

BT 623 Research Methodology

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BT 623 Research Methodology (2-1-0-6)

Course contents:

Introduction: Definitions and objectives of research, types of research, research approaches, significance of research, main components of research process; Defining a research problem: reviewing the literature, framing the research problem, hypotheses; Data collection, analysis and interpretation: designing of experiments, data types, methods of data collection, repeatability, reproducibility and reliability, sampling methods, statistical analysis, displaying of data; Scientific writing: types of scientific report, structure and components of conference and journal articles and theses, arts of writing, ethics and scientific conduct, ethics in life science studies, plagiarism, copyright, intellectual property rights.

Lecture 1

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Research is a rigorous and systematic process of inquiry aimed at discovering, interpreting, and revising knowledge about a specific phenomenon. It involves the collection and analysis of data, testing of hypotheses, and the application of scientific methods to generate new insights or validate existing theories.

Research can be theoretical or applied, and it often follows ethical guidelines to ensure the validity and reliability of results. It serves to address questions, solve problems, and contribute to the body of knowledge across various disciplines.

Brief history of research: Different Civilizations and their contributions

Indus Valley Civilization: Known for advanced urban planning, including sophisticated drainage systems and standardized brick sizes. Early foundations of Ayurveda, an ancient system of medicine, were laid down by scholars in this civilization. The concept of zero and other mathematical innovations were later developed by Indian scholars.

Mesopotamia: Early researchers in Mesopotamia made significant advancements in writing, mathematics, and astronomy. The Sumerians, for example, developed one of the earliest writing systems and mathematical concepts.

Ancient Egypt: Egyptian researchers made crucial contributions in fields like medicine, mathematics, and engineering, evident in their impressive architectural achievements like the pyramids and advancements in medical practices.

Ancient China: Early Chinese research led to significant discoveries and inventions such as papermaking, gunpowder, and the compass. Chinese scholars also made important contributions to medicine, astronomy, and mathematics.

A peep into the diverse contributions from various cultures and periods, illustrating how research has evolved through the accumulation and integration of knowledge from different parts of the world.

Brief history of research: Different eras and its contributions

Classical Antiquity:

Ancient Greece: Greek philosophers and scientists, such as Socrates, Plato, and Aristotle, made foundational contributions to logic, ethics, and natural sciences. Aristotle's empirical approach and classification system were particularly influential.

Ancient India: Indian scholars developed early mathematical concepts, including zero and the decimal system, and made advances in astronomy and medicine. The works of scholars like Aryabhata and the Ayurveda texts are notable contributions.

Ancient Rome: Roman researchers focused on applied sciences, engineering, and medicine. Innovations in construction, such as aqueducts and roads, and advancements in medical knowledge were key areas of research.

Brief history of research: Different eras and its contributions

Middle Ages:

Islamic Golden Age (c. 8th–14th centuries): Scholars in the Islamic world preserved, expanded, and transmitted knowledge from previous civilizations. Notable figures like Alhazen (Ibn alHaytham) advanced the study of optics and experimental science, while Avicenna (Ibn Sina) made significant contributions to medicine and philosophy.

Medieval Europe: Scholasticism, a method of critical thought, was prominent, with scholars like Thomas Aquinas integrating classical knowledge with Christian theology. Monastic scholars also preserved ancient texts and contributed to the development of early scientific thought.

Renaissance and Enlightenment:

Scientific Revolution (16th–17th centuries): This period saw the formalization of the scientific method and major advancements in various fields. Figures like Galileo Galilei and Isaac Newton made groundbreaking contributions in physics, astronomy, and mathematics.

Philosophical Developments: Thinkers like Francis Bacon emphasized empirical evidence and the systematic approach to scientific inquiry, while René Descartes focused on rationalism and deductive reasoning.

Brief history of research: Different eras and its contributions

19th Century:

Industrial Revolution: The growth of industry led to rapid advancements in technology and scientific research. The establishment of research institutions and professional societies became more common, furthering innovation and specialization in various fields.

