Unit 1: Introduction

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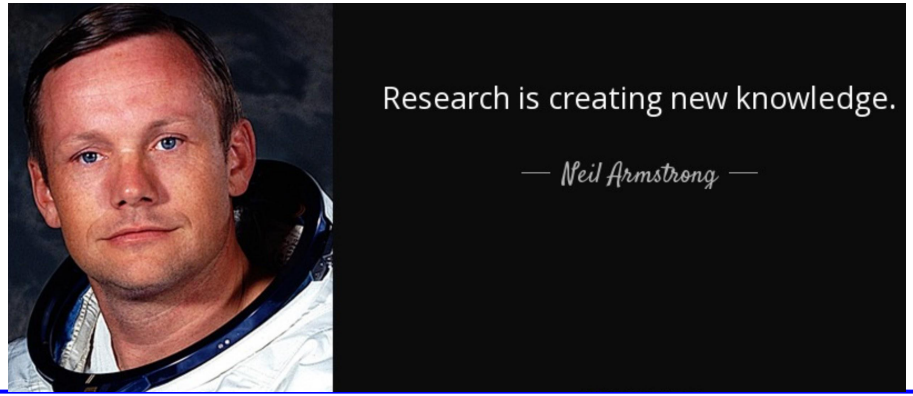
Contents

What is research?

- ➔ Research is a systematic investigation to discover new knowledge, validate existing facts, or solve problems.
- ➔ It involves data collection, analysis, and interpretation to reach meaningful conclusions.
- ➔ Research answers only those questions whose answers are not available in literature, i.e., in human knowledge
  - ◆ an original contribution to the existing stock of knowledge
- ➔ The most important process for advancing knowledge to promote progress.



What is research?

Why is Research Important?

- Expands knowledge
- Supports decision-making
- Solves real-world problems
- Drives innovation

Example:

- Medical research leads to new vaccines (e.g., COVID-19 vaccines).

Research Aim and Objectives

Aim = Big-picture goal (the "why")

- Example: "This study aims to reduce food waste in campus cafeterias."

Objectives = Steps to get there (the "how")

- Example:

1. Measure current food waste levels.
2. Interview students about eating habits.
3. Test 3 waste-reduction strategies.

Aim

Objectives

Research Aim and Objectives

How to Write a Strong Aim

Formula:

"To [action verb] [topic] in order to [impact]."

Examples:

- "To explore student stress levels to improve mental health services."
- "To compare ChatGPT and human tutors to identify learning gaps."

Tip: Avoid vague words like "understand" - be specific!

Research Aim and Objectives

How to Write SMART Objectives

Use the SMART criteria:

- Specific: "Survey 100 students" (not "ask people").
- Measurable: "Reduce waste by 20%."
- Achievable: Don't try to solve world hunger in 1 semester.
- Relevant: Don't study pizza toppings for a physics project.
- Time-bound: "Within 3 months."

Example:

"Improve grades." ❌

"Implement peer tutoring and measure grade changes by May." ✅

Research Aim and Objectives

Example 1: Real student

Topic: Sleep deprivation in college

- Aim: "To identify causes of poor sleep among freshmen."
- Objectives:
    1. Track 50 students' sleep with apps for 2 weeks.
    2. Interview 10 students about nighttime screen use.
    3. Compare GPA vs. sleep hours.

Research Aim and Objectives

Example 2: NLP

Topic: Fake news detection

• Aim: *"To improve transformer-based fake news classification using user engagement features."*

• Objectives:

1. Fine-tune BERT on LIAR dataset (baseline).
2. Incorporate metadata (retweets, account age) as auxiliary input.
3. Evaluate F1-score boost vs. text-only model on Reddit threads.

Research Aim and Objectives

Conclusion

RESEARCH AIMS VS. OBJECTIVES

	Aims	Objectives
Definition	General statements that describe the overall purpose of the research	Specific, measurable, and time-bound statements that describe the steps or tasks that need to be accomplished to achieve the research aims.
Focus	Big-picture goals of the research	Specific research tasks or activities that must be carried out to achieve those goals
Scope	Broader in scope and provide a general direction for the research	Narrower in scope and provide specific details about what the research will investigate and how it will be carried out
Context	Abstract and theoretical	Concrete and operational
Example	To investigate the impact of regular exercise on cardiovascular health.	1.Determining the impact of exercise on blood pressure, 2.Evaluating the impact of exercise on cholesterol levels, 3.Assessing the impact of exercise on the overall cardiovascular health of participants

Research Aim and Objectives

Common Mistakes

Too broad: "Study social media." ❌

Better: "Analyze Instagram's impact on study habits." ✅

Not measurable: "Understand climate change." ❌

Better: "Compare carbon footprints of electric vs. gas cars." ✅

Fix This Aim:

"To learn about exercise."

