



Design research en 'use context'

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Deel 1 van de Foundation Course in Interaction Design

Learning: an introduction

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1 About learning

Learning is an important part of the context of use of an interactive version of the course book (Saffer's 'Designing for Interaction'). As beginning designers, what should you know about the psychology of learning? Which design principles apply? What distinguishes the design of educational materials from other kinds of interactive media products?

2 Learning and e-learning: basic theory and context

2.1 WHAT IS LEARNING (AND 'E-LEARNING')?

Simply put, learning is the ability to remember, reproduce and use different kinds of content.

There are four kinds of content:

- **Facts...** "The *population of Spain* is 45,200,737 people."
- **Concepts...** such as: 'What is a suspect?' When can someone be considered a 'suspect', who can be held against their will, etc.?
- **Procedures...** such as what to do in case of a fire... these can be 'step by step', but can be supported by complex skills.
- **Principles...** these are complex sets of facts, concepts, procedures which support a strategic action: how to do a financial projection with a spreadsheet. Or to advise a student which specialization to choose.

For 'e-learning', Clark and Mayer¹ define 'e' as the 'how', and 'learning' as the 'what'. E simply means 'electronic', i.e., digitized, so it can be stored in electronic form. 'Learning' refers to the content and ways to help people learn it.

Examples of e-learning products include:

- English and cooking courses for game platforms like Nintendo DS
- Management and other courses for iPhone
- Programs for various kinds of disk stations which can be connected to a TV
- Web-based training
- Training designed for virtual classrooms with multiple participants
- Simulators for cranes and vehicles

2.2 LEARNING IS WORK

Our senses and brain have to work hard to learn, and our brains have a limited amount of "processing power". Users are conscious of how well or badly they feel while using an interactive product, but not of how well they are learning from it. So they may find the product pleasant and easy to use, but when their results are tested, they may actually be poor.

For designers, this means that users' initial responses can't be trusted as an indication of the effectiveness of a product for learning. For example, users may like a sound track or illustrations, but if these are draining processing power away from more important content, they reduce the effectiveness of the learning process.

2.3 THE ROLE OF INTERACTION DESIGNERS

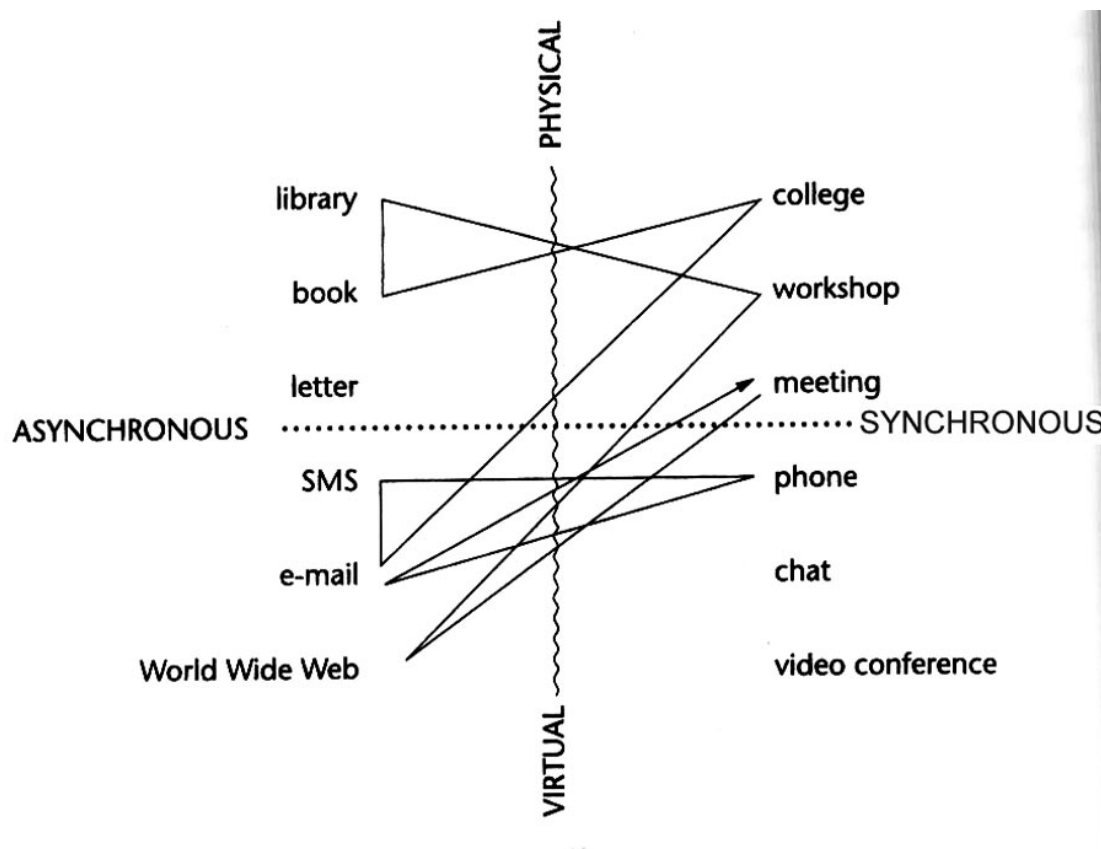
¹ Ruth Clark and Richard E. Mayer, *E-learning and the science of instruction: proven guidelines for consumers and designers of multimedia learning*. (San Francisco, US: Pfeiffer, 2008), 10–11.

