ELearning Principles and Practice

The Cognitive Theory of Multimedia Learning (CTML)
Interaction Design
The Cognitive Theory of Multimedia Learning (CTML)

- Multimedia learning is a cognitive theory of learning which has been popularized by the work of Richard E. Mayer and others.

- Multimedia learning happens when we build mental representations from words and pictures.

- Generally, the theory tries to address the issue of how to structure multimedia instructional practices and employ more effective cognitive strategies to help people learn efficiently.
The Cognitive Theory of Multimedia Learning

- The argument is that multimedia supports the way that the human brain learns.

- People learn more deeply from words and pictures than from words alone. This is referred to as the **multimedia principle** (Mayer 2005a).
The Multimedia Principle

- Use words and graphics rather than words alone
  - Text means either spoken or written form
  - Graphics must be explanatory, not decorative
- Why?
  - Relevant graphics promote active learning
  - i.e. Learners make connections between the text and the graphics

Attempt to use cognitive research to combine words and pictures in ways that maximize learning effectiveness.
The Cognitive Theory of Multimedia Learning

Based on three assumptions:

1. The dual-channel assumption
2. The limited capacity assumption
3. The active processing assumption
The Cognitive Theory of Multimedia Learning

- The dual-channel assumption is that working memory has auditory and visual channels (Pavio, 1971).

- The limited capacity assumption is based on cognitive load theory and states that each subsystem of working memory has a limited capacity.

- The active processing assumption suggests that people construct knowledge in meaningful ways when they:
  - (a) pay attention to the relevant material,
  - (b) organize it into a coherent mental structure, and
  - (c) integrate it with their prior knowledge.
Meaningful Learning

- Meaningful learning from words and pictures happens when the learner engages in five cognitive processes:
  1. selecting relevant words for processing in verbal working memory
  2. selecting relevant images for processing in visual working memory
  3. organizing selected words into a verbal model
  4. organizing selected images into a pictorial model
  5. integrating the verbal and pictorial representations with each other and with prior knowledge
Cognitive Theory of Multimedia Learning

The capacity of working memory is low!

Cognitive Theory of Multimedia Learning

Memory has
• Limited capacity
• Location of learning

Dual channels (auditory and visual)

Encoding
Once actively processed
Retrieval
Transfer of learning
The Triarchic model of Cognitive Load

- Essential processing (intrinsic load) relates to the essential material or information to be learned.

- Extraneous processing (extrinsic load) does not serve the instructional goal or purpose and reduces the chances that transfer of learning will occur.

- Generative processing (germane cognitive load) is aimed at making sense of the presented material. It is the activity of organizing and integrating information in working memory.
Cognitive Load

- Mayer (2009) made this model the organizing framework for the cognitive theory of multimedia learning.

- He stated that a major goal of multimedia learning and instruction is to “manage essential processing, reduce extraneous processing and foster generative processing” (p. 57).

- He identifies the following twelve multimedia instructional principles which were developed from nearly 100 studies:
12 Practical Principles

- Coherence Principle
- Signaling Principle
- Redundancy Principle
- Spatial Contiguity Principle
- Temporal Contiguity Principle
- Segmenting Principle

- Pre-training Principle
- Modality Principle
- Multimedia Principle
- Personalization Principle
- Voice Principle
- Image Principle
The Spatial Contiguity Principle

- Place corresponding words and graphics near each other

Why?
- The learner does not need to search for the relevant words and can therefore focus on understanding

A rabbit
The Temporal Contiguity Principle

- The sequencing of words and pictures
- Words and pictures should be presented simultaneously

Why?
- The simultaneous presentation of the two stimuli helps to form an association in the mind of the learner

A tiger
The Coherence Principle

- People learn better when extraneous material is excluded rather than included
- Adding interesting material can hurt learning
- Why?
  - Distraction: it guides attention away from the relevant material
  - Disruption: it prevents the learner building links between relevant material (due to the presence of irrelevant material)
  - Seduction: it can raise inappropriate prior knowledge
The Coherence Principle

- **Visual coherence**
  - Remove unnecessary words and pictures, however interesting you or the learner deems them to be.

