# Week 1: Chapter 2

## The Nature of Knowledge

# Chapter Objectives

- Understand the difference between knowledge, data, and information
- Explain the alternative views of knowledge
- Understand the different types of knowledge
- Recognize the various locations of knowledge

# What is Data?

- Data represents raw numbers or assertions
- Data comprises facts, observations, or perceptions
- Data lacks context, meaning or intent.

- Data is just bits: lots of zeros and ones.

# What is Data?

- **Example 1.** Bits representing a restaurant sales order including two large burgers and two medium-sized soft drinks.
- **Example 2.** One bit representing the observation that a tossed coin lands on heads.
- **Example 3.** 64 bits representing the wind component (*u* and *v*) coordinates for a particular typhoon's trajectory at specific instances of time.
  - Typhoon: a very violent tropical *storm*
  - Trajectory: the *path* described by a projectile flying or an object moving under the action of given forces.

# What is Information?

- *Information* is data with context and relevance
  - In contrast, data can include millions of useless garbage bits, which are nothing more than uninterpretable zeros and ones
- Information involves manipulation of raw data
  - Often, information can be used to obtain a more meaningful indication of trends or patterns
- Information is data with semantics.

# What is Information?

- **Example 1.** For the restaurant manager, numbers that he understands to indicate the daily sales of burgers and soft drinks.

- **Example 2.** Assume the context is a bet:
  - John offers to *pay* $10 for heads and *take* $8 for tails.
  - Susan understands that the last 100 tosses included 40 heads and 60 tails.
  - This is much more information than the outcome of a single toss, and can be interpreted to compute an expected value. (Information theory!)

- **Example 3.** A series of *u* and *v* components can be interpreted by storm software models to create a forecast of the typhoon trajectory.

# What is Knowledge?

- *Knowledge* is information with decision-making and action-directed utility and purpose
- Knowledge is defined by some as “a justified true belief” (Nonaka and Takeuchi 1995)
- Different from data & information
  - Knowledge is at the highest level in a hierarchy with information at the middle level, and data to be at the lowest level
  - It is the richest, deepest & most valuable of the three

- Knowledge is information with direction.

# What is Knowledge? (1)

- **Example 1.** The daily sales of burgers (plus other information like the amount of bread in the inventory) can be used to compute the amount of bread to buy (which is still information, but is more valuable information).
  - The *relationship* between the quantity of bread to be ordered, the quantity of bread currently in the inventory, and the daily sales of burgers (and other products that use bread) is knowledge.

# What is Knowledge? (2)

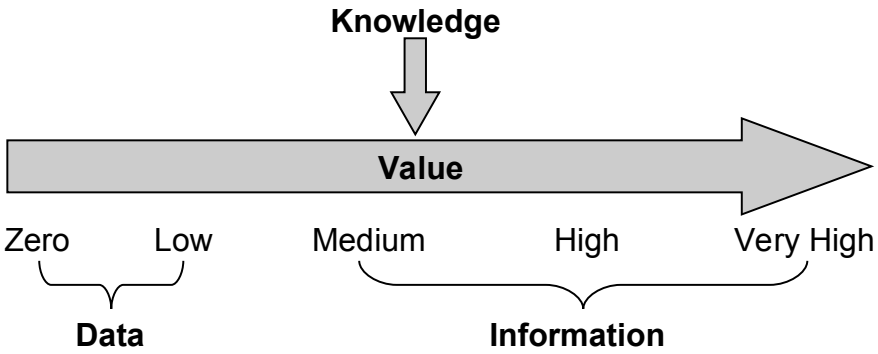
- **Example 2.** The expected value of the bet is still information, but is more valuable information.
  - The *relationship* between the probability of heads, the number of times the coin lands heads, and the total number of tosses (probability theory) is knowledge.

# What is Knowledge? (3)

- **Example 3.** The knowledge of a storm researcher as to the *relationship* of a series of *u* and *v* components to the probability of trajectories is used to predict a specific typhoon trajectory.

