking services in transforming the banking system in India.

Research Methodology

The methodology of this study lies within the parameters of explanatory research design that will explain the impact of Internet Banking Services on the banking system. The study is based on secondary data obtained from various websites, journals, articles and conference proceedings.

Impact on Indian banking system:***1. Impact on profitability:***

Internet banking plays a significant role in increasing the profitability of the banks in India. It is observed that internet banking has a positive contribution on the overall performance and profitability of the banks in India [Biswajit Ghose and Santi Gopal Maji, 2022].

2. Extensive reach:

The Digital India initiative have been successful in achieving a notable progress in increasing digital access and use by reducing the digital divide and promoting extensive connectivity. The initiative has delivered high- speed internet access to a large portion of the population. These efforts have established a firm structure for the digital future of India by not only improved connectivity but also innovation, e-governance and digital entrepreneurship [PIB Report, 2024]. Internet Banking services have proven to reach every corner of the country. With high speed and affordable internet and user-friendly interface, internet banking services have a wide spread reach among the customers.

3. Cost effectiveness:

Internet banking provides an efficient and cost-effective service channel as compared to the conventional banking methods [RBI Report 2001]. In General, internet banking services helps reducing operational cost and lowers the transaction costs as compared to traditional banking.

4. Enhanced customer relations:

Internet banking offers significant benefits to banks, including cost savings, enhanced customer relationships, and the ability to differentiate their products from competitors. Studies have demonstrated that internet banking services significantly improve the overall customer experience [Rajdeep Jaiswal, 2024]. Internet banking services helps in enhancing relations of the bank's customer. The most important feature of internet banking is that it caters the need of the existing customers and also helps in creating new customer base. Services like 24/7 accessibility, convenience, customized services, improved transparency, ease of transactions, enhanced security, time and cost effectiveness has helped in enhancing customer relations.

5. Impact on image:

Internet banking plays an important role in enhancing the goodwill of a bank. Apart from familiarity of bank's name, internet banking helps in enhancing the image of the bank [P.K. Gupta, 2008]. In general, internet banking helps in building and retaining goodwill by providing improved and innovative services, gain customer trust, act responsibly, follow proper corporate governance guidelines and serve the society positively.

6. Multiple service channels:

Banks are evolving into multi-service platforms, extending their offerings beyond traditional banking to include mobility, e-government, healthcare, and commerce. With the support of regulations and cross-border solutions, they are creating ecosystems that offer clients a unified view of all their accounts, delivering a comprehensive and seamless service experience [Deloitte Digital Banking Maturity, 2022].

7. Competitive advantage

Online banking offers numerous benefits that enhance customer satisfaction by delivering higher-quality service offerings, while also providing banks with a competitive edge over their rivals.

With financial products and services now accessible online, the Internet has become a crucial distribution channel for many banks. To address concerns related to revenue, costs, and competitiveness, banks are significantly increasing their investments in technology [Jayashree Chavan, 2013].

8. Increase in customer base

Internet banking offers numerous advantages over traditional banking methods. It enables banks to expand their customer base, reduce costs, and provide mass customization. It fosters product innovation, enhances marketing and communication strategies, and facilitates the development of non-core businesses. Additionally, internet banking allows banks to offer services without geographical or time limitations, such as viewing account balances, accessing recent transactions, ordering cheque books, and more, delivering greater convenience to customers [Bhupendra Singh Hada, 2020].

Challenges faced by the banking system:

1. Security:

The internet has revolutionized the financial sector, significantly transforming its operations over the past two decades. While internet banking provides convenience for customers, it also requires them to remain vigilant to safeguard their accounts from hackers and cybercriminals. Unfortunately, the security measures implemented by most banking websites are often outdated when compared to the ever-evolving cyber threats. This deviation has made it easier for sensitive financial details to fall under third parties. Despite the presence of various security protocols designed to prevent data breaches, these systems still have vulnerabilities [Leandre Gomes et. al., 2022].

2. Customer trust:

In the context of internet banking services, trust is defined as the confidence consumers have in the service provider's ability to deliver reliable services online. Given the significant investments banks have made in developing internet banking, the success of this service channel relies heavily on consumers' acceptance and ongoing usage [Irfan Bashir and Chendragiri Madhavaiah, 2015]. Customers have issues with trusting internet banking because of the concerns related to security, fraud, and privacy. Inadequate security measures make the customers sceptical towards these services. Furthermore, unfamiliarity with internet banking systems and new technology erodes the confidence of the customers. To address these issues, banks must strengthen security, improve transparency, and educate users on safe banking practices.

3. Customer awareness and Digital divide:

With the rise in technology and banks providing services through various electronic channels, consumers often lack adequate awareness about these services. Ensuring customer awareness should be a top priority for bankers. It is evident that some individuals prefer manual banking, but with proper guidance, they can be encouraged to become potential users of internet banking [Harihara Sudhan Ramakrishnan and Pavithra Varadharajulu, 2012]. The digital revolution in the financial sector has excluded those who are digitally disconnected from its benefits. In India, the 60% rich population are four times more likely to make digital payments compared to the poor 40% [India Inequality Report, 2022].

4. Privacy:

Many customers, including educated ones, are often unaware of privacy policies and fail to manage their ATM PINs and internet banking passwords securely. This represents a significant customer-related issue. On the other hand, internet banking is a frequent target for hackers and other cybercriminals. Understanding the security challenges associated with internet banking is essential for protecting both personal and business accounts from unauthorized access. Internet banks face various types of cyberattacks, employ fraud strategies, and implement prevention methods to enhance security [M. Parameshwari, 2019].

5. Implementation of new technology:

Despite the emergence of a tech-savvy and extensive consumer base in recent years, a combination of industry challenges and unique obstacles continues to hinder the growth of internet banking in India. The slow connectivity speeds significantly diminish the online banking experience for many customers who are eager to adopt such services [Megha Jain et. al., 2011]. Internet banking faces technological implementation failures due to various factors. Poor broadband penetration, especially in rural and semi-urban areas, coupled with outdated hardware and software, hampers seamless online banking experiences. Many banking systems lack scalability, struggling to handle sudden spikes in user traffic, which leads to server crashes and delays. Legacy systems often fail to integrate with modern technology, causing inefficiencies, while weak cybersecurity measures expose data vulnerabilities, undermining customer trust. Frequent technical glitches, inadequate technical support, and inconsistent digital literacy further discourage adoption, particularly in rural areas. Banks face significant challenges in implementing AI and other advanced technologies into their internet banking systems. Limited technical expertise and a shortage of skilled personnel further hinder the adoption of AI-driven solutions. Additionally, concerns about data security and regulatory compliance slow down the implementation process. As a result, banks struggle to leverage AI for personalized services, fraud detection, and operational efficiency, missing opportunities to enhance customer experiences and streamline operations.

6. Failure in corporate governance:

Banks with concentrated ownership structures often face potential conflicts of interest, which can pose challenges to effective governance. Additionally, weak regulatory enforcement highlights the need for consistent and effective implementation of guidelines to ensure compliance. Cultural factors play a significant role, as fostering a strong ethical and compliance culture within banking institutions requires ongoing efforts to overcome resistance to change and ingrained practices. Furthermore, raising awareness among stakeholders, particularly in remote areas, about their rights and responsibilities within the banking system remains a critical priority [Sanchita Jain et. al., 2024].

8. Customer support service:

It can be concluded that 96% of respondents identify limited customer support as the primary issue faced with internet banking [Namitha Krishnan, 2020]. Internet banking has brought great convenience, but a key challenge remains the failure in customer support services. Many users experience frustration due to slow response times, limited availability of support channels, and lack of expertise in resolving complex issues. When customers face urgent problems like fraud or technical glitches, ineffective support can erode trust in the service. To improve user satisfaction, it is essential for banks to enhance the responsiveness, availability, and training of their support teams, ensuring quick and efficient resolutions for all users.

