New way of organizing F16 maintenance training: blended learning solution

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ABSTRACT

Recent developments like the Advanced Distributed Learning (ADL) initiative emphasize the application of learning objects. Such modularization of learning content has large implications on the Instructional Design (ID) process. It requires innovation on a didactical, technical and organizational level. In this paper the actual implications of modularization of learning content in practice is discussed. We describe the results of a case study which illustrates the innovation of F16 maintenance training. In this case study we use a systematic and iterative approach to specify the ID requirements and to define prototypical lesson scenarios (Specifying Learning means in an Iterative Manner, SLIM). An important aim of the innovation was to increase training effectiveness and transfer of learning. The specification of task oriented learning objects is therefore very important. A challenge in this project was to create a coherent learning environment, despite of the fragmentation by means of learning objects. The most important steps in this study are: a) analyze the complex task, b) relate the critical desired behavior, conditions, and criteria for (minimal) performance of this task, c) select a relevant didactical model [we used the Four Components Instructional Design (4C/ID) model of van Merriënboer], and c) define the learning objects. All steps are conducted in intensive iteration and cooperation with the domain- and instruction experts. The chosen 4C/ID approach leads to defining a blended learning solution according to standardization developments of learning content to ensure reusability as well as the desired quality of education. This learning solution consists of the following components: paper based textbook, computer-based exercises, classroom-based teaching supported by multimedia, and emulation-based practice.

ABOUT THE AUTHORS

Nieke Janssen is a scientific researcher at TNO Human Factors, and is involved in research and development projects concerning the application of Information and Communication Technology (ICT) to improve learning processes. In her work she concentrates on learning solutions; how the teacher and learner interacts with (online) computer-based based training systems; support reusability of learning content. Central themes are standardisation issues in e-learning content design, retrieval and assemblence, and the design of training (development) tools.

Eddy Boot is a scientific researcher at TNO Human Factors, and is involved in research and developments projects concerning the application of Information and Communication Technology (ICT) to improve learning processes. He holds a degree in instructional technology and specializes in applying modern instructional theories like case-based learning and problem-based learning by means of advanced learning technology. Much of his research is related with the integration of work and learning ant the standardisation of learning technology.

Mattie van Gestel is First Lieutenant at the Royal Netherlands Air Force (RNLAF) and is involved in many instructional design and development projects for complex technical training. From his role as former instructor he currently is responsible for consulting on the use of technology based training solutions for the RNLAF. A main project that he was involved in is the development of an emulation for F-16 avionics maintenance training. In his function he is involved in all phases of the Instructional Design process, from requirements analyses to performing acceptation tests.

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INTRODUCTION

Due to technological and educational innovations, the area of training and instruction is constantly changing. As a result of technological innovations, training developers currently deal with advanced multimedia learning content. The development of such learning content is a very time-consuming, costly and specialized process. So, from a cost perspective there is a need to reuse the multimedia learning content as much as possible. From an educational perspective, the need has grown to provide training programs that are adaptive to the needs of specific learner groups or competences. A cost- and flexibility driven solution is to divide learning content into independent modules in order to reuse them more easily in new training arrangements. Technical standardisation initiatives, like ADL SCORM [1] have been set up to improve flexibility in (re)composing training material and to ensure the possibilities of technical and functional exchange of learning objects between organisations, training programs, and e-learning systems. For more background on designing instruction with learning objects see for example Hamel and Ryan-Jones (2002).

On the other hand, educational innovations are driven by increasing complexity of domain tasks. Due to technological changes, simple tasks are more and more taken over by machines. As a result, complex cognitive tasks that must be performed by humans because they require flexible problem solving behavior are becoming increasingly important in the field of industrial and vocational training (van Merriënboer, 1996, p. 1-2). Dealing with this complexity in conventional (e.g. classroom-based) education, where the learner is a passive consumer of mainly knowledge-based comprehension training, often leads to (too) lengthy training programs and problems with transfer to the workplace. To deal with this, the training programs should be shorter, and should only address the prerequisite knowledge and skills that are required to enable transfer to practice and applicability in existing as well as new situations. These conditions lead to modularization of the training so that the fragments can be reused in a diversity of learning settings and for a diversity of learner groups; a blended mix of learning activities, media and locations.
To achieve such a learning result, it is important that the learning process is supported and well structured. According to modern instructional theories, for example constructivist learning (Jonassen, 1983), learning is supported by studying cases and preparing case summaries or diagnoses of authentic tasks representing the same type of cognitive challenges as those in the real world. Since the key to meaningful learning is ownership of the problem, the cases should provide problems with emergent and definable aspects that motivate the learners to solve them. Also, the learning process is supported by allowing learners to solve problems collaboratively in teams, working towards developing a common conception of the problem.

Such a learning environment can only be created when the instructional strategy is applied throughout the training, resulting in a coherent training strategy. However, modularization of learning content leads to fragmentation of the learning process and threatens the (instructional) coherence of the learning environment. A potential risk of modularization of learning material is that the learning process is so divided into separate, independent modules that the learning environment as a whole lacks a meaningful structure and does not support learners sufficiently in their learning process.

The Royal Netherlands AirForce (RNLAF) and the Royal Norwegian AirForce (RNoAF) are currently also facing these problems. Together with TNO Human

[1] The Advanced distributed Learning (ADL) initiative provides a Sharable Content Object Reference Model (SCORM) that specifies learning objects that are standardised in structure and the way they connect to each other. The model prescribes a set of metadata fields that can be used to label the learning objects with information about the type of learning object, and the way it can be delivered in different learning settings (e-learning consortium, 2002). According to these initiatives, the application of 'learning objects' promises an effective and efficient way of creating, managing and reusing learning content. For lessons learned on the application of the ADL SCORM learning objects see Stout, Slosser & Hays (2001).