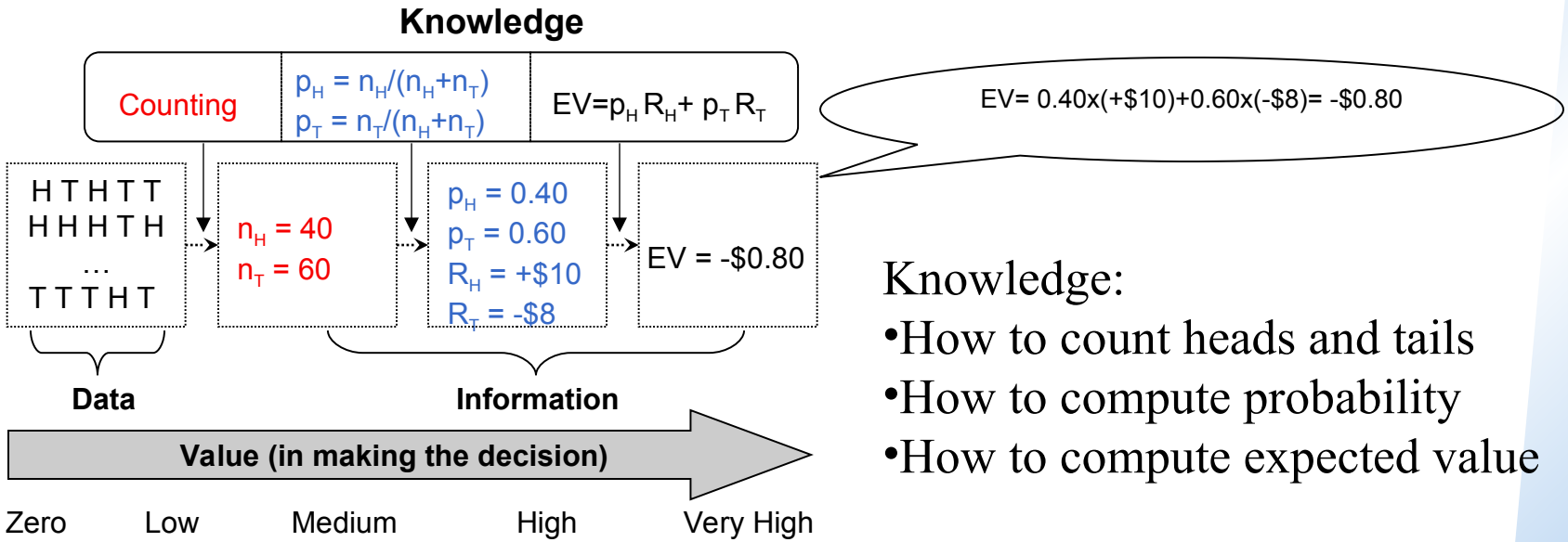
# Data, Information, and Knowledge

- Knowledge is information that helps to
  - *produce* information from data, or
  - *produce* more valuable information from less valuable information