Suggestions

1. Security:

Factors like Reliability, security, cyber-risk, convenience, and innovation, are key factors has a direct influence on preference and adoption of digital banking and customer satisfaction [Hitendra Lachhwani and Archie Kanwar, 2020]. To strengthen security measures in internet banking, banks can implement advanced encryption protocols multi-factor authentication. to safeguard user accounts from unauthorized access, with biometrics such as fingerprint and facial recognition further enhancing login security. AI-driven systems can be deployed to monitor transactions in real-time, instantly flagging and alerting customers about suspicious activities. Regular security audits and penetration tests are essential for identifying and addressing vulnerabilities in banking systems. Additionally, enabling customers to set up customized alerts for transactions, failed login attempts, or unusual geographic access can enhance account monitoring and provide an extra layer of security.

2. Awareness:

Banks must take proactive steps to educate customers about new technologies and services they offer. Extending customer interaction time with bank officials and adopting a friendly approach can significantly enhance customer satisfaction. These efforts will not only help retain existing customers but also attract new ones, ultimately contributing to improved banking services and the overall development of banks in India [Amutha Das, 2016]. To increase customer awareness, banks can run continuous educational campaigns through SMS, social media, and emails to inform customers about safe online banking practices, recognizing phishing attempts, and avoiding unsafe links. Hosting community workshops especially for less tech-savvy populations, can help teach both basic and advanced internet banking functionalities. Additionally, providing multilingual guides and mobile-friendly tutorials ensures accessibility and easy understanding of internet banking systems across diverse demographics.

3. Technology:

Implementing advanced technology allows banks to enhance customer service by offering faster, more convenient, and personalized experiences. Additionally, leveraging cutting-edge technology helps banks reduce operational costs by automating processes and improving overall efficiency. This not only enhances the user experience but also enables banks to maintain a competitive edge in the industry [Megha D. Shetty and Nikhitha M.K., 2022]. Banks can upgrade to cloud-based servers to handle increased user traffic and minimize downtime during peak usage periods. Additionally, replacing or integrating legacy systems with modern technology is crucial for delivering a seamless and efficient user experience. Leveraging AI enables banks to personalize banking experiences, predict customer needs, and identify fraudulent patterns effectively. Additionally, integrating biometric login methods, such as fingerprint or facial recognition, improves both user convenience and security.

4. Corporate governance:

To maintain financial stability, the sector must focus on financial and operational resilience while upholding robust corporate governance. Banks and financial institutions should reinforce their internal defence mechanisms, including assurance functions, and foster a culture of compliance and fairness. This approach is essential for sustaining the trust of both regulators and, more importantly, their customers [RBI Bulletin, 2024]. Promoting ethical practices involves training employees on compliance and ethical standards to foster a culture of accountability. Engaging

stakeholders, including customers, employees, and local communities, in discussions on corporate policies and decision-making enhances transparency and inclusivity. Additionally, strengthening internal controls and audit mechanisms helps address conflicts of interest and ensures strict adherence to governance standards.

5. Customer support

The availability of assistance through phone or online representatives demonstrates that customers are highly satisfied with this aspect. Improved communication between the bank and its customers significantly enhances satisfaction levels [Ankit Shah, 2011]. To enhance customer support, banks can establish 24/7 multi-channel assistance through toll-free numbers, chatbots, and live chat. Training support staff to address technical issues and complex queries efficiently ensures effective query resolution. Priority assistance can be implemented for urgent matters, such as fraud resolution or failed transactions, to guarantee quick resolutions. Additionally, providing a comprehensive FAQ section and interactive self-service tools empowers customers to resolve common issues independently.

Conclusion

Internet banking has transformed the Indian banking system, offering a seamless and cost-effective alternative to traditional banking. From enhancing profitability to extending reach, it plays a crucial role in modernizing financial services. Studies confirm that internet banking significantly boosts banks' performance, contributing to higher profitability. Initiatives like Digital India have bridged the digital divide, enabling extensive connectivity and access to high-speed internet, which supports banking services in even remote areas. This infrastructure has empowered banks to expand their customer base and provide 24/7 services with unparalleled convenience and flexibility. The cost-effectiveness of internet banking has helped banks reduce operational and transaction costs while enhancing customer relations through personalized services, transparency, and improved security. These features have built trust and goodwill, solidifying banks' reputations. Furthermore, banks now function as multi-service platforms, integrating mobility, e-governance, and commerce, offering customers a unified experience.

Internet banking also provides banks with a competitive edge by fostering innovation and delivering superior service quality. However, security concerns, customer trust, limited digital literacy, and inadequate infrastructure hinder wider adoption. Many users are unaware of the full range of digital banking services beyond basic transactions. Poor connectivity in rural areas, outdated technology, and insufficient customer support further restrict growth. Privacy issues, slow implementation of advanced technologies, and weak governance add to these challenges. To address these issues, banks must strengthen cybersecurity, improve customer education, and promote awareness of diverse digital services. Enhancing technical infrastructure, providing responsive support, and fostering an ethical compliance culture are crucial. By tackling these challenges and leveraging technology effectively, banks can sustain growth, gain a competitive edge, and meet the evolving needs of customers. Internet banking, thus, continues to reshape the Indian banking landscape, making it more accessible, efficient, and customer-centric.

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Impact of ICT on Students' Intellectual Growth

Ankita Singh and K Pratyusha Reddy

Department of Commerce

Institute for Excellence in Higher Education, Bhopal - 462016 India

Abstract

This study explores the impact of ICT on students' intellect, analysing both its benefits and challenges. It also provides insights into how emerging technologies like artificial intelligence and virtual reality can further enhance learning experiences. The findings emphasize the need for a balanced approach to ICT integration to maximize its intellectual benefits while addressing its limitations. Ultimately, ICT remains a powerful tool in modern education, but its success relies on accessibility, strategic implementation, and continuous advancements in digital learning methodologies. Primary data has been collected from the students of IEHE and F-test has been applied to check the hypothesis.

Keywords: *ICT, Student's Intellectual growth.*

Introduction

Impact refers to the effect or influence that a particular factor has on an individual or system. In this study, impact signifies the positive and negative changes brought about by the application of Information and Communication Technology (ICT) in students' intellectual growth. Application refers to the practical use of ICT in education. It includes digital learning tools such as e-books, educational apps, virtual classrooms, and online research platforms that assist students in acquiring knowledge efficiently. The application of ICT has expanded beyond traditional teaching methods, enabling interactive and self-paced learning.

ICT (Information and Communication Technology) encompasses all digital technologies that facilitate communication and information sharing. This includes computers, the internet, mobile devices, multimedia, and online educational platforms. The use of ICT in education has transformed learning experiences by making resources more accessible, interactive, and adaptable to individual needs.

Students are the primary focus of this study, as they are the learners who engage with ICT tools for academic purposes. The way students utilize technology determines its impact on their cognitive development, academic performance, and intellectual abilities. Intellect refers to a student's ability to think critically, solve problems, analyze information, and make informed decisions. ICT plays a significant role in shaping intellect by offering diverse learning experiences, promoting logical reasoning, and encouraging creativity. However, excessive use or misapplication of ICT may lead to challenges such as reduced attention span or dependency on technology.

This study aims to examine how the application of ICT influences students' intellect, both positively and negatively. It will explore how ICT enhances learning outcomes, fosters intellectual growth, and presents challenges that may affect students' academic success. By

analysing these aspects, the research will provide insights into the best practices for integrating ICT into education effectively.

Literature Review

Garrison and Vaughan (2019) investigated the influence of ICT in developing critical thinking abilities. Their findings demonstrated that students who actively participate in online conversations and problem-solving activities utilising ICT tools had greater levels of analytical reasoning than those who just use traditional learning techniques. They emphasised the need of digital literacy in helping pupils choose between genuine and untrustworthy sources of information. The study provides only a cross-sectional analysis without tracking intellectual growth over time.

