Advanced Learning Theories
Alejandra J. Magana, Ph.D.
admagana@purdue.edu

AGENDA
• Introduction to Learning Theories
• Role of Learning Theories and Frameworks
  • Learning Design
  • Research Design
• Dual Coding Theory
• Cognitive Load Theory
• Multimedia Learning Theory and Principles
• Embodied Cognition
• Considerations for Creating your Research Designs

LEARNING THEORIES
• What is a theory of learning?
  • A set of laws and principles about learning (Driscoll, 1994).
  • Learning theories are conceptual frameworks that describe how information is absorbed, processed, and retained during learning.
  • Cognitive, emotional, and environmental influences, as well as prior experience, all play a part in how understanding, or a world view, is acquired or changed, and knowledge and skills retained. (Wikipedia, 2016).

LEARNING THEORIES
• What is learning?
  • A process that brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, and making changes in one’s knowledge, skills, values, and world views (Illeris, 2004; Ormrod, 1995).
• How learning theories guide our research designs or learning designs?
  • They are hypotheses that describe how “exact” learning occurs.
  • They provide us with vocabulary a conceptual framework for interpreting the examples of learning that we observe.
  • They suggest where to look for solutions to practical problems.
• Note: The theories do not give us solutions, but they do direct our attention to those variables that are crucial in finding solutions.
THREE DIFFERENT PERSPECTIVES

- Learning can be fully understood in terms of observable events, both environmental and behavioral → behavioral perspective.

- Learning is mediated by memory processes inside the learner → cognitive perspective.

- Learning is a social enterprise, dependent upon interactions between the learner and his or her sociocultural environment → constructivist perspective.

BEHAVIORAL PERSPECTIVE

- Learning is the acquisition of new behavior through conditioning.
- Learning is manifested by a change in behavior.
- The environment shapes behavior.
- Contiguity and reinforcement are central to explaining the learning process.

COGNITIVIST PERSPECTIVE

- Focus on the learner rather than the environment.
- Two assumptions:
  - that the memory system is an active organized processor of information and
  - that prior knowledge plays an important role in learning.
- Cognitive theories look beyond behavior to explain brain-based learning.
CONSTRUCTIVIST PERSPECTIVE

• Views learning as a process in which the learner actively constructs or builds new ideas or concepts based upon current and past knowledge or experience.

• Learning involves constructing one’s own knowledge from one’s own experiences.

RELEVANT COGNITIVIST THEORIES OF LEARNING

• Paivio’s Dual Coding Theory
• Sweller’s Cognitive Load Theory
• Mayer’s Multimedia Learning
• Cognitive-Affective Theory of Learning with Media
• Embodied Cognition

DUAL CODING THEORY

• Involves the activity of two distinct subsystems: verbal and nonverbal (imagery).
• Systems are assumed to be composed of internal representational units: logogens and imagens.
• Logogens and imagens are activated as one recognizes, manipulates, or thinks about words or images.

DUAL CODING THEORY

• The representations are modality-specific:
  • different logogens and imagens correspond to visual, auditory, and haptic and motor properties of language and objects.

• The representations are connected to sensory input and response output systems as well as to each other:
  • they can function independently or cooperatively mediating verbal and nonverbal behavior.
IMPLICATIONS OF DUAL CODING THEORY

• Cognition is the variable pattern of the interplay of the two systems.

• There are two DCT hypotheses:
  • Nonverbal and verbal codes, being functionally independent, can have additive effect on recall.
  • Compound images that link pairs are formed during presentation and are reinstated during recall by concrete stimulus thereby increasing the probability of recalling the response.

• More concise information can be found here:
  • http://www.csuchico.edu/~nschwartz/paivio.pdf

COGNITIVE LOAD THEORY

• Is a theory of instruction that addresses directly the limitations of working memory.
  • Information processing occurs in working memory.
  • Working memory has limited capacity.
  • Long term memory has unlimited capacity.
  • Knowledge is stored in long term memory in the form of schemas.
  • CLT is designed to provide principles which lead to the construction of new schema stored in long term memory.

IMPLICATIONS OF COGNITIVE LOAD MEMORY

• There are two processes associated with storing knowledge in long term memory:
  • Schema Construction: categorizes elements of information.
  • Schema Automation: results from practice.