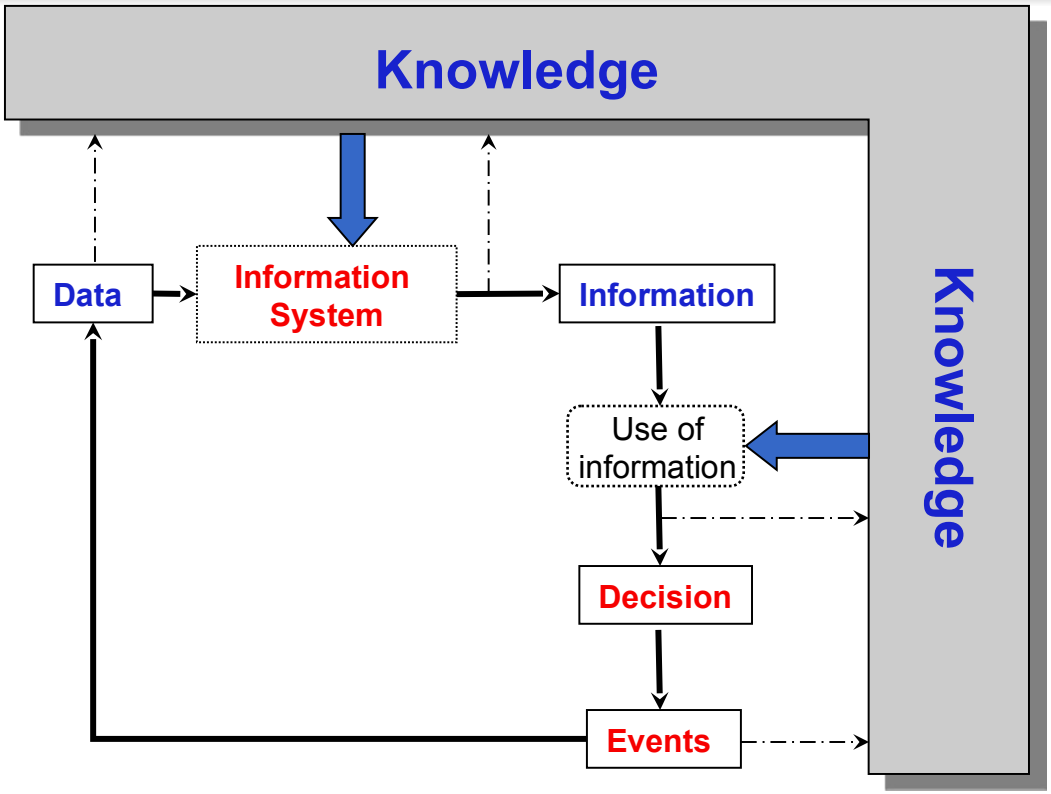
# Data, Information, and Knowledge: coin toss Example

- John offers $10 for head and -$8 for tail
- Last 100 toss is taken.
- help Suzan to take the decision of whether to participate in the bet?




Knowledge:
- How to count heads and tails
- How to compute probability
- How to compute expected value

# Data, Information, Knowledge and Events




Knowledge helps in producing information from data.
Knowledge is used with information to take decisions.
Decisions lead to events that produce more data

# Knowledge as Know-How

- Know-how distinguishes an expert from a novice
- Experts represent their know-how in terms of heuristics, based on experience
- Know-how is not book knowledge; it is practical experience

# Reasoning and Heuristics

Humans reason in a variety of ways:

- *Reasoning by analogy*: relating one concept to another
- *Formal reasoning*: using deductive or inductive methods
- *Case-based reasoning*: reasoning from relevant past cases

# Deductive and inductive reasoning

- *Deductive reasoning:* exact reasoning. It deals with exact facts and exact conclusions
- *Inductive reasoning*: reasoning from a set of facts or individual cases to a general conclusion

# Knowledge -Information Cycle

- Need to systematically identify, generate, acquire, diffuse, and capture the benefits of knowledge that provide a strategic advantage
- Clear distinction must be made between information – which is digitizable, and knowledge – which exists only in intelligent systems
  - Knowledge-information cycle looks at how information is transformed into knowledge and vice versa via creation and application processes

# Types of Knowledge

- **e·pis·te·mol·o·gy** *n.* The branch of philosophy that studies the nature of knowledge, its presuppositions and foundations, and its extent and validity.

  (*American Heritage Dictionary of the English Language, Fourth Edition*)
- Epistemology is a very old field with a long history.
- There are many classifications and characterizations of types of knowledge, e.g.:
  - individual, social, causal, conditional, relational and pragmatic
  - embodied, encoded and procedural
  - etc.
- *We must know what knowledge is, if we wish to manage it effectively!*

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# Perspectives of Knowledge

- Subjective view
  - Knowledge as a state of mind
  - Knowledge as practice
- Objective view
  - Knowledge as an object
  - Knowledge as access to information
  - Knowledge as capbility

# Subjective View of knowledge (1)

- dependent on human perception, and is socially constructed through interactions with individuals.
  - Knowledge has no existence independently of social practices and human experiences.
  - Knowledge is not an independent object.
  - Knowledge has no single location.
  - Knowledge is viewed as an ongoing accomplishment, which continuously affects and is influenced by social practices.