Selwyn (2021) investigated the effects of collaborative learning platforms on students' critical thinking skills. His research discovered that participating in virtual forums, digital case studies, and online debates promotes deeper investigation and independent thinking. He also stated that, while ICT presents kids with a wealth of material, instructors must provide direction in order for them to efficiently traverse digital content. The study is confined to students, making it difficult to generalize findings across different educational institutions.

Robinson (2022) studied the link between ICT and creative thinking in schooling. His findings revealed that digital platforms such as video editing software, graphic design apps, and music composition programs allow pupils to express themselves artistically. He also discovered that ICT promotes collaborative creativity since students may collaborate on assignments using shared digital workspaces. The research does not compare students who actively use ICT with those relying on traditional learning methods.

Kumar & Sharma (2021) investigated the function of ICT in enhancing computational thinking, a critical component of creativity. Their findings suggest that coding platforms like Scratch and Python assist students to acquire logical reasoning, problem-solving abilities, and innovative solutions to real-world problems. The study does not examine potential drawbacks such as digital distractions or over-reliance on technology.

Objectives

1. To explore the impact of ICT on students' intellectual development and learning.
2. To assess the role of ICT in enhancing decision-making, problem-solving, and critical thinking skills.
3. To evaluate how ICT contributes to academic success and fosters creativity.
4. To understand the challenges students face while using ICT for education.
5. To gather suggestions for improving the effectiveness of ICT in the learning environment.

Hypothesis

H₀ - There is no significant difference between ICT and students' intellectual growth.

H₁ - There is a significant difference between ICT and students' intellectual growth.

Research Methodology

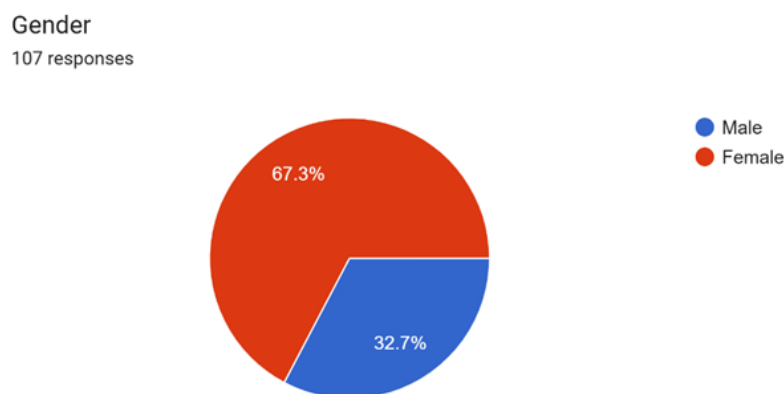
This study employs a mixed-method approach, utilizing both qualitative and quantitative research methods. A structured survey distributed to 110 participants pursuing their graduation from IEHE. In-depth interviews have also been conducted with the participants regarding various ICT tools they use in their daily academic life. F-test has been applied on the data to verify the study and results have been figured out. The findings have been shown and data has been analysed. Upon which suggestions have been given and conclusions have been drawn.

Limitations of the study

The limitations of the study include the following:

- A fairly limited sample size was used for the investigation. The study only included 110 students from IEHE which limits how far the results may be applied. To make more broadly applicable conclusions on student's intellect, a larger and more varied sample would be required.
- Because the study was restricted to IEHE, students behaviour may vary in other regions. Students' views on application of ICT tools may differ depending on a variety of social, cultural, and economic contexts.
- Selection bias may have resulted from the study's convenience sampling technique. Since the participants were not chosen at random, the results may be skewed because people who are more engaged in academics are more likely to complete the poll.
- Personal interviews and questionnaires were one of the primary sources of data for the study. To project a more positive self-image, respondents might have underreported their involvement in less sustainable behaviours or oversold their dedication to sustainability.

Data collection

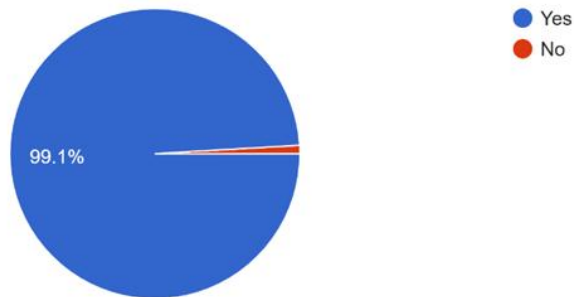


Out of 110 participants randomly chosen, 107 participants filled the data. 35 males and 72 females participated in the research study. All the students belong to IEHE.

Findings

Q1. Do you use ICT (Information and Communication Technology) for learning?

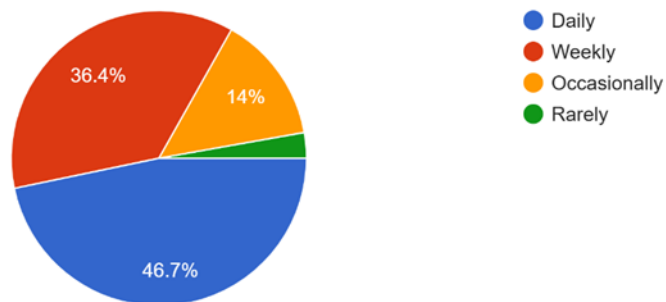
107 responses



Data showed that 99% students prefer using ICT tools for learning.

Q2. How frequently do you use ICT tools for learning?

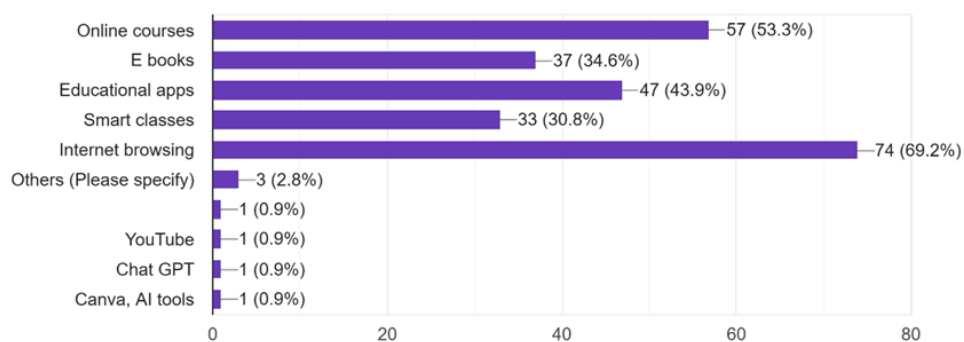
107 responses



Data showed that 46.7% students daily, 36.4% students weekly, 14% students occasionally and 2.9% students rarely use ICT tools for learning.

Q3. Which ICT tools do you use the most for learning? (Tick all that apply)

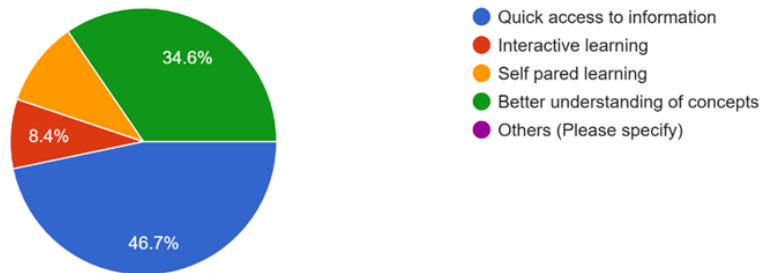
107 responses



Data showed that students use various ICT tools for better academic experience. Tools like e-books, smart classes, AI tools, various study apps etc. are student's all time saviours.

Q4. What is the primary reason you use ICT for learning?