Designers have a critical role to play in increasing learning results. Good visual and interaction design reduces cognitive load². Designers optimize alignment, proximity, contrast, and all other key 'Gestalt' visual basics. They optimize feedback and flow, regulating the dialogue of stimulus and response with users, which is critical to the learning process.

2.4 CONTEXT OF USE OF E-LEARNING

E-learning usually is part of a larger set of learning activities, which happen in various different places and at different times. Where does e-learning fit in?

Caroline Nevejan³ has provided us with a model to understand the context in which learning takes place. The model, illustrated below, contains two axes: one for simultaneity, and one for the difference between physical and virtual. The diagram below⁴ illustrates how learning activities are distributed in time and between the real and virtual worlds.



² 'The burden imposed on working memory in the form of information that must be held plus information that must be processed.' Ruth Clark and Richard E. Mayer, *E-learning and the science of instruction: proven guidelines for consumers and designers of multimedia learning*. (San Francisco, US: Pfeiffer, 2008), 39.

³ Caroline Nevejan, *Synchroon/Asynchroon: Onderwijsvernieuwing in de informatiesamenleving*. Amsterdam, the Netherlands: Hogeschool van Amsterdam, 2003. Quoted in: John Thackara, *In the bubble: designing in a complex world*. (Cambridge, Massachusetts, US: MIT Press, 2005), 146.

⁴ Caroline Nevejan, *Synchroon/Asynchroon: Onderwijsvernieuwing in de informatiesamenleving*. Amsterdam, the Netherlands: Hogeschool van Amsterdam, 2003. Quoted in: John Thackara, *In the bubble: designing in a complex world*. (Cambridge, Massachusetts, US: MIT Press, 2005), 146.

The question for designers: what is the right place for e-learning in the larger process? Too often, materials intended for simultaneous, physical use are simply 'digitized', while they bring no added benefit.

One important note: previous knowledge is THE most important factor in success of e-learning applications, so it's important to establish the beginning situation of learners. The principles presented in this document apply mainly to learners who are beginners.

3 Theories: a brief overview

3.1 BEHAVIORISM

This is based on strengthening correct responses, and weakening incorrect responses. *Behaviorism focuses on repeating new patterns of behavior until they become automatic.*

Behaviorism tends to find expression in 'programmed instruction'. In this method, learning materials are cut up into very small pieces (frames). Each piece contains some statements and a question (usually fill in the blank). The students read the text, and immediately answer the question.

An example might be a language course which the student learns new concepts and words, answering fill-in-the-blank questions, moving forward one small step at a time.

3.2 COGNITIVISM

These theories focus on the way our senses, and long- and short-term memories work. *Cognitivism focuses on the thought processes behind the behavior.* Typical cognitive strategies are the creation of categories and 'schemas' for input, which helps to embed it in a pre-existing 'framework'.

An example of a 'schema' would be 'methods of design research - observation, interviews, activities'. Once you have this 'schema' or idea in your memory, it becomes a framework ready to have new content added to it.