# Subjective View of knowledge (2)

- Knowledge as State of Mind
  - Beliefs of individuals within the organization
  - Various individuals have differing experiences and backgrounds → knowledge differs from one another.
  - We would like to enhance knowledge of individuals so that they can apply them to best pursue organizational goals
- Knowledge as Practice
  - Knowledge is held by a group not individuals
  - Beliefs are collective and reflected in organizational activities

# Objective View of knowledge

- According to the objective view, reality is independent of human perceptions and can be structured in terms of *a priori* categories and concepts.
  - Knowledge can be located.
- Knowledge as Objects
  - Something that can be stored, transferred, and manipulated.
- Knowledge as Access to Information
  - Knowledge enables access and utilization of information.
- Knowledge as Capability
  - Not merely access to information – instead, emphasizes knowledge as a strategic capability that can potentially be applied to seek a competitive advantage.

# Types of Knowledge

- Knowledge are classified as:
  - (2) Procedural or Declarative
  - (2) Tacit or Explicit
  - General or Specific
    - (3) General, Technically Specific or Contextually Specific

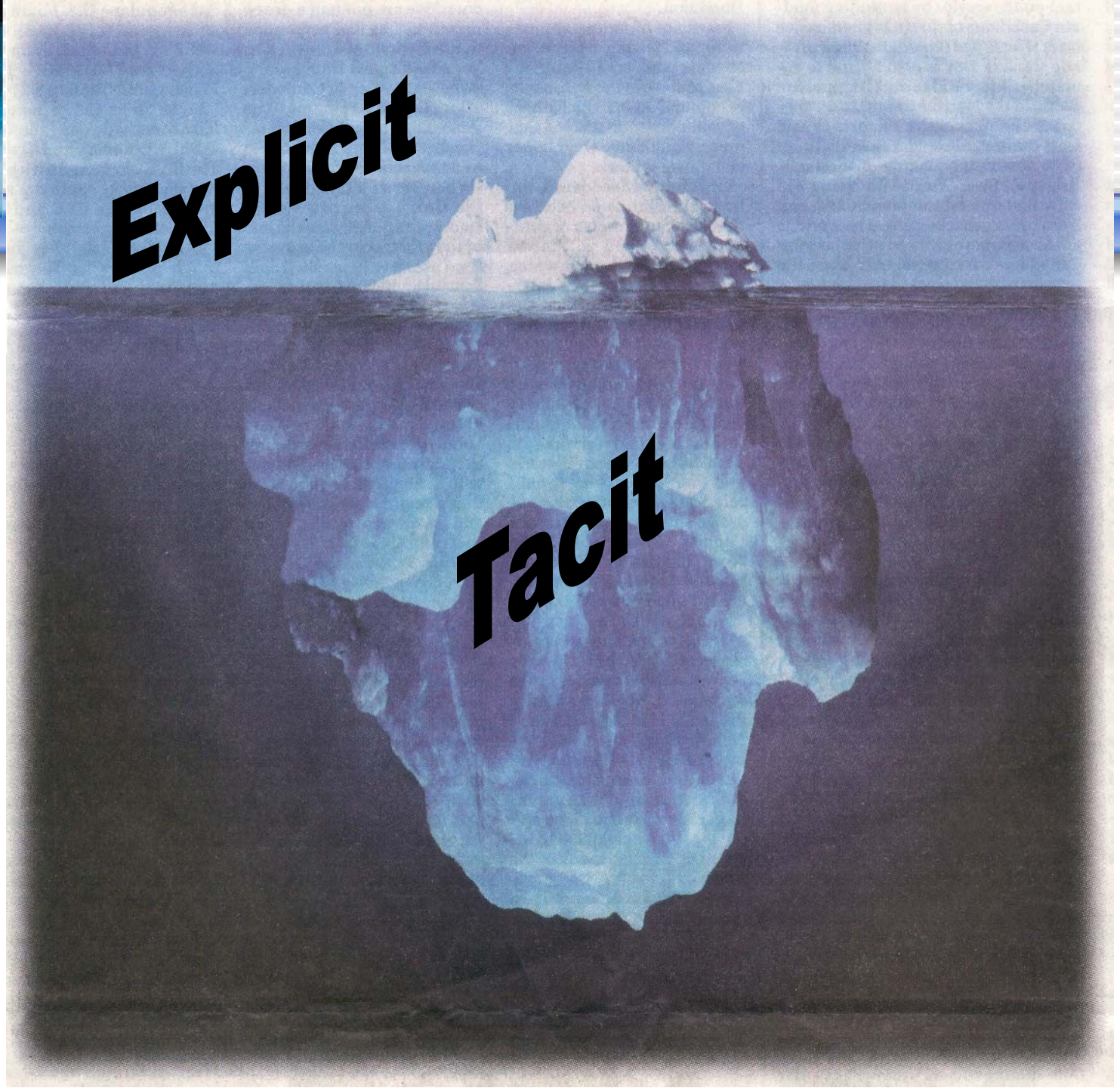
- We have 12 (2 x 2 x 3) types of knowledge