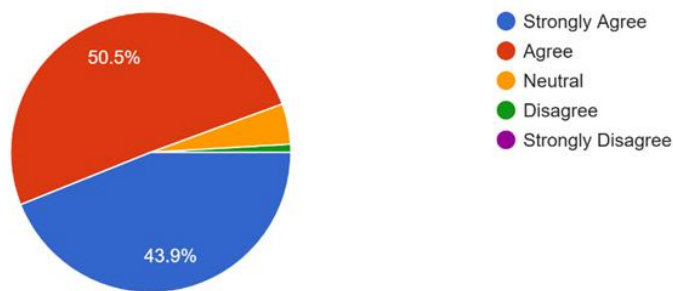
107 responses



46.7% students use ICT tools to have a quick access to information. 34.6% students use ICT tools to understand various concepts in a moment. 8.4% students interact with other students over internet. Remaining 10% students are self-paced learners.

Q5. Do you think ICT has improved your ability to understand and retain academic concepts better?

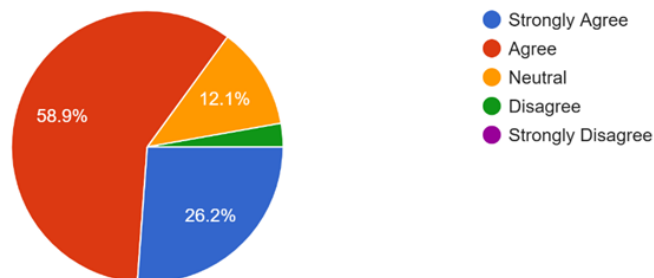
107 responses



43.9% students agree strongly that using ICT tools has made their academic experience easy. 50.5% students use ICT as per their convenience. Almost 6% population is still not comfortable in using ICT.

Q6. Has ICT improved your ability to think critically and solve problems?

107 responses



58.9% students have agreed that using ICT has resulted in improving their thinking ability and problem solving ability. 26.2% students are comfortably using ICT and are excelling because of

ICT. 12.1% students gave a neutral response. There are still 2.8% students who believe ICT is not helping them in their academics.

Data analysis

F-Test Two-Sample for Variances		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	1.009346	1.728972
Variance	0.009346	0.652266
Observations	107	107
df	106	106
F	0.014328	
P(F<=f) one-tail	0	
F Critical one-tail	0.725451	

Hypothesis testing

Table: Acceptance & Reaction of Null Hypothesis

T-test	Significance level	t-calculated	t-critical	Comparison	Result
One-tail	0.05	0.014	0.725	t-calculate < t-critical	H0: Accepted Ha: Rejected

The F-Test table provides a comparison of the variances of two variables to determine whether they are significantly different.

Interpretation of the F-Test Table is as follows:

1. Mean Values:

Variable 1: 1.009346 Variable 2: 1.728972
--

The second variable has a higher mean, indicating a greater average value compared to the first variable.

2. Variance:

Variable 1: 0.009346 Variable 2: 0.652266
--

The variance of Variable 2 is significantly higher than Variable 1, suggesting greater dispersion in its data.

3. F-Statistic (F = 0.014328):

The calculated F-value is very small, indicating that the variance of Variable 1 is much smaller than that of Variable 2.

4. F Critical Value (0.725451, one-tail):

The F critical value is much higher than the calculated F value.

Since F value < F critical, we fail to reject the null hypothesis, meaning there is no significant difference between the variances of the two groups.

The F-Test indicates that while the variances appear different numerically, the statistical test suggests they are not significantly different. This implies that both groups have similar levels of variance, even though the second variable has a higher mean.

Suggestions

- To overcome ICT-related learning challenges, structured digital literacy programs should be introduced to provide proper guidance for both students and teachers.
- Technical issues can be minimized through regular system maintenance, upgraded infrastructure, and cloud-based learning platforms.
- To address internet connectivity problems, institutions should offer offline learning resources, expand Wi-Fi zones, and collaborate with service providers.
- Information overload can be managed by providing structured digital content and using AI-powered filters to help students access credible information.
- To bridge the communication gap and ensure doubt clarification, live interactive sessions, AI chatbots, and discussion forums should be encouraged. Fact-checking tools and media literacy education can help students distinguish between reliable and false information, improving their critical thinking skills.
- A holistic approach that includes enhanced ICT training, infrastructure improvements, and AI-driven personalized learning tools is essential for a seamless and effective digital learning experience.

Conclusion

The integration of ICT in education has significantly shaped students' intellectual development by enhancing cognitive abilities, critical thinking, creativity, and academic performance. Online resources, virtual simulations, and AI-powered platforms help students develop deeper analytical reasoning, enabling them to process and evaluate information effectively. However, despite its numerous advantages, ICT-based education presents several challenges, including digital distractions, the digital divide, and information overload, which can hinder students' ability to focus and retain information. Many students struggle to differentiate between credible and misleading online content, leading to cognitive overload and reduced critical thinking. Furthermore, disparities in access to technology create unequal learning opportunities, limiting ICT's potential for all students. To maximize its benefits, educational institutions must ensure equitable access to digital tools, provide teacher training, and implement strategies to minimize digital distractions and foster responsible technology use.

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Nykaa's Influence on Women's Online Shopping Behaviour

Alisha Khan

Department of Commerce

Institute for Excellence in Higher Education, Bhopal - 462016 India

Abstract

Nykaa has emerged as a transformative force in India's e-commerce sector, particularly within the beauty and wellness industry. This study explores Nykaa's significant influence on women's online shopping behaviour, examining how its digital marketing strategies, influencer collaborations, and personalized shopping experiences have positioned it as a leading platform in the online beauty market. By analysing consumer behaviour trends, pricing strategies, and brand loyalty, the research aims to uncover how Nykaa has reshaped purchasing patterns and empowered women in their consumer choices. A comparative analysis with other e-commerce platforms will highlight Nykaa's unique value proposition. Primary data from surveys and interviews will provide insights into Nykaa's lasting impact, offering recommendations for future marketing strategies to enhance engagement and purchase frequency. This study contributes to the broader understanding of online consumer behaviour and the evolving role of digital platforms in shaping modern retail habits.

Key words: *E-commerce, Consumer behaviour, Digital marketing strategies, Influencer marketing impact, Brand loyalty in online retail, Women's online shopping trends.*

Introduction

In recent years, e-commerce has revolutionized consumer behaviour, especially in the beauty and wellness sector. Among the many brands driving this change, Nykaa stands out with its innovative digital marketing strategies, influencer partnerships, and personalized consumer experiences. Nykaa's approach to marketing has not only reshaped purchasing behaviours but also empowered women to make informed and confident decisions in their beauty and wellness purchases. This study aims to examine Nykaa's impact on women's online shopping behaviour and identify how its digital marketing strategies have influenced consumer choices.

Literature Review

1. Singh, N., Moolchandani, R., & Bhatia, A. (2019)

This study explores the various factors affecting online purchasing decisions among women in India. Through a structured questionnaire and factor analysis, it identifies key determinants such as perceived services, ease of use, usefulness, and repurchase intention. The findings provide valuable insights into the online shopping behaviours of female consumers, particularly in the context of e-commerce platforms like Nykaa.

2. Kapoor, K., Tamilmani, K., Rana, N. P., Patil, P., Dwivedi, Y. K., & Nerur, S. (2021)

The study reviews the impact of social media influencers on consumer behaviour, focusing on how influencers shape trust, brand perceptions, and purchase decisions. It supports our research on Nykaa, where influencers play a key role in brand visibility, though not the main driver of purchases.

3. Tuhin, M. S., & Hashim, R. B. A. (2024)

Tuhin and Hashim's study examines the factors influencing online shopping behaviour among Bangladeshi women, focusing on product quality, brand trust, convenience, and influencer marketing. They find that consumers prioritize product authenticity and are heavily influenced by promotions and influencer recommendations. This aligns with our research on Nykaa, where product trust and influencer marketing play a significant role in shaping women's purchasing decisions

Research Objectives

- To assess how Nykaa's digital marketing strategies have impacted women's online shopping habits.
- To understand the role of influencer collaborations in shaping purchasing behaviour.
- To explore the significance of personalized shopping experiences in driving brand loyalty.
- To offer recommendations for future marketing strategies based on consumer insights.

