2018

Grounded Strategies for Instructional Design

Grounded instructional strategies are rooted in established theories and research on human learning. They form the basis for designing and sequencing meaningful e-learning interactions and for creating online, blended and classroom learning environments. Instructional strategies grounded in research and theory are outlined and compiled to facilitate the instructional design of training and educational programs. Gaining further understanding is recommended when interested in a particular strategy by reading related reference.
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Grounded Instructional Strategies

Table 1 outlines primary instructional events associated with published instructional strategies that are grouped according to major classes of learning theories. Guidelines and criteria for selecting a grounded strategy follow, along with further details about each strategy.

Table 1. Primary events associated with grounded instructional strategies

Constructivist (Learner-Centered) Approaches		
Experiential Learning (Pfeiffer & Jones, 1975) 1. Experience 2. Publish 3. Process 4. Internalize 5. Generalize 6. Apply	**Experiential Learning Model** (Kolb, 1984) 1. Concrete experience 2. Reflective observation 3. Abstract conceptualization 4. Active experimentation	**Guided Experiential Learning** (Clark, 2004) 1. Goals 2. Reasons and activation 3. Demonstration 4. Application 5. Integration 6. Assessment
Learning by Doing (Schank, Berman & Macpherson, 1999) 1. Define goals 2. Set mission 3. Present cover story 4. Establish roles 5. Operate scenarios 6. Provide resources 7. Provide feedback	**Problem-Based Learning** (Barrows, 1985; Boud & Feletti, 1997) 1. Start new class 2. Start new problem 3. Problem follow-up 4. Performance presentation(s) 5. After conclusion of problem	**Collaborative Problem-Solving** (Nelson, 1999) 1. Build readiness 2. Form and norm groups 3. Determine preliminary problem 4. Define and assign roles 5. Engage in problem-solving 6. Finalize solution 7. Synthesize and reflect 8. Assess products and processes 9. Provide closure
Problem Solving: Story Problems (Jonassen, 2011) 1. Present story problem 2. Compare to analogies 3. Parse problem sets 4. Generate equation/algorithm 5. Solve problem 6. Check answer	**Problem Solving: Decision Making** (Jonassen, 2011) 1. Present problem/case 2. Compare to similar cases or analogies 3. Generate options 4. Analyze options 5. Make decision 6. Report selection	**Problem Solving: Troubleshooting** (Jonassen, 2011) 1. Present problem/case in simulation 2. Refer to system model 3. Call on cases library (worked examples) 4. Practice troubleshooting

Grounded Instructional Strategies

Table 1 outlines primary instructional events associated with published instructional strategies that are grouped according to major classes of learning theories, including constructivist (learner-centered), behavioral and cognitive information processing, and neurobiological approaches to explaining how and why people learn. Guidelines and criteria for selecting a grounded strategy follow, along with further details about each strategy.

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Problem Solving: Story Problems (Jonassen, 2011) 1. Present story problem 2. Compare to analogies 3. Parse problem sets 4. Generate equation/algorithm 5. Solve problem 6. Check answer	**Problem Solving: Decision Making** (Jonassen, 2011) 1. Present problem/case 2. Compare to similar cases or analogies 3. Generate options 4. Analyze options 5. Make decision 6. Report selection	**Problem Solving: Troubleshooting** (Jonassen, 2011) 1. Present problem/case in simulation 2. Refer to system model 3. Call on cases library (worked examples) 4. Practice troubleshooting
Problem Solving: Strategic (Jonassen, 2011) 1. Present simulation of typical and atypical cases 2. Recognize key components 3. Discriminate typical and atypical situations 4. Take action based on nature of situation 5. Provide feedback 6. Reflect on actions	**Problem Solving: Policy Analysis** (Bardach, 2000) 1. Define the problem 2. Assemble evidence 3. Construct alternatives 4. Select and apply criteria 5. Project outcomes 6. Confront trade-offs 7. Make decision 8. Tell your story	**Problem Solving: Design** (Dym & Little, 2004) 1. Problem Definition 2. Conceptual Design 3. Preliminary Design 4. Detailed Design 5. Final Design

Table 1 (con't). Primary events associated with grounded instructional strategies

Constructivist (Learner-Centered) Approaches (con't)		
BSCS 5E Model (BSCS, 2005; Bybee, 2002) 1. Engage 2. Explore 3. Explain 4. Elaborate 5. Evaluate	**WebQuest** (Dodge, 1998) 1. Introduction 2. Task 3. Process 4. Resources 5. Evaluation 6. Conclusion	**Case-Based Reasoning** (Aamodt & Plaza, 1994) 1. Present New Case 2. Retrieve Similar Cases 3. Reuse Information 4. Revise Proposed Solution 5. Retain Useful Experiences
Simulation Model (Joyce, Weil, & Showers, 1992) 1. Orientation 2. Participant Training 3. Simulation Operations 4. Participant Debriefing 5. Appraise and redesign the simulation	**Inquiry Training** (Joyce, Weil, & Showers, 1992) 1. Confrontation with the Problem 2. Data Verification 3. Data Experimentation 4. Organizing, Formulating and Explanation 5. Analysis of inquiry process	**Inductive Thinking** (Taba, 1967) 1. Concept Formation 2. Interpretation of Data 3. Application of Principles
Jurisprudential Inquiry (Oliver & Shaver, 1971) 1. Orientation to the Case 2. Identifying the Issues 3. Taking Positions 4. Exploring the Stance(s) 5. Refining and Qualifying the Positions 6. Testing Factual Assumptions Behind Qualified Positions	**Scaffolded Vee Diagram** (Crippen, Archambault, & Kern, in press) 1. Big Problem 2. Initial Ideas 3. Concept Map 4. Analysis and Artifacts 5. Claims 6. Expert Opinion 7. Reflection	**Historical Inquiry** (Waring, 2011) 1. A Hook 2. Identify Fundamental Questions 3. Engage in Primary and Secondary Sources 4. Recognize Multiple Perspectives and Historic Causation 5. Create Plausible Narratives 6. Assess Skills, Knowledge and Attitudes 7. Reflect on Experience
Adaptive Instructional Design (Schwartz, Lin, Brophy & Bransford, 1992) 1. Look Ahead & Reflect Back 2. Present Initial Challenge 3. Generate Ideas 4. Present Multiple Perspectives 5. Research and Revise 6. Test Your Mettle 7. Go Public 8. Progressive Deepening 9. General Reflection and Decisions 10. Assessment	**Eight Events of Student-Centered Learning** (Hirumi, 2002, 1998, 1996) 1. Set Learning Challenge 2. Negotiate Goals and Objectives 3. Negotiate Learning Strategy 4. Construct Knowledge 5. Negotiate Performance Criteria 6. Assess Learning 7. Provide Feedback (Steps 1-6) 8. Communicate Results	**Constructivist Learning** (Jonassen, 1999) 1. Select Problem 2. Provide Related Case 3. Provide Information 4. Provide Cognitive Tools 5. Provide Conversation Tools 6. Provide Social Support

Table 1 (con’t). Primary events associated with grounded instructional strategies