• CLT addresses the reduction of working memory load during the formation of new schema.

• CLT identifies 3 types of cognitive load:
  • Intrinsic cognitive load
  • Extrinsic cognitive load
  • germane cognitive load

IMPLICATIONS OF COGNITIVE LOAD MEMORY

• Intrinsic cognitive load:
  • Are characteristics of materials themselves.
  • Is created in any content being learned in working memory.
  • Cannot be altered.
  • Can have a high or low levels of interactivity among elements.

• Extrinsic cognitive load:
  • Is unnecessary load.
  • Is seen in poorly designed learning materials.
  • Can be altered with instructional intervention.
  • Can exceed working memory if put with high intrinsic load.

• germane cognitive load:
  • Relates the work put into creating a permanent store of knowledge, or a schema
  • Can help manage intrinsic load.
  • Is directly relevant to schema construction.
  • Contributes to learning.
  • Should be maximized.
IMPLICATIONS OF COGNITIVE LOAD

• According to Rebetz (2006:12-13) Sweller, based on his cognitive load theory, describes a series of effects and guidelines to create learning materials:

  - Goal free effect: novice learners with a specific learning goal (like a precise question to answer) focus on the goal and pay no attention to other information. This is detrimental to learning.
  - Worked examples effect: using known and resolved examples diminish cognitive load and improves comprehension.
  - Problem completion effect: the worked-out example should be followed by a similar but unresolved problem to maximize motivation.
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- Three main assumptions are:
  1. There are two separate channels (auditory and visual) for processing information (sometimes referred to as Dual-Coding theory);
  2. Each channel has a limited (finite) capacity similar to Sweller’s notion of Cognitive Load;
  3. Learning is an active process of filtering, selecting, organizing, and integrating information based upon prior knowledge.

- The principle known as the “multimedia principle” states that:

  “People learn more deeply from words and pictures than from words alone.”

MULTIMEDIA LEARNING

- Humans can only process a finite amount of information in a channel at a time, and they make sense of incoming information by actively creating mental representations.

- Memory structure:
  - sensory (which receives stimuli and stores it for a very short time),
  - working (where we actively process information to create mental constructs (or “schema”),
  - long-term (the repository of all things learned).

- The brain does not interpret a multimedia presentation of words, pictures, and auditory information in a mutually exclusive way;
- Rather, these elements are selected and organized dynamically to produce logical mental constructs.

- Twelve principles can shape the design and organization of information presentation:
  1. Coherence Principle: People learn better when extraneous words, pictures and sounds are excluded rather than included.
  2. Signaling Principle: People learn better when cues that highlight the organization of the essential material are added.
  3. Redundancy Principle: People learn better from graphics and narration than from graphics and on-screen text.
  4. Spatial Contiguity Principle: People learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.
  5. Temporal Contiguity Principle: People learn better when corresponding words and pictures are presented simultaneously rather than successively.
  6. Spatial Contiguity Principle: People learn better when corresponding words and pictures are presented simultaneously rather than successively.
  7. Segmenting Principle: People learn better from a multimedia lesson is presented in user-paced segments rather than as a continuous unit.
  8. Pre-processing Principle: People learn better from multimedia lessons when they know the names and characteristics of the main concepts.
  9. Modality Principle: People learn better when corresponding words and pictures are presented simultaneously rather than successively.
  10. Multimedia Principle: People learn better from words and pictures than from words alone.
  11. Voice Principle: People learn better when the narration in multimedia lessons is presented in a friendly human voice rather than a machine voice.
  12. Image Principle: People do not necessarily learn better from a multimedia lesson when the speaker’s image is added to the screen.
THE COGNITIVE-AFFECTIVE THEORY OF LEARNING WITH MEDIA

- Assumptions:
  - Humans have separate channels for processing different information modalities
  - Only a few pieces of information can be actively processed at any one time in working memory within each channel
  - Meaningful learning occurs when the learner spends conscious effort in cognitive processes such as selecting, organizing and integrating new information with existing knowledge
  - Long-term memory consists of a dynamic, evolving structure which holds both, a memory for past experiences and a memory for general domain knowledge
  - Motivational factors mediate learning by increasing or decreasing cognitive engagement
  - Metacognitive factors mediate learning by regulating cognitive processing and affect
  - Differences in learners' prior knowledge and abilities may affect how much is learned with specific media.

