Visual Design Principles

1. Overall Goal

Inform and Perform eLearning Goals

Type	A Visual Used To	Examples
Inform	Lessons that communicate information	• Company history • New product features
Perform-Procedures	Lessons that build procedural skills (near transfer)	• How to log on • How to complete an expense report
Perform-Principle	Lessons that build principle-based skills (far transfer)	• How to close a sale • How to design a Web page

2. Architecture Analysis

Four Instructional Architectures

Architecture	Features	Learning Assumptions	Examples	Best Used For
Receptive: Information Acquisition	• Delivery of content • Few or no opportunities for interaction	• Includes lots of info with limited practice opportunities • Passive absorption of information	• PowerPoint lectures • Video lessons • Texts	• Inform goals • Learners with content knowledge • Building awareness • Briefings
Directive: Response Strengthening	• Bottom up sequences • Short lessons • Frequent questions • Corrective feedback • Deductive approach	• Require frequent responses from learners with immediate feedback • Gradual building of	• Programmed Instruction • Much software training	• Perform-procedure goals • Learners who are novice to content • Procedural tasks

Architecture	Features	Learning Assumptions	Examples	Best Used For
	• Avoidance of errors • Instruction provides questions and feedback	knowledge chains through frequent learner responses and feedback		
Guided Discovery: Knowledge Construction	• Problem-centered lessons • Opportunities to try and learn from errors • Inductive approach • Instructors as coaches • Often uses collaboration and simulation	• Provide job-realistic problems and supporting resources • Knowledge and skills constructed by engaging in solving authentic job problems with support • Mistakes are learning opportunities	• Problem-centered training • Cognitive apprenticeships	• Perform-principle goals • Learners with some content knowledge • Far-transfer tasks • Building problem solving skills
Exploratory	• Rich network of learning resources • Good navigational interfaces	• Learners take responsibility for learning; High learner control	• Some Internet courses that contain multiple options and links	• Learners with content knowledge and good metacognitive skills • Far transfer and conceptual learning

Four Instructional Strategies and Their Graphic Needs

Strategy	Description	Learner Response and Control	Framework Graphic
Receptive	Learner is exposed to information as in a lecture or linear video.	Learners are viewed as passive sponges or empty vessels that absorb content. Has little control over the pace of the instruction.	Can be elaborate, attention getting. Since there is often very little interaction, the graphics need to constantly pull the learner in.
Directive	Learner is presented with small chunks of instruction including ample opportunity to practice. Typical strategy is to present the rule, example, and then provide a practice.	Learners are viewed as active but novices who are hand-held and walked through instruction step by step. Learners have control over the pace of the instruction, but are generally guided or restricted in terms of the sequence.	Requires standardized navigation. Also, especially in e-learning, requires standard interaction elements—buttons for answers, feedback, and so forth.
Guided Discovery	Learner learns by doing in a "real-life" environment, with guidance and coaching provided.	Learners are viewed as active participants in their learning. Has control over pacing and sequence, through what is covered.	Graphics simulated work environments. Coaches or Guides often have an on-screen character.
Exploratory	No prescribed path or "best sequence." Instructional content is organized in an appropriate schema (procedurally, alphabetically, etc.) and the learners choose the best path for their needs.	Learners are viewed as experienced and capable of identifying the training and knowledge they need. Complete control in terms of pacing and sequence and what is covered.	Display must accommodate multiple possible choices at all times. Common e-learning display frameworks take on the appearance on online references.

3. Learner Profile

Novice vs. Advanced vs. Mixed

Determine the level of expertise that the learner has on the eLearning content.