# Procedural vs. Declarative Knowledge (1)

- *Declarative knowledge* (or *substantive knowledge*) focuses on beliefs about relationships among variables.
  - e.g., "all other things being equal, greater price charged for a product would cause some reduction in its number of sales"
  - Can be stated in the form of logical propositions, expected correlations, or formulas relating concepts represented as logical symbols and/or mathematical variables.
  - Often characterized in KM circles as "know-what".

# Procedural vs. Declarative Knowledge (2)

- *Procedural knowledge* focuses on beliefs relating procedures or processes: sequences of steps or actions to desired (or undesired) outcomes.
  - e.g., the procedure that should be followed in a government organization in deciding on whom to ward the contract for a particular area (e.g., information system development)
  - Often characterized in KM circles as "know-how".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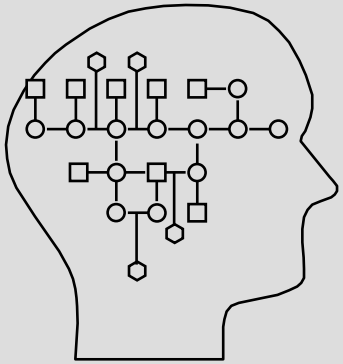
# Tacit vs. Explicit Knowledge (1)

## Tacit Knowledge



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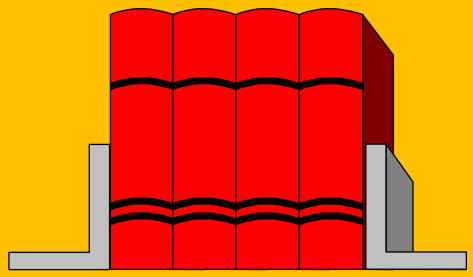
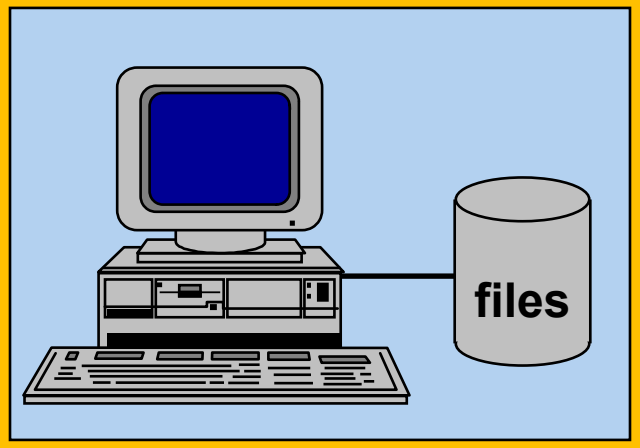


## Explicit Knowledge

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# Procedural vs. Declarative: Automobile Manufacturing Example

- *Declarative knowledge regarding quality/cost optimization*
  - Effect that quality of each component would have on final product
  - Reliability, fuel consumption, deterioration over time, quality of the ride
  - Set of components needed for each model
  - Prices of various alternatives for each component

- *Procedural knowledge regarding assembly process*
  - Steps in engine assembly process
  - Which tasks can be performed in parallel
  - Amount of time each step should take
  - Amount of waiting time between successive steps

# Tacit vs. Explicit Knowledge (1)

- *Explicit knowledge* refers to knowledge that has been expressed into words and numbers
  - e.g., basic principles for stock market analysis as in a textbook
    - Such knowledge can be used by investors to make buy/sell decisions
  - Can be shared formally and systematically in the form of data, specifications, manuals, drawings, audio or videotapes, computer programs, patents, etc.

