The integration of instruction strategies into an e-learning environment

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SUMMARY

Most e-learning environments are applications in which the teacher uploads study materials that students download. This approach to e-learning discards the fact that didactic principles should be part of a broader instruction strategy aimed at achieving certain goals. It is possible for e-learning tools to support and improve didactical principles. This paper demonstrates how several instruction strategies can be integrated successfully into an e-learning environment. Further, the paper points out the various issues that should be addressed by an e-learning application to increase workflow efficiency for all actors involved in student education. We use a newly developed e-learning environment to illustrate how e-learning tools can help in reaching these efficiency goals.

Introduction

Research by the American Ministry of Education showed that 56 % of American universities offer their education partly by means of distance learning via the Internet. Students seem to be very enthusiastic about distance education by means of e-learning, since the number of students applying for online lectures is growing rapidly (Tabs, 2003). Most e-learning environments are places where the teacher uploads study materials that students download. The e-learning environment thereby discards the many didactic principles that could be supported and improved using e-learning tools. Important didactic principles are competence-based learning and learning aimed at a practical application of theoretical insights. In particular, these didactic principles should be part of a broader instruction strategy aimed at reaching certain didactic goals in an interactive way. Further, students should be able to study, and gather knowledge at the exact moment they need it. All theoretical information and course elements should be easily accessible to a student whether at work or at home. This paper will show how instruction strategies that contain several didactic principles can be successfully integrated in an e-learning environment.

Educational institutions are under constant pressure to work in a cost-efficient way (Abbott and Doucouliagos, 2003; Moonen, 1994; Johnes, 1997). E-learning tools can help reach efficiency goals by attuning the workflow of all those involved in education. The processes of student education are various: authoring educational materials; designing courses and allocating students and teachers to them; study and communication facilities for students; and supervision, evaluation and grading by teachers. Handling all these processes and attuning them makes various demands of an e-learning environment; for instance, an option for users to reuse content parts is essential for cost-efficient authoring. Further, the possibility of testing and grading within the electronic environment leads to a decrease in administrative burden. In addition, developers of educational materials should be able to cooperate digitally and share workload, which requires excellent content management. This paper will demonstrate how a learning content management system (LCMS) can support various educational processes and those involved in them.

The general objective of this paper is to contribute to knowledge of e-learning environments, by showing the ways in which instruction strategies can be designed to contain several didactic principles, and how these instruction strategies can be integrated in an e-learning environment. In this way we show how distance learning can make effective use of the internet and e-learning tools ([1]). We will describe how this approach to course design has been applied in a newly developed e-learning environment called Sophia. The paper will also point out the various issues that should be addressed by an e-learning application to increase workflow efficiency in student education. We will use the new e-learning environment to describe how these issues can be tackled.

The organisation of the paper is as follows. In Section 2 we show why there is a need for distance education by means of e-learning. Section 3 elaborates on ways in which didactic principles could be integrated in instruction strategies. The importance of organising the educational processes and the ways in which this can be facilitated by an LCMS is discussed in Section 4. This section also gives two examples of educational processes and shows how activities are organised for different actors in these two processes. In Section 5 preliminary results are presented from a survey of students and interviews with teachers and content developers. Section 6 presents concluding remarks.

The case for distance learning using the Internet

In the current knowledge-based economy, sharing and transferring knowledge is essential to the competitive position of firms and generating economic growth (Goldstein and Ford 2001; Welle-Strand and Thune 2003). It is generally acknowledged by firms that, to maintain their competitive position, they have to provide their employees with access to relevant training. Further, issues such as employability and flexibility are becoming increasingly important to employees as well. The competitive labour market forces employees

([1]) Please note that distance learning does not necessarily mean that the educational material is delivered to the student via an e-learning environment, i.e. web-based education. In fact, in the early days of distance education, the interaction between students and the educational institution took place solely by means of written educational materials and mail. Similarly, e-learning does not necessarily imply distance learning. E-learning systems are perfectly capable of supporting classroom education. Actually, Blackboard - as a widely adopted e-learning environment - started as a system to assist classroom education.

to maintain and increase their level of knowledge and constantly update their competences to consolidate their positions, or acquire better ones, in the labour market (Burgess and Russell, 2003; Chute et al., 1999; Krempl, 1997).

