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The 3DE: an Environment for the Development of Learner-Oriented Customised Educational Packages

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Abstract

The objective of the 3DE, Design, Development and Delivery Electronic Environment of Educational Multimedia, is to create a new electronic learning environment and the related methodology focusing on students' individual learning styles, prior knowledge and goals. The 3DE system analyses the personal learning style of each learner and matches the learning contents with personal learning styles. The learning style test used in the 3DE environment is based on Kolb's theory of learning processes and learner styles [1] *and the learning style instrument developed by Honey and Mumford* [2]. *The 3DE tool, custom course compiler, will be used in building the most suitable course packages for the learner's needs from a specific micromodule library. The 3DE system enables better learning performance, thanks to the learner-oriented customised educational packages. The design of the 3DE learning environment is based on the constructivist learning paradigm.*

1. Introduction

In general, interactive educational multimedia material is designed without considering the learner's individual differences, such as for example, learning style or previous knowledge. The same type of course is offered to all learners even though customisation of the course would be both possible and beneficial. Several researchers have found evidence that presenting information through a variety of approaches leads to more effective instruction [3,4,5,6,7]. Learning style, which means approaches to learning and studying [8], has proven to have an impact on the effectiveness of student learning, resulting from student response to different teaching methods. For example, Heitmeyer and Thomas [9] found students to be more comfortable with certain instructional strategies than others as a result of their preferred learning style. Research has additionally shown improved attitudes, behaviour and grades when the instructional environment complements the student's learning style preference [10,11].

This paper presents a novel approach to design interactive educational multimedia material. The 3DE approach accounts for the diversity of the learners. The learning material is classified not only for the content, but also for the way in which the content is meant to be learned by different learners and what are the learning goals and previous knowledge of the learner. The 3DE, an acronym for Design, Development and Delivery Electronic Environment for Educational Multimedia [12], is a research project within the European Union IST 5th Framework Programme [13], carried out by a consortium of four partners: COREP (Italy), ARDEMI (France), STI (Spain), Vaasa Polytechnic (Finland). The goal of the 3DE project is to define, design, build, and launch a development environment which is able to build courses customised for the needs of each learner in an automated or guided way. Courses are built in an automated way from a library of 'micromodules' - logically undivided learning units - taking into account the specification of final educational/training goals and the results of the learner's competence/ preference analysis. Several different custom packages can be built from the same pool of micromodules. Basically, the teacher-learner relation is changed from the 1-to-N paradigm - one teacher for many learners, as in standard classrooms - or 1-to-1, as in computer based environments where each learner has access to a virtual teacher, towards a N-to-1 model: The learner can select among several available teachers the one who best suits his learning style.

An extensive use of engineering methodologies – reusable modules compliant with international standards – for the design and development reduces the development time, while the learner-centred personalisation reduces the time required to learn, thus improving the effectiveness of current web-based learning packages, and reducing the total effective cost.

The paper proceeds as follows. Chapters 2 and 3 describe the pedagogical approach of the 3DE project

which is the main topic of this paper. Chapter 2 presents the general model of school learning and the learning paradigm on which the 3DE project is based. Chapter 3 next discusses the learning style typologies and presents the one selected for the 3DE project and the development of the learner style analysis. Chapter 4 gives an overview of the whole 3DE system. The final Chapter 5 summarises and concludes the paper.

2. Background of the pedagogical approach

2.1. The model of school learning

Why has the 3DE project seen it important to account for the learner's learning style when designing interactive educational multimedia courses? The answer lies in the learning paradigm adopted by the 3DE project. Before discussing the learning paradigms we present the general model of school learning in Figure 1. It shows that learning is a complicated phenomenon where different factors affect the learning outcome. There are many background variables, relating to the learner and the learning environment, which affect learning. Both of these factors affect the learner's learning process indirectly. The effects of these background variables are filtered via the learner's perceptions and interpretations. For example, what the learner thinks about his intelligence or abilities, directs his motivation and learning orientation. Also, how he views the teacher's evaluation methods, directs his learning strategies. When the learner monitors and controls his own cognitive processes – such as reasoning, comprehension, problem-solving, learning – metacognitive actions are taken. The learning outcome can be evaluated both in quantity and in quality. The quantitative measuring units measure how much has been learnt and the qualitative ones what has been learnt, in which way and how deeply. Earlier, it was only the teacher who evaluated the learner's performance but now the self-assessment of the learner is emphasised, too. There is also a feedback dimension in the model. It means that the learning outcome will affect the learner's perceptions and interpretations, which in turn affect learning in new learning situations. Finally we have to remember that learning does not take place in isolation but, on the contrary, it is bound to the situation and social context and culture. [19]