3.3 CONSTRUCTIVISM

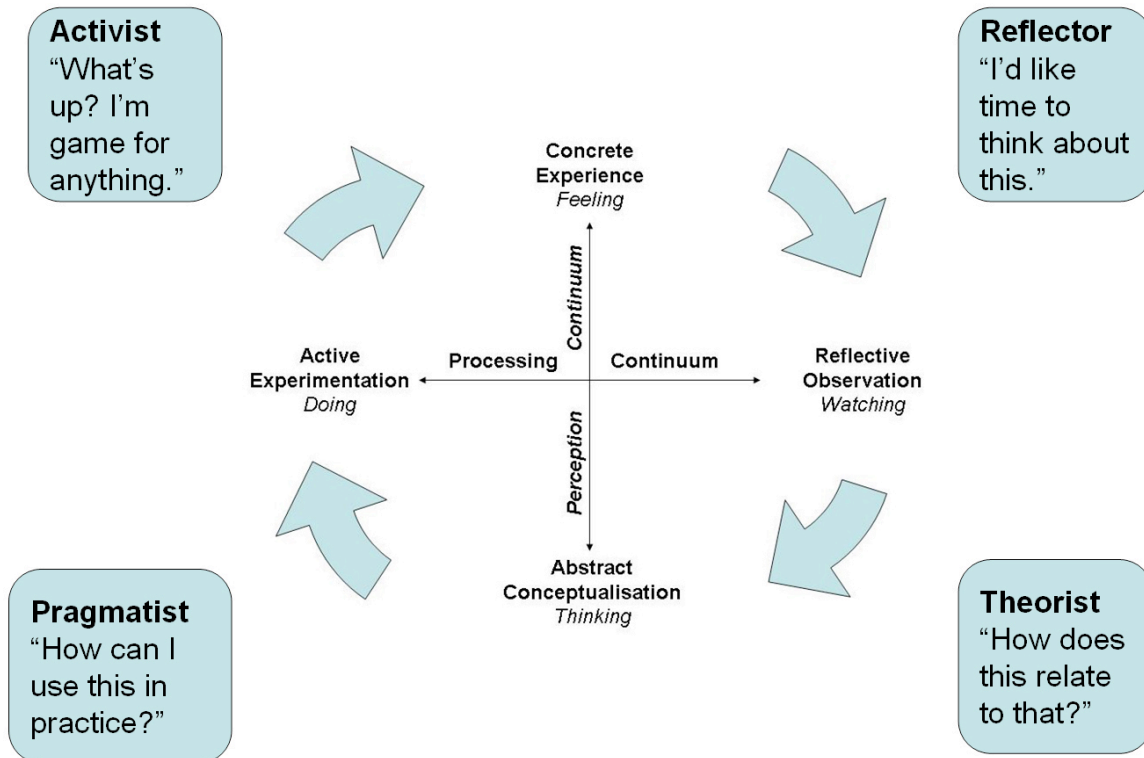
According to this view, we construct our own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. *Constructivism focuses on preparing the learner to problem-solve in ambiguous situations.* When we encounter something new, we have to reconcile it with our previous ideas and experience, maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, we are active creators of our own knowledge. To do this, we must ask questions, explore, and assess what we know, compare it to what we already know, and make new connections.

Examples: problem-based learning, such as happens in the school in the design projects, in which teams get a briefing and then learn while trying to arrive at a solution.

3.4 KOLB'S MODEL: LEARNING PROCESS AND LEARNING STYLES

One widely-used model was created by David Kolb. It's based on the idea that there are four main kinds of learning activities, which can be seen as phases in a cycle. People may start the cycle at any point, and then go through all the remaining phases. According to Kolb, people start the process at different points in the cycle. Simply put, he identifies the following 'styles' of learning:

1. Activist - problem solving, group discussion; trainer is 'model professional'
2. Reflector - lectures, videos; trainer is 'expert interpreter'
3. Pragmatist - peer feedback, skilled activities; trainer is 'coach/helper'
4. Theorist - case studies, theory readings; trainer stays out of learner's way



4 Interactivity: what advantages does it offer?

4.1 PRACTICE WITH AUTOMATED, TAILORED FEEDBACK

Examples:

Ad Bok's Dutch reading and writing program 'TiO'. The student writes a text of their own, and the program provides all kinds of suggestions (feed-forward) to improve it. Things like: "This is getting a bit long for an introduction... can you think of ways to say the same thing with less words?" Or: "You've used that word twice already in this paragraph - is it really necessary? Or do you know another one that means the same thing?"