Changes in the education demand influence the teaching methods to be employed. Traditional education methods may not suit the growing need for lifelong learning, with more portable and flexible learning methods better suiting employer and employee needs. Web-based teaching methods (as opposed to classroom-based) provide more possibilities for on-the-job and just-in-time learning (Cantoni et. al., 2004; Driscoll, 2002; Kruse, 2004; Rosenberg, 2000). Employers need their employees to be well-educated and flexible but employees cannot be out of the office for many hours or days to follow a classroom-based education programme. Web-based tools make it possible to provide the employee with appropriate study materials at the exact moment he/she faces a problem in his/her work situation. Moreover, an employee is able to study during quiet times at work. The employee can even study at home or in any other place that is suitable to him/her. Davis (2000) lists several benefits for firms when deciding on web-based teaching methods, focused on the following issues: high speed and relatively low cost of web-based methods; long geographical distance to traditional teaching institutions; globalisation of the company leads to geographically dispersed subsidiaries which should have access to the same training facilities; investments in technical infrastructure are made already; and leading-edge mentality of firms makes them want to be frontrunners in all respects, using cutting edge technology ([2]).

Whereas employers value the way in which web-based courses increase the competitive position of their firm at relatively low cost (Kruse, 2004), employees value the flexibility that web-based courses provide (Kruse, 2004; Collis, 1998). Collis (1998) reports that employees place particularly high value on '(a) not having to move from their homes and work in order to attend required sessions; (b) having flexibility within the pre-determined time frame of a course with respect to completing assignments; (c) being able to omit aspects of a course that were inconvenient or judged not directly relevant to them

([2]) Many anecdotal reports on corporate learning (Greengard, 1998; Davy, 1998; Berger, 1998) give illustrations of successful implementation of distance learning in organisations. For an overview of the claimed benefits of distance learning in these reports, see Burgess and Russell (2003). In a scientific study, Gaines-Robinson and Robinson (1989) developed guidelines for organisations to increase the effectiveness of corporate learning.

(particularly group meetings); (d) being able to vary the amount of communication that was required of them with other students or the need to get together physically with other students or the instructor; and (e) flexibility in being able to adapt assignments better related to their workplace duties' (Collis 1998, p. 376).

However, the issue goes beyond the mere change in delivery of education from classroom-based to web-based (Baer, 1998; Parikh and Verma, 2002). The needs for just-in-time learning and general availability of education materials throughout geographically dispersed subsidiaries of a company call for a shift in didactic paradigm as well (Leidner and Jarvenpaa, 1995; De Block and Heene, 1995). Whereas, in traditional education, the teacher is the provider of knowledge, in web-based education the student should be more involved in the learning process itself. The student should become the central actor, choosing exactly those teaching materials that provide the knowledge he/she needs at a certain moment (Al-Nuaimy, Zhang and Noble 2001; Collis, 1998).

Most web-based learning tools currently available on the market (3) are still largely based on traditional didactic principles. It is still the teacher who provides knowledge by uploading education materials, usually in the form of articles, cases or assignments. Students can download the materials and interact with the teacher by e-mailing or contributing to discussion groups. Popular commercial systems like Blackboard and WebCT, which is currently integrated with Blackboard, are designed in this way, as well as popular open source systems like Moodle and Sakai. These systems generally include templates for discussion forums, quizzes and exercises such as multiple-choice and true/false questions. Components for document distribution, a grade book, discussion, live chat, assignment uploads, and online testing are included as well (see Wheeler, 2008, for an overview of Sakai functionality and http://www.snlonline.net/Blackboard/Blackboard%20Functionality.pdf for a brief overview of Blackboard/WebCT functionality). Teachers fill in these templates and then release them for students to use. The main objective of these systems seems to be to simplify teacher and student workflow. Important didactic principles such as just-in-time learning, competence-based learning and learning aimed at a practical application of theoretical insights are largely discarded

(3) For a comprehensive list of e-learning systems see http://elearning-india.com/content/blogcategory/19/38/ [cited 26.2.2008].

in such systems. Further, it is not recognised that activities such as quizzes and exercises should be part of a broader strategy that aims to fulfil a certain educational goal.

As an answer to the drawbacks of the existing applications for distance education, a new system called Sophia ([4]) was developed in the Netherlands. Sophia is an e-learning environment which supports all educational processes for students as well as for content developers, teachers and managers. Sophia provides templates for teachers, as do Moodle, Blackboard and Sakai. However, Sophia's templates provide comprehensive instruction strategies which are firmly rooted in a number of didactical principles. This goes far beyond, for instance, providing a template for multiple choice questions. In Sophia, multiple choice questions might be used as a part of a much broader instruction strategy. An instruction strategy contains a complete didactic scenario on how to teach students certain theoretical knowledge or specific competences. Education technology scientists have provided ideas on how, for example, a multiple choice test can be used as a component in a broader didactic scenario that will reach certain didactical objectives.