IMPLICATIONS OF INTERACTIVE MULTIMODAL LEARNING

- Multimodal learning environments use two different modes to represent content knowledge: verbal and non-verbal.
- Student understanding can be enhanced by the addition of non-verbal knowledge representations to verbal explanations.
- The most effective learning environments are those that combine verbal and non-verbal representations of knowledge using mixed-modality presentations.
- Assumes that human cognitive architecture includes independent, limited-capacity processing channels.
  - Verbal and non-verbal materials can be presented via visual modality alone.
  - This configuration is more likely to overload students' cognitive capacity during learning.
  - Verbal materials can be presented in the auditory modality and non-verbal materials can be presented in the visual modality.

IMPLICATIONS OF MULTIMODAL LEARNING

- Five common types of interactivity: dialoging, controlling, manipulating, searching, and navigating.

![Fig. 1 A cognitive-affective model of learning with media.](image)

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<thead>
<tr>
<th>Table 3</th>
<th>Five Design Principles and Corresponding Theoretical Rationale</th>
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<tbody>
<tr>
<td><strong>Guided Activity</strong></td>
<td>Students learn better when allowed to interact with a pedagogical agent who helps guide their cognitive processing.</td>
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<tr>
<td><strong>Reflection</strong></td>
<td>Students learn better when asked to reflect upon correct answers during the process of meaning making.</td>
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<td><strong>Feedback</strong></td>
<td>Students learn better with explanatory rather than corrective feedback alone.</td>
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<tr>
<td><strong>Pacing</strong></td>
<td>Students learn better when allowed to control the pace of presentation of the instructional materials.</td>
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<tr>
<td><strong>Pretraining</strong></td>
<td>Students learn better when they receive focused pretraining that provides or activates relevant prior knowledge.</td>
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Guided activity encourages essential and generative processing by prompting students to engage in the selection, organization, and integration of new information.
Reflection promotes essential and generative processing by encouraging more active organization and integration of new information.
Explanatory feedback reduces extraneous processing by providing students with proper schemes to repair their misconceptions.
Pacing control reduces representational holding by allowing students to process smaller chunks of information in working memory.
Pretraining helps guide the learner’s generative processing by showing which aspects of prior knowledge to integrate with incoming information.
EMBODIED COGNITION

- Refers to the enactment of knowledge and concepts through the activity of our bodies.
- Human cognition is deeply rooted in the body’s interactions with its physical environment.
- When appropriate sensomotor systems are engaged, the converging inputs can create stronger and more stable memory traces and knowledge representations.

IMPLICATIONS OF EMBODIED COGNITION

- Assumptions:
  - Cognition is situated
  - We off-load cognitive work onto the environment
  - The environment is part of the cognitive system
  - Cognition is for action
  - Offline cognition is body based
- Use of Mixed Reality:
  - New technologies and interfaces can now accept natural physical movement as input into digital environments.
  - Allow seamless blend of virtual and physical elements.
  - Emphasis on conceptual understanding.

WHAT HAVE WE LEARNED?

- We have conducted a series of pre/posttest quasi-experimental designs.
PILOT STUDIES

• Study 1 (2012-2013):
  • Cognitive load theory (Sweller, 1994) was adapted to include the tactile channel in combination with the visual channel.
  • We compared two groups: simulation-only vs. visuohaptic simulation.
  • Findings suggested students in the visuohaptic group experienced cognitive overload related to the novelty and excitement of using haptic technology.
  • Split-attention effect occurs when learners have to process and integrate multiple and separated sources of information.
  • Solution: Pre-training of students about haptic devices was identified as a useful approach to managing cognitive load during the experiment.

PILOT STUDIES

• Study 2 (2013-2014):
  • Multimedia learning principles were used to improve cognitive load management during the experiment:
    • the pre-training principle and
    • the self-paced and modality principles in the form of an instructional (power point) unit.
  • We compared three groups: power point unit, power point unit and simulation only and power point unit and visuohaptic simulation.
  • The three conditions had a similar impact on student learning.
  • Solution: we implemented a ‘guided activity’ technique embedding the use of visuohaptic simulations within an inquiry-based learning unit.