Class Votes:

A) "To compare gym vs. home workouts for stress relief."

B) "To exercise more."

C) "To prove exercise exists."

Features of Research

- Features of research" refer to the key characteristics that define high-quality, systematic, and valid research.
- These features ensure that the study is credible, useful, and ethically conducted.

Why Are Research Features Important?

- They help distinguish proper research from casual observations or opinions. For example:
  - Casual Statement: "I think students who study at night perform better." (Opinion, not research)
  - Research-Based Statement: "A study of 500 students found that night studiers scored 15% higher." (Follows research features)

Motivation of Research

- What makes people to undertake research? This is a question of fundamental importance.
- The possible motives for doing research may be either one or more of the following:

1. Desire to get a research degree along with its consequential benefits,
2. Desire to face the challenge in solving the unsolved problems,
3. Desire to get intellectual joy of doing some creative work,
4. Desire to be of service to society, and
5. Desire to get respectability.

However, this is not an exhaustive list of factors motivating people to undertake research studies.

Features of Research

1. Systematic Process: Research follows a structured, step-by-step method (not random).

Example:

Weak: Trying different fertilizers on plants randomly.

Systematic: Testing Fertilizer A on 50 plants and Fertilizer B on 50 others under controlled conditions.

2. Logical: Uses facts, data, and reasoning (not guesses).

Example:

Illogical: "Social media causes depression because I feel sad after scrolling."

Logical: "A meta-analysis of 20 studies shows a 30% higher depression risk in heavy social media users."

Features of Research

3. Empirical (Based on Observation/Experiments): Relies on real-world data, not just theories.

Example:

Non-empirical: "AI will replace doctors someday." (Speculation)

Empirical: "In 100 surgeries, AI-assisted robots reduced errors by 40% compared to human-only teams."

4. Replicable: Others should be able to repeat the study and get similar results.

Example:

Unreplicable: "A mysterious herb cures headaches." (No method provided)

Replicable: "In a double-blind trial, 200mg of herb X reduced headache duration by 50% (method: RCT, n=100)."

Features of Research

5. Objective (Unbiased): Avoids personal opinions; focuses on neutral analysis.

Example:

Biased: "Our company's product is the best!"

Objective: "Third-party tests show our product is 10% faster than competitors!"

6. Generalizable: Findings should apply beyond the study sample.

Example:

Non-generalizable: "5G is safe because my friend's phone didn't harm him."

Generalizable: "A study of 10,000 5G users found no adverse health effects (95% CI)."

Features of Research

7. Ethical: Protects participants' rights (consent, privacy, no harm).

Example:

Unethical: Testing a drug on patients without telling them.

Ethical: Getting informed consent and FDA approval before trials.

Types of Research

Research can be of the following types:

1. Descriptive versus Analytical
2. Applied versus Fundamental
3. Quantitative versus Qualitative
4. Conceptual versus Empirical

Types of Research: Descriptive versus Analytical

Descriptive Research

A type of research carried out to **describe** characteristics, behaviors, or phenomena as they exist without manipulation.

Methods: surveys and fact finding enquiries.

Key Features:

- Focuses on "What?" (e.g., current trends, patterns).
- The researcher has no control over the variables; he can only report what has happened or what is happening.
- Often used in market research, sociology, and network analysis.

Types of Research: Descriptive versus Analytical

Descriptive Research: Example in Wireless Communication:

Study: "4G Network Coverage in Urban City of Nepal"

Method: Collect signal strength (RSRP, SINR) data from 500 base stations.

Outcome: "Midtown Kathmandu has 98% coverage, while Pokhara has 75% due to fewer towers."

• Industry Use: Helps telecom companies identify dead zones for infrastructure upgrades.

Types of Research: Descriptive versus Analytical

Analytical Research

A type of research carried out to **examine** why or how something happens by **analyzing** relationships between variables.

Methods: comparative studies, correlation analysis, experiments, and simulations.

Key Features:

- Focuses on "Why?" (e.g., root causes, influencing factors).
- Often involves hypothesis testing.
- Used in **engineering**, medicine, and economics.