In the following sections, we will show how instruction strategies, and thereby didactical principles, are fully integrated into a web-based education tool.

Instruction strategies

We have argued that a web-based environment should contain comprehensive didactical strategies designed to reach certain learning objectives. In this section, we show how these instruction strategies can be integrated in a web-based system. This is illustrated with the newly developed learning environment Sophia but any other e-learning system could implement the same ideas.

The instruction strategies provide the core of the Sophia application around which several other supportive facilities are designed. Student

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([4]) The Sophia e-learning environment was created in a project that was undertaken with funds from the Digital University. The Digital University is a joint initiative of 10 Dutch universities of both master and bachelor degree aims at developing e-learning content and tools and disseminating them among Dutch universities. At the end of the project, Sophia was turned into a commercial package. The Sophia e-learning environment is easily accessible from every computer around the world with internet admission, i.e. no software has to be downloaded to have access to Sophia. Sophia is ASP-based (active server page technology).

learning goes through different stages, from mastering basic and essential concepts and methods to applying this knowledge in practical situations (Gonzàlez-Castaño et al., 2001). Sophia provides online functionality supporting all these stages: diagnosing the knowledge the student already possesses; providing the student with activities that will help him/her fill knowledge gaps; providing the student with assignments on real-life case(s) and letting the student apply the theoretical knowledge to a real-life problem; testing whether the student possesses the required level of knowledge or competence. It might not be straightforward to teach and evaluate competences while using a web-based tool. In accordance with Ulrich et al. (1995), we define competence as a student's ability to handle real-life situations in a professional manner by integrating and applying knowledge, skills, insights and attitude and to reflect on the chosen approach. In a web-based application, competences can be increased, for example, by showing video fragments of real-life situations and posing questions about how such a situation should be handled.

All instruction strategies cover one or more learning stages (see Table 1). The fact that not all stages are covered by each strategy opens possibilities for blended learning. It is possible for an organisation to make a deliberate choice about the way in which each

Table 1. **Overview of instruction strategies in Sophia**

Learning stages / Instruction strategies	(a) Detection of knowledge or competence gaps	(b) Acquisition of knowledge or competences	(c) Practise application of knowledge or competences	(d) Examination
1. Diagnose	x	x		
2. Diagnose and test	x	x		x
3. Combination +	x	x	x	x
4. Combination			x	x
5. Practice +	x	x	x	
6. Practice			x	
7. Exam +	x	x		x
8. Exam				x
9. Problem-based learning (PBL)	x	x		x
10. Project-based				x

learning phase is supported, either by web-based teaching or by offline methods. For example, some organisations might prefer to take the examination in a classroom environment, while all other learning phases take place online.

Note that while some instruction strategies cover an identical set of learning stages, they differ in the adopted didactic scenario. For example, instruction strategies 'diagnose and test', 'exam +' and 'problem based learning' all provide e-learning materials for several processes. Below we will explain the distinct didactic principles guiding each task type ([5]). The '+' refers to the addition of materials that detect knowledge or competence gaps and lead the student to the acquisition of knowledge or competencies. For example task types with a '+' contain a sophisticated multiple choice test which is described below the discussion of the 'diagnose' type. In fact, the '+' refers to the integration of a 'diagnose' type task in the overall structure of the task.

Task types 'diagnose' and 'diagnose and test' are rooted in an objectivist model of learning, with the annotation that the transmission of knowledge is tailor-made to the needs of the student. Tasks of this type identify the knowledge level of students using sophisticated multiple choice questions ([6]). After completing the test, the student receives advice for further study that is conditional on the mistakes made. The students are provided with knowledge on exactly those areas where they experience gaps. Course developers will usually employ diagnose tasks at the beginning of a course. Based on the knowledge gaps, the students are directed towards tasks (of other instruction strategies) that will provide them with knowledge, insights, skills and attitude on specific subjects. Diagnose tasks can be used in combination with a classroom exam, while diagnose and test tasks are specifically designed to evaluate student's level of knowledge and competence online. Diagnose and test tasks are typically used as a conclusion to an entire course.

([5]) In the design of e-learning materials authors can choose to develop a task which adopts a certain instruction strategy. Therefore, instruction strategies are also called task types.

([6]) To provide sophisticated multiple choice questions, Sophia is partly integrated with Question Mark Perception (QMP). QMP is a computer-assisted assessment system which allows several distinct forms of multiple choice questions and incorporates several mechanisms for differentiated feedback. Empirical evidence indicates that simply showing students the correct answer has less effect on learning than providing elaborate feedback on the correct and incorrect elements of the given answer (Dempsey, Driscoll and Swindell, 1993). Moreover, the motivation of students is positively influenced by feedback tailor-made to the answer of the student (Ross and Morrison, 1993).