4. Cognitive Optimization

Instructional Methods for Encoding

Learning Outcome	Implicit Encoding Methods	Explicit Encoding Methods
Memory (Recall/Recognition)	• Mnemonics • Representative graphics	• Maintenance Rehearsal
Complex Mental Models	• Organizational, Transformational, Interpretive Graphics • Analogies • Examples	• Elaborative Rehearsal: 1. Argumentation 2. Collaborative Learning

Three Memories Involved in Learning

Memory	Features
Sensory	• Separate memories for different senses e.g. visual and auditory • Duration of sensory data is brief
Working	• Center of conscious cognition • Limited capacity • Brief duration of new content • Includes separate areas for processing and storage of auditory and visual sensory data
Long-Term	• Storage but no processing of content and skills • Large capacity for storage • Permanent repository of knowledge • Knowledge stored in two forms: o Declarative—facts and concepts o Procedural—skills

5. Content Analysis (Validation)

The Five Content Types

Content Type	Description	Examples
Fact	A type of supporting knowledge that designates unique, specific content about objects, events, or people.	• The specific six log-on codes • The order entry screen • The product specifications
Concept	A type of supporting knowledge that involves a category of objects, events, or ideas usually designated by a single word.	• Chair • Integrity
Procedure	Tasks that involve the same steps each time they are performed. Also called near-transfer tasks.	• Accessing e-mail • Completing a routine customer order
Process	A type of supporting knowledge that describes state changes about how systems work.	• How a toilet flushes • The performance appraisal process
Principle	A comprehensive law that includes predictive relationships. Far-transfer tasks that require workers to adapt to unique situations.	• Laws of genetic inheritance • Making a sale • Writing a report

An Overview of How to Visualize

Content Type	Shows How To
Facts	Use representational and organizational visuals to illustrate concrete and discrete factual information. Emphasizes the design and placement of memory aids to help workers retrieve facts when needed.
Concepts	Use visuals to help learners build mental models of concepts that will enable them to make discriminations on the job.
Procedures	Use transformational visuals to illustrate the steps the learner takes to perform a procedural task. Emphasizes how to support transfer of learning and manage cognitive load.
Processes	Use transformational visuals that incorporate representational visuals for concrete processes and analogical visuals for abstract processes to help workers build mental models of how systems work.
Principles	Visualize guided-discovery lesson architectures to support problem-centered learning as well as how to use interpretive visuals to display scientific principles.

Tips for Visualization

Content Type	Tips
Facts	• Visualize factual information in a format and location that will make facts accessible to the worker or learner when needed on the job or in the lesson • Use representational graphics for concrete facts • Visualize factual information in the context of the job environment • Group related facts together in an organizational visual to make them easier to learn or find • Use interactive fact graphics in multimedia lessons • Encourage learners to engage in factual visuals by asking learners to interpret data or apply factual information in the context of performing a related job task • Eliminate or de-emphasize extraneous details in visuals of fact content
Concepts	• For concrete concepts, place two or more visual examples on the screen or page so they are contiguous to each other and to a text definition • Use representational graphics when the concept is concrete • Use cuing techniques and callouts to identify the discriminating features • For concrete concepts, place one or more visual counterexample(s) on the screen or page contiguous with examples • For abstract concepts, use visual analogies to make the ideas more concrete • For multiple concepts, use organizational visuals to illustrate coordinate and subordinate relationships • Sequence important lesson concepts prior to the main lesson content such as task or process • Engage learners in concept visuals by making them interactive on the computer or by asking related questions about them • Use mouse rollovers for definitions where it is not important to compare; where it is important to simultaneously view two or more definitions or examples, display pop-ups that can remain in view until closed • Use visuals for practice of concepts that require learners to discriminate between valid and invalid instances of the concept
Procedures	• On performance aids, use diagrams (with or without text) to illustrate procedural instructions that involve moderate to high spatial complexity. • Design training and performance aids to effectively accommodate the representational and transformational visuals needed to illustrate the action steps ○ In manuals use left-to-right layout of full screens with numbered