Behavioral & Cognitive Information Processing (Teacher-Directed) Approaches		
Nine Events of Instruction (Gagne, 1977, 1974) 1. Gain Attention 2. Inform Learner of Objective(s) 3. Recall Prior Knowledge 4. Present Stimulus Materials 5. Provide Learning Guidance 6. Elicit Performance 7. Provide Feedback 8. Assess Performance 9. Enhance Retention and Transfer	**5 Component Lesson Model** (Dick, Carey, & Carey, 2009) 1. Pre-Instructional Activities 2. Content Presentation and Learning Guidance 3. Learner Participation 4. Assessment 5. Follow Through Activities	**Elements of Lesson Design** (Hunter, 1990) 1. Anticipatory Set 2. Objective and Purpose 3. Input 4. Modeling 5. Check for Understanding 6. Guided Practice 7. Independent Practice
Direct Instruction (Joyce, Weil, & Showers, 1992) 1. Orientation 2. Presentation 3. Structured Practice 4. Guided Practice 5. Independent Practice		
Neurobiological Approaches		
Brain Rules (Medina, 2014) 1. **Survival:** The human brain evolved. 2. **Exercise:** Boosts brain power. 3. **Sleep:** Sleep well, think well. 4. **Stress:** Stress inhibits learning. 5. **Wiring:** Every brain is wired differently. 6. **Attention:** Avoid boring things. 7. **Memory:** Repeat to remember. 8. **Sensory Integration:** Stimulate senses. 9. **Vision:** Vision trumps all other senses. 10. **Music:** Listening boosts cognition. 11. **Gender:** Male/female brains differ. 12. **Exploration:** We are natural explorers.	**Brain-Based Teaching** (Jensen, 2005) 1. Malleable memories 2. Non-conscious experience runs automated behaviors 3. Reward and addiction dependency 4. Attentional limitations 5. Brain seeks and creates understanding 6. Rough drafts/Gist learning 7. Input limitations 8. Perception influences our experience 9. Malleability/Neural plasticity 10. Emotional-Physical state dependency	**Interplay Strategy** (Hirumi et al., under review; Hirumi & Stapleton, 2014; Stapleton & Hirumi, 2011) 1. Expose 2. Inquire 3. Discover 4. Create 5. Experiment 6. Share
Principles of Natural Learning (Caine, Caine, McClintic & Klimek, 2005) 1. Relaxed Alertness a. Challenge enhances, threat inhibits b. Social brain/mind c. Innate search for meaning d. Emotions are critical to patterning 2. Orchestrated Immersion a. The brain processes parts and whole b. All learning engages the physiology. c. Meaning occurs through patterning d. Learning is developmental 3. Active Processing a. Declarative and procedural memory b. Focused attention & peripheral perception. c. Conscious and unconscious. d. Each brain is uniquely organized.		

Table 1 (con't). Primary events associated with grounded instructional strategies

Alternative Approaches		
4Mat System (McCarthy, 1987)	**SQR** (Maier, 1990)	**SQ3R** (Robinson, 1961)
1. Create an experience 2. Reflect/Analyze experience 3. Integrate reflective analysis 4. Develop concepts/skills 5. Practice defined "givens" 6. Practice adding something 7. Analyze application 8. Apply to new experience	1. Summarize 2. Question 3. Response	1. Survey 2. Question 3. Read 4. Recite 5. Review

Grounding your Designs

Grounded design is "the systematic implementation of processes and procedures that are rooted in established theory and research in human learning (Hannafin, Hannafin, Land, & Oliver, 1997, p.102)." Four conditions are basic to grounded design:

- Designs must be rooted in a defensible theoretical framework;
- Methods must be consistent with the outcome of research conducted to test, validate, or extend the theories upon which they are based;
- Designs must be generalizable to situations beyond the unique conditions in which they are being utilized; and
- Grounded designs and their frameworks must be validated iteratively through successive implementation.

Without a solid grounding in theory, educational activities, whatever their intent, represent "craft-based" approaches to instruction, solutions carved by one person for one specific environment. This is not to say that such activities are ineffective, only that they may not be applicable to circumstances beyond those in which they were initially employed. Grounding the design of your instruction helps you explain and predict the results of your instruction by identifying key variables that affect student learning. It enables you to continuously improve your designs as well as add to the knowledge base of the theory and strategy you applied.

Application of a grounded instructional strategy guides the overall design and sequencing of key learning interactions. Selection of an appropriate strategy requires the instructor and/or instructional designer to consider the desired learning outcomes as well as his or her personal values and beliefs about teaching and learning (Hirumi, 2013). It may also require the instructor and the instructional designer to step out of his or her comfort zone, applying a strategy that s/he may have yet to experience.

A fundamental systematic design principle is that the nature of the desired **learning outcomes** should drive the instructional design process. For instance, the specific technique used to analyze an instructional situation should be based on targeted learning outcomes (Jonassen, Tessmer & Hannun, 1999). Similarly, learner assessment methods should be determined by the nature of specified objectives (Berge, 2002; Hirumi, 2002d). The same principle applies to the selection of a grounded instructional strategy.

For example, to teach people how to use of a new photocopying machine (a relatively simple procedure), a teacher-directed instructional strategy may be more effective and efficient than constructivist or learner-centered approaches. In cases where there is basically one correct answer and/or one correct method for deriving the answer, learners do not necessarily have to interact with others learners to derive meaning and construct their own knowledge through social discourse. In contrast, if the desired learning outcome requires higher-order thinking, where there may be more than one correct answer or more than one method for deriving the correct answer, then more learner-centered or related problem-based approaches to teaching and learning may be appropriate.

In selecting an appropriate strategy, it is also important to take in account the instructor's **educational philosophy and epistemological beliefs**. If the instructor believes that people derive meaning and construct knowledge through social interactions, then constructivist, learner-centered, and cooperative instructional strategies may support his or her beliefs. In contrast, if the instructor or designer believes people learn by processing information through sensory, short-term, and long-term memory, than an instructional strategy based on information processing theories of learning, like Gagne's Nine Events of Instruction (Gagne, 1977), may resonate with his or her educational philosophy. If the instructor is a pragmatist and believes that meaning is constructed by individuals based on their interpretation and understanding of reality, s/he may take an eclectic approach, selecting from a range of behaviorist to constructivist instructional strategies depending on the situation. Furthermore, if and instructional designer is working with an instructor and/or subject matter expert to create the online materials, then it may be important to discuss and, if necessary, reconcile any differences in philosophy prior to initiating any designs.

Selecting an appropriate instructional strategy is neither simple, nor straight-forward. Much depends on the desired learning goals and objectives, but concerns for the learner, the context and beliefs held by the teacher or instructional designer also mediate the selection process. Perhaps even a stronger influence is time and expertise. With insufficient time or training, educators often revert to what they know best; that is, teacher-directed methods and materials. To select an appropriate instructional strategy, the instructor and/or designer must have the time and skills necessary to analyze several important variables. They must also have the confidence, desire and the opportunity to apply alternative instructional strategies within the context of their job.

Inquiry, Experiential and Problem-Based (Learner-Centered) Approaches

Experiential Learning Model
(Pfeiffer & Jones, 1975)

Based on the belief that people learn best by doing, the experiential learning model can start with didactic (passive) forms of instruction but soon progresses to experiential (active) forms of learning.

1. **Experience** – Immerse learner in "authentic" experience (e.g., real or simulated job task).
2. **Publish** – Talking or writing about experience. Sharing observations, thoughts, and feelings.
3. **Process** – Debrief: Interpret published information, defining patterns, discrepancies and overall dynamics, making sense of the information generated by group.
4. **Internalize** – Private process, learner reflects on lessons learned, means of managing conflicting data and requirements for future learning.
5. **Generalize** – Develop hypotheses, form generalizations and reach conclusions from information and knowledge gained from lesson.
6. **Apply** – Use information and knowledge gained from lesson to make decisions and solve problems.

Experiential Learning
(Kolb, 1984)

Building upon earlier work by John Dewey and Kurt Levin, American educational theorist Kolb believed that "learning is the process whereby knowledge is created through the transformation of experience" (1984, p. 38). The theory presents a cyclical model of learning, consisting of four stages shown below. One may begin at any stage, but must follow each other in the sequence:

1. **Concrete experience** (or "DO") - Where the learner actively experiences an activity such as a lab session or field work.
2. **Reflective observation** (or "OBSERVE") - When the learner consciously reflects back on that experience.
3. **Abstract conceptualization** (or "THINK") - Where the learner attempts to conceptualize a theory or model of what is observed
4. **Active experimentation** (or "PLAN") - Where the learner is trying to plan how to test a model or theory or plan for a forthcoming experience

Kolb's four-stage learning cycle shows how experience is translated through reflection into concepts, which in turn are used as guides for active experimentation and the choice of new experiences. Kolb identified four learning styles which correspond to these stages. The styles highlight conditions under which learners learn better. These styles are:

- Assimilators, who learn better when presented with sound logical theories to consider
- Convergers, who learn better when provided with practical applications of concepts and theories
- Accommodators, who learn better when provided with "hands-on" experiences
- Divergers, who learn better when allowed to observe and collect a wide range of information

Guided Experiential Learning

(Clark, 2004)

Clark's (2004) Guided Experiential Learning (GEL) fosters skill development and the learning of factual information in the context of how it will be used. It assumes that learning occurs best in context of a goal that is relevant, meaningful, and interesting to students; and (b) content knowledge is best learned in context of relevant tasks closely related to how students will use it outside of the learning environment.