4.2 INTEGRATION OF COLLABORATION AND SELF-STUDY

Wikis, blogs, and e-learning products for self-study enable students to form flexible teams and work at times convenient to them. Individual students can improve on their weak points to support group work.

4.3 DYNAMIC ADJUSTMENT OF INSTRUCTION BASED ON LEARNING

Adaptive instruction: math tests that get more difficult when the works gets too easy. Or keep the level steady until they begin to solve problems more quickly. Allows more individual instruction, and motivates.

4.4 USE OF SIMULATION AND GAMES

Games can inspire high motivation and offer rich contexts.

The following description is from the game 'A Force More Powerful':

'Can a computer game teach how to fight real-world adversaries—dictators, military occupiers and corrupt rulers, using methods that have succeeded in actual conflicts—not with laser rays or AK47s, but with non-military strategies and nonviolent weapons? Such a game, **A Force More Powerful (AFMP)**, is now available. A unique collaboration of experts on nonviolent conflict working with veteran game designers has developed a simulation game that teaches the strategy of nonviolent conflict. A dozen scenarios, inspired by recent history, include conflicts against dictators, occupiers, colonizers and corrupt regimes, as well as struggles to secure the political and human rights of ethnic and racial minorities and women.'

4.5 REGISTRATION OF ACTIVITIES FOR RE-USE

By enabling recording, you turn individual sessions into resources which can be shared and browsed selectively.

4.6 GENERATION AND VISUALIZATION OF DATA ABOUT THE LEARNING PROCESS

Generation of data - statistics can be extracted and visualized from the registered data, allowing teachers, students and managers to optimize learning. This can include scores, attendance, time spent on activities, but also feedback on quality of learning activities (ratings).

5 Design: key principles and guidelines

5.1 THE USER: FOUR KEY ASPECTS

5.1.1 Dual channels

People have separate channels for processing VISUAL / PICTORIAL material and AUDITORY / VERBAL material. Distributing information across these channels - i.e., reducing the cognitive load on each - increases learning results.

5.1.2 Limited capacity

People can only actively process a few bits of information in each channel at one time. In other words, there's a limit to the amount of texts, sounds and moving and non-moving images we can take in, and remember and relate to each other. With e-learning more than anything else: less is more! We talk about **essential processing** - i.e., processing ONLY what is beneficial to the learning process.

Cognitive Load is a term that refers to the load on working memory during instruction. This means that for e-learning, more than other products, **less is more**. This often contradicts popular ideas, for example, that beautiful, elaborate video footage with sound is categorically 'better', because 'young people today expect that', etc. etc. It's not that simple - the point is that everything requires processing power, so extra material burdens the learner's short-term memory and senses.

5.1.3 Active processing

Learning occurs when people engage in appropriate processing - for example, recognizing and focusing on relevant material, organizing the material into a coherent structure, and integrating it into what they already know.

5.1.4 Transfer

New knowledge and skills must be retrieved from long-term memory during performance. So we measure the success of learning by checking how much knowledge is in your long-term memory, and whether you can retrieve for use when you do something.

6 Design principles for e-learning

6.1 THE MULTIMEDIA PRINCIPLE: VISUALS CAN IMPROVE LEARNING

A visual (film, animation, drawing, etc.) should be part of a 'whole' that the user assembles in their mind. In other words, the user should be actively engaging in learning by mentally making connections between the text and the visual representations.

Types of graphics

Different types of graphics work for different types of learning. In the explanation of graphic types below, we use the example of a computer application with visuals and non-audio text, teaching how a bicycle pump works.

Decorative

For: esthetic appeal or humor.

Examples: visual of person riding bicycle in lesson about how bicycle pump works; graphic motifs related to bicycles.

Representational

Visuals that illustrate the appearance of an object.

Example: learning unit on how a bike tire pump works - photo of pump, showing what kind of pump we're dealing with.