- **Sound coherence**
  - Remove unnecessary sounds from a presentation, however interesting you or the learner deems them to be.

- **Word coherence**
  - Eliminate unnecessary words.

- Be wary of cognitive overload!
The Modality Principle

- Present words as audio narration rather than onscreen text
- Images/video with audio narration is better for learning than images/video with text
- Why?
  - It splits the information across two cognitive channels (auditory and visual) rather than all through a single channel (visual)
The Personalization Principle

- Use conversational style and virtual coaches
- Why?
- Allows the learner to engage with the learning as a social conversation

• However: Image Principle - People do not necessarily learn more deeply from a multimedia presentation when the speaker’s image is on the screen rather than not on the screen.

Nina says “Use a virtual coach!”
Other Principles

- **Signaling Principle** – People learn better when cues that highlight the organization of the essential material are added.

- **Segmenting Principal** – People learn better when a multimedia lesson is presented in user-paced segments rather than as a continuous unit.
Other Principles

- Pre-training Principle – People learn more deeply from a multimedia message when they receive pre-training in the names and characteristics of key components.

- Voice Principle – People learn better when the words in a multimedia message are spoken by a friendly human voice rather than a machine voice.
These twelve principles are grouped in a framework based on the three types of cognitive load (Mayer 2009):

- reducing extraneous processing - coherence, signaling, redundancy, spatial contiguity, temporal contiguity
- managing essential processing - segmenting, pre-training, modality
- fostering generative processing - multimedia, personalization, voice, image
Boundary Conditions (the Individual Differences Principle)

- “... multimedia effects, contiguity effects, and split-attention effects depend on individual differences in the learner.”

- “students who lack prior knowledge tended to show stronger multimedia effects and contiguity effects than students who possessed high levels of prior knowledge”

- “students who scored high on tests of spatial ability showed greater multimedia effects than did students who scored low on spatial ability”

A Cognitive Theory of Multimedia Learning: Implications for Design Principles
Richard E. Mayer and Roxana Moreno
University of California, Santa Barbara
The Locus of Control

- Learner control versus program control
  - This principle has more variables than the others
  - For example, for most students, a higher level of program control results in better learning outcomes
  - There are exceptions:
    - Adult learners prefer a greater sense of control especially over the pace of learning
    - Consider having more learner control for more advanced courses and more program control for basic courses

Regardless of the context, navigation should be simple, clear and intuitive. Avoid complicated paths through the content where a user could get lost.
Has its critics...

How applicable are results in a non-didactic, immersive learning environment?


Research trials too narrow


But ........ 3 decades plus 00’s of experiments, mean it should stay as a robust, evolving theory
References

In practice the divisions are more blurred
Interaction Design

- “Interaction Design refers to the shaping of interactive products and services with a specific focus on their use.” Lowgren (2013)

- Interaction Design Association (IXDA) Definition:

  “Interaction Design (IXD) defines the structure and behaviour of interactive systems.

  Interaction Designers strive to create meaningful relationships between people and the products and services that they use, from computers to mobile devices to appliances and beyond.”
Interaction Design

- Interaction design is not about the behaviour of the interface, it is about the behaviour of people.
Interaction Design and Instructional Design (IxD and ID)

- Sound pedagogical design for a learning experience does not by itself guarantee success.

- For technology-based learning, interaction design is a necessary function of a positive outcome.
Interaction Design and Instructional Design (IxD and ID)

- Poor usability distracts the learners from the goals and objectives of the instructional experience, thus poor IxD directly influences the success of ID.

- The last thing we should want is for our students to have to learn a difficult interface before they can learn a difficult concept.

- IxD is paramount to learner success in interacting with the instructional interface.
Five Essential Principles

- Consistency
- Feedback
- Visibility
- Predictability
- Learnability
Five Essential Principles – 1. Consistency

- People are Sensitive to change
- Differences can cause distraction.
- When learners start asking why it is the way it is or why it is different they are focused on the interface and not the content or the experience.
Amenities

Brief introductory statement about the amenities at the B&B. Donec erat ut dui duis, viverra ac, vulputate scelerisque, viverra molestias, tortor. Donec suscipit, arcu quis volutpat, accusantium, velit justo vehicula libero.