Hypothesis

Null Hypothesis (H_0): Nykaa's digital marketing strategies do not significantly influence women's online shopping behaviour.

Alternative Hypothesis (H_1): Nykaa's digital marketing strategies significantly influence women's online shopping behaviour.

Research Methodology

Data Source: This research utilizes primary data collected through an online survey distributed to women who have experience shopping for beauty and wellness products online. A total of 30 respondents participated in the study. The questionnaire consisted of 7 structured questions designed to gather insights on factors such as exposure to digital marketing, influence of advertisements and influencers, purchase behaviour, and brand loyalty specific to Nykaa.

To examine the relationship between Nykaa's digital marketing strategies and women's purchasing decisions, a One-Proportion Z-Test was applied. This test was used to determine whether a significant proportion of respondents had been influenced to make a purchase solely due to Nykaa's advertisements or influencer promotions, thereby helping to validate the research hypothesis.

Analysis and interpretation

Interpretation: A large majority (70%) of participants stated they would recommend Nykaa to others. This demonstrates a strong level of customer satisfaction and brand trust, further reinforcing the influence of Nykaa's marketing and overall customer experience. Positive word-of-mouth, especially in digital spaces, is a key indicator of a brand's impact, and this result supports the conclusion that Nykaa holds a favorable position in the minds of women consumers.

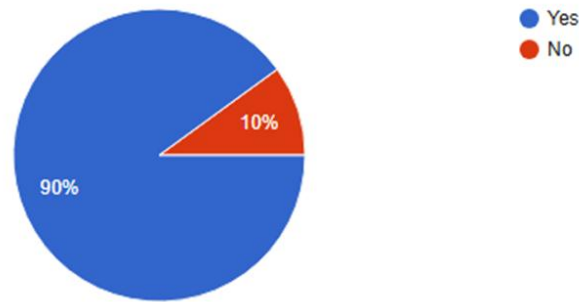


Figure 1: Pie Chart Indicating Respondents' Willingness to Recommend Nykaa

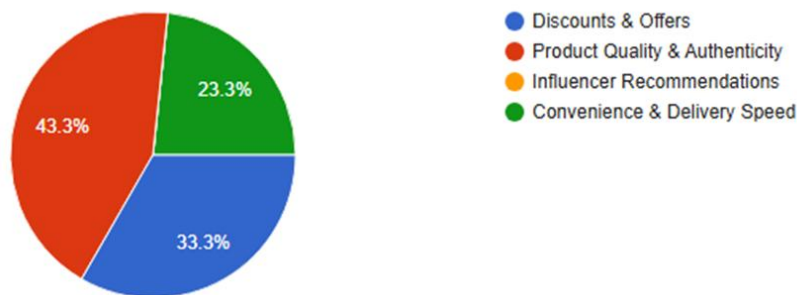


Figure 2: Key Factors Influencing Purchase Decisions on Nykaa

Interpretation: The chart reveals that Product Quality & Authenticity (43.3%) is the most significant factor influencing women's purchasing decisions on Nykaa. This suggests that trust in genuine products is a top priority for consumers. Discounts & Offers (33.3%) also play a major role, reflecting the importance of price sensitivity. Interestingly, Convenience & Delivery Speed (23.3%) is also a notable factor, while Influencer Recommendations received little or no response, indicating that while influencer marketing might spark interest, it may not be the primary trigger for actual purchases.

Survey Question Considered for Hypothesis Testing

Have you ever purchased a product from Nykaa solely due to an advertisement or influencer promotion?

- Total respondents 30
- Number of "Yes" responses 21

• Sample proportion ($\hat{p}$)	21/30 = 0.70
• Hypothesized proportion (p_0)	0.5
• Significance level (α)	0.05

Z-Test Formula

$$Z = (\hat{p} - p_0) / \sqrt{[p_0 (1 - p_0) / n]}$$

Where,

$\hat{p}$ = sample proportion (0.70)

p_0 = hypothesized proportion (0.50)

n = sample size (30)

$$Z = (\hat{p} - p_0) / \sqrt{[p_0 (1 - p_0) / n]}$$

$$Z = (0.70 - 0.50) / \sqrt{[0.50 \times (1 - 0.50) / 30]}$$

$$Z \approx 2.19$$

Decision

- At 5% level of significance, the critical Z-value is ± 1.645
- Since $Z = 2.19 > 1.645$, we reject the null hypothesis

Findings

- 70% of respondents reported making a purchase from Nykaa solely because of advertisements or influencer promotions, showing the strong impact of digital marketing.
- 90% of participants said they would recommend Nykaa to others, indicating high customer satisfaction and trust in the brand.
- The top factor influencing purchase decisions was Product Quality & Authenticity (43.3%), showing that consumers prioritize genuine products.
- Discounts and offers (33.3%) also play a crucial role, especially in attracting price-sensitive buyers.
- While influencer promotions help create brand visibility, they were not the leading factor in final purchase decisions.
- Convenience and fast delivery (23.3%) were important to many shoppers, highlighting the value of a smooth post-purchase experience.

Suggestions

- Nykaa should continue to focus on highlighting the quality and authenticity of its products in marketing campaigns to strengthen consumer trust and encourage repeat purchases.
- Given that younger consumers (18-24 age group) are highly motivated by discounts, Nykaa should create personalized promotions and exclusive offers tailored to this demographic to drive sales.
- Since convenience and fast delivery are important to shoppers, Nykaa should work on improving logistics to ensure quicker delivery times and enhance the overall ease of browsing and purchasing on the platform.
-

- While influencer marketing isn't the primary purchase driver, it plays a significant role in brand awareness. Nykaa should continue collaborating with influencers who align with the brand's values and can authentically promote product quality.
- Since Nykaa already has loyalty programs, it can further enhance these by offering more personalized rewards and increasing awareness to ensure customers fully utilize the benefits, boosting brand loyalty.

Conclusion

This research highlights the significant influence of Nykaa's digital marketing strategies on women's online shopping behaviour in the beauty and wellness sector. The study reveals that advertisements and influencer promotions play a major role in driving purchases, particularly for 70% of the respondents. Product quality and authenticity were identified as the most important factors influencing purchase decisions, while discounts and offers also held significant weight. Despite the role of influencer marketing in creating awareness, it was not the primary driver for actual purchases. To further enhance engagement, Nykaa should continue emphasizing product authenticity, offer targeted promotions for younger consumers, and focus on improving delivery speed and convenience. Future research could explore the influence of other factors such as age and online shopping experience to gain a more comprehensive understanding of consumer behaviour in the beauty e-commerce space.

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Maritime Power Race: India and China in the Indian Ocean

M Lipika and Sadhana Pandey

Department of Political Science

Institute for Excellence in Higher Education, Bhopal - 462016 India

Abstract

India and China are the great powers of Asia in the 21st century. Their large population and young individuals having a majority of the total population have generated opportunities for economic development. India- China relations are complex. In 1962, the war between the two became a major constraint in their bilateral relations. At present, the Indian Ocean region constitutes a large part of trade routes and choke points. China and India aim to harness the Indian Ocean region for regional and global interests. China, through its String of Pearls strategy, has increased its naval presence in the arena and India has responded through a counter-encirclement strategy as Necklace of Diamonds. To counter Chinese Dominance, India has conducted maritime diplomacy at three levels, such as high-level Bilateral visits, project Mausam, and regional cooperation.