PILOT STUDIES

• Study 3 (2014-2015):
  • Guided by the cognitive-affective theory of learning with media we implemented:
    • the ‘guided activity’ technique embedding the use of visuohaptic simulations within an inquiry-based learning unit.
  • Hypothesis: help students to first develop an expectation of the phenomenon explored (e.g., a hypothesis to test) which was then confirmed or rejected by using the visuohaptic simulations.

PILOT STUDIES

• Study 4 (2014-2015):
  • We introduced a ‘signaling’ technique to help learners build connections between two modes of representation to:
    • make explicit connections and mappings between the force feedback felt by students, the simulation presented visually on the screen, and concrete explanations of the corresponding phenomenon by means of question prompts.
  • Three single-group studies were conducted:
    • Undergraduate engineering students
    • Undergraduate technology students
    • Undergraduate engineering technology students from a different demographic setting.
  • Students from all three groups improved their conceptual understanding of electric field for distributed charges.
WHERE WE ARE NOW?

- Pilot 5 (2015-2016):
  - We are implementing a coherence principle (removing extraneous elements) is combined with signaling principle following a progression:
    - Minimal visual supports only
    - Minimal visual supports and haptic feedback
    - Some visual supports and haptic feedback
    - Full visual supports and haptic feedback
  - We are conducting qualitative studies using think-aloud procedures
  - We are identifying the tactile and visual cues that can result in conceptual learning

USES OF LEARNING THEORIES

- Can inform the design of learning experiences.
  - E.g., use of a signaling principle to guide learning
  - E.g., use of scaffolding methods to support learning
- Can inform the design of research studies.
  - In the form of theoretical frameworks, conceptual frameworks and methodological frameworks.
  - Refer to philosophical stances informing the methodology or methods of a study.
  - Provide a context for the research process and ground its logic and criteria.

EDUCATIONAL RESEARCH FRAMEWORKS

- Constructivist frameworks
  - Constructivism and social constructivism
  - Symbolic interactionism
  - Models and modeling
  - Pedagogical content knowledge
- Hermeneutic frameworks
  - Hermeneutics and the meaning of understanding
  - Phenomenology
  - Phenomenography
  - Action research
  - Situated cognition
  - Communities of practice
  - Narrative analysis
- Critical Theory frameworks
  - Critical theory
  - Feminism
  - The Afrocentic framework

LEARNING DESIGN VS. RESEARCH DESIGN

IMPLICATIONS OF LEARNING THEORIES
METHODOLOGY ≠ METHODS

• Methodology: is a theoretical argument that researchers use in order to justify their research methods and design.

• Methods: the techniques or procedures used to gather and analyze data related to some research question or hypothesis.

• Methodology is a theoretical justification for the methods used in a study.

METHODS

• Are the tools and procedures we use for our inquiries and methodology is about the framework within which they sit.
  • Participants
  • Procedures
  • Data Collection Methods
  • Data Analysis Methods

HOW EDUCATIONAL FRAMEWORKS INFORM RESEARCH DESIGNS?

• In a typical experiment performed in science the researcher chooses a particular analytical instrument.

• In an experiment performed by a computational scientist, she chooses a particular analytical or statistical method or a particular computational simulation tool.

• For qualitative research studies in education, the theoretical framework plays a role analogous to the role of the instrument.

(Bodner & Orgill, 2006)

THEORETICAL, METHODOLOGICAL OR CONCEPTUAL FRAMEWORKS

• Are a system of:
  • ideas,
  • aims,
  • goals,
  • theories,
  • assumptions
  • about:
    • knowledge;
    • how research should be carried out;
    • how research should be reported that influences what kind of experiments can be carried out;
    • the type of data that result from these experiments.

(Bodner & Orgill, 2006)
What are the three fundamental components of an educational research study?
- A theoretical framework upon which the study will be built;
- Guiding research questions that the study will try to answer that are consistent with the theoretical framework;
- A methodology that is appropriate for probing the guiding research questions.

What is first?
The first step in a research study often involves the construction of the guiding research questions.

(Bodner & Orgill, 2006)