Swimming Pool and Hot Tub


Gazebo

## Garden Room

The Garden room is a large ground floor room. It features a private bath with jacuzzi tub, California king bed, double futon in the sitting area and a single futon "window seat."

In addition to access to the upstairs kitchenette and common areas this room has a small refrigerator, microwave and satellite TV with DVD player.

Additional amenities include soft fluffy towels, ceiling fan, clock radio, reading lights, hair dryer. Most of the lights are on dimmers.

<table>
<thead>
<tr>
<th>PHOTO</th>
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Photo caption appears here  | Photo caption appears here  | Photo caption appears here |
Consistency

- We should be very careful about how we design components so that people can begin to recognise them.

- Elements that have similar behaviour should have similar appearance.
Consistency

Welcome to the World of Orchids!

Orchid flowers have a magical beauty and allure, with incredible colors, shapes, and scents. Maybe this contributes to the belief that orchids are difficult to grow and bloom. In reality, most orchids are not difficult plants. As a matter of fact, some are practically indestructible. With a few basic tips for orchid care, you can make your orchid grow, thrive, and bloom.

Learning About Your Orchid

AboutOrchids.com offers information about basic care for common orchids. They are very diverse plants that grow in wide varieties of environments all over the world, but this site focuses on the most common kinds of orchids available for sale and which are best suited for a beginner. If you find that one of these tips or techniques is not working for you, check our resources to help you do some more research about your plant to find more advanced care information.

The first step to taking care of your orchid is learning what kind of orchid it is. Most of the orchids commonly found for sale are hybrids that have been created specifically for their flowers and ease of care in homes and offices.

What kind of orchid do I have?

How do I take care of my orchid?

Once you know what kind of orchid you have, you can learn about its natural environment and the conditions under which it is more likely to thrive and bloom again.

• How do I make it bloom again?
• How much water does it need?
• Should I fertilize it?

What’s wrong with my orchid?

More Orchid Care Information >
Consistency
Consistency

• Components with different behaviours should have different appearances.

• Learners will recognise when there are different interactions available when components use different indicators and structure.
Consistency

- Changes in appearance and behaviour can attract unwanted attention.

- Pay attention to details because sloppy design can be distracting, and inattention to detail reduces credibility and trust.

- Consistency goes unnoticed
  - We only really notice when things differ or fail.
Consistency: It’s all in the details...

- Strive for consistency in both appearance and behaviour:
  - Colour, pattern and texture
  - Size, proportion and rotation
  - Shape
  - Alignment (use grids and guides)
  - Typography
  - Visibility
  - Transitions and motion graphics
  - Rollovers / mouseovers
  - Tooltips
  - Layers and pop-ups
Five Essential Principles – 2. Visibility

http://upload.wikimedia.org/wikipedia/commons/8/89/UscitaQuincinetto.JPG
Visibility

- You cannot invite interaction and engage learners with your material if they are not aware that the opportunity to interact exists.

- Hidden interactions decrease usability and efficiency

- Do not make your learners search for interactions when they need to complete their task.
Visibility

- Discoverability should not involve luck or chance.

- People should be able to presume, deduce or infer that an opportunity to interact exists.

- Rollovers/mouseovers work best when people realise they are present or assume they are available.
Visibility

Understanding How Orchids Grow

Rainforests are like crowded cities of plants and animals. Trees grow like apartment buildings with many plant residents attached to their branches and trunks. The trees crowd together as they reach for the sun. Plants absorb light, water, and nutrients, and turn sunlight into energy. Rain falls a lot, sometimes in massive downpours, other times in slow drips and drizzles. High humidity, the amount of water vapor in the air, means it is always damp. Breezes move the air, and temperatures fluctuate between daytime warmth and nighttime coolness. Plants, animals, and insects leave debris. These decompose quickly in the high humidity, leaving nutrients that are valuable assets and are consumed quickly.

Orchids are successful in this competitive environment because they grow as epiphytes, living on trees above the rain forest floor. By growing as air plants, orchids are not shaded by dense plant growth on the ground. They also place themselves out of reach from hungry animals and insects that cannot fly or climb. Their sponge-like roots quickly absorb water and nutrients within reach.