Tasks of the types 'combination +', 'combination', 'practice +', 'practice', 'exam +', and 'exam' are firmly rooted in constructivist ideas on just-in-time learning (Schoening, 1998). After detecting and filling the knowledge gaps, the student starts out with a problem relevant for a specific firm. The assignment will lead the student to both relevant theory on this problem and background information on the firm. It is up to the student to decide which information to use for solving the assignment. Students are immersed in a real world context and discover how to use certain theoretical concepts and methods. Theoretical insights are gathered at the exact moment they are needed to solve the assignment (just-in-time). 'Combination +' type tasks provide online facilities for all phases in the learning process, whereas tasks of types 'combination', 'practice +', 'practice', 'exam +', and 'exam' leave room for fulfilling one or several learning stages offline.

Finally, problem-based learning tasks and project-based tasks find their origin in a cooperative model of learning, problem-based learning (Birch, 1986; Norman, 1988; Norman and Schmidt (1992); Dolmans et al., 1994) and project-based learning (Blumenfeld et al., 1991) ([7]). Tasks of these types are always integrated with offline activities. In type 9 tasks, students typically start with an online discussion on a specific case description designed to entice them into investigating problems: these discussions take place in small groups. Students ask and refine questions and debate ideas for possible solutions. This stage is concluded with identification of the gaps in collective knowledge and setting collective learning objectives, which guide a student in his/her individual self-studies (Norman and Schmidt, 1992). The self-study has to address individual knowledge gaps as well. These individual gaps are identified by an online diagnostic test. This tailored approach is system driven: no staff experts are involved. The diagnostic test determines the individual student's knowledge gaps based on the correct and incorrect answers given by the student in the test. Even the exact kind of mistake made in the diagnostic test leads to specific knowledge gap identification. As a conclusion to the self-study phase, students are subject to another diagnostic test which determines their intellectual progress. In a subsequent group session (usually in a classroom), students will communicate their ideas and findings on the collective learning

([7]) For a detailed description of the benefits of project-based learning, see Blumenfeld et al., 1991, pp. 372-372.

objectives to each other and ask new questions until, finally, all learning objectives have been reached to full satisfaction of all students. Students conclude tasks of this type with a final diagnostic test in addition to an individual assignment; the latter is graded by the teacher. In project-based tasks a similar approach is adopted. The point of departure comes from an online project-assignment which leads to an online discussion among students on how to manage the project. The final goal is to produce a certain artefact (such as a model, a report, a videotape or computer program) in a group effort. This artefact is handed in (online via the e-learning system) to a teacher who grades the end result.

From the perspective of a learning content developer, a course usually contains several tasks. Developers of e-learning materials start out by choosing an instruction strategy suitable for the specific objective they want to reach with a certain task. As we have seen above, there are at least two sides to this. First, is choosing which phases of the learning process will be supported online and which will be provided in another way (by classroom lectures, books, videos, etc.). Second, is choosing a suitable didactic approach. Once chosen, Sophia will make sure that the didactic scenario of the chosen instruction strategy is closely followed. It does this by providing the building blocks (components) for the task, which have to be filled with content materials by the developer. Therefore, the electronic environment ensures that every produced task adopts a high quality didactic approach.

Organising the workflow

In traditional education systems, each teacher develops their own materials and quality is ensured by personal control. With the shift in the role of the teacher from knowledge provider to facilitator of the learning process, organising the production of educational materials has to undergo a shift as well (Collis, 1998). An e-learning environment can simplifymanaging educational processes and increase the specialisation of actors. Therefore, process control becomes much more important than personal control. An e-learning environment can provide each actor producing education materials with sufficient tools to undertake their task. Moreover, specialisation will increase workflow efficiency for all involved in student education.

With Sophia, we created an e-learning environment that fulfils these requirements. Three distinct features of Sophia that make sure that educational processes are streamlined are differentiation in roles to ensure specialisation benefits, content management system to foolproof the application, and opportunities for reuse of resources. Each of these features is discussed below.

Differentiation in roles

Educational institutions are under constant pressure to work in a cost-efficient way. E-learning tools can increase the efficiency of production and delivery in education by enabling different actors to specialise in their roles. Sophia distinguishes eight roles: product manager, administrator, author, moderator, supervisor, assessor, mentor and student. Each role gives access to specific possibilities and incorporates several responsibilities.