1. **Goals** – Including learning objectives, problems to be solved, what students will be able to do at the end of the lesson.
2. **Reasons and Activation** – Rationale and overview for the goals and objectives. Answers questions about value and utility such as: "Why is learning to do this important to me?" "What value does it hold for me, my job, mission or my team?" "What risk will I avoid if I learn it?" Briefly describe (and when possible, provide a visual model of the location of) the lesson in the larger course and sequence of lessons and then describe the instructional strategy
3. **Demonstration** – Promotes learning by demonstrating what is to be learned rather than merely telling information about what is to be learned. The demonstration can direct students to relevant information and provide multiple representations or scenarios for comparison. The demonstration should also be accompanied by job aids that summarize the action and decision steps.
4. **Application** – Students are required to use their new knowledge or skill to solve problems or show comprehension of new concepts.
5. **Integration** – Students are encouraged to integrate (transfer) the new knowledge or skill by the following activities:
   - 1.1 Watch me: Gives students the opportunity to publicly demonstrate their new knowledge or skill.
   - 1.2 Reflection: Asks students to reflect-on, discuss, and defend their new knowledge or skill.
   - 1.3 Creation: Encourages students to create, invent, and explore new and personal ways to use their new knowledge.
6. **Assessment** – Practice must be reviewed and checked against a list of concepts or action and decision steps derived from standard procedures.

Learning by Doing
(Schank, Berman & Macpherson, 1999)

The primary goal is to foster skill development and the learning of factual information in the context of how it will be used. Assumes that learning occurs best in context of a goal that is relevant, meaningful, and interesting to students, and when content knowledge is learned in context of relevant tasks closely related to how students will use it outside of the learning environment.

1. **Define Goals**
   1.1 Process knowledge goals
   1.2 Content knowledge goals
2. **Set Mission**
   2.1 Must be motivational
   2.2 Must be somewhat realistic
3. **Present Cover Story**
   3.1 Must be motivating and create the need for the mission
   3.2 Must allow opportunities to practice the skills and seek the knowledge
4. **Establish Roles** (who the students will play)
   4.1 Must be one who uses the necessary skills and knowledge
   4.2 Must be motivating
5. **Operate Scenarios**
   5.1 Must be closely related to both the mission and the goals
   5.2 Must have decision points with consequences that become evident
   5.3 The consequences must indicate progress toward completing the mission
   5.4 A negative consequence must be understand as an expectation failure
   5.5 Plenty of operations for students to do (most time practicing skills)
   5.6 Should not require more than what the goals call for
6. **Provide Resources**
   6.1 Provide the information the students need to succeed in their mission
   6.2 Information must be well organized and readily accessible
   6.3 Information is often best provided in the form of stories
7. **Provide Feedback**
   7.1 Must be situated, so it is indexed properly as an expectation failure
   7.2 Must be just-in-time, so the student will use it
   7.3 Can be given in three ways (a) consequences of actions, (b) coaches, (c) domain experts’ stories about similar experiences.

Problem-Based Learning
(Barrows, 1985; Boud & Feletti; 1997)

Disenchanted with medical students' ability to apply information learned from lectures, Barrow's developed this model to enhance transfer.

1. **Start New Class**
   - 1.1 Introductions
   - 1.2 Climate Setting (including teacher/tutor role)
2. **Start New Problem**
   - 2.1 Set problem
   - 2.2 Bring problem home
   - 2.3 Describe the product/performance required
   - 2.4 Assign tasks
   - 2.5 Reason through the problem (i.e., ideas/hypotheses, facts, learning issues and action plan).
   - 2.6 Commitment as to probable outcome
   - 2.7 Learning issues shaping/assignment
   - 2.8 Resource identification
   - 2.9 Schedule follow-up
3. **Problem Follow-Up**
   - 3.1 Resources used and their critique
   - 3.2 Reassess the problem (i.e., ideas/hypotheses, facts, learning issues and action plan).
4. **Performance Presentation(s)**
5. **After Conclusion of Problem**
   - 5.1 Knowledge abstraction and summary
   - 5.2 Self-evaluation

Collaborative Problem-Solving

(Nelson, 1992)

The goals are to develop content knowledge in complex domains, problem-solving and critical thinking skills, and collaborative skills. It should only be used when those types of learning are paramount and when the students and instructor are receptive to this approach to learning, with its shift in roles and power relationships.

1. **Build Readiness**
   - 1.1 Overview of collaborative problem solving process
   - 1.2 Develop an authentic problem or project to anchor instruction
   - 1.3 Provide instruction and practice in group process skills
2. **Form and Norm Groups**
   - 2.1 Form small heterogeneous work groups
   - 2.2 Encourage groups to establish operational guidelines
3. **Determine Preliminary Problem**
   - 3.1 Negotiate a common understanding of the problem
   - 3.2 Identify learning issues and goals
   - 3.3 Brainstorm preliminary solutions or project plans
   - 3.4 Select and develop initial design plan
   - 3.5 Identify sources of needed resources
   - 3.6 Gather preliminary information to validate the design plan
4. **Define and Assign Roles**
   - 4.1 Identify the principal roles needed to complete the design plan
   - 4.2 Negotiate the assignment of roles
5. **Engage in Problem-Solving**
   - 5.1 Refine and evolve the design plan
   - 5.2 Identify and assign tasks
   - 5.3 Acquire needed information, resources, and expertise
   - 5.4 Disseminate acquired information, resources, and expertise to group
   - 5.5 Engage in solution or project, report contributions and group activities
   - 5.6 Participate in intergroup collaborations and evaluations
   - 5.7 Conduct formative evaluations of the solution or project
6. **Finalize Solution**
   - 6.1 Draft the final version of solution or project
   - 6.2 Conduct final evaluation or usability test of the solution or project
   - 6.3 Revise and complete the final version of the solution or project
7. **Synthesize and Reflect**
   - 7.1 Identify learning gains
   - 7.2 Debrief experiences and feelings about the process
   - 7.3 Reflect on group and individual learning processes
8. **Assess Products and Processes**
   - 8.1 Evaluate the products and artifact created
   - 8.2 Evaluate the processes used
9. **Provide Closure**

Problem-Solving: Story/Word Problems
(Jonassen, 2011)

One of the most common types of problems presented to students in primary, secondary and post-secondary education, story problems are typically solved by identifying key values in a short story, and selecting and applying an appropriate algorithm to generate a correct answer. Contemporary approaches to story problems emphasize a conceptual understanding of the problem before generating an answer.

1. **Present word problem.** Provide structural or situational models and/or instruction to help learners classify the problem.
2. **Compare to analogies.** Provide analogous problems to compare current problem.
3. **Parse problem set.** Provide identifiers to help learners analyze and identify key values and factors to consider in solving the problem.
4. **Generate equation/algorithm.** Provide equation builders and calculators to help learners solve the problem.
5. **Solve problem.**
6. **Check answer.**

Problem-Solving: Decision Making
(Jonassen, 2011)

Decision making is the most common type of problem we face in everyday life. Decision making is also central to solving other types of more complex problems. In short, decisions are made by selecting one or more potentially useful or fulfilling options from a larger set of options. Decisions are made be made from a list of options, selecting or rejecting a particular option, or by formulating and evaluating options.