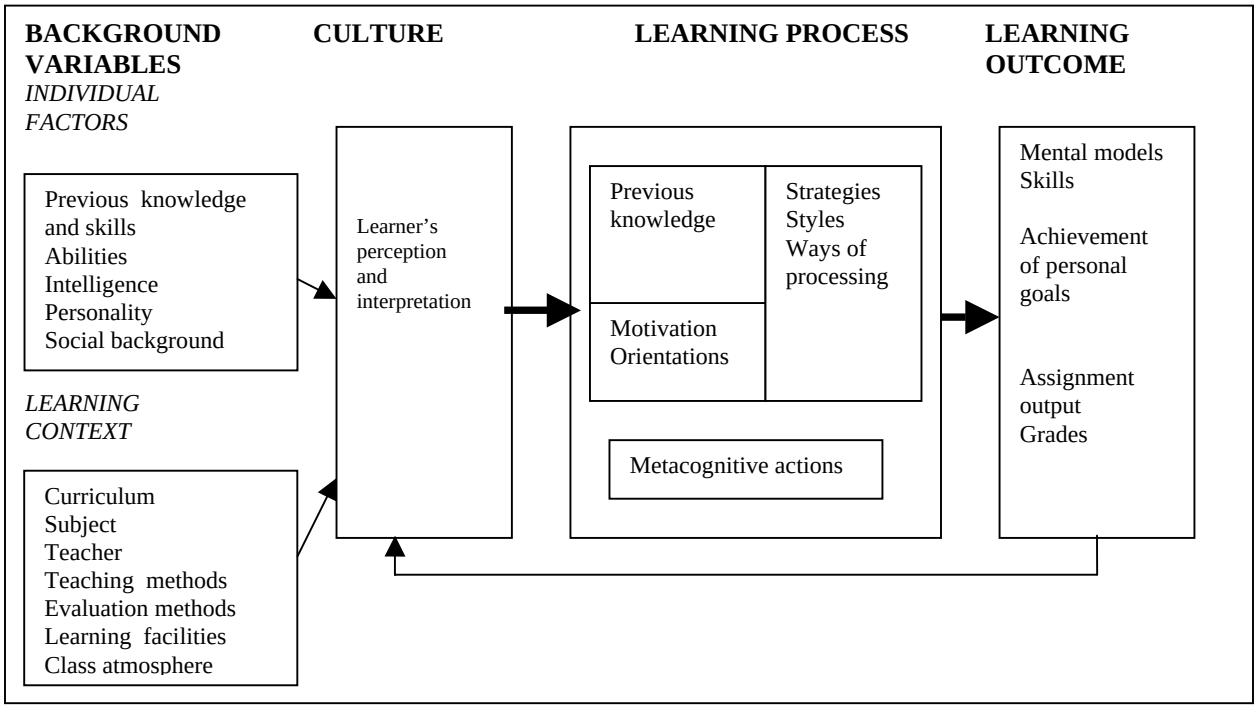

Figure 1. General model of school learning (developed by following the references 14,15,16,17,18,19)