A supervisor is responsible for composing the educational programme (learning path). The supervisor can either choose an instruction strategy (or mix of strategies) that is considered useful for the course, and subsequently instruct authors to make tasks of this type, or create a learning path with already existing tasks (created by authors for another course). The latter is called reuse (we revisit this issue later). The supervisor monitors the student progress in the learning paths created by himself/herself. When the course period is over, the supervisor closes the learning path by sending students their final grade.

Authors are responsible for the creation of tasks. As mentioned in Section 2, Sophia provides an author with a limited set of building blocks to construct a task. These building blocks ensure a sensible didactic approach and pave the way for further specialisation in the authoring process. Several blocks do not require expert content knowledge to be filled, such as the inclusion of websites that are relevant for cases. This work can be executed by a (low-wage) student assistant. This specialisation within the authoring process provides opportunities for cost efficient content production, since easy tasks can be directed to lower wage content developers. The content experts can focus on filling those building blocks that require expert knowledge.

The role of the student is quite straightforward. A student visits the Sophia website and logs in with a unique login name and password. The learning paths direct students to their tasks on different subjects. Questions can be posed to the mentor. Usually, learning paths are concluded with tasks testing the competences of the student ([8]): assessors grade these tasks. The supervisor grades overall performance in the learning path. A student is still able to access his/her study materials after assignments have been graded but not allowed to make changes.

The mentor supports students by answering questions on the education material and uses facilities such as email and FAQ (frequently asked questions). A mentor has access to overviews of student progress, which enables him/her to focus on students that need assistance. Assessors are responsible for grading student tasks. Sophia supports assessors in a number of ways. First, assessors can make use of answer models, describing the essential elements that a correct answer contains. Second, the system assures objectivity across assessors in the grading the same assignments for different students. Depending on the task type, assessors have access to an overview of the grading behaviour (and rationale) of other assessors for a specific assignment. The moderator role is created for instruction strategies that incorporate discussion groups related to a certain subject. The moderator monitors the discussion groups, deletes improper contributions and undertakes action against contributors who abuse the system.

The roles discussed deal explicitly with educating the student; an additional role is created to organise the administration of students. The administrator can add or remove users, plus design general homepages containing information on the educational institution or the company that offers the courses. Role-specific information can also be displayed. Students/employees are welcomed to the training facility and are instructed in use of the system. Authors are instructed in the process of creating educational materials with the application. In addition, a role is created for organising the use of the system as a whole. Sophia allows organisations to use their own 'look and feel' for their courses as well as using different sets of functionalities. The product manager looks after the specific needs of institutions. This role organises and manages access by different organisations to different functionalities.

Below are two illustrations of how educational processes are organised within Sophia. The first example shows how the supervisor interacts with students on the learning path level (Figure 1):

Step 1: The supervisor creates a learning path by giving a description

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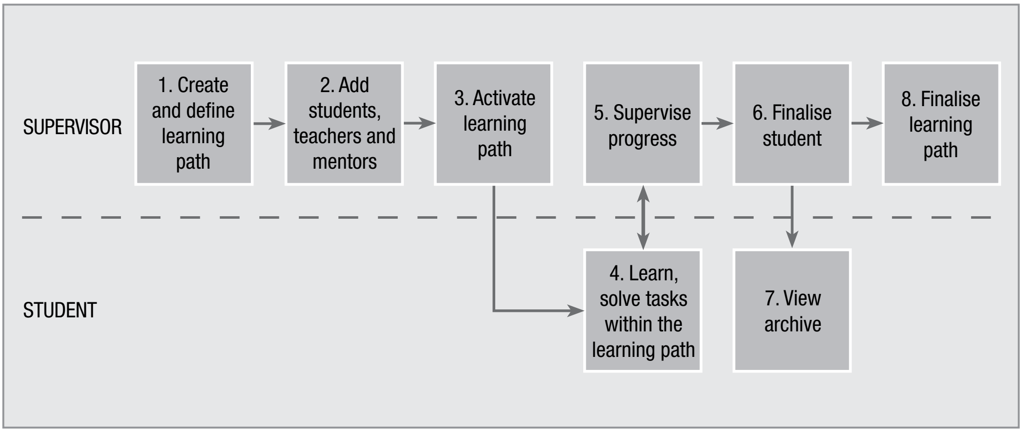
([8]) This is not to deny the possibility for blended learning in the system that enables a choice for offline examination.

Figure 1. **Supervisor and student activities at learning path level**



of the course, defining a start and an end date (9), choosing a number of tasks to be included in the course and making decisions on how the course should be assessed. In addition, the supervisor can schedule several offline tasks, for instance group meetings, class lectures or presentations.

Step 2: The supervisor determines which students can participate in the course by adding them to the learning path. Assessors and mentors are also added.