# Tacit vs. Explicit Knowledge (2)

- *Tacit knowledge* includes insights, intuitions, and hunches, that are not verbalized or documented
  - e.g., stock market analysts who make recommendations to investors concerning likely short-term and long-term market trends within some industry, based on years of observation
  - Difficult to express and formalize
  - Therefore often difficult to share (can't tell somehow how to do it!)
- We can convert explicit knowledge to tacit knowledge and the vice versa

# Tacit vs. Explicit Knowledge (3)

- We often convert explicit knowledge to tacit knowledge
  - e.g., when an individual reads a book and learns from it (but not by rote memorization, which would still be explicit knowledge)
- We can sometimes convert tacit knowledge to explicit knowledge
  - e.g., when an individual with lots of tacit knowledge writes a book formalizing that knowledge
  - Often a difficult conversion that requires hard efforts!

# General vs. Specific Knowledge

- *General knowledge* is possessed by a large number of individuals and can be transferred easily across individuals
  - e.g., headache is one symptom of brain hemorrhage

- *Specific knowledge*, or "*idiosyncratic knowledge*", is possessed by a very limited number of individuals, and is expensive to transfer
  - e.g., how to operate on a patient suffering a stroke.
    - *stroke (ILLNESS): if someone has a stroke, an artery (=tube carrying blood) in their brain suddenly bursts or becomes blocked, so that they may die or be unable to use some muscles*
  - Two types of SK: Technically specific and Contextually specific

# Technically vs. Contextually Specific Knowledge

- *Technically specific knowledge* is deep knowledge about a specific area.
  - Includes tools and techniques for solving problems in that area.
  - Often acquired via formal training + experience in the field.
    - e.g., scientific knowledge possessed by a physicist
    - e.g., knowledge about computer hardware possessed by an engineer

- *Contextually specific knowledge* refers to the knowledge of particular circumstances of time and place in which work is to be performed.
    - e.g., the detailed knowledge that design engineers possess about the idiosyncrasies of the particular design group in which they are working
      - Idiosyncrasy: an unusual or unexpected feature that something has
    - e.g., a basketball forward's detailed knowledge of the team's center
  - Cannot be acquired through formal training.

# Examples of the Different Types of Knowledge– 12 types

| | | General | Contextually Specific | Technically Specific |
|---|---|---|---|---|
| Declarative | Explicit | A book describing factors to consider when deciding whether to buy a company's stock. This may include price to earnings ratio, dividends | A company document identifying the circumstances under which a consultant team's manager should consider replacing a team member who is having problems with the project. | A manual describing the factors to consider in configuring a computer so as to achieve performance specifications |
| | Tacit | Knowledge of the major factors to consider when deciding whether to buy a company's stock. | A human relations manager's knowledge of factors to consider in motivating an employee in a particular company. | A technician's knowledge of symptoms to look for in trying to repair a faulty television set. |
| Procedural | Explicit | A book describing steps to take in deciding whether to buy a company's stock. | A company document identifying the sequence of actions a consultant team's manager should take when requesting senior management to replace a team member having problems with the project. | A manual describing how to change the operating system setting on a computer so as to achieve desired performance changes. |
| | Tacit | Basic knowledge of the steps to take in deciding whether to buy a company's stock. | A human relations manager's knowledge of steps to take in motivating an employee in a particular company. | A technician's knowledge of the sequence of steps to perform in repairing a television set. |

# Knowledge and Expertise

- *Expertise* can be defined as knowledge of higher quality
- An “expert” is one who is able to perform a task much better than others. The difference lies in the depth of his expertise when compared with that of the others from his own domain.
- Often, an expert possesses many different types and levels of knowledge
- Expertise is within a *domain* and Domains can be of various degrees of sophistication
  - expert brain surgeon > medical intern
  - expert mathematician > secondary school math student
  - expert bus driver > novice driver

