

MORE THAN FACTS AND FIGURES - A TYPOLOGY OF E-LEARNING ACTIVITIES FOR THE NATURAL SCIENCES (WITH AN EXAMPLE FROM "DO-IT-YOUR-SOIL")

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The didactic design of an e-learning environment should provide an effective interface between the learner, the learning material and learning activities. This article proposes a typology according to which six categories of e-learning activities in natural sciences are distinguished: assimilation, reproduction, application, generation, communication and reflection of knowledge. The different types of activities are illustrated by examples from "Do-It-Your-Soil", an e-learning course in soil science. The typology can be used as a source for writing new e-learning material in other scientific fields, but also as a tool for evaluating and profiling existing learning material.

1. INTRODUCTION

Developing e-learning material for the natural sciences has a special challenge: the variety of natural phenomena is huge. Students have to acquire a large amount of knowledge about the various forms and processes nature has to offer. The overwhelming importance of facts in natural sciences implies an inherent danger for teachers: It is easy to just concentrate on facts and figures and forget about the learning process of students. However, all teaching still implies active participation by the learner.

2. DIDACTIC DESIGN FOR E-LEARNING

In general learning can be described as a process in which a learner changes his or her behavior or knowledge as a result of an experience. Learning starts with the perturbation of the actual state of knowledge and comes to a (provisional) end, if the calibrated knowledge fits the experience (Figure 1). Learning proceeds in a cycle, as knowledge never fits experience completely (see Bateson & Bateson 1987: 36 f.).

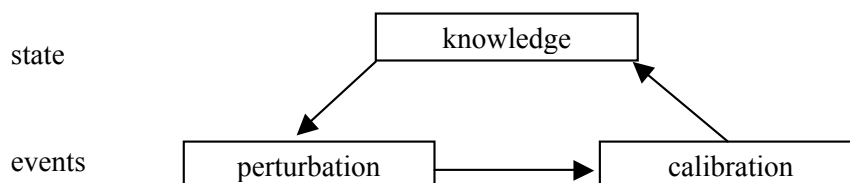


Figure 1: Learning cycle

Knowledge is constructed in the minds of individuals but needs to be communicated and shared between individuals. Thus, e-learning is not lonely learning. The learning process has a dialogic structure. Different actors are involved in perturbing and confirming the knowledge

of the learner: e.g. the author of the learning material, the tutor as well as other learners (Figure 2).

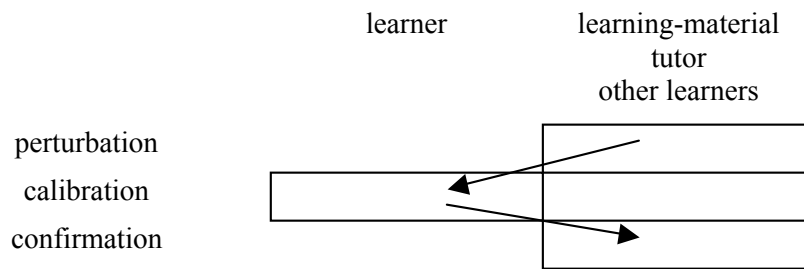


Figure 2: Dialogic structure of the learning process

In the process of knowledge reconstruction, design assumes a decisive role. Design here means not just an added decoration to a technical structure. The aim of design is to create the interface between the three main domains (Bonsiepe 1996: 19):

1. a user, who wants to perform a task
2. a task, that has to be performed by the user and
3. a tool, that is needed to perform the task effectively.

In the didactic context of e-learning the learner has to perform a learning task using an learning environment as a tool. The interface of the e-learning environment helps the learner to transform mere data into processed data (information) and into confirmed information (knowledge).

Didactic design of an e-learning interface has to structure the information and the interaction between the actors in the learning process. On one hand, problems can be presented by the learning material, a tutor or other learners. On the other hand, feedback as a confirmation of a acquired knowledge can also be provided by the computer, by a tutor or by other learners. A computer program, for example, will automatically give immediate feedback at the end of a multiple choice test. A group of learners may discuss and evaluate a written text as a proposal for the solution of a real-world problem. The mix and quality of feedback is an important feature of e-learning environments.

E-learning material reflects the explicit or implicit conception of the course designer. The following table shows the three main didactic conceptions underlying an e-learning environment:

Learning strategies	Directed learning	Self-directed learning	Collaborative learning
Type	learning by telling	learning by doing	learning through reflection and discussion
Learning methods	instructor centered	learner centered	team centered
Learning situations	simple, all information given	more complex, within the given information	complex, realistic, beyond the information given
Instructor role	direct leadership	facilitating, coaching	coaching , moderating
Learner role	passive	active	active, reflective

Figure 3: Learning strategies (Seufert / Back / Häusler 2001: 56)

The advantages and disadvantages of these didactic conceptions for e-learning have been largely discussed (see Schulmeister 1996, Schulmeister 2001). Despite the differences between these conceptions, didactic design of a an e-learning interface raises the same fundamental questions:

1. How the information should be structured and presented, so that students can easily absorb it.
2. Which kind of activities should be provided to give students the opportunity to (re)construct, apply and confirm new knowledge.
3. How the communication and cooperation between students, tutors and authors effectively can be organized.