Content Type	Tips
	action steps that show action sequences o On computers, use animations of full screens accompanied by narration of action steps and text summaries of steps placed on the screen for memory support o On computers, keep number of steps demonstrated within the 7 ± 2 guideline o On computers, introduce steps sequentially and prevent users from accessing them out of sequence o In manuals or computers, integrate text labels or action steps into the illustration o In manuals or computers, show the actions from the visual orientation of the performer • Use visuals to draw attention to warnings placed right before or within the action step • In training of computer procedures in e-learning, provide learners with opportunities to practice with simulations of the system that use representational visuals o Provide visual feedback by showing the actual system response to learner input (error message or next action) o Provide text feedback placed on the screen
Processes	• Sequence illustrations of individual process components first shown in system context followed by transformational illustrations of the entire process • Layout process graphics to mirror their real-world spatial arrangements • Use visual analogies to illustrate abstract processes • Engage learners with process visuals depending on the medium in which they are displayed • Manage cognitive load by explaining animations with audio narration and by providing functionality that supports learner study, such as magnify, replay, fast forward, and pause
Principles	• Design checklists, job aids, or worksheets to aid learners in PCL • Use interpretive graphics and dynamic simulations to model principles in action • Engage learners with simulations to promote problem solving • Use questions to engage learners with static interpretive visuals

Common Mistakes to Avoid When Visualizing

Content Type	Common Mistakes
Facts	• Placing factual information in inaccessible places in the work environment or lesson • Grouping factual information together in one location in the lesson rather than integrating it with related lesson content • Including unrelated facts and never integrating them in the lesson • Requiring memorization of factual information when a reference aid could be developed and used • Overemphasizing representational graphics of facts in lessons because they are easier to identify and visualize than other types of content
Concepts	• Omitting important concepts or providing only a brief definition without supporting examples • Using only one example to illustrate a complex and new concept • Failing to show examples contiguous with each other, with definitions, and with counterexamples • Embedding concepts in main lesson sections and thus overloading the learner • Including practice that asks learners to define concepts rather than to discriminate them • Locking learners into a sequential sequence for displaying examples and nonexamples. Concepts are ideal for engaging interactions where the learner has control of investigating samples and comparing them to nonexamples
Procedures	• Using visuals that do not accurately reflect the work environment • Using representative visuals that are not transformational, they do not show action flows • Showing the action area of the equipment or interface out of context of the whole equipment screen • Failing to include or draw attention to warnings • Physically separating words from visuals • Failing to provide the learner with an orientation to where the procedure falls among a series of procedures or within the entire job task • Allowing learners to experience steps out of sequence
Processes	• Failing to teach the process at all or not using visuals to illustrate the process • Displaying process visuals out of context or in arrangements that do not reflect their real-world configurations • Overloading learners by illustrating complex processes all at once in animations • Failing to promote engagement of the learner with the process visuals • Oversimplifying the process to fit display real estate constraints
Principles	• Using procedure or process visuals that imply a fixed sequence of steps that never varies to teach principles

Content Type	Common Mistakes
	• Failing to promote learner engagement with interpretive visuals • Using a discovery learning approach with visual simulations • Removing details that carry important cues to the appropriate diagnosis or application of principle • Developing elaborate visual environments such as virtual reality that obscure the key tasks or do not contribute to learning

Summary of Guidelines

Content Type	Guidelines
Facts	• Use representational visuals to show concrete facts in job context. • In the work or training environment, display discrete factual data where it can easily be seen when needed. • Use organizational visuals to display multiple discrete facts. • Use mnemonic visuals when physical memory aids are not available and facts must be recalled. • Use relational visuals to illustrate or support discovery of relationships or trends in numeric data. • Engage learners with factual visuals by including them in practice exercises involving other related content types.
Concepts	• Display two or more representational graphics contiguous with each other and with text definitions. • Create counterexamples to help the learner build an accurate mental model. • Use visual analogies especially for more abstract or unfamiliar concepts. • Display related concepts together (contiguity principle). • Use organizational graphics to illustrate related concepts and their features. • Promote learner engagement with concept visuals.
Procedures	• Promote learning through demonstrations that combine transformational and representational visuals. • Design transformational graphics that show activity flow from the performer's perspective in the job environment. • Manage cognitive load in visual presentations when procedures or visuals are complex, learners are novice, or the presentation is instructionally paced, such as uses audio or animation. • Use visuals to draw attention to and illustrate warnings. • For online practice of computer procedures, support