1. **Present problem/case**
2. **Compare to similar cases or analogies**
3. **Generate options**
   a. Construct decision matrix
   b. Construct choice set
   c. Conduct force field/SWOT analysis
4. **Analyze options**
5. **Make decision**
6. **Report selection**

Problem-Solving: Troubleshooting and Diagnosing
(Jonassen, 2011)

People are often tasked with troubleshooting or diagnosing a problem. The simplest form of troubleshooting consists of finding a faulty component in a device and either repairing or replacing it. More complex forms requires professionals to diagnose a physical or mental problem. People may use analytical reasoning skills or use analogies based on examples to diagnose problems. It's important to keep in mind that if one is good at troubleshooting or diagnose one type of problem does not mean they are good at troubleshooting or diagnosing other kinds of problem.

1. **Present problem/case in simulation**
2. **Refer to system model**
3. **Call on case library (worked examples)**
4. **Facilitate use of analytical and/or analogical reasoning skills**
5. **Practice troubleshooting/diagnosing**
6. **Provide feedback**

Problem-Solving: Strategic
(Jonassen, 2011)

Strategic problem solving is a multifaceted activity that requires the use of complex strategies while maintaining situational awareness. They often occur under uncertain conditions that make them ill-structured. Expert problem solvers often base decisions on experience; they see situations as a prototype of what they've seen before and take actions without considering many options. Experts use pattern recognition rather than deductive reasoning to solve strategic problems. Thus, presenting many cases is essential for developing strategic as well as diagnostic problem solving skills.

1. **Present simulation of typical and atypical cases**
2. **Recognize key components**
   a. Relevant cues
   b. Plausible goals
   c. Expectations
3. **Discriminate typical and atypical situations**
4. **Take action based on nature of situation**
5. **Provide feedback**
6. **Reflect on actions**

Problem-Solving: Policy Analysis
(Bardach, 2000)

Policy problems are often complex, involving many people, such as planners, analysts, managers, legislators, citizens, and other stakeholders. Solving problems with policy is complex because different stakeholders typically hold different values and beliefs, and seek different outcomes that are difficult to equate. Most policy problems are economic but have political, social, environmental, emotional and other implications.

1. **Define the problem.** Be clear about the nature and extent of the problem.
2. **Assemble evidence.** Assess policies that others have used to assess the nature and extent of the problem being defined.
3. **Construct alternatives.** Model alternatives, identifying causal relationships and related incentives and constraints.
4. **Select and apply criteria.** Evaluate alternatives by selecting and applying evaluation criteria (e.g., for efficiency, equality, fairness, freedom, legality).
5. **Project outcomes.** Predict possible by constructing scenarios.
6. **Confront trade-offs.** Compare and contrast alternatives using a decision matrix.
7. **Make decision.**
8. **Tell your story.** Communicate decisions along with rationale for the decisions.

Problem-Solving: Design
(Dym & Little, 2004)

Professionals in and across disciplines solve design problems to create products, processes, systems, activities, and a many other outcomes. Needless to say, different people use different methods with vary assumptions within and across disciplines to solve design problems. The following is an example of an engineering design process.

1. **Problem Definition**: From the client statement, clarify objectives, establish user requirements, identify constraints, and establish functions of product by providing a list of attributes.
2. In the **Conceptual Design** phase, establish design specifications and generate alternatives.
3. In the **Preliminary Design** phase, create model of design and test and evaluate the conceptual design by creating morphological charts or decision matrices.
4. During **Detailed Design**, refine and optimize the chosen design.
5. For the **Final Design**, document and communicate the fabrication specifications and the justifications for the final design.

BSCS 5E Model
(BSCS, 2005;
Bybee, 2002)

The natural inquiry of children and problem-solving of adults follow a pattern of initial engagement, exploration of alternatives, formation of explanations, use of the explanations, and evaluation of the explanations based on efficacy and others. Activities encourage conceptual change and a progressive reforming of ideas.

1. **Engage** activities provide the opportunity for teachers to identify students' current concepts and misconceptions. Although provided by a teacher or structured by curriculum materials, these activities introduce major ideas in problem situations. How do students' explain this situation?
2. **Explore** activities provide a common set of experiences for students and opportunities for them to "test" their ideas with their own experiences and those of peers and the teacher. How do students' exploration and explanation of experiences compare with others?
3. **Explain** activities provide opportunities for students to use their previous experiences to recognize misconceptions and to begin making conceptual sense of the activities through construction of new ideas and understandings. Allows introduction of formal language, terms and content information that makes students' previous experiences easier to describe and explain.
4. **Elaborate** activities apply or extend the student's developing concepts in new activities and relate their previous experiences to the current activities. How does the new explanation work in a different situation?
5. **Evaluate** activities serve as a summative assessment of what students know and can do. How do students understand and apply concepts and abilities?

WebQuest

(Dodge, 1998)

WebQuest is an inquiry-oriented strategy in which most or all of the information used by learners is drawn from the Web.

1. **The Introduction** orients students and captures their interest
2. **The Task** describes the activity's end product
3. **The Process** explains strategies students should use to complete the task
4. **The Resources** are the Web sites students use to complete the task
5. **The Evaluation** measures the results of the activity
6. **The Conclusion** sums up the activity and encourages students to reflect on its process and results

Case-Based Reasoning
(Aamodt & Plaza, 1994)

Case-based reasoning is a problem solving paradigm that utilizes the *specific* knowledge of previously experienced, concrete problem situations (cases). A new problem is solved by finding a similar past case, reusing it in the new problem.

1. **Present:** new case or problem
2. **Retrieve**: Given a target problem, retrieve cases from memory that are relevant to solving it. A case consists of a problem, its solution, and, typically, annotations about how the solution was derived.
3. **Reuse**: Map the solution from the previous case to the target problem. This may involve adapting the solution as needed to fit the new situation. In the pancake example, Fred must adapt his retrieved solution to include the addition of blueberries.
4. **Revise**: Having mapped the previous solution to the target situation, test the new solution in the real world (or a simulation) and, if necessary, revise. Suppose Fred adapted his pancake solution by adding blueberries to the batter. After mixing, he discovers that the batter has turned blue -- an undesired effect. This suggests the following revision: delay the addition of blueberries until after the batter has been ladled into the pan.
5. **Retain**: After the solution has been successfully adapted to the target problem, store the resulting experience as a new case in memory. Fred, accordingly, records his newfound procedure for making blueberry pancakes, thereby enriching his set of stored experiences, and better preparing him for future pancake-making demands.

Simulation Model
(Joyce, Weil, & Showers, 1992)

Based on the application of cybernetic principles to education, the purpose of this model is to help students develop skills and knowledge by examining the consequences of their actions.

1. **Orientation**
   - 1.1 Present broad topic of simulation and major concepts
   - 1.2 Explain simulation and gaming
   - 1.3 Give overview of the simulation
2. **Participant Training**
   - 2.1 Set-up scenario (rules, roles, procedures, scoring, types of decisions, goals)
   - 2.2 Assign roles
   - 2.3 Hold abbreviated practice session
3. **Simulation Operations**
   - 3.1 Conduct game activity and game administration
   - 3.2 Feedback and evaluation (of performance and effects of decisions)
   - 3.3 Clarify misconceptions
   - 3.4 Continue simulation
4. **Participant Debriefing**
   - 4.1 Summarize events and perceptions
   - 4.2 Summarize difficulties and insights
   - 4.3 Analyze process
   - 4.4 Compare simulation activity to the real world
   - 4.5 Appraise and redesign the simulation

Inquiry Training Model
(Joyce, Weil, & Showers, 1992)

This model is designed to promote strategies of inquiry and the values and attitudes that are essential to an inquiring mind including: process skills (e.g., observing, collecting and organizing data), active learning, verbal expression, tolerance of ambiguity, and logical thinking.