3. A TYPOLOGY OF E-LEARNING ACTIVITIES

Here we propose a typology of e-learning activities for natural sciences consisting of the following six categories:

- **Assimilation of knowledge:** These activities help the learner to assimilate new knowledge. Visualizations and animations transform invisible processes to facilitate understanding.
- **Reproduction of knowledge:** These activities give an opportunity to reconstruct information in different forms to check understanding.
- **Application of knowledge:** With these activities the learner applies his knowledge to a real or virtual system or process. They are part of the confirmation process for new knowledge.
- **Generation of knowledge:** With these activities the learner solves a given problem. Doing this, the learner creates new knowledge that has to be confirmed by other activities.
- **Communication of knowledge:** With these activities the learner can compare his own knowledge with that of other learners. The feedback of other learners provides a social confirmation of new knowledge.
- **Reflection of knowledge:** These activities help the learner to evaluate his knowledge and to plan his learning process.

<p>Assimilation of knowledge:</p> <ul style="list-style-type: none"> - to use understanding clues (intros, summaries, context) - to explore a virtual space - to recognize a pattern - to interpret a scheme or a visualization - to follow an animation step by step 	<p>Reproduction of knowledge:</p> <ul style="list-style-type: none"> - to choose the correct item: multiple choice, correct/false, yes/no - to combine items: drag-and-drop; combinations: word-word, word-sentence, word-image - to structure information, to create a table - to complete a scheme or a text (gap filling) - to make notes - to categorize items in a taxonomy - to collect information in a graph or a table - to measure a (virtual) object
<p>Application of knowledge:</p> <ul style="list-style-type: none"> - to work on a case study - to solve a problem - to answer an open question - to describe a phenomenon or a system - to analyze a phenomenon or a system - to calculate a parameter or variable - to describe the state of a process - to work out a solution - to carry out a (virtual) experiment 	<p>Generation of knowledge:</p> <ul style="list-style-type: none"> - to formulate a hypothesis - to invent an experiment - to create ideas for solutions - to design a scheme of a system or a process - to write a concept or a report - to map reality into mathematical equations and graphs - to develop a model of a system or a process - to invent future scenarios

<ul style="list-style-type: none"> - to compare results of an experiment with a hypothesis - to use a (virtual) tool - to manipulate a (virtual) model 	
<p>Communication of knowledge:</p> <ul style="list-style-type: none"> - to carry out a survey - to exchange ideas - to communicate problems - to discuss and evaluate a solution - to work out an alternative solution - to write a group report - to take part in a (virtual) role play 	<p>Reflection of knowledge:</p> <ul style="list-style-type: none"> - to fix learning objectives - to reflect on learning objectives - to do an assessment test - to do a self evaluation - to use a learning portfolio

Figure 4: Learning typology developed within Do-It-Your-Soil

4. APPLICATION OF THE TYPOLOGY

The proposed typology of e-learning activities can be used for different purposes, e.g.

- as a basis for constructing sequences and combinations of e-learning activities
- as a tool for analyzing and profiling existing e-learning material
- as a source for writing new learning material

This paragraph shows the application of the typology to the first module (Module 1) of the e-learning program Do-it-your-soil (DIYS).

4.1. Constructing sequences of activities

DIYS has a modular structure and offers a guided tour through the learning material, but also allows stepping in at each learning sequence. DIYS is inspired by the idea of a "Leitprogramm", i.e. guided learning by solving structured problems (Frey & Frey-Eiling 1994), which was modified during the course of DIYS development. A DIYS sequence consists of 3-6 thematic units representing a sequence of growing complexity. These thematic units, which are called "topics", consist of a combination of didactic bricks such as introduction, exercise, explanation, synthesis. Each sequence is completed by an open question about the topics of the sequence. At the end of a module, the students have to apply their knowledge to a case of a real-world problem presented ("case study.") (Figure 5)