2.2. Learning paradigm

Our view of learning in the 3DE project is based on the constructivist paradigm which can be described as the

modern approach to learning compared to the other, more traditional paradigms such as behavioural and cognitive learning paradigms which have existed in the field of education and psychology before the development of the constructivist view. These different paradigms emphasise different parts of the learning model shown in Figure 1. The behavioural view, in general, assumed that the outcome of learning is change in observable behaviour and emphasised the effects of external events on individual. [20]. The behaviourist researchers were mainly interested in the relations between the background variables and the learning outcome variables measured quantitatively with the course grades or other similar quantitative measuring units (Figure 1). In the 1960's the cognitive view of learning started to replace the behavioural view and the researchers became interested in the learning process itself (Figure 1). Since the 80's the current paradigm in the educational science has been constructivism. The basic idea of constructivism is the learner's own active contribution to his learning process in a social context where the learner constructs his own knowledge by combining new information and experiences to his existing knowledge structures. As a result, information as such can never be transferred from one person to another, because all the information will be interpreted differently by individual learners in different contexts. One of the best-known representatives of the constructive learning theory is D. Kolb. One of his contributions to the theory has been in verifying the existence of different learning styles of individual learners. [2, 21]

The 3DE project has adopted the constuctivist view of learning and the 3DE learner classification is based on Kolb's theory. We believe that the learning process is very important part in the learning model (Figure 1) and are therefore designing a learning environment which involves such important variables of the learning process as the learning style, previous knowledge and learning goals. Also the metacognitive process is emphasised while developing the learning environment. The 3DE learning environment includes material to enhance the learning skills. A separate 'Learning to learn' unit where the learner can get information about the learning skills and techniques is available in the beginning of each course.

3. Learning style model and testing

The most important decision in the pedagogical design of the 3DE project was the selection of the learning style model and the related learning style test. The group from Vaasa Polytechnic evaluated various models in order to select the most useful for the purposes of the 3DE. Learning style models can be classified in many ways. Summarising Curry's [22] and Riding and Rayner's [23] classifications of learning style models we arrived at the following grouping. The examples of the models are given in parenthesis:

- Instructional preferences (Dunn & Dunn)
- Social interaction models (Perry,Raichman & Grasha)
- Personality levels (Myers & Briggs, Keirsey)
- Information processing
  - based on experiential learning (Kolb)
  - based on orientation to study (Entwistle, Biggs)

The final choice was to develop our own learning style test based on Kolb's theory [1] and Honey & Mumford's model which is an application of Kolb's theory [2]. Both of these belong to the last group of models and they were chosen because they concentrate on the learning process. In our opinion, the other models categorise learners on the basis of less relevant aspects related to learning, such as the whole personality [22] or senses and the environmental factors [24]. Learning is mainly related to perceiving and processing information, and the selected model measures these characteristics. The Honey & Mumford's learning style [2] names and the style descriptions are also used in the 3DE learning style profiling due to their clear vocabulary.

There are four different learning styles in the learning style model chosen for the 3DE project. These learning styles are:

- **Activists** (Style A) who are active learners. They like to discuss the things to be learned and work actively on the subject in a group. Activists like diverse tasks, new experiences and problems from which to learn.
- **Reflectors** (Style B) who also learn from new experiences, but they do not want to be actively involved in them. Reflectors like to observe situations, to study the subjects and make analyses and reports. They need time to produce new ideas and theories based on the new experiences.
- **Theorists** (Style C) who like to have the things to be learned offered in their context: models, systems or theories. They analyse things deeply and like to listen to or read about interesting ideas that emphasise rationality and are well argued.
- **Pragmatists** (Style D) who like to study things with practical advantages and they like opportunities to implement what they just have learned. They value high face validity and real problems and enjoy chances to practice techniques with feedback from experts.

The learning style test, which is still under validation process, developed in the 3DE project consists of 56 questions of the type "I am eager to test new ideas in practice" or "I get bored with routines" or I try to consider things in their entire context" or "I like listening more than talking" etc. We use a 4-point scale ranging from 1 = I fully disagree to 4 = I fully agree.