1. **Confrontation** with the Problem
   - 1.1 Explain inquiry procedures
   - 1.2 Present discrepant event
2. **Data Gathering** - Verification
   - 2.1 Verify nature of objects and conditions
   - 2.2 Verify the occurrence of the problem situation
3. **Data Gathering** - Experimentation
   - 3.1 Isolate relevant variables
   - 3.2 Hypothesize (and test) casual relationships
4. **Organizing, Formulating and Explanation** - Formulate rules or explanations
5. **Analysis of Inquiry Process** - Analyze inquiry strategy and develop more effective ones.

Inductive-Thinking Model
(Taba, 1967)

Based on information-processing theories of human learning, the inductive-thinking model was developed to enhance students' acquisition of concepts, information processing skills as well as their convergent use of information to solve problems.

1. **Concept Formation**
   - 1.1 Enumeration and listing
   - 1.2 Grouping
   - 1.3 Labeling, Categorizing
2. **Interpretation of Data**
   - 2.1 Identify critical relationships
   - 2.2 Explore relationships
   - 2.3 Make inferences
3. **Application of Principles**
   - 3.1 Predicting consequences, explaining unfamiliar phenomena, hypothesizing
   - 3.2 Explaining and/or supporting the predictions and hypotheses
   - 3.3 Verifying predictions

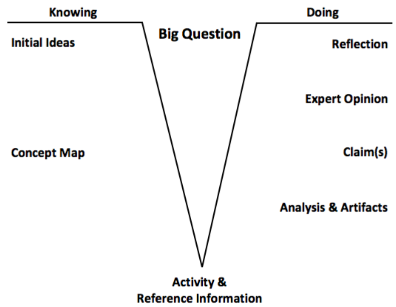
Jurisprudential Inquiry Approach
(Oliver & Shaver, 1971)

Based on Socratic modes of discussion, the purpose of this model is to help students resolve complex, controversial issues within the context of a productive social order:

1. **Orientation** to the Case
2. **Identifying** the Issues
3. **Taking** Positions
4. **Exploring** the Stance(s), patterns of argumentation
5. **Refining and Qualifying** the positions
6. **Testing** Factual Assumptions behind qualified positions

Scaffolded Vee Diagram

(Crippen, Archambault, & Kern, in press; Knaggs & Schneider, 2011)



A Scaffolded Vee Diagram serves as a guide for autonomous learning. The diagram supports students as they engage in the process of generating a scientific argument while focusing their attention on the elements of scientific knowledge (Figure 1).

Figure 1. A modified form of Gowin's Vee diagram.

1. **Big Question**. Contextualizes the inquiry and triggers motivation. Each lesson focuses on answering a big question that is based on relevant, real world problem.
2. **Initial Ideas**. Capture student ideas related to the concepts associated with the Big Question.
3. **Concept Map**. A semantic representation of student understanding.
4. **Analysis and Artifacts**. Produces a set of data in the form of an artifact that will be used in constructing a scientific claim.
5. **Claims**. Describes an evidence-claim-reason related to the big question.
6. **Expert Opinion**. Describes the scientific knowledge related to the big question.
7. **Reflection**. Analyzes and critiques how students' ideas are similar and different.

Authentic Historical Inquiry

(Waring, in press; 2011)

History is about the names, dates and events, but to spark students' interest and make connections between history and real life, instruction must shift from memorization to investigations that allow for the construction of authentic historical narratives. We must expose students to skills and knowledge in ways that are authentic and true to the methods used by professionals in the field. In other words, instead of teaching history, we should teach students how to be historians.

1. **A Hook**. Engage students with a thought provoking image, document, or other source related to the content or an activity that involves a process or concept similar to what is needed in the inquiry.
2. **Identify Fundamental Questions**. Students must have opportunities to ask and answer questions of personal interest.
3. **Engage in Primary and Secondary Sources**. A variety of sources (published or unpublished documents, oral histories, visual documents, artifacts, etc.) should be sought to answer the questions..
4. **Recognize Multiple Perspectives and Historic Causation**. Multiple alternative perspectives must be considered. Finding polar extremes or one cause for an event or one answer to the fundamental question is not sufficient.
5. **Create Plausible Narratives**. Opportunities to construct historical narratives that explain an event or answer fundamental questions utilizing the spectrum of sources, while noting where gaps in the sources or the author's knowledge exist.
6. **Assess Skills, Knowledge and Attitudes**. Consider assess plausible narratives utilizing (a) performance or product checklists, or (b) an analytic or holistic portfolio assessment rubric.
7. **Reflect on Experience**. Ask students to reflect on and share their experiences, identifying areas for future learning and investigation.

Adaptive Instructional Design
(Schwartz, Lin, Brophy & Bransford, 1992)

The primary goal of this theory is to teach a deep understanding of disciplines, while simultaneously fostering the skills of problem-solving, collaboration and communication, through the use of problem-based learning, followed by more open-ended project based learning.

1. **Look Ahead and Reflect Back**
   1.1 Provides an understanding of the goals, context and challenges
   1.2 Provides an opportunity to try it right now (pretest)
   1.3 Consists of motivational series of images, narrative, and questions
   1.4 Helps students represent a specific problem as an example of a larger set of issues
2. **Present Initial Challenge**
   2.1 Helps students develop a shared, initial mental model of what's to be learned
   2.2 Challenge selection: Motivating, interesting, invites student-generated ideas
3. **Generate Ideas**
   3.1 Helps students make their own thinking explicit
   3.2 Helps students see what other students are thinking
   3.3 Encourages sharing of ideas
   3.4 Helps teacher assess current state of student knowledge
   3.5 Provides students with a baseline to more easily see how much they learn
4. **Present Multiple Perspectives**
   4.1 Provide a way to introduce students to vocabulary and perspectives of experts
   4.2 Allow students to compare their ideas to experts' ideas
   4.3 Provide guidance on what students need to learn about
   4.4 Provide expertise, guidance, models of social practice in the domain
   4.5 Provide realistic standards of performance
   4.6 Indicate that multiple perspectives exist in the domain
5. **Research and Revise** (to help students explore a challenge)
   5.1 Consult resources
   5.2 Collaborate with other students
   5.3 Listen to "just-in-time" lectures
   5.4 Complete skill-building lessons
   5.5 Look at legacies left by other students
   5.6 Conduct simulations and hands-on experiments
6. **Test Your Mettle** (formative assessment)
   6.1 Multiple choice tests, checklists, essays, experiments, projects
   6.2 Feedback suggests which resources to consult to reach target
7. **Go Public**
   7.1 Present best solutions (oral, multimedia, print) and leave legacy of tips and ideas for future students
   7.2 Makes thinking visible
   7.3 Helps students learn to assess others and themselves
   7.4 Helps set standards for achievement
   7.5 Helps students learn from each other
   7.6 Motivates students to do well

Eight Events for Student Centered Learning
(Hirumi, 2002, 1998, 1996)

Based on constructivist theories of human learning, Hirumi presents seven instructional events that occur during a course to help students construct their own meaning based on their own interests and prior knowledge structures, and to promote independent, life-long learning:

1. **Set Learning Challenge** (Authentic Problem) for class
2. **Negotiate Learning Goals and Objectives** with learners
3. **Negotiate Learning Strategy** with learners
4. **Learners Construct Knowledge**
5. **Negotiate Performance Criteria** with learners
6. **Assess Learning** (Self, Peer & Expert Assessment)
7. **Provide Feedback** (Throughout Steps 1-6)
8. **Communicate Results**

Constructivist Learning
(Jonassen, 1992)

The primary goal of this theory is to foster problem-solving and conceptual development. It is intended for ill-defined or ill-structured domains.