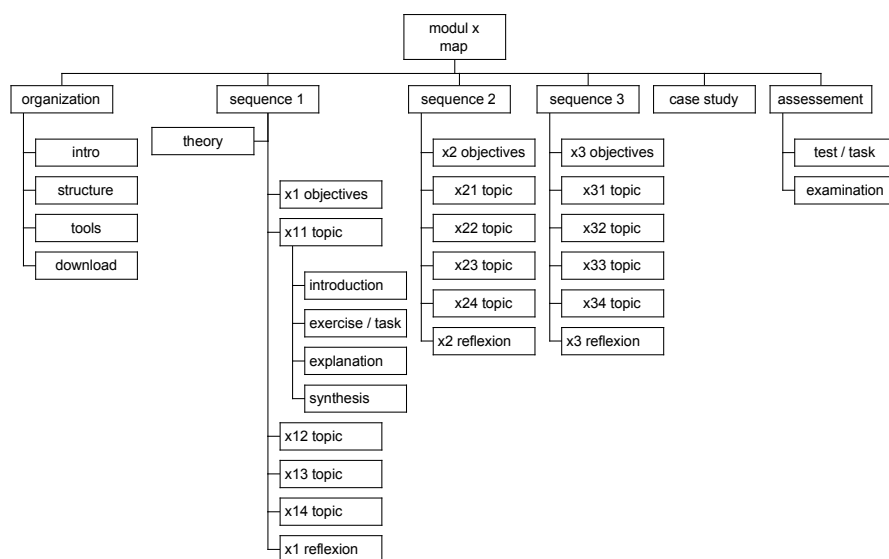


Figure 5: The modular structure of Do-It-Your-Soil

4.2. Analyzing and profiling Module 1 of DIYS

The typology shown above (Figure 4) can also be used as a **tool for evaluating and profiling existing e-learning material**. The typology was used to analyze the learning activities within the thematic units of Module 1 (beta version) of DIYS (Figure 6).

	Thematic Unit	Assimilation	Reproduction	Application	Generation	Communication	Reflection
	Learning objectives	-	-	-	-	-	X
S1	Plants	R	-	-	-	-	-
	Soil water	F	-	-	-	-	-
	Atmosphere	F, E	Mc	-	-	-	-
	T/S diagram	F, E	-	-	-	-	-
	ET calculator	E	-	-	-	-	-
	Open question	-	-	X	X	-	-
S2	Desorption curves	F	-	-	-	-	-
	Meaning of curves	E	-	-	-	-	-
	Capillary model	E	DD	-	-	-	-
	Pore volume	E	-	-	-	-	-
	Real soil	E	-	-	-	-	-
	Open question	-	-	X	X	-	-
S3	Calculation model	E	Mc	-	-	-	-
	Measuring profiles	E	M	C, Ma	-	-	-
	Measuring curves	E	M, Mc	C, Ma	-	-	-
	Water storage	E	M	C, Ma, U	-	-	-
	Open question	-	-	X	X	-	-
S4	Case study	-	X	X	X	X	-
	Reflecting objectives	-	-	-	-	-	X

Figure 6: Analysis of e-learning activities used in module 1 (beta version) of Do-It-Your-Soil. Abbreviations: S1, S2, S3, S4 - Sequences 1-4; E - explore a virtual space; F - follow an animation step by step; Mc - Multiple Choice Test; DD - Drag and Drop exercise; M - measure a virtual object; C - compare results with a hypothesis; Ma - manipulate a (virtual) model)

The result of the analysis presented in Figure 6 clearly reflects the increasing complexity of Module 1. In Sequence 1, e-learning activities are mainly of the type "follow an animation step by step" and "explore a virtual space". In Sequence 2, more emphasis is put on the exploration of virtual spaces. In Sequence 3, a model is introduced that encompasses "measuring virtual objects", "using a virtual tool", "manipulating a virtual model" and "comparing results". Sequence 4 is a case study problem that has to be discussed within the group of students. Related activities are found in the types "Generation" and "Communication" of knowledge.

The allocation of time to the various activities in a learning sequence gives a good characterization of the e-learning-material. The three learning strategies may roughly be characterized by the profiles shown in Figure 7. In comparison, the profile of module 1 of DIYS shows that the learning strategy implicitly focuses on assimilation of knowledge.

	Directed Learning	Self-directed Learning	Collaborative Learning	Do-It-Your-Soil
Assimilation	40%	30%	20%	45%
Reproduction	30%	20%	0%	20%
Application	30%	20%	20%	15%
Generation	0%	10%	20%	10%
Communication	0%	0%	20%	5%
Reflection	0%	20%	20%	5%

Figure 7: Learning strategies and learning activities (estimates of the authors)

4.3. Writing new learning material

The typology is also a **source for writing new learning material**. Comparing the results of the analysis of Module 1 (beta version) with the typology shows:

- Only a small selection of e-learning activities was used in the first 2 sequences ("following...", "exploring...")
- There is still a lack of reproducing and applying activities in Sequences 1 and 2. While DIYS got very positive feedback in general, one of the most commonly heard comments by our test students was: "There should be many more exercises".
- Some types of e-learning activities that might be expected in material devoted to a natural science are missing completely, i.e. "describing and analyzing a phenomenon", "formulating hypotheses", "carrying out virtual experiments", "designing a scheme or a concept". The reason is that the idea of the DIYS course was primarily to practice application and problem-solving, but not to teach theory or research.

With respect to DIYS our conclusion is that we will add more exercises in applying and reproducing knowledge. However, it would be more difficult to add activities like e.g. "formulating and testing hypotheses" because this might lead to a complete restructuring of a sequence.

5. Conclusion

Today many authors of e-learning material are scientists, who are specialists in their scientific field and academic writers, but not specialists in didactic design of an e-learning environment. The typology of e-learning activities may help them to find appropriate learning activities, once the learning objectives are fixed. There is a close relationship between learning objectives and learning activities. A student can not learn to analyze real-world problems or synthesize solutions for them, if the e-learning material only provides for reproduction activities. The typology is a tool for didactic designers. It was created to enrich the e-learning material of Do-It-Your-Soil. Hopefully, it is also useful for other e-learning environments.

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