Step 3: As soon as the supervisor has included all relevant tasks and other information in the learning path, he/she will activate it. From this moment on, students have access to the course and can start solving tasks. The supervisor can continue to add new students to this course but is not allowed to adapt tasks in the course or add tasks to the course.

Step 4: The student solves the learning tasks in the course. The specific activities that have to be carried out by the student depend on the didactic model adopted for the tasks. The second example below demonstrates the activities of the student for a certain instruction strategy.

Step 5: The supervisor monitors the progress of all students: there are several overviews that assist. The supervisor can oversee which students have started working on the course.

(9) It is also possible for the supervisor to create a learning path in which students can start and finish whenever they want to, without a deadline being set for having finished all tasks.

Furthermore, he/she can observe whether tests have been finished and what proportion of the tasks have been solved by each student. In a more detailed view, the supervisor monitors each student's answers to each assignment. A student is aware of the fact that answer behaviour can be watched; this deters him/her from filling in false answers to the questions.

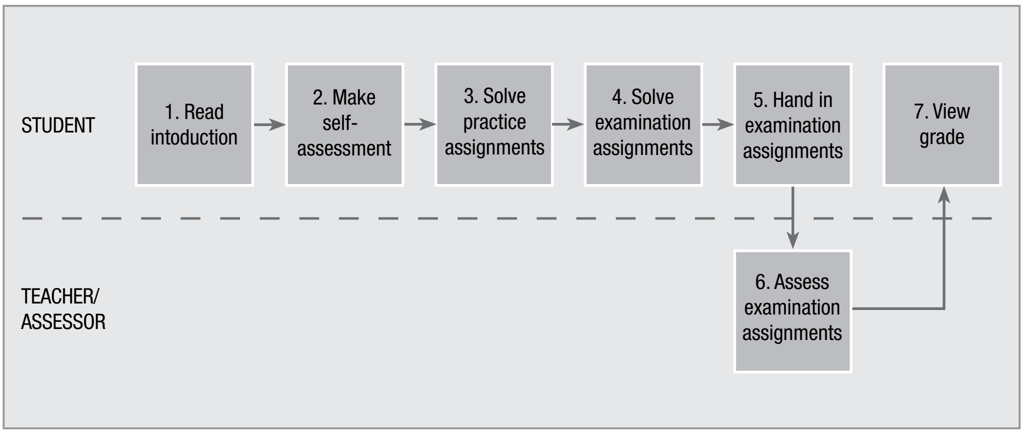
Step 6: As soon as a student has completed all tasks in the learning path and his/her tasks are graded by the assessor, the supervisor finalises the learning path for this student. If all students have completed the course, the supervisor finalises the entire learning path.

Step 7: A student is able to examine overviews of all the courses he/she has completed. The student can see his/her grade for every course and take a detailed view of all the tasks and assignments completed.

The second example of workflow organisation within Sophia describes the processes between student and assessor at task level. What happens here depends on the instruction strategy chosen for a task. Figure 2 shows the activities of the student and the assessor for a task that adopts the 'combination+ task' didactic principle.

Step 1: The student reads the introduction to the task, which contains introductory notes as well as the educational goals that will be achieved when the task has been finished.

Figure 2. **Student and teacher activities at task level**



Step 2: The student assesses his/her knowledge of the subject of the task in a diagnostic test, comprising a predefined number of multiple choice questions. Immediately after answering a question, the student receives a detailed explanation of why the chosen answer was wrong or right, advice, containing a reference to a textbook paragraph, that gives further information on the subject of the question. After finishing all multiple choice questions of the self assessment, the student receives an overview of the entire test. This overview shows the test questions, the answers given by the student with the accompanying feedback and advice, and the correct answers. The student can use this overview when reviewing the literature to fill the gaps in his/her knowledge of the subject of the task. Note that the self assessment is not compulsory for the student.

Steps 3 and 4: Practice and examination assignments take the form of open questions that ask for the application of theoretical concepts to problems relevant to a specific firm. An example of such an assignment is ‘Describe the marketing mix for Mercedes Benz’. To solve the problems raised in this assignment the student needs to gather knowledge on the concept ‘marketing mix’, gather knowledge about Mercedes Benz, and apply the theoretical knowledge of marketing mix to the case of Mercedes Benz.