Flower pots of bark or moss mimic these conditions. Orchid roots stay in high humidity, and have air flow around them.
Visibility

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Visibility

- Try to avoid situations where learners falsely believe that they have reached the end of content or of an experience.

- Use hinting and “false bottoms” when more content and interactivity exists below the fold, farther down the screen, or beyond the visible area.
Visibility
Visibility

Strategic Plan
Provost, Dr Patrick Prendergast talks to Broadcaster and Historian, Dr Myles Dungan on Trinity’s Strategic Plan 2014–2019

What’s happening
Upon the Wild Waves: A Journey through Myth in Children’s Books
October 2014 - April 2015
Visibility

- Signal the availability of interaction with visual indicators that invite people to touch or click.
  - People are ‘click happy’. They will attempt to interact with anything that could possibly be clickable or touchable.

- Standard interface components such as hyperlinks, buttons, thumbnails, scrollbars and form elements are understood to be interactive.

- Different text colour and decoration, 3D and depth cues, icons, and textures invite interaction.
Visibility

Things that say “interact with me”

Now that you have completed Your lesson, *take our on-line quiz*
Five Essential Principles – 3.

Learnability

http://3.bp.blogspot.com/-u3Hn6kL4Iw4/
Learnability

- Interactions should be easy to learn AND easy to remember.
  - Ideally: use it once, learn it, and remember it forever.
  - Practically: use it a few times, learn it, and hope to remember it for the next visit or use.
Learnability

- Learning theories from psychology can help us better understand how people acquire and retain knowledge and skills.
  - **Operant Conditioning:** Getting a reward or positive feedback increases the probability that people will engage in that behaviour again. Getting a punishment or making an error decreases the probability that people will engage in that behaviour again.
  - **Observational Learning:** Seeing someone else model or demonstrate the behaviour and then imitating or repeating what we have seen. Video tutorials are good examples of observational learning.
Learnability

- Learnability is often equated with ‘ease of use’, but even interfaces that are easy to use may require learning.
  - The more we use an interface (and the more we learn), the easier it becomes.
  - Practice leads to habits, and extensive practice leads to automaticity.

- “Intuitive” really means “single trial learning”.
Learnability: The Effects of Practice

As quick as possible

More Practice = Less Errors
Less Time = Expert

Errors ++
Novice

Time ++
Practice ++
Learnability

- People learn behaviours from experiences across the web and devices and even from real-world places and objects.
  - *Transfer of Learning*: We take our experiences with us and attempt to apply them in similar situations.
  - *Perceived affordances*: When the affordances of real objects are represented metaphorically or analogously in digital form.

- Take advantage of what people already know.
Learnability

Buttons

Sliders

Tabs

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Author liz west from Boxborough, MA. This file is licensed under the Creative Commons Attribution 2.0 Generic license.
Five Essential Principles – 4. Predictability
Predictability

- The design should set accurate expectations about what will happen *before* the interaction has occurred.

- Learner behaviour can reveal whether or not they are able to accurately predict what will happen:
  - When they do not know what they can do or what will happen, they will attempt interacting with anything that could possibly be clickable or touchable.
  - When they know what they can do and can predict what will happen, they will interact with only what is necessary to complete their task and accomplish their goal.
Predictability

- Use previews to set expectations and define constraints for new or complex interactions.

- Show what can be done while the interface loads.

- Show a high-level view of the organisational system or structure to provide context (e.g., a map)
Predictability

- Labels, instructions, icons and images can all be used to set expectations about:
  1. What to do
  2. What will happen.
  3. Where the learner will go.
  4. How the interface will respond.
Potting Media & Repotting Orchids

Orchids do not grow in soil. Soil does not allow enough air to flow around orchid roots. There are many materials which can anchor orchid roots while still permitting air to move around them. Ground tree bark and moss are two of the most common. They are often combined with perlite, vermiculite, or charcoal to keep the mix open and permit air flow. Do not use barbecue charcoal since it contains chemicals that will kill the plant.