Keywords - *China, India, Indian Ocean, Maritime System, Necklace of Diamonds and String of Pearls.*

Introduction

Alfred Mahan (Historian and naval officer) said “Whoever controls the Indian Ocean dominates Asia. This ocean is the key to the seven seas”. Geographically, the Indian Ocean constitutes 20% ocean which spans three continents and twenty-eight countries as a major international trade route. In recent years this region has gained prominence for India and China to control trade routes, create dominance, and militarization.

85% of China’s energy requirement passes through the Indian Ocean which concerns PRC of piracy, blockade, or any type of disruption that could harm its economic and energy security interests. China’s competitive assertiveness can be interpreted through its naval presence in the region and the development of strategic and military ties with Pakistan, Bangladesh, Sri Lanka, and African nations. Recently India has been enlarging its regional cooperation, energy security, and economic interests in the region. India similarly responded by strengthening naval ties with Bangladesh, Sri Lanka, Iran, and Myanmar.

China’s String of Pearls

China aspires to become a superpower which is why the country needs to expand its market, business, trade, and other facilities in different countries. The Belt and Road Initiative (BRI) is concerned with economic ties, trade expansion, market access, infrastructural development, and new establishments. The String of Pearls is a geopolitical strategy to build commercial facilities, make smooth and safe passage for maritime business, and establish military networks and bases for protecting trade interests around Indian neighbours in the region.

China aims to limit India's influence in the Indian Ocean by establishing a network of strategically placed allies. String of Pearls focuses on establishing maritime bases in Myanmar, Bangladesh, Maldives, Pakistan, Oman, Mauritius, and Djibouti to enhance trade interests and security concerns. China, in recent years, has heavily invested in the viable ports of Bangladesh (Chittagong), Myanmar (Sittwe and Kyaukpya), Pakistan (Gwadar) and Sri Lanka (Hambantota and Colombo)

Moreover, China holds an opinion that, with such purported 'encirclement' with bases, China might be in a future conflict threatening Indian interests, putting the International Sea of Line of Communications (ISLS) at risk and endangering the U.S. oceanic superiority.

India and the Indian Ocean

The Indian Ocean Region (IOR) is considered as India's backyard and its natural sphere of influence by some Indian scholars. In recent years, the focus of maritime thinking has shifted towards a greater emphasis on maritime supremacy—with principal concern on Indian oceanic trade, protection of Economic Exclusive Zones [EEZ], and expansion of Indian strategic depth in the ocean.

Apart from its geo-strategic importance, the Indian Ocean is significant to India for energy security, and oil demand has increased in the country, along with its growing economy and population. India's oil import is 80% [for crude oil] and 45% for natural gas [LNG]. India is greatly dependent on the marine trade that passes from the international shipping lanes across the Indian Ocean Region (IOR). Most of the energy required [80% of crude oil] is imported through the Indian Ocean Region—which makes it a vital region for India to monitor and dominate.

Indian maritime strategists have stated that the Chinese oceanic 'encirclement' of India or to keep India strategically lopsided and isolated in its sphere of influence, India has formulated a counterbalance strategy to deepen and broaden its cooperation with countries like the USA, Iran, Myanmar, Singapore, Sri Lanka, Malaysia, and Indonesia.

Necklace of Diamonds

India has started working on the 'Necklace of Diamonds' strategy which aims at garlanding, the counter encirclement. India is expanding its naval bases and is improving relations with strategically placed countries by building ports, extensive Coastal Surveillance Radar (CSR) systems, importing state-of-the-art surveillance planes, deepening defence ties, expanding bilateral relations with South Asian countries, Island nations in the Indian Ocean region, Southeast Asian Nations and carrying out regular military exercises with navies of USA, Japan, Australia.

India is developing Chabahar port in Iran, located close to the Gwadar Port in Pakistan and it is close to the Strait of Hormuz. The Iranian Port is also accessing Afghanistan and can do business with Central Asia by using this port.

India is building a deep-sea Port at Sabang (Indonesia) located right at the entrance of the Strait of Malacca (a choke point for China) and India's Andaman & Nicobar Islands.

India got military access to Sabang Port providing a support base for India against any security threat in the Indian Ocean Region and South East Asia Region. Sittwe Port is a deep-water port constructed by India in 2016 at Sittwe, the capital of Rakhine (Myanmar) , on the Bay of Bengal. The port is being financed by India as a part of the Kaladan Multi-Modal Transit Transport Project aimed at developing transport infrastructure in south-western Myanmar and north-eastern India to provide alternative connectivity to Kolkata.

India got military access to the Duqm Port (Oman) in 2018 located close to the Strait of Hormuz, also more than 30% of oil exports pass through this channel. It facilitates India's crude oil imports from the Persian Gulf. Besides this port is situated between two Chinese bases-Djibuti and Gwadar.

India has signed an agreement for access to Changi (Naval Base), Singapore, which is located close to the Strait of Malacca.

In 2015 India and Seychelles jointly agreed to develop naval bases in Assumption Island as it is of strategic importance to India and China desperately wants to increase its presence in the African continent by the Maritime Silk Route (MSK).

India and France recently agreed to a strategic agreement that allows both countries' warships to access each other's naval bases throughout the Indian Ocean. The Indian navy has access to crucial French ports, including Djibouti.

India's Act East Policy is closely connected with its long-term vision of developing its North-Eastern Region (NER). It has been used to make important military and strategic agreements with Vietnam, Japan, the Philippines, South Korea, and Indonesia, among others.

It can be analysed that India has maintained cordial relations with nations in China's periphery. This will give strategic access to India and the pattern can be seen as a 'necklace of diamonds' garlanding China in a counter encirclement.

Challenges ahead

China's investments in the string of pearls strategy exceed the investment made by India for its Necklace of Diamonds. Almost all nations(in the region) have economies dependent on China and no country wants to get into a cold war with China. India's "Necklace of Diamonds" involves several countries with differing interests, and it can be difficult to find common ground and ensure the smooth implementation of the strategy.

Conclusion

India and China share a double-edged sword history since their independence which affects security dilemmas and the global maritime system. In recent years, border skirmishes have sharpened India's security concerns and have resulted in regional competition in the Indian Ocean. The geopolitical environment will unfold in ambiguous ways shortly.

Some scholars also hold the view that it is too early to analyse the effectiveness of any one strategy implemented by the two countries in this competitive dynamics. It is also important to note that both countries have certain common nations for executing developmental projects that would create uncertainty to escalate tensions. Also, the encirclement strategy is not an

official strategy but an interpretation of the activities of both India and China in the region by various academicians.

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भारतीय खाद्य संरक्षण विधियां

मीरा यादव

गृह विज्ञान

शासकीय महात्मा गांधी स्मृति स्नातकोत्तर महाविद्यालय इटारसी 461111 (म.प्र.)

सारांश

भोज्य पदार्थ को सड़ने से व खराब होने से बचाने हेतु सभी क्रियाएं खाद्य संरक्षण के नाम से जानी जाती हैं, जिसमें भोज्य पदार्थों को कुछ घंटे से लेकर कुछ सालों तक सुरक्षित रखा जाता है। सड़ने एवं खराब होने की प्रक्रिया को रोका जाना ही खाद्य संरक्षण है। भोजन संरक्षण एक ऐसी रूपरेखा है जो खाद्य पदार्थों को सूक्ष्म जीवाणु, एंजाइम तथा स्वतः ऑक्सीकरण द्वारा खराब होने से बचाती है।

प्राकृतिक आपदाओं जैसे बाढ़, सूखा, भूकंप, चक्रवात आदि का सामना करने से बहुसंख्य जनसंख्या को भोजन सामग्री उपलब्ध कराना एक चुनौती है। अतः उत्पादन के समय आवश्यकता से अधिक उत्पादन भोज्य सामग्री को संरक्षित करना अति आवश्यक है। जिससे आवश्यकता पड़ने पर इनका उपयोग किया जा सके। समय रहते यदि भोज्य पदार्थ को संरक्षित कर लिया जाता है, तो भविष्य में वह बहुत काम आते हैं। संरक्षित भोज्य पदार्थ का उपयोग कर व्यक्ति समय एवं ऊर्जा की बचत कर सकता है।