1. **Select Problem**
   - 1.1 Problem should be interesting, relevant and engaging, to foster learner ownership
   - 1.2 Problem should be ill-defined or ill-structured
   - 1.3 Problem should be authentic (what practitioners do)
   - 1.4 Problem design addresses context, representation, and manipulation space
2. **Provide Related Cases** or worked examples to enable case-based reasoning and enhance cognitive flexibility.
3. **Provide Information**
   - 3.1 Provide learner-selectable information just-in-time
   - 3.2 Available information should be relevant and easily accessible
4. **Provide Cognitive Tools** that scaffold required skills, including problem-representation, knowledge-modeling, performance-support, and information-gathering tools
5. **Provide Conversation and Collaboration Tools** to support discourse communities, knowledge-building communities, and/or communities of learners.
6. **Provide Social/Contextual Support** for the learning environment

Additional Instructional Activities to Support Learning:

- Model the performance and the covert cognitive processes
- Coach the learner by providing motivational prompts, monitoring and regulating the learner’s performance, provoking reflection, or perturbing learners’ models.
- Scaffold the learner by adjusting task difficulty, restructuring the task, and/or providing alternative assessments

Teacher-Directed Approaches to Teaching and Learning

Nine Events of Instruction

(Gagne, 1974, 1977; Gagne & Medsker, 1996)

Based on information processing theories and models of human learning, Gagne posits that every unit of instruction should contain the following nine events to facilitate student learning:

1. **Gain Attention.** Use thought provoking questions, images and information to gain learners attention**.**
2. **Inform Learners of Objective(s).**
3. **Stimulate Recall** of prior knowledge to facilitate assimilation of new skills and knowledge.
4. **Present Stimulus Materials** chunking content into smaller pieces to facilitate encoding.
5. **Provide Learning Guidance** such as mnemonics, highlights and tips to facilitate interpretation, synthesis and application of content information.
6. **Elicit Performance** requiring behaviors that are aligned to objectives.
7. **Provide Feedback** about performance.
8. **Assess Performance** using methods and criteria aligned to objectives.
9. **Enhance Retention and Transfer** by asking learners to reflect on and/or apply new knowledge and skills under different conditions.

Five Learning Components

(Dick, Carey, & Carey, 2009)

To facilitate the instructional design process, Dick, Carey and Carey (2009) organized Gagne's nine events of instruction into five major learning components:

1. **Pre-instructional Activities** prior to beginning of formal instruction, addressing three factors:
   1.1 Motivating learners
   1.2 Informing learners of the objectives
   1.3 Stimulating recall of pre-requisite skills
2. **Content Presentation and Learning Guidance** explains what the unit is bout by presenting information, concepts, rules, and principles to be learned in either deductive or inductive manner. Learning guidance is integrated with content presentation using cues, outlines, diagrams, models, still and motion graphics, highlights, flowcharts, examples, etc.
3. **Learner Participation** with feedback enhances learning by giving learners an opportunity to practice what they learned using practical exercises, scenarios, and embedded tests.
4. **Assessment** including entry skills tests, pretests, practice tests, and posttest presented to learners at appropriate moments before, during or after the lesson.
5. **Follow-Through Activities** including memory aids or job aids, parallel problem scenarios, and learner plans that help learners memorize skills and facilitate the transfer of learning to new contexts.

Direct Instruction Model

(Joyce, Weil, & Showers, 1992)

Based on behaviorist theories of human learning, this model is designed to facilitate learning through stimulus-response conditioning and is said to generate and sustain motivation through pacing and reinforcement.

1. **Orientation**
   - 1.1 Establish lesson content
   - 1.2 Review previous learning
   - 1.3 Establish lesson objectives
   - 1.4 Establish lesson procedures
2. **Presentation**
   - 2.1 Explain/demonstrate new concept or skill
   - 2.2 Provide visual representation of task
   - 2.3 Check for understanding
3. **Structured Practice**
   - 3.1 Lead group through practice example in lock step
   - 3.2 Students respond to questions
   - 3.3 Provide corrective feedback for errors and reinforce correct practice
4. **Guided Practice**
   - 4.1 Students practice semi-independently
   - 4.2 Circulate, monitor student practice
   - 4.3 Provide feedback through praise, prompt, and leave
5. **Independent Practice**
   - 5.1 Students practice independently at home or in class
   - 5.2 Provide delayed feedback

Elements of

Lesson Design

(Hunter, 1990)

Widely known model for preparing lesson plans taught to pre-service teachers. Often used to evaluate lesson plans prepared by practicing educators.

1. **Anticipatory Set** – How will students' attention be focused**?**
2. **Objective and Purpose** – What will students learn and why?
3. **Input** – What new information will be discussed?
4. **Modeling** – How can teacher illustrate new skill or content?
5. **Check for Understanding** – How can teacher determine if students are learning?
6. **Guided Practice** – What opportunities are given to practice new materials?
7. **Independent Practice** – How can assignments be used for retention and transfer?

Neurobiological Approaches to Teaching and Learning

Brain Rules
(Medina, 2014)

Brain scientists have uncovered details every business leader, parent, and teacher should know—like the need for physical activity to get your brain working its best. In Brain Rules, Dr. John Medina, a molecular biologist, shares his lifelong interest in how the brain sciences might influence the way we teach our children and the way we work. He describes 12 brain rules: What scientists know about how our brains work.

SURVIVAL: The human brain evolved. The brain is a survival organ. It is designed to solve problems related to surviving in an unstable outdoor environment. The strongest brains survive, not the strongest bodies

EXERCISE: Exercise boosts brain power. The human brain evolved under conditions of almost constant motion. From this, one might predict that the optimal environment for processing information would include motion..

SLEEP: Sleep well, think well. When we're asleep, the brain is not resting at all. It is almost unbelievably active! Loss of sleep hurts attention, executive function, working memory, mood, quantitative skills, logical reasoning, and even motor dexterity.

STRESS: Stressed brains don't learn the same way. Your brain is built to deal with stress that lasts about 30 seconds. The brain is not designed for long term stress when you feel like you have no control. You can actually watch the brain shrink.

WIRING: Every brain is wired differently. What YOU do and learn in life physically changes what your brain looks like – it literally rewires it. We used to think there were 7 categories of intelligence, but may number more than 7 billion.

ATTENTION: We don't pay attention to boring things. What we pay attention to is profoundly influenced by memory. Our previous experience predicts where we should pay attention. Culture matters too.

MEMORY: Repeat to remember. The brain can only hold about seven pieces of information for less than 30 seconds! To extend the 30 seconds to a few minutes or even an hour, you will need to consistently re-expose yourself to the information.

SENSORY INTEGRATION: Stimulate more of the senses. Our senses work together! Those in multisensory environments always do better than those in unisensory environments.

VISION: Vision trumps all other senses. We are incredible at remembering pictures. Our brain sees words as lots of tiny pictures, and we have to identify certain features in the letters to be able to read them. That takes time.

MUSIC: Study or listen to boost cognition. Ideas about how music affects the brain long have been the providence of anecdote. But the research has been maturing for a while now.

GENDER: Male and female brains are different. By more than 2 to 1, women are more likely to get depressed than men, a figure that shows up just after puberty and remains stable for the next 50 years. Males exhibit more antisocial behavior.

EXPLORATION: We are powerful and natural explorers. The desire to explore never leaves us despite the classrooms and cubicles we are stuffed into. We learn, not by passive reaction to the environment but by active testing through observation, hypothesis, experiment, and conclusion.

Principles of Natural Learning
(Caine, Caine, McClintic & Klimek, 2005; Caine & Caine, 1997)

Caine and Caine (1997) conclude that, "Optimizing the use of the human brain means using the brain's infinite capacity to make connections–and understanding what conditions maximize this process." They identify three essential conditions for complex learning to occur. By addressing the 12 principles of natural learning, educators may establish the three fundamental conditions for complex learning.