# Types of Expertise

- Associational Expertise
- Motor Skills Expertise
- Theoretical (Deep) Expertise

# Types of Expertise: Associational Expertise

- In most fields: desirable for experts to have detailed understanding of underlying theory
- But not always necessary!
  - e.g., TV repairman
    - can fix nearly all common problems
    - but does not understand transistor theory or CRT/LCD/plasma display theory
    - works mainly by *associating* observations of performance/symptoms to specific repair actions
    - based on experience, rather than analysis
- Can have expert-level *associational* knowledge
- May not understand the inner workings of the device
  - may not know how to proceed when encountering a new, previously unseen problem
  - may not be able to invent or design new devices well

# Types of Expertise: Motor Skills Expertise

- Motor skill knowledge is predominantly physical rather than cognitive
- Humans learn this type of knowledge via repeated performance (practice), E.g.,
  - Riding a bicycle
  - Kicking a football
  - Wakeboarding or water skiing
- Expert reactions seem spontaneous and automatic
  - From encountering thousands of past instances
  - A small amount of conscious thinking is still necessary…
  - … but too much conscious thinking can actually degrade performance

# Types of Expertise: Theoretical (Deep) Expertise

- Finding solutions to technical problems often requires going beyond a superficial understanding of the domain
- Must apply creative ingenuity
- Based on theoretical knowledge of the domain
- Cannot be solved via associational expertise
- Acquired via formal training and hands-on problem solving
- Very easily forgotten unless continually used, due to theoretical and often abstract nature
- E.g., engineers and scientists

# More Types of Knowledge

# Types of Knowledge:
## Knowledge Complexity

- Simple knowledge focuses on one basic area
- Complex knowledge draws upon multiple distinct areas of expertise

# **Types of Knowledge:** Role of Knowledge within Organizations

- Support knowledge relates to organizational infrastructure and facilitates **day-to-day** operations
- Tactical knowledge pertains to the **short-term** positioning of the organization relative to its markets, competitors, and suppliers
- Strategic knowledge pertains to the **long-term** positioning of the organization in terms of its corporate vision and strategies for achieving that vision

# Characteristics of Knowledge

- Explicitness
- Codifiability
- Teachability
- Knowledge Specificity

# Explicitness of Knowledge

- *Explicitness* refers to the extent to which knowledge exists in an explicit form (as opposed to a tacit form).

# Codifiability and Teachability of Knowledge

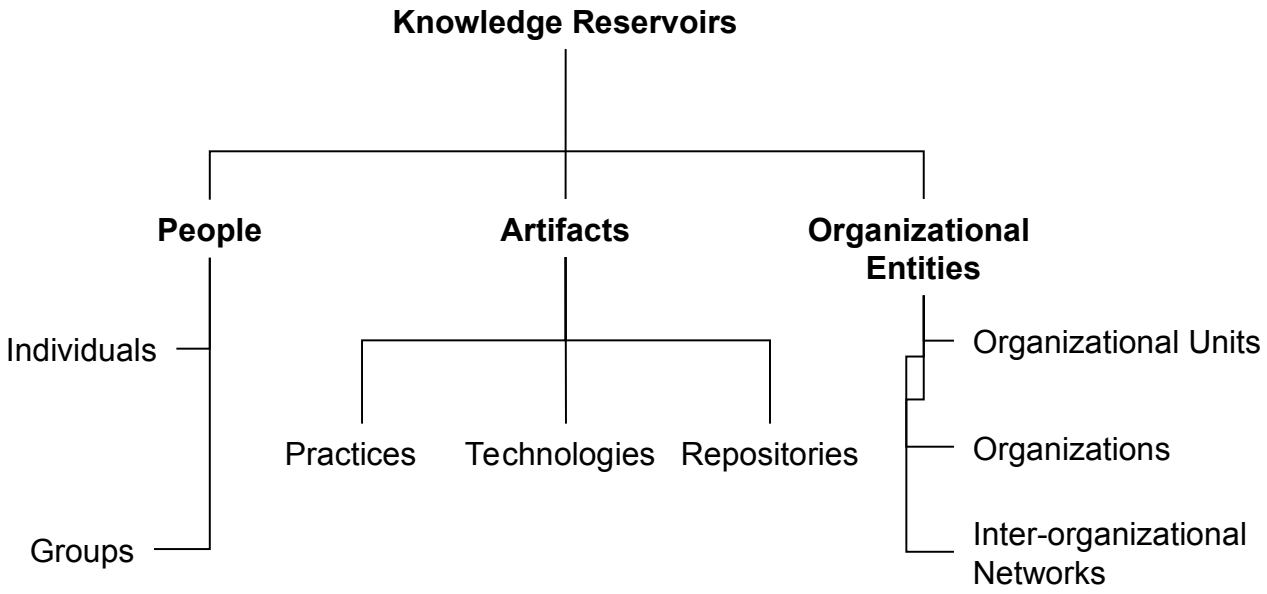
- *Codifiability* reflects the extent to which knowledge can be articulated or codified (i.e., made explicit) …
  - even if the resulting codified (explicit) knowledge might be difficult to teach to another individual …
  - e.g., it's hard to teach the explicit knowledge of how to fix PC problems.