संरक्षण भोज्य पदार्थ जैसे - सूखे फल व सब्जियां, हिमीकृत फल, मांस, सब्जियां डिब्बा बंद खाद्य पदार्थ, पेय पदार्थ, केचप, सॉस, चटनी, जैम, जेली, मारमलेड, मुरब्बा, अचार आदि। भोजन संरक्षण हेतु नए-नए अभियान, उद्योग, फैक्ट्रियां, संस्थाएं कई लोगों को टेक्निकल ज्ञान प्रदान करता है एवं रोजगार के अवसर भी बढ़ते हैं।

शब्दकोश - भोजन, फल, सब्जियां, संरक्षण, अनाज, मानव, तकनीकी।

परिचय

भोजन में सूक्ष्म जीव, फफूंदी या कीट, क्रमिक पैदा होने का मुख्य कारण भोज्य पदार्थों में उपस्थित नमी तथा वातावरण में उपस्थित तापक्रम में वृद्धि है। भोज्य पदार्थ को सड़ने से व खराब होने से बचाने हेतु सभी क्रियाएं खाद्य संरक्षण के नाम से जानी जाती हैं, जिसमें भोज्य पदार्थों को कुछ घंटे से लेकर कुछ सालों तक सुरक्षित रखा जाता है। सड़ने एवं खराब होने की प्रक्रिया को रोका जाना ही खाद्य संरक्षण है। भविष्य के उपयोग के लिए भोज्य पदार्थों को अधिकतम पोषक तत्वों को संभालना ही संरक्षण का उद्देश्य है।

भारत जैसे अधिक जनसंख्या एवं विकासशील देशों में भोज्य पदार्थों का उत्पादन उनकी आवश्यक मात्रा को पूर्ण करने में समस्या आती है। अधिकतर भोज्य पदार्थ की कुछ मात्रा संग्रहित तथा संरक्षित कर भविष्य के उपयोग हेतु रखना पड़ता है। प्राकृतिक आपदाओं जैसे बाढ़, सूखा, भूकंप, चक्रवात आदि का सामना करने से बहुसंख्य जनसंख्या को भोजन सामग्री उपलब्ध कराना एक चुनौती है। अतः उत्पादन के समय आवश्यकता से अधिक उत्पादन भोज्य सामग्री को संरक्षित करना अति आवश्यक है। जिससे आवश्यकता पड़ने पर इनका उपयोग किया जा सके।

भोजन संरक्षण एक ऐसी रूपरेखा है जो खाद्य पदार्थों को सूक्ष्म जीवाणु, एंजाइम तथा स्वतः ऑक्सीकरण द्वारा खराब होने से बचाती है। भोज्य पदार्थों के मूल आकार एवं स्वरूप को परिवर्तित कर या अपरिवर्तित रखकर उनके पोषण मूल्य को यथा संभव बनाए रखते हुए बिना विकृति दीर्घकाल तक सुरक्षित रखने की विधियां एवं तकनीक को खाद्य संरक्षण कहा जाता है।

खाद्य पदार्थों के मूल रंग, गंध, आकार एवं स्वाद में कुछ अवधि के उपरांत जीवाणु, खमीर एवं फफूंदी नामक सूक्ष्म जीवाणुओं की क्रियाओं के कारण परिवर्तन आ जाता है, जिससे वह खाद्य पदार्थ खाने योग्य नहीं रहते। अतः संरक्षण के द्वारा इन परिवर्तनों को रोक सकते हैं। खाद्य संरक्षण के माध्यम से खाद्य पदार्थों को सूक्ष्म जीवों से दूर रख सकते हैं। सूक्ष्म जीवों की वृद्धि तथा गतिविधियों पर रोक लगा सकते हैं। भोज्य पदार्थ के एंजाइम को नष्ट कर उन्हें क्रियाशील करना भोज्य रासायनिक क्रियाओं पर रोक लगा सकते हैं। भोज्य पदार्थ के विनाशशील घटकों को प्रभावित करके भोज्य पदार्थों को संरक्षण किया जा सकता है।



मौसम में विशिष्ट फल एवं सब्जियां स्थान विशेष पर अधिक मात्रा में उत्पादित होते हैं। उनका उपयोग करने पर भी काफी ज्यादा मात्रा में भोज्य पदार्थ रह जाते हैं। उन्हें संरक्षित कर दूसरे स्थान पर या अन्य मौसम में उपयोग में लाया जा सकता है। संरक्षण न करने पर वे भोज्य पदार्थ खराब जाते हैं और उन्हें फेंकना पड़ता है।

मौसम के अनुसार भोज्य पदार्थ सस्ते प्राप्त हो जाते हैं। उन्हें ज्यादा मात्रा में खरीद कर दूसरे मौसम में उपयोग कर आर्थिक संतुलन बनाए रखा जा सकता है। समय रहते यदि भोज्य पदार्थ को संरक्षित कर लिया जाता है तो भविष्य में वह बहुत काम आते हैं। संरक्षित भोज्य पदार्थ का उपयोग कर व्यक्ति समय एवं ऊर्जा की बचत कर सकता है। भोजन संरक्षण की विधियों का उपयोग कर भोज्य पदार्थों को रंग, रूप, सुगंध तथा स्वाद को रुचिकर बनाया जा सकता है। संरक्षण के द्वारा भोज्य पदार्थ को लंबी यात्रा, शिविर, आपातकाल के समय आसानी से उपयोग में लाया जा सकता है।

भोजन संरक्षण हेतु नए-नए अभियान, उद्योग, फैक्ट्रियां, संस्थाएं कई लोगों को टेक्निकल ज्ञान प्रदान करता है, एवं रोजगार के अवसर भी बढ़ते हैं। भोजन संरक्षण चाहे जिस तरीके का उपयोग कर किया जाए वह कुछ सिद्धांतों के आधार पर ही संरक्षण किया जाता है। विज्ञान के कई क्षेत्र जैसे- सूक्ष्म जीव विज्ञान, रसायन विज्ञान, भौतिक विज्ञान, जीव रसायन, विज्ञान एवं जीव विज्ञान के सिद्धांतों का व्यावहारिक स्वरूप अपनाया जाता है।



खाद्य संरक्षण की विधियां

खाद्य संरक्षण की विधियों को चार प्रमुख भागों में बांटा गया है -

- 1 - भौतिक विधियां
- 2 - रासायनिक विधियां
- 3 - किण्वन विधियां
- 4 - अरोगाणुता की विधियां

भौतिक विधियां

भौतिक विज्ञान के सिद्धांत पर आधारित भौतिक विधियां इस प्रकार हैं। इसमें कम एवं अधिक तापमान एवं नमी के निष्कासन के सिद्धांत का प्रयोग कर परीक्षण की विधियां विकसित की गई हैं। उदाहरण -