1. **Relaxed Alertness**. An optimal state of mind that we call relaxed alertness, consisting of low threat and high challenge.
   a. Learning is enhanced by challenge and inhibited by threat
   b. The brain/mind is social
   c. The search for meaning is innate
   d. Emotions are critical to patterning
2. **Orchestrated Immersion**. The orchestrated immersion of the learner in multiple, complex, authentic experience.
   a. The brain/mind processes parts and wholes simultaneously
   b. All learning engages the physiology.
   c. The search for meaning occurs through patterning
   d. Learning is developmental
3. **Active Processing**. The regular, active processing of experience as the basis for making meaning.
   a. Two approaches to memory: To store isolated facts, skills, and procedures; To make sense of experience.
   b. Learning involves both focused attention and peripheral perception.
   c. Learning is both conscious and unconscious.
   d. Each brain is uniquely organized.

Interplay Strategy
(Hirumi et al., under review; Stapleton & Hirumi, 2014; Stapleton & Hirumi, 2011)

Based on the belief that the learning of facts, concepts and principles occurs best in context of how they will be used, the Interplay strategy evokes emotions and sparks imagination, based on cognitive neuroscience research, to enhance experiential learning theories by addressing three primary conventions of interactive entertainment and their related elements (i.e., Story - characters, events, worlds; Game – rules, tools, goals; Play – stimulus, response, consequences).

1. **Expose** – Exposure provides the back-story to entice empathy for the character or player, and orients the audience into the same reference point or point of view. Exposure sets up specified learning objectives in a meaningful way to invite the student to contribute, to engage and to achieve the challenges set before them.
2. **Inquire** – Inquiry validates Exposure. If exposure sets a desire to learn, then inquiry is automatic. Inquire provides a response to student's curiosity with something to do that showcases different elements that will be used later.
3. **Discover** – Discovery provides the personal reward, achievement, and the "ah ha" moment. The consequences of discovery, whether negative or positive, provide feedback to inspire further exploration to the next level of achievement.
4. **Create** – Transforms the experience from being merely reactive to truly interactive. Instead of responding to cues, the learner contributes to the content by applying the elements of the subject matter in novel ways.
5. **Experiment** – Provides an opportunity to assess learning and provide feedback without losing or winning. The goal is less about the hypothesis being right or wrong, but rather setting up the elements of the subject matter so that new knowledge can be gained. Failure should be fun.
6. **Share** – The sharing of personal experiences and feelings is facilitated at the end of the lesson or unit, to seal the memory of the learning experience. Sharing compels learners to put lessons learned in their own perspective as well as others.

Brain-Based Learning Principles

(Jensen, 2005)

Jensen posits 10 ***brain-based*** *principles that he views are most important to learning. He notes that another person might come up with a different list and still be correct and that everyone neither agrees on these principles nor on the brain-based learning strategies that can be inferred from the principles. However, these are the principles that drive Jensen's work.*

1. **Malleable memories.** Memories are often not encoded at all, encoded poorly, changed or not retrieved. Memories are susceptible to inattention, erosion over time, subject bias, misattribution and a host of other confounding conditions. Memories are strengthened by frequency, intensity and practice under varying conditions and contexts.
2. **Non-conscious experience runs automatic behaviors**. The complexity of the human body requires that we automate many behaviors. The more we automate, the less we are aware of them. Most of our behaviors have come from either "undisputed downloads" from our environment or repeated behaviors that have become automatic. This suggests potential problems and opportunities in learning.
3. **Reward and addiction dependency**. Humans have a natural craving for positive feelings, including novelty, fun, reward and personal relationships. There is a natural instinct to limit pain even if it means compromising our integrity. For complex learning to occur, students need to defer gratification and develop the capability to go without an immediate reward.
4. **Attentional Limitations**. Most people cannot pay attention very long, except during flow states, because they cannot hold much information in their short-term memory. We are born with the capacity to orient and fixate attention when it comes to contrast, movement, emotions or survival. Adapting the content to match the learner provides better attention and motivation to learn.
5. **Brain seeks and creates understanding**. The human brain is a meaning-maker and meaning seeker. We assign value and meaning to many everyday occurrences whether it's on intentional or not. Meaning-making is an important human attribute that allows us to predict and cope with experiences. The more important the meaning, the greater the attention one must pay in order to influence the content of the meaning.
6. **Rough Drafts/Gist Learning**. Brains rarely get complex learning right the first time. Instead they often sacrifice accuracy for simply developing a "rough draft" of the learning material. If, over time, the learning material maintains or increases in its importance and relevance, the brain will upgrade the rough draft to improve meaning and accuracy. To this end, prior knowledge changes how the brain organizes new information. Goal-driven learning proceeds more rapidly than random learning. Learning is enhanced by brain mechanisms with contrasting output and input goals.
7. **Input Limitations**. Several physical structures and processes limit one's ability to take in continuous new learning. The "slow down" mechanisms include the working memory, the synaptic formation time for complex encoding and the hippocampus. While we can expose our brain to a great deal of information in a short time frame, the quality of that exposure is known as "priming" and is not considered in-depth learning. Schools typically try to cram as much content as possible in a day as possible. You can teach faster, but students will just forget faster.
8. **Perception influences our experience**. A person's experience of life is highly subjective. Many studies show how people are easily influenced to change how we see and what we hear, feel, smell and taste. This subjectivity alters experience, which alters perception. When a person changes the way they perceive the world, they alter their experience. It is experience that drives change in the brain.
9. **Malleability/Neural Plasticity**. The brain changes every day and more importantly, we influence those changes. New areas of brain plasticity and overall malleability are regularly discovered. It is known that experience can drive physical changes in the sensory cortex, frontal lobes, temporal lobes, amygdala and hippocampus. In addition whole systems can adapt to experience such as the reward system or stress response system.
10. **Emotional-Physical State Dependency**. Nearly every type of learning includes a "go" or "no go" command to the brain in our neural net signaling process. These complex signals are comprised of excite or suppress signals. Emotions can provide the brain's signals to either move ahead or not. Thus, learning occurs through a complex set of continuous signals which inform your brain about whether to form a memory or not. Both emotional and bodily states influence our attention, memory, learning, meaning and behavior through these signaling systems.

Alternative Approaches to Teaching and Learning

4Mat System Model
(McCarthy, 1987)

Based on research and literature on learning styles, this eight-step cycle of instruction is meant to capitalize on students' learning styles and brain dominance processing strengths. Rather than focus on one learning style, this method encourages students to examine and experience all learning styles.

1. **Create** an experience
2. **Reflect/Analyze** Experience
3. **Integrate** reflective analysis into concepts
4. **Develop** concepts/skills
5. **Practice** defined "givens"
6. **Practice** adding something of oneself
7. **Analyze** application for relevance, usefulness
8. **Apply** to new more complex experience

SQR Model
(Maier, 1990)

This strategy is designed to encourage students' to take responsibility for their learning and to give students a way to generate their own ideas. In general, this strategy is geared toward enhancing student learning from reading, but may be applied in other context.

1. **Summarize**
   - 1.1 Read materials
   - 1.2 Write a summary of the materials in journal
2. **Question**
   - 2.1 Write question on the materials in journal
   - 2.2 Discuss summaries and questions in small group
   - 2.3 Select "best" question to share with whole class based on ability to provoke engaging discussions
   - 2.4 Discuss "best" questions with whole class utilizing questioning techniques
3. **Response** - Write a response to the small group or whole group class discussion (summary of main points)

SQ3R Study Strategy
(Robinson, 1961)

This strategy is designed to help students develop their study skills, particularly in relation to reading assignments.

1. **Survey** - Readers preview materials to develop general outline for organizing information.
2. **Question** - Reader raises questions with expectation of finding answers in materials
3. **Read** - Reader attempts to answer questions by reading
4. **Recite** - Reader answers questions out loud or in writing
5. **Review** - Reader rereads portions of materials to verify answers given during previous step

References

Aamodt, A. & Plaza, E. (1994). Case-Based Reasoning: Foundational Issues, Methodological Variations, and Systems Approaches. *Artificial Intelligence Communications*, *7*(1), 39-59. Retrieved March 15, 2005 from the World Wide Web: http://www.lai-cbr.org/theindex.html.