The student has to gather knowledge of concepts and terms in textbooks (Sophia will have a hyperlink to a brief description of each difficult concept accompanied by a reference to a paragraph in a textbook that gives further information on the concept). Knowledge about the firm to which the problem has to be applied can come from within or outside the system. For an elementary level course, a course developer will choose to provide students with access to case information within the e-learning environment. It is important that studying case information is made enjoyable for students; this is done by including images, video fragments and hyperlinks to relevant websites in the text of the case. Evaluations show that students experience these cases as very motivating. For more elaborate course levels, a course developer can decide to let students gather case information on their own in online and offline sources. The didactic idea behind this component of this instruction strategy is that students develop the skill to gather relevant information to solve a real-life problem.

The student fills in the solution of each assignment in a text field and he/she submits it by clicking a button. In the case of a practice assignment, the student will receive the correct answer, which he/she can compare to the submitted answer. This component of the combi task ensures that the student learns to formulate his/her solution in an effective way. Since the answer has to be put in writing, the student is forced to think it through and formulate his/her arguments effectively. In offline forms of distance education, solutions to assignments are often included at the end of the tutorial book and students generally do not solve assignments on their own before looking at the solutions provided in the tutorial. In this approach, students are not stimulated to develop writing and argumentation skills. An online course using Sophia provides an added stimulus to students who are intrinsically motivated to take the practice of their writing skills seriously, since their answering behaviour can be observed by a supervisor.

An examination assignment generally follows an approach similar to the one for practice assignments. Although examination assignments apply to a different case, they are of the same level as the practice assignments. A notable difference between practice and examination assignments is in the feedback given to the student. After submitting an answer to an examination assignment, the student does not receive the correct answer. While practice assignments are designed for educating, examination assignments have the sole purpose of testing.

Step 5: After completing the examination assignments of the course, the student hands them to the assessor (online).

Step 6: The assessor grades the assignments.

Step 7: The student is able to examine an overview of the course, see his/her grade, and all the tasks and assignments completed.

Reuse of resources

An efficient LCMS is characterised by many opportunities for reuse of objects. Objects can be resources, tasks and even entire courses (learning paths). One of the facilities that enable reuse of resources is the library where authors can store learning objects such as images, cases, websites and text files. Other authors can be granted access to certain libraries, thereby enabling them to reuse materials developed earlier. A glossary can also be reused, the object being a specific glossary term, accompanied by a description and an advice about where to find a more elaborate discussion of the term in the literature. Reuse is not limited to a single glossary item but covers entire glossaries pertaining to specific content fields. Conditional access protects content objects in Sophia against being overwritten unintentionally. Editing of objects is only allowed for authors within one content group (authoring in a specific content field). Authors of other content groups may be granted use of existing resources, but the only way for them to make adaptations is to copy the original objects to their own resource library before editing it.

Tasks can be (re)used in an unlimited number of courses. This is sensible because a task is a learning object created to fulfil a specific educational objective and one specific task could very well be useful in several different courses. A supervisor is able to compose different courses by (re)combining tasks; all tasks designed by authors within a certain content group can be used freely in learning paths. A content management system protects tasks against being rewritten (see 3.3). Entire learning paths can be reused as well, for instance for another group of students.

Content management system

Where developers of educational materials cooperate digitally and learning objects are reused, a content management system is required to manage different versions of learning objects. The content of education materials needs to be updated regularly: updating and revising learning objects implies danger of having different versions of the same object operational simultaneously. A content management system needs to assure that tasks used by students cannot be altered or removed unintentionally by other actors in the system. This issue is tackled by introducing a life-cycle for tasks ([10]). Tasks can only be edited by legitimate authors during certain phases of the life-cycle of a task.

([10]) Learning paths undergo a somewhat different, though similar life cycle with the following phases: draft, active and closed.

A task is subject to five phases. First, the author develops a task in the draft phase. As soon as this is complete, the author will label the task 'ready-for-use', the second phase of its life-cycle. An author is allowed to withdraw the task from this phase, since it has not yet been added to a course. The third phase is 'active', meaning added to a learning path and not able to be altered by authors. An addendum function allows supervisors and authors to add recent information to the tasks in this stage of the life-cycle. All students using these tasks will immediately be notified of this additional information. Large revisions of active tasks are only possible by copying an active task to the draft phase, in which the task can be revised. Once revised, the task is declared 'ready-for-use' by the author and can be included in new courses by the supervisor. However, unaltered tasks remain in circulation. The author can block an outdated task, a fourth stage in its life-cycle. Active learning paths containing a blocked task will still be operational. However, a supervisor cannot include blocked tasks in new learning paths. Only 'ready-for-use' and 'active' tasks are available for the creation of new learning paths. Blocked tasks that are not used in any courses automatically enter the final phase of their life-cycle. These 'closed' tasks are obsolete and may be deleted from the system by the author.