- फ्रिज के द्वारा - 4 डिग्री से 10 डिग्री पर फ्रिज या कोल्ड स्टोरेज में खाद्य संरक्षण।
- हिमीकरण विधि - फ्रीजर में 20 से 0 डिग्री सेल्सियस पर भोज्य पदार्थों के अंदर के पानी को बर्फ में परिवर्तित करना।
- शुष्क हिमीकरण विधि- तरल नाइट्रोजन के वेग से भोज्य पदार्थ को बर्फीला बनाकर।
- कार्बोनेशन विधि - पेय पदार्थ में कार्बन डाइऑक्साइड घोलकर।
- पाश्चुरीकरण विधि - पेय पदार्थों को दूध फलों के रस हेतु 175 डिग्री से 195 डिग्री फारेनहाइट पर 1 से 5 मिनट तक गर्म कर एकदम ठंडा करना।
- ऊष्मा निर्जला मी कारण विधि-भोज्य पदार्थों का संगठन एवं प्रकृति के अनुसार अलग-अलग तापमान 100 डिग्री सेल्सियस या 212 डिग्री फारेनहाइट या इससे अधिक तापमान पर सूक्ष्म जीवाणुओं को पूर्ण नष्ट करना, धूप में सुखना
- नमी निष्कासन - भोज्य पदार्थ के अंदर की नमी को धूप में सुखाकर कम करना, हटाना, जिससे सूक्ष्म जीव, एंजाइम की रासायनिक क्रिया अवरुद्ध हो।
- निर्जलीकरण विधि- अलग-अलग प्रकार के ड्रायर में ईंधन या विद्युत से निश्चित तापमान पर निर्धारित अवधि तक बंद वातावरण में सुखना।
- हिम शुष्कन विधि - भोज्य पदार्थ के जल को बर्फ में बदलकर बर्फ का वाष्प में परिवर्तन कर सुखना।
- निम्न ताप वाष्पीकरण विधि- पेय पदार्थ के जल को बर्फ में परिवर्तित कर गाढ़ा बनाकर रखना।
- झाग चटाई शुष्कन विधि - भोज्य पदार्थ में ग्लिसरीन, मोनिस्टअरेट, अंडा, मूंगफली सैलूलोज आदि के उपयोग से झाग उत्पन्न कर सुखना। इससे कम तापमान पर तथा कम समय में संरक्षण क्रिया पूर्ण होती है।
- विकिरण विधि - (पराबैंगनी किरण) विकिरण की बहुत ही थोड़ी मात्रा से भोज्य पदार्थों के सूक्ष्म जीवों को तथा किण्वकों को नष्ट करना।

रासायनिक विधियां

- रासायनिक विज्ञान के नियमों, सिद्धांत का प्रयोग कर रासायनिक पदार्थ के गुण, धर्म का प्रयोग कर रासायनिक विधियां भोजन परीक्षण हेतु उपयोग में लाई जाती हैं जैसे-
- नमक का उपयोग - 18 से 20% नमक की उपस्थिति भोज्य पदार्थ में परासरण दबाव उत्पन्न कर संरक्षण का कार्य करती है।
- अम्लता का उपयोग - साइट्रिक एसिड, टार्टरिक, सिरका अम्ल के रूप में भोज्य पदार्थों में संरक्षण का कार्य करता है।
- शक्कर का उपयोग - 68 से 70% मात्रा में भोज्य पदार्थ में शक्कर मिलाई जाए तो सूक्ष्म जीव, किण्वक, प्रसारण दबाव से निष्क्रिय हो जाते हैं।
- तेल का उपयोग - तेल सूक्ष्म जीवों का प्रतिरोध एवं फफूंदी का निरोधक के रूप में संरक्षण करता है।
- रासायनिक संरक्षण- अनुज्ञा प्राप्त रासायनिक संरक्षण के रूप में सोडियम बेन्जोएट एवं पोटैशियम मेटाबाईसल्फाइट की बहुत थोड़ी मात्रा संरक्षण का काम करती है। सूक्ष्म जीव परिरक्षक उदाहरण -टाइलोसिन भोज्य पदार्थ में उत्पन्न कर संरक्षण किया जाता है।

किण्वन विधियां

किण्वन की प्रचलित विधियों में एंजाइम द्वारा शक्कर, स्टार्च का अपघटन कर अल्कोहल, कार्बन डाइऑक्साइड, एसिटिक एसिड या लैक्टिक एसिड बनकर संबंधित भोज्य पदार्थ को संरक्षित करते हैं।

- अल्कोहल किण्वन विधि - भोज्य पदार्थ जैसे -अनाज, शर्करा में खमीर द्वारा अल्कोहल एवं कार्बन डाइऑक्साइड बनाकर संरक्षण करना।
- एसिटिक एसिड किण्वन विधि- अल्कोहल में सिरका जीवाणु से एसिटिक अम्ल बनता है। 5 से 7% एसिटिक अम्लों सूक्ष्म जीवाणुओं को नष्ट कर संरक्षण करता है।

- लैक्टिक अम्ल किण्वन विधि - लैक्टोज पर लैक्टिक जीवाणु की क्रिया से लैक्टिक अम्ल बनता है ,जिससे परिरक्षण संभव है ।

अरोगाणुता की विधियां

अरोगाणुता की विधियां खाद्य संरक्षण हेतु एक प्रक्रिया है, जिससे भोज्य पदार्थ में सूक्ष्म जीवाणुओं का प्रवेश नहीं होने दिया जाता।

- सूक्ष्म जीवों का प्रवेश रोकने की विधि
- सूक्ष्मजीवों को ऑक्सीजन की पूर्ति न कर अक्रियाशील बनाना ।



खाद्य संरक्षण भोज्य पदार्थ

- सूखे फल व सब्जियां, हिमीकृत फल, मांस, सब्जियां डिब्बा बंद खाद्य पदार्थ, पेय पदार्थ, केचप सॉस, चटनी, जैम, जेली, मार्मलेड मुरब्बा, अचार आदि ।
- चिल स्टोरेज - व्यापारिक स्तर पर चीज, पनीर, अंडा, दूध, दही वह अन्य भोज्य पदार्थों को जिन्हे अल्प समय तक रखना है 35 डिग्री फारेनहाइट से 45 डिग्री फारेनहाइट पर चिल स्टोरेज में संरक्षित किया जाता है ।
- कोल्ड स्टोरेज - व्यापारिक स्तर पर लंबे समय तक मांस, मछली, अंडा, मक्खन, सब्जियां आदि को संरक्षित रखने के लिए कोल्ड स्टोरेज का उपयोग किया जाता है । इसमें 0 से 32 डिग्री फारेनहाइट तक तापमान रखा जाता है । इनका उपयोग बड़े व्यापारिक क्षेत्रों, जहाजों, देसी फार्मों में किया जाता है ।
- गैस संग्रहागार - फल व सब्जियां निरंतर जल व कार्बन डाइऑक्साइड गैस निष्कासित करते रहते हैं, जिससे उनकी ताजगी कम होती जाती है ,इस विधि में गैस का उपयोग करके भोजन को सड़ने से बचाया जाता है । फल, हरी पत्ते वाली सब्जियां, आलू, प्याज, अंडा, मांस आदि को काफी लंबे समय तक सुरक्षित रूप से संग्रहित करके रखा जाता है ।



घरेलू विधि

घर पर भी अनाज, दालों का भंडारण करने से पूर्व धूप में सुख लिया जाता है। नीम की सूखी पत्ती, नमक की डली हल्दी की गांठें, नींबू की पत्तियां, सदाबहार की पत्तियां, जो भी उपलब्ध है, उनका उपयोग किया जाता है इन्हें डालकर अनाज का भंडारण करते हैं। यह सामग्री स्वास्थ्य के लिए हानिकारक नहीं होती है, संग्रह के बर्तन हवा अवरुद्ध ढक्कन वाले होने चाहिए जिससे नमी, हवा अनाज में प्रवेश न कर सके।

उपसंहार

भोज्य पदार्थों के संरक्षण के द्वारा दैनिक आहार में विविधता लाई जा सकती है। जिससे भोजन की एकरसता समाप्त होती है, और व्यक्ति भोजन करने की इच्छा में वृद्धि होती है।

अचार, मुरब्बा, चटनिया, क्षुधावर्धक का कार्य करते हैं। आम व अन्य फलों का अचार, मुरब्बा, जैम, जेली के रूप में संरक्षण करके तथा हरी पत्तेदार सब्जियों को मौसम के समय सुखाकर पूरे वर्ष रोटी, पराठा या दाल आदि में मिश्रित कर भोजन का पोषण मूल्य बढ़ाया जा सकता है।

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