Darwin and Evolution: Charles Darwin's theory of evolution by natural selection represented a significant shift in biological research and understanding, demonstrating the power of systematic research in explaining natural phenomena.

20th Century to Present:

Modern Research Practices: The 20th century saw the refinement of the scientific method and the rise of interdisciplinary research. Advances in technology, such as computers and highthroughput techniques, revolutionized data collection and analysis.

Global Collaboration and Big Data: The advent of digital technologies and the internet facilitated global collaboration and the analysis of large datasets. Research has increasingly become a collaborative, interdisciplinary effort, addressing complex global challenges in fields such as genomics, artificial intelligence, and climate science.

A comprehensive framework of research phases, key innovations and the dominant sciences:
This framework highlights how research methodologies and dominating sciences have evolved through different phases, reflecting advancements in technology and the growing complexity of scientific inquiry.

Research 1.0: Traditional Research

Era: Pre 20th century

Characteristics: Research focused on fundamental observations, theoretical analysis, and early experimentation. Methods were often descriptive and qualitative.

Innovations:

Writing Systems: Early systems like cuneiform and hieroglyphics for recording observations.

Manual Instruments: Basic tools like the astrolabe and early microscopes.

Theoretical Models: Early theoretical frameworks in philosophy and natural sciences.

Dominating Sciences:

Philosophy: Early natural philosophy and ethics.

Astronomy: Observational astronomy using basic tools.

Medicine: Early forms of medical knowledge and herbal remedies.

A comprehensive framework of research phases, key innovations and the dominant sciences:

Research 2.0: Modern Research

Era: Early to mid 20th century

Characteristics: Formalization of research methodologies, systematic experimentation, and the growth of academic research institutions.

Innovations:

Scientific Method: Emphasis on hypothesis testing and controlled experiments.

Statistical Tools: Advanced statistical methods and tools (e.g., ANOVA, regression analysis).

Laboratories: Modern laboratories with advanced experimental setups.

Dominating Sciences:

Physics: Development of quantum mechanics and relativity.

Chemistry: Advances in organic and physical chemistry.

Biology: Progress in genetics and evolutionary theory.

A comprehensive framework of research phases, key innovations and the dominant sciences:

Research 3.0: Digital Research

Era: Late 20th century to early 21st century

Characteristics: Transformation of research through digital technologies and the internet, leading to new methods of data collection, storage, and analysis.

Innovations:

Computational Tools: Introduction of software for data analysis and modeling (e.g., MATLAB, R).

Digital Databases: Creation of online repositories and digital archives.

Internet and Communication: Enhanced collaboration through digital platforms.

Dominating Sciences:

Computer Science: Development of algorithms, software, and digital tools.

Information Technology: Advancements in data storage, retrieval, and communication.

Biotechnology: Growth in molecular biology and genomics.

A comprehensive framework of research phases, key innovations and the dominant sciences:

Research 4.0: Collaborative and Interdisciplinary Research (Current Phase)

Era: Early 21st century to present

Characteristics: Emphasis on collaborative, interdisciplinary approaches and open science to address complex global challenges.

Innovations:

Big Data Analytics: Technologies for handling and analyzing large datasets (e.g., Hadoop, Spark).

Collaborative Platforms: Tools for teambased research and data sharing (e.g., GitHub, Slack).

Open Access: Broader dissemination of research through openaccess publishing.

Dominating Sciences:

Data Science: Advanced techniques in data analysis and visualization.

Environmental Science: Research on climate change, sustainability, and ecosystems.

Health Sciences: Interdisciplinary approaches in public health and personalized medicine.

A comprehensive framework of research phases, key innovations and the dominant sciences:

Research 5.0: DataDriven and AIAugmented Research (Emerging Future Phase)

Era: Present and future

Characteristics: Integration of AI and machine learning into research practices, enabling advanced data analysis and realtime insights.