When to Re-Pot Your Orchid

How to Re-Pot an Orchid

Re-Potting Orchids

In the wild orchids are epiphytes, or air plants, growing with their roots exposed to the elements. In a pot with moss or bark, orchid roots don’t enjoy the same air movement. When the potting media starts to decompose, even less air can move through it. Some plants, like Paphiopedilums, are sensitive to decomposing potting media and need to be repotted annually. Others, like Cymbidiums, dislike repotting and do not need to be repotted often.

Only use clean pots with drainage holes in the bottom. Clay pots are porous, which means that water and air can pass through the sides. While the roots will enjoy the added circulation, they will also dry out faster, especially on hot summer days.
Five Essential Principles – 5. Feedback

http://www.amazon.com/Lightning-Reaction-Electric-Shock-Game/dp/B003Y3LSIS
Feedback

- Feedback can provide information about:
  1. Location
  2. Status or progress
  3. Future events or possibilities
  4. Completion or closure
Five Essential Principles – 5. Feedback
Feedback

- Minimise interruption of the learner’s experience or actions

- Feedback should complement the experience, not complicate it.

- Allow “undo” to reverse choices and correct mistakes.
  - Mistakes are incorrect choices, but they do not always result in errors.
  - Undo can be used to revert to prior states to recover from a mistake or from an error that may not be understood.
Feedback

- Every interaction should produce a noticeable and understandable reaction.

- Acknowledge interactions. Let people know they have been heard (or felt or seen).

- Failing to acknowledge an interaction can lead to unnecessary repetition of actions and possibly errors or mistakes.
Five Essential Principles – 5. Feedback

Progress Indicators

Step by step

Definite

Indefinite

Thank you please wait while we deal with your request
Summary

The five principles are interrelated:

- **Consistency**: As long as the interfaces are consistent within themselves and across related or similar experiences, people will be able to apply what they have learned and interact more efficiently and effectively.

- **Visibility**: When interactions are visible and noticed, and when their outcomes can be accurately predicted, people will interact with the interface.

- **Predictability**: Once people have learned how an interface works, they are able to transfer that knowledge and skill to other, similar interfaces.

- **Learnability**: When meaningful feedback is provided after an interaction, people will understand how their actions led to the outcomes. With practice, their learning becomes stronger.

- **Feedback**: The five principles are interrelated: when meaningful feedback is provided after an interaction, people will understand how their actions led to the outcomes. With practice, their learning becomes stronger.
Summary

- Professional design is important to establish credibility and trust.
  - Nuance and polish often make the difference between average and excellent.
  - Do not be different just to be different, and do not keep reinventing the wheel.

- Leverage design patterns
  - A reusable solution to a recurring problem.
  - The content may change, but the interaction and process remains the same.
  - Interactions and outcomes become consistent and predictable.
Summary

- Prototype!
  - Sometimes the design in our head is a better idea than the actual experience.
  - Solicit feedback from others, and do not take constructive criticism personally.
“You are not designing for yourself”
In-class Exercise - Analyse an Interactive Device or Service

- In groups of 3 or 4, choose an interactive device or service to analyse. This could be an ATM, or a ticketing machine, a remote control, a mobile app or website.

- Use the following questions (if relevant) to generate a blog post analysing the service/device:

1. What do I recognise when I inspect the device/service initially?
2. Do I perceive feedback when I use the device/service (interface change, sound, clicks, weight, surface texture etc)?
3. What is the device’s or service’s context for use?
4. Is anything missing?
Analyse an Interactive Device or Service

5. What goals does the device/service address?

6. I have a goal; does the device/service facilitate it or get in the way?

7. Consider other modalities for achieving the same goal (e.g. talking, landline, mobile phone, Skype).

8. What is explicit and what is implicit?

9. What is usable (or conversely unusable)?

10. Do I need further explanation to understand some aspect?

11. How can I learn about what something does?

12. How do I know where I am (in the system)?

13. Where am I in the process?
Analyse an Interactive Device or Service

14. What do I feel about using this device/service?
15. What are my impressions about this device/service?
16. Who can work with this device/service? Easily?
17. Is it easy to make a mistake?
18. What are the consequences of making a mistake?
19. Can I recover from the mistake easily?
20. Do I feel comfortable experimenting with the device/service?
21. What happens if it breaks?
References