Types of Research: Descriptive versus Analytical

Analytical Research: Example in Wireless Communication:

Study: "Why Does 5G mmWave Have Poor Indoor Penetration?"

Method: Test mmWave signals against different building materials (concrete, glass, wood).

Outcome: "Concrete walls attenuate mmWave signals by 30 dB, requiring indoor repeaters."

• Industry Use: Guides antenna placement and small-cell deployment strategies.

Types of Research: Applied versus Fundamental

Applied Research

A type of research carried out to **solve** specific, practical problems with immediate real-world applications.

Methods: Prototyping, field trials, clinical tests, and optimization algorithms.

Key Features:

- Goal-oriented (e.g., improving a product or process).
- Funded by industries and governments for direct implementation.

Types of Research: Applied versus Fundamental

Applied Research: Example in Wireless Communication:

Project: "AI-Based Beamforming for Stadiums"

Method: Use machine learning to dynamically steer antennas toward high-density crowds.

Outcome: "Data speeds improved by 50% during the Super Bowl."

• Industry Use: Deployed by Ericsson and Nokia for large venues.

Types of Research: Applied versus Fundamental

Fundamental Research

A type of research carried out to expand theoretical knowledge without immediate practical use.

Methods: mathematical modeling, lab experiments, and theoretical physics.

Key Features:

- Explores "What if?" questions.

Lays the foundation for future technologies (e.g., quantum computing).

Types of Research: Applied versus Fundamental

Fundamental Research: Example in Wireless Communication:

Study: "Terahertz (THz) Communication for 6G"

Method: Simulate THz wave propagation in different atmospheric conditions.

Outcome: "THz offers 100 Gbps speeds but is absorbed by oxygen molecules."

• Industry Use: Samsung and Huawei invest in THz research for 6G networks.

Types of Research: Quantitative versus Qualitative

Quantitative Research

A type of research carried out to measure variables and generalize results using numerical data.

Methods: Surveys with closed-ended questions, experiments, statistical analysis.

Key Features:

- Uses metrics, percentages, and statistical models.
- Common in engineering, finance, and network performance testing.

Types of Research: Quantitative versus Qualitative

Quantitative Research: Example in Wireless Communication:

Experiment: "Latency Comparison: 5G vs. 4G"

Method: Measure ping times for 1,000 devices on both networks.

Outcome: "5G averages 5ms latency; 4G averages 50ms."

Industry Use: Used by carriers to market 5G's speed advantage.

Types of Research: Quantitative versus Qualitative

Qualitative Research

A type of research carried out to explore meanings, experiences, and social contexts in depth.

Methods: interviews, focus groups, ethnography, and case studies.

Key Features:

- Focuses on "How do people feel?" rather than numbers.
- Used in user experience (UX) research and policy-making.

Types of Research: Quantitative versus Qualitative

Qualitative Research: Example in Wireless Communication:

Study: "Why Do Users Distrust 5G Health Claims?"

Method: Interview 50 people about their concerns over radiofrequency (RF) exposure.

Outcome: "Most fear radiation but lack scientific literacy on RF safety."

Industry Use: Helps regulators design better public awareness campaigns.

Types of Research: Conceptual versus Empirical

Conceptual Research

A type of research carried out to develop new theories, models, or frameworks without testing.

Methods: Literature reviews, thought experiments, and theoretical proposals.

Key Features:

- Often published as white papers or academic articles.
- Used in philosophy, economics, and futuristic tech (e.g., 6G).

Types of Research: Conceptual versus Empirical

Conceptual Research: Example in Wireless Communication:

Paper: "A Blockchain-Based Spectrum Sharing Model for 6G"

Method: Propose a decentralized system for dynamic spectrum allocation.

Outcome: Published in IEEE Journal as a visionary framework.

Industry Use: Inspires startups to explore blockchain for telecom.

Types of Research: Conceptual versus Empirical

Empirical Research

A type of research carried out to validate hypotheses using observable, measurable evidence.

Methods: Experiments, fieldwork, and data collection.

Key Features:

- Relies on real-world testing (not just simulations).
- Critical for product validation and regulatory compliance.

Types of Research: Conceptual versus Empirical

Empirical Research: Example in Wireless Communication:

Trial: "Testing Drone-Based LTE Networks in Disaster Zones"

Method: Deploy drones with LTE base stations after a hurricane.