Relational

Illustrate a quantitative relationship among two or more variables.

Example: graph showing the relationship between temperature and air pressure in tires.

Organizational

Depicts relations among elements. Certain kinds of matrices also belong to this category.

Example: a diagram with 'boxes and arrows' showing a 'cutaway' view of a bicycle tire.

Transformational

Depict changes over time.

Example: animations, videos showing how to pump up or check a bike tire. Or how the pump works.

Interpretive

Make invisible relationships and elements visible.

Example: saturation of color or amount of dots are used to illustrate air pressure in the pump.

Important: use the right kind of graphic for the content. Facts can be shown with representational and organizational graphics (the picture of a pump: 'This is our pump'). Processes or procedures might be shown with transformational, or interpretive graphics (animation of air flow, or graphic with colors to show compression).

6.2 THE CONTIGUITY PRINCIPLE: WORDS AND IMAGES SHOULD BE CLOSE AND SIMULTANEOUS

Words have to be close to graphics, to minimize eye-movement and processing.

Feedback has to be embedded in the same screen as the material.

Don't present instructions separately, or in advance.

Synchronize spoken words with graphics. So: don't put narration in advance of an animation that illustrates it.

The narration should accompany the animation.

The point is - the closer all these things are to each other, the less energy people have to spend matching them up and creating meaningful relationships between them.

6.3 THE MODALITY PRINCIPLE: WHEN ACCOMPANYING GRAPHICS WITH LANGUAGE, PRESENT WORDS AS AUDIO NARRATION RATHER THAN ON-SCREEN TEXT

This splits the information across two channels - visual/pictorial, and auditory/verbal.

However, keep in mind that learner's may have varying degrees of control over the material. And there may be exceptions:

- When non-native speakers have trouble understanding the language, and the text may help clarify it
- Does the negative effect of on-screen text decline, as learners become more experienced?

6.4 THE COHERENCE PRINCIPLE: ADDING INTERESTING MATERIAL CAN HURT LEARNING

Some see the 'enrichment' of material - 'spicing it up' with extra, beautiful visuals, or sound, or extra facts and information, as a way of making it less boring, and therefore more effective. There is also the 'emotional arousal' theory of learning - that students learn better when the material provokes an emotional response.

That all sounds logical, until you realize:

- It all takes processing power, which is taken away from learning
- You can't ADD interest to material - if you're learning Russian, the 12 common ways of changing the ending of a noun remain exactly as dull and difficult, no matter how much singing, dancing, animation, beautiful pictures of Tsar Peter or extra fun facts you add to it. Forget it.

Example: when a little bit of low, unobtrusive music was added to a narrated animation, the student's performance on tests (transfer) dropped between 20 and 67 percent. When video's of lightning were added to

the text & graphics version of a lesson, the student's performance on tests also dropped hugely (students who had done the lesson without the video did 30% better.) The same thing happened with extra little stories.

Here, Mayer mentions what he calls signalling.⁵ What he calls 'signalling', we call graphic design! I've already seen powerful evidence of the effect of design in user tests and professional practice. In one case, users complained that a font was way too small to read. Our designers changed the alignment, not the font size. In the new version, the users thought the font was bigger - they could read it without problems. And it was still the exact same size.

6.5 THE PERSONALIZATION PRINCIPLE: USE CONVERSATIONAL STYLE AND VIRTUAL COACHES

This is our old friend 'tone of voice', the thing editors and copywriters use. As designers, we know that the tone of voice of a text creates the relationship of a user and a product in the mind of the user - formal, informal, direct, careful, clipped and precise, exuberant, restrained... tone of voice is critically important. Here, the important thing is to realize that especially with INTERACTIVE media, we experience the 'machine' (usually a computer) as an intelligent being, and we treat it like it was human. This happens at a deep, unconscious level. If it has a 'voice' which radiates a certain 'personality', we immediately respond to it as a personality.

Why does this help learning? Because we're social beings, we'll try harder to understand something which another human being is telling us, than something which we perceive as non-human, just stuff on a screen.