Innovations:

Artificial Intelligence and Machine Learning: Advanced algorithms for data analysis and predictive modeling (e.g., neural networks, deep learning).

Real Time Data Collection: IoT sensors and technologies for continuous data monitoring.

Virtual and Augmented Reality: VR and AR for immersive simulations and enhanced visualization.

Dominating Sciences:

Artificial Intelligence: Research in machine learning, neural networks, and automation.

Robotics: Development of intelligent systems and autonomous robots.

Systems Biology: Integration of complex biological systems and computational models.

Knowledge, Research and their interconnectedness

Knowledge and research are closely related but distinct disciplines. Knowledge encompasses understanding gained through various means, while research systematically generates, validates, and refines knowledge through structured methodologies. Research enriches and expands the scope of knowledge, ensuring its accuracy and applicability, while knowledge provides the context and foundation for further research. Their interplay drives the advancement of science, technology, and societal progress.

Knowledge

Knowledge is the awareness, understanding, or familiarity gained through experience, education, or personal insight. It encompasses facts, information, and skills acquired through various means.

Characteristics:

- *Dynamic*: Continuously evolving as new information and experiences are encountered.
- *Contextual*: Dependent on the context in which it is applied.
- *Subjective and Objective*: Can be based on personal perceptions (subjective) or verifiable facts (objective).

Research

Research is a systematic, structured process aimed at discovering new knowledge, validating existing knowledge, or solving specific problems. It involves rigorous methodologies to ensure the reliability and validity of findings.

Characteristics:

- *Systematic*: Follows structured methods and procedures.
- *Objective*: Aims for impartiality and minimization of bias.
- *Replicable*: Methods and findings should be reproducible by others.

Types of Knowledge:

1. Tacit Knowledge:

Description: Personal and contextspecific knowledge that is difficult to articulate. It is gained through experience and practice.

Examples: Craftsmanship, intuitive problemsolving skills, and personal expertise.

2. Explicit Knowledge:

Description: Knowledge that is easily documented, codified, and communicated. It includes structured information that can be written down or conveyed through media.

Examples: Textbooks, research papers, and standard operating procedures.

Sources of Knowledge:

Experience: Gained through direct engagement and practice.

Education: Acquired through formal instruction and learning.

Cultural Transmission: Passed down through traditions, practices, and social interactions.

Books and Media: Documented information available through publications and digital media.

Types of Research:

1. Basic Research:

Description: Conducted to increase fundamental understanding without immediate practical application.

Examples: Theoretical studies in physics or fundamental research in biology.

2. Applied Research:

Description: Focuses on solving practical problems and addressing specific issues with direct applications.

Examples: Development of new technologies, medical interventions, or engineering solutions.

3. Qualitative Research:

Description: Explores phenomena through nonnumerical data to understand concepts, experiences, and social contexts.

Examples: Interviews, focus groups, and ethnographic studies.

4. Quantitative Research:

Description: Involves numerical data and statistical analysis to identify patterns, relationships, and generalize findings.

Examples: Surveys, experiments, and longitudinal studies.

Knowledge and Research: The interconnection

Knowledge Creation:

Research contributes to the creation of new knowledge by discovering new facts, theories, and insights. Existing knowledge provides a foundation upon which research builds and refines.

Knowledge Application:

Research findings are often applied to solve real world problems and guide decision making. Applied knowledge from research can lead to new questions and further research.

Knowledge Enhancement:

Research enhances knowledge by providing rigorous methods for validation, refinement, and critical analysis, leading to more accurate and reliable understanding.

Knowledge Sharing:

Research disseminates findings through academic publications and other media, contributing to the broader body of knowledge and informing future research.

Evolution of Knowledge:

Both knowledge and research are dynamic, with research driving the continuous update and improvement of knowledge. This evolution adapts to new discoveries, technologies, and societal changes.

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Prof. Lingaraj Sahoo

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