Outcome: "Drones restored communication for 10,000 users within 24 hours."

Industry Use: Adopted by FEMA for emergency response.

The 6Ps of Research

The various aspects of research can be categorized as the 6Ps:

1. Purpose,
2. Products,
3. Process,
4. Participants,
5. Paradigm and
6. Presentation

- You should take care of all of these aspects in any research project.
- To ensure it's well-planned, ethical, and impactful.

The 6Ps of Research: Purpose

- Purpose (Why?)
- Purpose is the goal of your research—what problem are you solving?
- Without a clear purpose, research can become directionless.

Example:

- Purpose: "Make smartphone batteries last longer."
- Why? People hate charging phones multiple times a day.

- Purpose: "Find a faster way to detect COVID-19."
- Why? Slow tests delay treatment and spread the virus.

The 6Ps of Research: Products

- Product (What?)
- The tangible outcome of your research—what are you creating?
- Research should produce something useful (a tool, theory, or solution).

Example:

- Product: A new AI chip that speeds up video calls.
- How? By optimizing neural networks for real-time processing.

- Product: A drone that detects crop diseases early.
- How? Using infrared cameras + machine learning.

The 6Ps of Research: Products

- Davis and Parker (1997) summarize the different types of contributions to knowledge as:
  - new or improved evidence;
  - new or improved methodology;
  - new or improved analysis;
  - new or improved concepts or theories.
- To this we can add:
  - new or improved computer-based product.

Note: A thesis, dissertation, conference paper or journal article is also a product of your research — usually these are the means by which your knowledge outcomes are disseminated to the wider academic community.

The 6Ps of Research: Process

- Process (How?)
- The step-by-step method you'll use to achieve your goal.
- A clear process ensures your results are reliable.

Example:

- Process:
  a. Survey developers about coding challenges.
  b. Build a new debugging tool.
  c. Test it with 100 programmers.
- Outcome: "Tool reduces bug-fixing time by 40%.

Example:

- Process:
  a. Collect air samples from 10 cities.
  b. Analyze microplastic levels.
  c. Compare to health data.
- Outcome: "Higher microplastics link to lung issues."

The 6Ps of Research: Participants

- Participants (Who?)
- The people involved—researchers, test subjects, or data sources.
- Ethical treatment of participants is critical.
- Directly involvement: by interviewing them or observing them
- Indirectly involvement: editors to whom you submit a research paper

Example: In medical research

- Participants: 100 patients testing a new diabetes drug.
- Ethics: They must give informed consent and can quit anytime.

Example: In AI Research

- Participants: 1,000 online users whose data trains a chatbot.
- Ethics: Data must be anonymous to protect privacy.

The 6Ps of Research: Paradigm

- Paradigm (Approach?)
- A pattern or model or shared way of thinking hat shapes research approach
- Need for a ‘paradigm shift’ to mean that a new way of thinking is required