The results of the learning style test are described with adjusted parameters for each of the four basic styles A,B,C and D mentioned above. The numbers identify a sequence of preferred styles, with precise positions in the range from very high (100) to very low preference (0). The learner is therefore identified by a four-digit sequence of numbers representing the results for the styles A,B,C and D. The parameters are stored in the 3DE database, and are given back to the student as a written report with some explanations. [25]

Also the learning styles of the course and of each micromodule are described with similar parameters, included in the metadata of the learning units. Since it is very difficult to evaluate precise parameters for each learning unit, conventional values of parameters are assigned to the main and the secondary learning style. More refined classification can be achieved through more experience later in the project. [25]

The results of the learning style test are used to match the 3DE courses with each learner's personal learning style. The learner can choose whether to use the version of a course that best matches his preferred learning style, or whether to try the other versions in order to develop his weaker learning styles. [25]

4. The 3DE system

4.1. The general model of the 3DE system

The customised learning packages are built from a library of micromodules designed specifically for different learning styles. Figure 2 presents a complete view of the 3DE project structure.

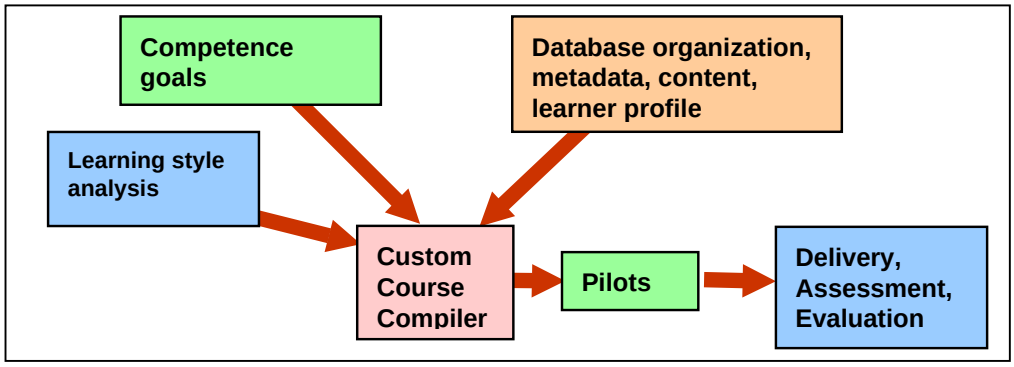

Figure 2. Global view of the 3DE project

For the designers and developers, the development of a customised course in the 3DE starts with the definition of the final educational goals, options and constraints, e.g. the language, the maximum length of a 'lesson', or special interface requirements for impaired people.

It is possible to start to build the customised course with the help of the micromodule library and the learner data, taking into account all the previous points. An automated tool, with the supervision of a real teacher will carry this out. The next step is the delivery of the course and tests in between. This phase can be tailored for specific user needs, and will exploit the Internet.

For the learner the steps through a 3DE course are:

1. Selection of the final educational goal;
2. Competence and learning preference analysis;
3. Attending the course, with total freedom of time, place, speed, including:

- a mix of studying, solving problems and exercises, depending on the learning style preferences;
- use of simulators and virtual laboratories;
- learning to learn exercises;
- interaction and co-operation with real tutors and other learners;
- self-evaluation tests in between;
- final test, with certification of results, if required;
- final course evaluation and final self-evaluation.

4.2. The custom course compiler

The Custom Course Compiler (CCC) is the heart of the 3DE project. It builds customised courses from the micromodule library taking into account individual learning styles and final learning goals, and the prerequisites required. The content elements in the 3DE are organised in a hierarchy of learning objects, micromodules, themes, course, with the standards of CEN/ISSS LTWS [26], as shown in Figure 3 .

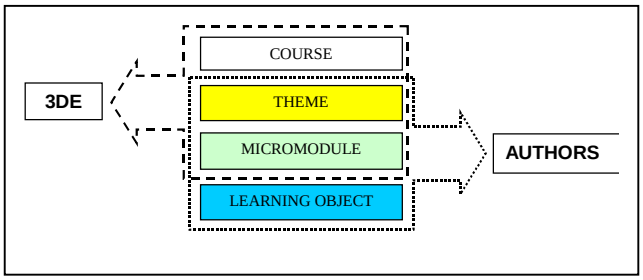

Figure 3. 3DE object hierarchy

The *learning object* is an elementary resource, such as a text, a drawing, or a video clip. The learning objects are not handled in the 3DE system: no learning style parameter is directly associated with them. It is the responsibility of the author to select the proper object for each case.