Bardach, E. (2000). *A practical guide for policy analysis*. New York, NY: Chatham House

Barrows, H. S. (1985). *How to design a problem based curriculum for the preclinical years*. New York: Springer Publishing Co.

Boud, D., & Feletti, G. (1997). *The Challenge of Problem-Based Learning* (2nd ed.). London, Kogan Page Limited.

BSCS Center for Professional Development (2005). *Learning Theory and the BSCS 5E Instructional Model.* Retrieved November15, 2005 form http://www.bscs.org/library/ handoutlearningtheory5E.pdf

Bybee, R. W. (2002). Scientific inquiry, student learning, and the science curriculum. In R. W. Bybee (Ed.). *Learning Science and the Science of Learning* (pp. 25-36). Arlington, VA: NSTA Press.

Caine, R. N., & Caine, J. (1997). *Education on the Edge of Possibility*. Alexandria VA: Association for Supervision & Curriculum Development.

Caine, R. N., Canine, J., McClintic, C. & Klimek, K. (2005). *12 Brain/Mind Learning Principles in Action: The fieldbook for making connections, teaching, and the human brain.* Thousand Oaks, CA: Corwin Press.

Clark, R. E. (2004). *Design Document for a Guided Experiential Learning Course*. Submitted to satisfy contract DAAD 19-99-D-0046-0004 from TRADOC to the Institute for Creative Technologies and the Rossier School of Education, University of Southern California.

Crippen, K. J., Archambault, L., & Kern, C. (in press). Using Scaffolded Vee Diagrams to Enact Inquiry-Based Learning. In A. Hirumi (Ed.). *Grounded Designs for Online and Hybrid Learning: Practical Guidelines for Educators and Instructional Designers*. Eugene, WA: International Society for Technology in Education.

Dick, W., Carey, L., & Carey, J. O. (2009). *The Systematic Design of Instruction* (7th edition), Upper Saddle River, NJ: Pearson.

Dodge, B. (1998). *The WebQuest Page*. Retrieved April 3, 2000 from the World Wide Web: http://edweb.sdsu.edu/webquest/webquest.html

Dym, C. L., & Little, P. (2004). *Engineering design: A project-based introduction*. New York, NY: Wiley.

Gagne, R.M. (1977). *The Conditions of Learning* (3rd ed.). New York: Holt, Rinehart, and Winston.

Gagne, R.M. (1974). *Principles of Instructional Design*. New York: Holt, Rinehart and Winston.

Gagne, R.M., & Medsker, K.L. (1996). *The conditions of learning: Training applications*. Orlando, FL: Harcourt Brace College Publishers.

Hannafin, M. J., Hannafin, K. M., Land, S. M., & Oliver, K. (1997). Grounded practice and the design of constructivist learning environments. *Educational Technology Research & Development, 45*(3), 101-117.

Hirumi, A. (2013). Three levels of planned elearning interactions: A framework for grounding research and the design of elearning programs. *Quarterly Review of Distance Education, 14*(1), 1-16.

Hirumi, A. (2002). Student-centered, technology-rich, learning environments (SCenTRLE): Operationalizing constructivist approaches to teaching and learning. *Journal for Technology and Teacher Education, 10*(4), 497-537.

Hirumi, A. (1998, March). *The Systematic Design of Student-Centered, Technology-Rich Learning Environments*. Invited guest presentation given at the first Education Graduate Students and Academic Staff Regional Meeting, Guadalajara, Mexico.

Hirumi, A. (1996, February). *Student-Centered, Technology-Rich Learning environments: A cognitive-constructivist approach*. Concurrent session held at the Association for Educational Communication and Technology Conference, Indianapolis, Indiana.

Hirumi, A., Atkinson, T., Stapleton, C. (2011). *Interplay: Evoking Emotions and Sparking Imagination through Story, Play and Game*. Concurrent Session presented the annual Association for Educational Communication and Technology conference, Jacksonville, FL. Nov. 8-12.

Hirumi, A., Reyes, R., Rivera-Gutierrez, Johnson, K., D., Kleinsmith, A., Kubovec, S., Eakins, M., Bogert, K., Lok, B., & Cendan, J. (under review). Advancing virtual patient simulations and experiential learning with Inter*PLAY*: Examining how theory informs design and design informs theory. *Computers & Education.*

Hunter, M. (1990). Lesson Design Helps Achieve the Goals of Science Instruction. *Educational Leadership*. *48*(4), 79-81.

Jonassen, D. (2011). Designing constructivist learning environments. In C. M. Reigeluth (Ed.). *Instructional Design Theories and Models: Vol. 2. A New Paradigm of Instructional Theory (pp. 215-239)*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Jonassen, D. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.). *Instructional Design Theories and Models: Vol. 2. A New Paradigm of Instructional Theory (pp. 215-239).* Hillsdale, N.J.: Lawrence Erlbaum Associates.

Jensen, E. (2005). *Teaching with the brain in mind*. Alexandria, VA: Association for Supervision and Curriculum Development.

Joyce, B., Weil, M., & Showers, B. (1992). *Models of Teaching* (4th ed.). Needham Heights, MA: Allyn and Bacon.

Knaggs, C. M., & Schneider, R. M. (2011). Thinking Like a Scientist: Using Vee-Maps to Understand Process and Concepts in Science. *Research in Science Education*.

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Maier, J.N. (1990). *SQR: Summary, Question, Respond, A discussion strategy for developing critical thinking.* Unpublished curriculum development.

Medina, J. (2014). *Brain rules: 12 principles for surviving and thriving at work, home, and school*. Seattle, WA: Pear Press.

McCarthy, B. (1987). *The 4MAT System: Teaching to Learning Styles with Right/Left Mode Techniques*. Barrington, Ill.: Excel, Inc.

Nelson, L. (1999). Collaborative Problem-Solving. In C. M. Reigeluth (Ed.). *Instructional Design Theories and Models: Vol. 2. A New Paradigm of Instructional Theory (pp. 241-267)*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Oliver, D., & Shaver, J. (1971). *Cases and Controversy: A Guide to Teaching the Public Issues Series*. Middletown, CT: American Education Publishers.

Pfeiffer, J.W., & Jones, J.E. (1975) Introduction to the structured experiences section. In J.E. Jones & J.W. Pfeiffer (Eds.). *The 1975 annual handbook for group facilitators*. La Jolla, CA: University Associates.

Schwartz, Lin, Brophy, S., & Bransford, J. D. (1992). Toward the development of flexibly adaptive instructional designs. In C. M. Reigeluth (Ed). *Instructional Design Theories and Models: Vol. 2. A New Paradigm of Instructional Theory (pp. 183-213)*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Shank, R. C., Berman, T. R., & Macpherson, K. A. (1992). Learning by doing. In C. M. Reigeluth (Ed). *Instructional Design Theories and Models: A New Paradigm of Instructional Theory (pp. 161-179)*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Stapleton, C. & Hirumi, A. (2014). Designing InterPLAY learning landscapes to evoke emotions, spark the imagination, and promote creative problem solving. In A. Hirumi (ed). *Grounded Designs for Online and Hybrid Learning: Designs in Action.* Eugene, WA: International Society for Technology in Education.

Stapleton, C. & Hirumi, A. (2011). Interplay instructional strategy: Learning by engaging interactive entertainment conventions. In M. Shaughnessy & S. Fulgham (eds). *Pedagogical Models: The Discipline of Online Teaching* (pp. 183-211). Hauppauge, NY: Nova Science Publishers, Inc.

Taba, H. (1967). *Teacher's Handbook for Elementary School Social Studies*. Reading, MA: Addison-Wesley Publishing Co., Inc.

Waring, S. M. (in press). Conducting Authentic Historical Investigations in the Digital Age. In A. Hirumi (Ed.). *Grounded Designs for Online and Hybrid Learning: Practical Guidelines for Educators and Instructional Designers*. Eugene, WA: International Society for Technology in Education.

Waring, S. M. (2011). *Preserving History: The construction of history in the K-16 classroom.* Charlotte, NC: Information Age Press.