We call this 'activating the social response'. In tests, students who learned from materials written in a conversational style - written from the first person, addressing the in the second person - showed much better results. The addition of 'virtual coaches' - cartoon and real characters - also increased the effectiveness. (Interestingly, cartoon and human figures were equally effective). Voice quality is extremely important. Also, we can make an author 'visible' - for example, by introducing text as an interview.

6.6 THE SEGMENTING PRINCIPLE: MANAGING COMPLEXITY BY BREAKING A LESSON INTO PARTS

When a video of a lecture is put online, it should be broken up into at least 8 or 9 small segments, which can be played independently, with the images edited in over the voice. Certain web TV formats are already pioneering effective design patterns for this (one example is the PBS broadcasting network in the US, in the websites for 'Frontline' and other programs). Another example is the Khan Academy, with its online math and other lessons.

Within segments, users should have control of their progress through the material. Here, our expertise as interaction designers can make a world of difference. Design patterns like time-lines with thumbnails, navigation with multiple page numbering - elegant, highly usable design can make or break e-learning applications.

Researchers still don't know with certainty:

- How long segments should be - ten? Thirty? Sixty seconds? Longer?
- Where to break into meaningful segments?

However, interaction designers have built up a world of experience and best practices precisely in this area!

6.7 THE PRE-TRAINING PRINCIPLE: MAKE SURE LEARNERS KNOW KEY CONCEPTS IN ADVANCE

A brief presentation of key concepts in advance, as for example a diagram showing the main parts of a bicycle pump and what they're called. In cognitive learning theory, this is called creating 'advance organizers' - that is, frameworks which make a place in one's memory, into which new information can then be integrated.

⁵ Signalling includes using headings, bold, italics, underlining, capital letters, larger font, color, white space, arrows and related techniques to draw the learner's attention to specific parts of the display or page.

7 Related topics for further study:

- How to use examples in e-learning
- Design of practice activities
- Group distance learning in virtual environments
- Creating effective navigation for e-learning products
- E-learning for higher-level problem-solving skills
- Simulations and games in e-learning

8 Sources

Clark, Ruth, Richard E. Mayer, *E-learning and the science of instruction: proven guidelines for consumers and designers of multimedia learning*. San Francisco, US: Pfeiffer, 2008.

Comprehensive, in-depth, transparently structured and easily scannable guide to e-learning. Includes:

- 'design dilemmas', mini-cases in which the reader is invited to decide the best design choice.
- checklists for e-learning products ('What to look for...')
- CD with good and bad examples
- extensive suggested reading lists at the end of each section

Clark, Ruth, Frank Nguyen, John Sweller, *Efficiency in learning: evidence-based guidelines to manage cognitive load*. San Francisco, US: Wiley/Pfeiffer, 2006.

Focuses on cognitive load theory, i.e., how to ensure essential processing and minimize extraneous processing. Contains CD with examples and lists of specific design tips for creation of audio-visual teaching materials, among others.

Clark, Ruth, Chopeta Lyons, *Graphics for learning: proven guidelines for planning, designing and evaluating visuals in training materials*. San Francisco, US: Wiley/Pfeiffer, 2004.

In-depth explanation of the right and wrong ways to integrate visuals into educational materials.

Nevejan, Caroline, *Synchroon/Asynchroon: Onderwijsvernieuwing in de informatiesamenleving*. Amsterdam, the Netherlands: Hogeschool van Amsterdam, 2003.

Quoted in: Thackara, John, *In the bubble: designing in a complex world*. Cambridge, Massachusetts, US: MIT Press, 2005.

Crone, Eveline, *Het puberende brein*. Amsterdam, the Netherlands: Bert Bakker, 2008.

Highly readable explanation for non-scientists by brain researcher Crone, who has done pioneering work on adolescent brain development. Focuses on the 'learning, social, emotional and creative brains' of adolescents. (Dutch language)

Bremner, Gavin, Allen Slater. *An Introduction to Developmental Psychology*. Malden, Massachusetts: Blackwell Publishing, Ltd, 2004.

Vast, but transparently structured and easily scannable guide to this complex subject. Each chapter starts with an overview of key concepts, and ends with a concise summary and discussion points. Of interest for e-learning:

- Chapter 8, Cognitive Development
- Chapter 12, Memory Development and Eyewitness Testimony
- Chapter 16, Social Development, part V, 'Practical Issues', Educational Implications