Content Type	Guidelines
	transformational visuals with on-screen contiguous text to provide directions, feedback, and memory support.
Processes	• Use transformational visuals such as flow diagrams and animations that show state changes in the process. • Manage load when presenting process visuals by teaching system components first, providing words in audio format, and using attention-focusing strategies. • Use interpretive visuals such as schematics and visual analogies to represent abstract process such as how computer program code works. • Promote engagement with process visuals in ways that help learners build a cause-and-effect model of the system.
Principles	• Use representational visuals of the job environment to display PCL lesson. • Use graphic design devices to manage cognitive load during PCL. • Assign analysis of video-taped cases to promote learning principles that involve high degrees of interpersonal activity. • Engage learners with explanatory visuals including visual simulations and static interpretive visuals to build rich mental models that underlie principles.

6. Graphics Function Analysis

Communication Functions of Graphics

The communication purpose such as to show motion or to illustrate quantitative relationships

Function	A Graphic Used to	Examples
Decorative	Add aesthetic value or humor to the materials.	• Art on the cover of a book • Visual of a general in a military lesson on ammunition
Representational	Depict an object in a realistic fashion.	• A screen capture of a software screen • A photograph of equipment • A picture of the new product in a sales lesson
Mnemonic	Provide retrieval cues for factual information; facilitate recall of factual information by relating the new fact to information	• A picture of a stamped letter in a shopping cart to recall the meaning of the Spanish word, Carta (letter) • "Please do not throw sausage pizza away" as memory support

Function	A Graphic Used to	Examples
	familiar to the learner.	
Organizational	Show qualitative relationships among content; group lesson content and show relationships among it	• A two-dimensional course map • A map of lesson topics • A chart showing relationships among events • A concept map
Relational	Show quantitative relationships among two or more variables	• A line graph • A pie chart
Transformational	Show changes in objects over time or space; show change through time or space in order to show how something works or how to do something.	• An animation of the weather cycle • A video showing how to operate equipment; • n animated demonstration of how to use an application screen • A picture of stages in a business process
Interpretive	Illustrate a theory, principle, or cause-and-effect relationships; make invisible relationships explicit and thus build a mental model of the functions or principles behind processes or events.	• A schematic diagram of equipment • An animation of molecular movement • A schematic diagram of a power supply • A line graph showing changes in variables over time

Psychological Functions of Graphics

How visuals interact with human learning processes such as attention or retrieval

Instructional Event	Definition	Example
Support Attention	Graphics and graphic design that draw attention to important elements in an instructional display and that minimize divided attention	• An arrow to point out the relevant part of a computer screen • Placement of graphic close to text that describes it
Activate or Build Prior Knowledge	Graphics that engage existing mental models or provide high-level content overview to support acquisition of new information	• Visual analogy between new content and familiar knowledge • Graphic overview of new content
Minimize Cognitive Load	Graphics and graphic design that minimize	• Line art versus photograph • Relevant graphic versus decorative

	extraneous mental work imposed on working memory during learning	graphic
Build Mental Models	Graphics that help learners construct new memories in long-term memory that support deeper understanding of content	• A schematic diagram to illustrate how equipment works • A visual simulation of how genes are transmitted from parents to offspring
Support Transfer of Learning	Graphics that incorporate key features of the work environment; graphics that promote deeper understanding	• Use of software screen simulation that looks and acts like actual software • Use of a visual simulation to build a cause-and-effect mental model
Support Motivation	Graphics that make material interesting and at the same time do not depress learning	• A graphic that makes the relevance of the skills to the job obvious • An organizing visual that clarifies the structure of the material

Types of Interest

Type of Interest	Interest Generated From	Example
Situational:	The graphics placed in instructional materials	Photographs of customers of different ages and racial groups used in customer service training
Emotional	Visuals that arouse curiosity, humor, or strong feelings	A space-fantasy theme used in computer training to add fun and stimulate learner curiosity
Cognitive	Visuals that clarify the lesson content	A graphic organizer used to show the relationships among lesson topics in a computer training course
Personal:	The learner's own predispositions	A soccer graphic used as a visual analogy in a team building course because many of the learners are soccer fans