Survey results

The system has been partly evaluated among students, teachers and content developers. Two main topics were covered: views on the instruction strategies and views on how the workflow was organised.

The evaluation was only of the 'combination +' task, since that comprises all four learning stages: detection of knowledge or competence gaps; acquisition of knowledge or competences; application of knowledge or competences; and examination. Evaluations of the other instruction strategies are still awaited. Five students filled in a questionnaire during a course that employed 16 'combination+' type tasks. The questionnaire contained open questions on whether the students liked working with such tasks or whether they encountered problems, either content-related or technical. The overall view of these five students was that the way in which the tasks were presented was easy to understand and use. The tasks motivated them to engage in further study of the textbook and related study materials. Students unanimously reported being very pleased to work on assignments related to practical situations that challenged them to apply their (theoretical) knowledge and competences. Hardly any technical problems were encountered.

In addition, an evaluative survey was carried out among 32 students that finished the course with the ‘combination +’ tasks. Seventeen students completed the questionnaire (response rate of 53.1 %) which contained mostly open questions. All students reported being pleased to work on assignments related to real-life situations, stating that the tasks ‘encourage you to a structured and analytic approach of practical situations’ and ‘force you to think’. Several students felt that ‘you learn a lot by analysing the cases’ and that ‘it is enjoyable to alternately read and make practical assignments’. Students reported an average score of 7.9 on a 10-point scale (10 being maximum) for course satisfaction.

Views on how the workflow was organised came from interviews with teachers and content developers. Informal discussions were held with five teachers and five content developers. On educational materials, teachers felt that the templates that were provided by the system were very helpful. They thought about the goals they wanted to achieve with a certain task and then chose a suitable instruction strategy. After that, they felt that they did not have to worry about didactics, because the system had integrated this in the templates. Content developers reported that in cases when large teams of developers are involved, it became very easy to keep track of the status of development of a course. One of the content developers was positive about being able to see at home whether the others reached milestones in the design of the course. A reported disadvantage was that the templates force a teacher to follow a certain didactic design and there is no room for alternative designs, which might also be good from a didactical point of view. A few content developers mentioned that they had alternative ideas for instruction strategies which they would like to have implemented in the system. Taken as a whole, teachers and content developers liked the ease with which materials could be distributed to students and the potential for maintenance and reuse of content. Some teachers, however, were critical on the ease of use of the system, saying that there were many buttons and the system should be simplified.

All teachers stated that the online assessment was easy to use. The electronic assessment environment gives the teacher a view of both the student’s answer and the answer model. Teachers value the fact that they do not have to search their papers for the answer model and the opinion of other teachers on similar answers. They stated that the electronic system made the grading process accurate and pleasant to do. Further, the teachers stated that the system made it possible to grade a student's performance within thirty minutes. In comparison, an average competence-oriented course at the same university has an assessment burden of one hour per student. The specific design of the course therefore reduced the regular assessment burden of a course by 50 %.

Summary and concluding remarks

In this paper, we illustrate the issues that have to be taken into consideration in the design of an effective e-learning environment. The shifting role of the teacher in web-based learning systems calls for the integration of didactic principles in instruction strategies, which in turn are part of the e-learning application, and the specialisation of all actors involved in educational processes. This will create opportunities for increasing efficiency in producing educational materials. Moreover, it is a significant advantage that an e-learning system with integrated didactics tailors the supply of educational materials to the exact need of each student, something that would be much too costly if it had to be done by content developers. Widely adopted commercial e-learning environments like Blackboard, as well as popular open source systems like Moodle and Sakai, should consider whether it would be interesting to increase their consideration of didactics and integrate it in their systems, instead of adding tools and gadgets. Only with fully-fledged instruction strategies incorporated in the learning environment is it possible for a web-based system fully to support a teacher in teaching via the Internet. This is especially true for situations in which the learning is based completely on electronic materials and where the teacher is not available face-to-face.

The first preliminary evaluations of using Sophia indicate that the system meets the goals of integrated instruction strategies and workflow management. The system is easy to use for students as well as teachers and managers in educational institutions. All users interviewed appreciate the didactic principles incorporated in the instruction strategies. The system proves to be very effective in organising educational processes such as the development of educational materials (especially by large teams of authors), the distribution of materials to students, and the maintenance of content. Future challenges for Sophia pertain to ensuring that the system remains simple in its use. Currently the number of instruction strategies is limited to a coherent set but there is continuous pressure from content developers for an increase; the inherent risk is that the set of instruction strategies becomes too complex to manage for content developers. This would make it very hard for content developers to recognise the instruction strategy that would be most suitable to specific learning objectives.

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