The *micromodule* is an elementary, logically undivided learning unit, composed of learning objects, links and relations, and a presentation interface. The micromodule is an autonomous unit which can be used alone to teach an elementary concept. To give a more precise idea of what a micromodule is, we can say that the learner will spend on a single micromodule, reading a screen page, viewing a video, a time ranging from 5 to 15 minutes. This time includes different activities, such as reading, interactive tasks, following external links, tests and exercises. The micromodule is described by a set of didactical metadata which includes its characterisation in terms of learning style provided by an external validator, the prerequisites necessary to understand the micromodule content (input) and the learning goals (output). This information is used by the CCC to select the best micromodules for each course/learner pair.

The *theme* is an intermediate step from micromodules to courses, and it consists of an organised sequence of micromodules. The chaining of prerequisites among the micromodules within a theme is guaranteed by the authors. The CCC will not verify the chaining of micromodules inside themes. A theme is also characterised by didactical metadata, including the learning style parameters. We assume that in general micromodules within the same theme are developed by the same author or development group. That is, there is some direct communication among the people who develop the theme to guarantee chaining and coherence. Inside the theme any sequencing problem is solved by the author(s). In order to develop a new theme an author can reuse learning objects and even complete micromodules from other themes, but they are assembled as a new independent theme.

A *course* is a set of themes linked by their prerequisites and organised into an oriented graph, such as in Figure 4. The chaining of themes takes into account the prerequisite verification: if a theme X requires the learner to have preliminary information which is provided by themes Y and Z, these themes must be in the chain before X. Usually, there are different themes for the same topics but, with different learning styles. Therefore, a course corresponds to several paths within the same set of topics. The CCC, visiting the graph, chooses the path where all the themes best match the student's learning style (Figure 4).

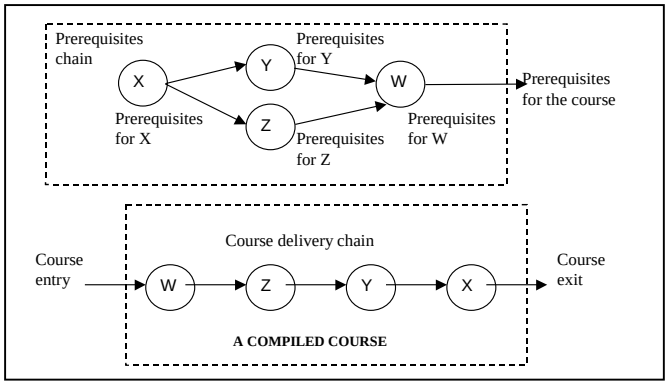

Figure 4. Graph of the course and compiled course

In the <learning object, micromodule, theme, course> sequence the control moves softly from the authors to the system, as shown in Figure 3. Learning objects are seen and controlled only by the authors. The micromodules and themes have a common ownership, and the course is assembled by the CCC, without intervention by the author.

5. Conclusions

The 3DE project develops a methodology and tools to build courses customised for the requirements and needs of individual learners. A different version of each course is built from a library of micromodules, specifically prepared for different learning styles. The aim is to improve the effectiveness of web-based teaching packages by reducing both the development costs and the user effort to learn.

The structure of the system evolved from micromodules to themes. Themes are assembled by authors who take care of prerequisite chaining. The Custom Course Compiler checks micromodule prerequisites inside a theme and builds courses by using themes which satisfy the learner's learning objectives, competence and learning styles.

This paper described the general structure of the project and the result of the first phase, devoted to the definition of the pedagogical design. The project, started in March 2000 with a work plan for 3 years, has completed the educational design phase, and is now dealing with the development of core tools and with short pilot courses, to test the design methodology. Details and updates on the project status are available in the project website [12]. The

final 3DE learning environment should be available by the year 2003.

The 3DE cooperates with other European projects on different aspects of learning material development, and keeps track of the development in standards for metadata.

6. References

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