A Summary of Individual Differences Affecting Use of Graphics

Learner Type	Description	How to Support with Graphics
Low Prior Knowledge	Learners with little or no background in the lesson content	For higher-level learning, most benefit from use of explanatory visual representations of content that are congruent with text because the visual can reduce load and provide a secondary route to forming mental models (Cuevas, Fiere, and Oster [2002]; Gyselinck and Tardieu [1999]; Mayer and Gallini [1990]).
High Prior Knowledge	Learners with background in the lesson content	Often won't need multiple representations so most benefit from either text or visual alone rather than redundant presentations of information (Kalyuga and others [2002]; Mayer and Gallini [1990]).
Visual-Spatial Preference	Expressed preference for information presented in a visual format	Cannot predict spatial abilities based on preference questionnaires. Not useful as a way to adjust graphic treatments (Mayer and Massa [2003]; Kozhevnikov, Hegarty, and Mayer [2002]).
– *High Spatial Preference*	Learners who prefer information presented with graphics	May have iconic or spatial visual ability, (Kozhevnikov, Hegarty, and Mayer [2002]).
– *High Verbal Preference*	Learners who prefer information presented in words	Most have average spatial ability but some may have high or low spatial ability (Kozhevnikov, Hegarty, and Mayer [2002]).
Spatial Aptitude	Mental capability to hold and manipulate visual information	Includes both iconic and spatial visualizers as well as spatial span. Learners who are low in spatial aptitude will often not benefit from graphics in lessons (Mayer and Sims [1994]; Mayer and Moreno [2003]). Provide visual support for low spatial aptitude learners when tasks require spatial ability.
– *Iconic Visualizer*	Learners with ability to hold and reproduce accurate	This style is useful when accurate images will contribute to task

Learner Type	Description	How to Support with Graphics
	visual images	accomplishment. However, they will need help on tasks that require abstract spatial representations (Kozhevnikov, Hegarty, and Mayer [2002]).
– *Spatial Visualizer*	Learners with ability to manipulate and interpret spatial data	Individuals with this style are able to solve spatial problems by manipulating visual information in abstract ways.
– *Spatial Span*	The ability to hold multiple visual images in memory	Some individuals can hold more visual information in memory than others. Avoid taxing visual span by presenting visual information in a simultaneous manner.
Visual Literacy	Learners vary in the time and effort they invest in learning from graphics	To encourage all learners to process visuals, include instructional techniques that promote engagement with graphics (Schnotz, Picard, and Hron [1993]; Gyselinck and Tardieu [1999]).

7. Cognitive Learning Events

7 Cognitive Events of Learning

Cognitive Process	Description	Sample Instructional Methods
Attention	Using visuals to focus attention to the important parts of the instruction and to avoid dividing attention during learning • Maintaining a high overall attention capacity • Focusing on important content and methods • Minimizing divided attention	• Minimize fatigue • Signals and cues such as headers, arrows, colors, text styles • Questions • Learning objectives • Integration of visuals and text • A red arrow draws the eye to the important part of a complex application screen

Cognitive Process	Description	Sample Instructional Methods
Use of Prior Knowledge	Using visuals to either activate relevant prior knowledge in long-term memory or to provide a high-level preview of the content • Activating existing prior knowledge • Building relevant prior knowledge	• Comparative advance organizers • Expository advance organizers • Introductory problem discussions • A graphic advance organizer gives a visual preview of the lesson content
Management of Working Memory Load	Using visuals to reduce load imposed on working memory during learning • Maintaining maximum working memory capacity for learning processes	• Job aids and memory support • Worked examples • Chunking content • Using a line drawing rather than a photograph
Building of Mental Models in Long-Term Memory	Using visuals to help learners build a deeper understanding that will support discrimination or problem solving • Active processing of new content in working memory that results in encoding into existing mental models in long-term memory	• Practice exercises • Questions • Collaborative assignments • Graphics • Analogies • Using an interpretive visual to show an invisible process
Transfer from Long-Term Memory into Working Memory	Using visuals to promote retrieval of new knowledge and skills after training • Implanting cues at the time of learning that facilitate retrieval from long-term memory to working memory when needed on the job	• Near transfer: high fidelity simulation • Far transfer: multiple varied context examples and case exercises • Using a screen capture that looks like the one learners will use on the job
Metacognitive Support	• Selection of learning goals, use of effective learning strategies and monitoring of learning progress	• Learning objectives • Diagnostic quizzes with feedback • Cognitive support methods as described above
Motivation	Using visuals to draw on learner personal interest or promote situational cognitive interest in instructional materials • Encourages investment of effort and persistence to achieve learning goals	• Encouraging internal attributions • Writing with concrete, vivid language • Evaluating individuals against standards—not each other