- *Teachability* reflects the extent to which the knowledge can be taught to other individuals (e.g., through training, apprenticeship, etc.) …
  - even if the taught knowledge might remain in tacit form …
  - e.g., it's relatively feasible to teach the tacit knowledge of how to play basketball.

# Specificity of Knowledge

- *Specificity* refers to the extent to which knowledge is specific (as opposed to general).
- High level of specificity → knowledge that
  - can be acquired or effectively used only by individuals possessing certain specific knowledge
  - is possessed by a very limited number of individuals
  - is expensive to transfer

# Reservoirs of Knowledge



# KM Cycle Processes

- Knowledge Capture
- Knowledge Creation
- Knowledge Codification & Refinement
- Knowledge Sharing
- Knowledge Access
- Knowledge Application
- Knowledge Evaluation & Re-Use

# Building Knowledge

- Learning from all kinds of sources to:
  - Obtain Knowledge
  - Analyze Knowledge
  - Reconstruct (Synthesize) Knowledge
  - Codify and Model Knowledge
  - Organize Knowledge

# Obtaining Knowledge

- Create new knowledge
  - Research and development projects
  - Innovations, experimentation, trial and error
  - Reasoning with existing knowledge
  - Hire new people
- Import knowledge from existing sources
  - Elicit knowledge from experts
  - Acquire from manuals, books, other documents
  - Transfer people between departments
- Observe the real world

# Analyzing Knowledge

- Extract what appears to be knowledge from obtained materials
  - Analyze transcripts, reports about new concepts
  - Listen to explanation and select key concepts
- Abstract extracted material
- Identify patterns to describe, estimate
- Create explicit relations between knowledge elements (e.g. causal, correlation, contribution nets)
- Verify that extracted content is correct through observation

# Reconstruct (Synthesize) Knowledge

- Generalize analyzed materials to obtain broader principles
- Generate hypotheses to explain observed behaviour in terms of causal factors
- Establish conformance between new and existing knowledge (validity, coherence)
- Update total knowledge pool by incorporating new knowledge
  - Discard old, false, outdated, no longer relevant knowledge

# Codify and Model Knowledge

- Represent knowledge in our minds by building mental models
- Model knowledge by assembling declarations and relational statements into a coherent whole
- Document knowledge in books and manuals
- Encode knowledge into knowledge bases (computerized KBS tools)

# Organize Knowledge

- Organize new knowledge for specific uses
  - E.g. sequence for diagnostics, help desk, FAQs
- Organize new knowledge according to an established framework
  - Categorize according to organizational standards
  - Taxonomy, ontology, official list of key words, attributes, linguistic/translation guidelines….

# Conclusions

- Knowledge is different from data & information
- Knowledge in an area can be defined as justified beliefs about relationships among concepts relevant to that particular area
- Knowledge can be of different types
- Knowledge has several characteristics
- Knowledge resides is several different places

# Chapter 2

## The Nature of Knowledge