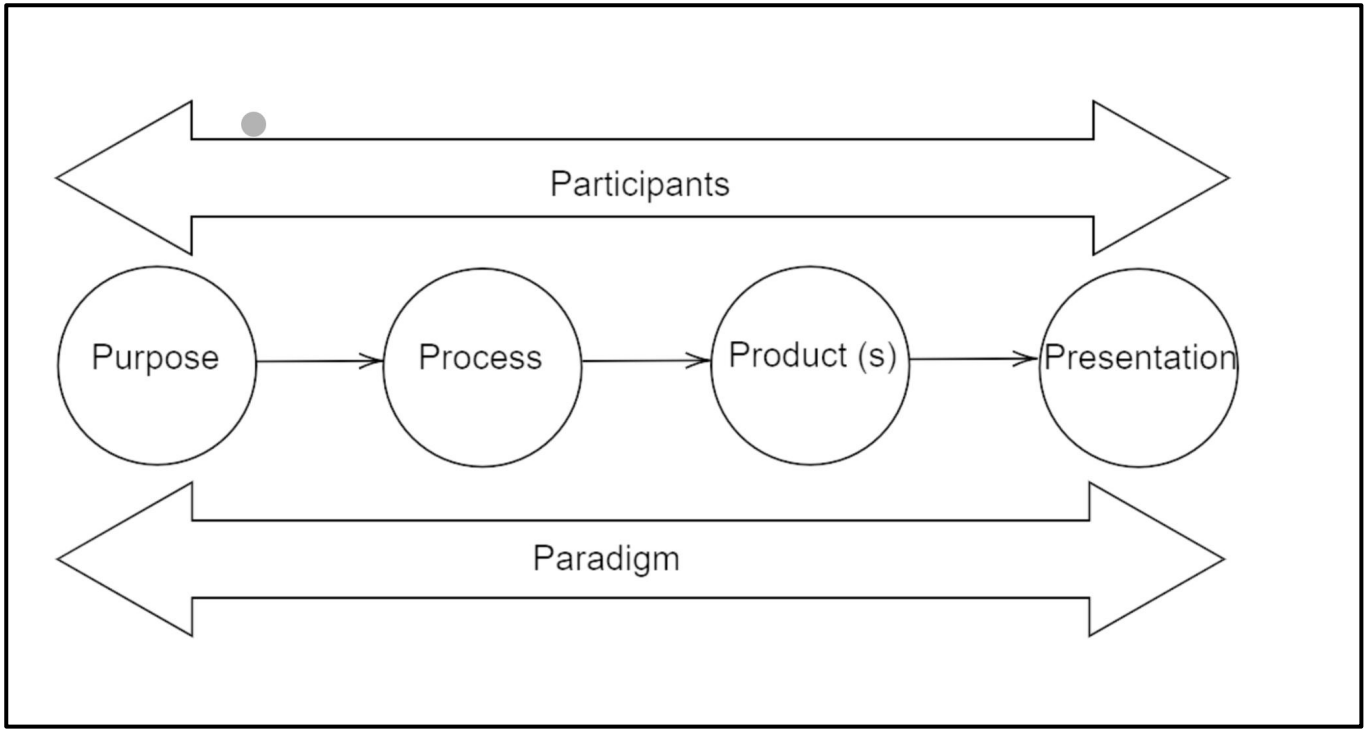
The 6Ps of Research: Presentation

- Presentation (Sharing?)
- How you'll communicate results (report, video, conference, etc.).
- Means by which research is disseminated and explained to others.
- Even great research fails if no one understands it.

Example:

- Presentation: Publish a paper at an AI conference.

The 6Ps of Research: Diagram view



Research and Project

Both structured activity but they serve different purpose, follow different method, and produce different outcome.

Research and Project

Research

1. Definition: Systematic investigation to discover new knowledge or validate existing theories.

   Example: Studying how AI can predict earthquakes using seismic data." (Seeks new knowledge)

2. Primary Goal: To explore, explain, or prove something (theoretical or empirical).

   Example: Does 5G radiation affect human cells?" (Seeks answers)

Project

1. Definition: A planned task or activity to achieve a specific goal, often using existing knowledge.

   Example: Building an AI-based earthquake alert system." (Applies existing knowledge)

2. Primary Goal: To create, implement, or deliver something practical (product, service, solution).

   Example: Installing 5G towers in a city." (Delivers infrastructure)

Research and Project

Research

3. Nature of Work: Open-ended - May not have a predefined outcome.

Example: "Can quantum computers break RSA encryption?" (Uncertain outcome)

4. Method used: Follows scientific methods (experiments, surveys, simulations).

Example: Clinical trials for a new drug (hypothesis testing).

Project

3. Nature of Work: Goal-oriented - Has a clear deliverable (e.g., software, building, report).

Example: "Developing a quantum-resistant encryption algorithm." (Fixed deliverable)

4. Method used: Follows management methodologies (Agile, Waterfall, Six Sigma).

Example: Mass-producing and distributing the drug (logistics planning).

Research and Project

Research

5. Time Frame: Flexible timeline - Can take years (no fixed deadline).

Examples:

"Studying climate change effects over 10 years." (Long-term)

6. Outcome: Produces knowledge (theories, findings, publications).

Example: A paper on "Neural Networks for Cancer Detection." (Knowledge)

Project

5. Time Frame: Fixed timeline - Must finish by a set date (e.g., construction deadline).

"Building a solar power plant in 18 months." (Time-bound)

6. Outcome: Produces tangible results (products, services, infrastructure).

Example: A hospital AI tool that diagnoses cancer from X-rays. (Product)

Research versus Project

	Research	Project
Purpose	generate new knowledge	achieve specific goals or objectives
Approach	a systematic inquiry process	a structured project management approach
Scope	focus on theoretical exploration	specific objectives to accomplish
Outcomes	new insights, theories, or empirical evidence	tangible deliverables or outputs

End of Chapter 1
Any Questions???