Cognitive Process	Description	Sample Instructional Methods
		• Visualizing a job-relevant problem scenario as a context for learning

8. Media Element Principles (MEPs)

Guidelines for Media Element Principles

Principle	Guidelines
Multimedia	• Use relevant graphics and text to communicate content. • Use relevant graphics explained by audio narration to communicate content.
Contiguity	• Integrate the text into the graphic on the screen. • Avoid covering or separating information that must be integrated for learning. • Avoid covering or separating information that must be integrated for learning. • Design space for feedback to be visible close to practice answers.
Coherence	• Avoid irrelevant graphics, stories, and lengthy text. • Avoid irrelevant videos, animations, music, stories, and lengthy narrations.
Modality	• Maintain information the learner needs time to process in text on the screen, for example, directions to tasks, new terminology (Exception to Modality Principle)
Redundancy	• Do not present words as both onscreen text and narration when there are graphics on the screen.
Personalization	• Write in a conversational style using first and second person • Use virtual coaches (agents) to deliver instructional content such as examples and hints. • Script audio in a conversational style using first and second person. • Script virtual coaches to present instructional content such as examples and hints via audio.

Summary Guidelines

Topic	Guidelines
Graphics and Focused Attention	• Use signals and cues to draw attention to important content. • Use color and contrast as a visual signal to support focused attention. • Use color to improve job performance with high visual search tasks.
Graphics and Divided Attention	• Place text close to the visuals it describes. • Avoid distracting visuals.
Advance Organizers	• Use comparative advance organizers when learners have relevant prior knowledge • Use expository advance organizers when learners lack relevant prior knowledge. • Avoid seductive details in lesson introductions.
Cognitive Load	• Use graphics rather than text to represent spatial content. • Plan graphics that are consistent in style and low in complexity. • Explain complex graphics with words in audio. • Use words or graphics alone when information is self-explanatory. • Teach the components of a complex visual display first when you need learners to acquirer deeper understanding.
How Graphics Help Build Mental Models	• Use organizational graphics to communicate qualitative relationships. • Use charts and graphs to communicate quantitative relationships. • Use transformational visuals to communicate changes in time or space. • Use interpretive visuals to communicate cause-and-effect relationships.
Context is King for Near Transfer Skills	• Use representational visuals to promote transfer of near transfer skills.
Mental Models are King in Far Transfer Learning	• Use visuals to build understanding of how it works. • Use visuals to make abstract ideas concrete. • Use varied context visual examples to build understanding. • Use visuals to promote inductive learning. • Use visual mnemonics to support memory.
Edutainment and Learning	• Build materials high in situational interest for learners with low personal interest. • Use visuals that make lesson relevance obvious. • Avoid graphics that use emotional interest to motivate learning. • Use techniques to build cognitive situational interest to motivate learning.
Visual versus Verbal Learners	• For low prior knowledge learners, add graphics that are

Topic	Guidelines
	congruent with text. • For high prior knowledge learners, use only words or only visuals. • Encourage all learners to process visuals effectively. • Visual/verbal style preferences may not predict effectiveness of graphics
Three Types of Spatial Ability	• Minimize demands on spatial span by displaying visuals in a synchronized rather than a successive manner. • For spatial tasks, provide visual support to help low spatial learners succeed.

** content references: E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multi-Media Learning," Ruth Colvin Clark and Richard E. Mayer*