Factors, the joint forces searched for a solution to achieve coherence throughout all modules of the fragmented learning environment. This paper describes a case study of how we dealt with this problem (Janssen, Boot and Verstegen, in press).

BACKGROUND

The goal of the study was to create a generic instructional design for the mechanical technical F16 training[2], specifying the learning goals, the learning activities, and learning means for specific modules of the training. For this purpose, the SLIM method (Specifying Learning materials on an Iterative Manner) has been used (Verstegen and van de Hulst, 2000). The main steps of the SLIM method are:

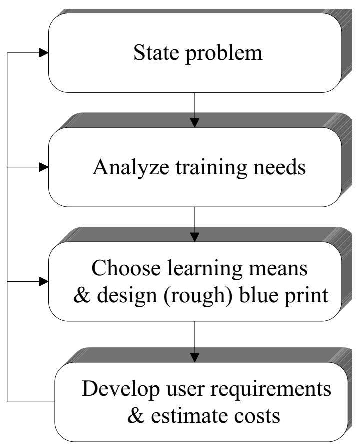

Figure 1. Main steps SLIM method (Verstegen and van de Hulst, 2000)

The SLIM method has been developed to support the process of specifying a needs statement for, usually expensive, learning means according to the needs of an organization. What learning means should look like, depends on what should be learned with them, by whom and how. Often there is not enough time and manpower for detailed analysis. It also is difficult to determine early on in the acquisition process whether the proposed solutions will be financially and technically feasible. Therefore, the SLIM method works in an iterative way: no time is lost and new information and new ideas can be taken into account immediately. The systematic SLIM method ensures that all important aspects are addressed.
To collect and discuss all the important information quickly and efficiently, the method prescribes to organize workshops with all participants: instructors, managers, domain experts, and representatives from the work floor. In between the workshops the participants return to their workplace to collect additional information and discuss the results with their colleagues. Under supervision of an instructional design expert one first goes through the steps of the SLIM method on a more global level in order to get a rough idea of the possible solutions and the factors that play a role in the decision process. After the first walkthrough one works out the steps in more detail and finishes those steps that were not yet sufficiently addressed. The participants bring in their own expertise and they eventually make the decisions about the ID. The role of the workshop organizer is to facilitate the workshops, to structure and guide the discussions, to guard the time and the quality, and to report the results. On request the workshop organizer also brings in it's expertise in the field of education and instructional design.

In the opinion of the RNLAF and the RNoAF the current training strategy for their F-16 maintenance training does not meet the new requirements; to be time and cost efficient while improving the transfer of training to practice. These two Air Forces aim to improve this by customizing the training packages towards training of function-specific competencies, which the professionals need to acquire, so that the length of the training decreases. In order to serve specific function profiles, the Air Forces have adopted an Instructional Design (ID) model that is based on a competency-based training strategy, the Four Components Instructional Design (4C/ID) model. 4C/ID is specialised in training design for complex cognitive skills, defined as skills that consist of a set of highly interrelated constituent skills with different characteristics and different learning processes underlying their acquisition (van Merriënboer, 1996). According to the model, environments for complex learning can be described in terms of four interrelated blueprint components (Van Merriënboer, Clark, and de Crook, 2002, p. 43-55)

1. Learning tasks, which are the actual tasks the learners will be working on during the training program. Learning tasks are organized in a simple-to-complex sequence of task classes, that is, categories of equivalent learning tasks. Learning tasks within the same task class start with high build-in learner support, which disappears well before the end of the task class (i.e., a process of "scaffolding").
2. Supportive information, which is helpful to the learning and performance of aspects of the learning tasks that require variable performance over problem situations. It explains how a domain is organized, how to approach tasks or problems in this domain, and provides cognitive feedback on the quality of task performance.

[2] The official name of the training is Mechanic Technical Training Package (MTTP).

3. Just-in-time information, which is information that is prerequisite to the learning and performance of aspects of learning tasks that show invariant performance over problem situations. It provides algorithmic specifications of how to perform those aspects.
4. Part-task practice, which provides additional repetitive practice for selected constituent skills that need to be performed at a very high level of automaticity after the training. It is only necessary if the learning tasks do not provide enough repetition to reach the desired level of automaticity.

In the case study the four components of 4C/ID have formed the basis for the ID. According to the model we analysed the tasks that needed to be trained and identified combinations of coherent skills that also exist in practice.

METHOD

The SLIM method has been applied by means of three workshops of two days. The participants were instructors, Subject Matter Experts (SMEs), managers, and policy makers. Because of this mix of people with different backgrounds, there was lot of discussion. Sometimes we split up in smaller groups to discuss things independently and to make joint decisions afterwards more successfully. Besides, individual interviews were held to gather sufficient in depth domain knowledge.
The steps of the SLIM method guided us through the ID phases. The domain has been analysed in terms of the tasks that need to be learned, their internal relations, and specific target groups that they apply to. Central subjects of investigation were:

- what should be learned: which learning goals, which level of performance?
- how should learning take place: what kind of learning activities, which instructor roles?
- with which learning means should learning take place: media, distributed learning?

We used the 4C/ID methodology to analyse the task domain, build a task hierarchy, and identify clusters of skills, in order to come to groups of learning tasks that the domain consists of. We got a clear insight in the domain, what information is supportive for learning and for the task performance, what tasks show invariant performance, and whether (parts of) tasks need to be automated. Then we started gathering information about factors that could influence the suitabilioty of certain learning activities to achieve a learning goal or acquire a competence. Examples of these factors are characteristics of the target learners, like: discipline, motivation and reading abilities, preferences of the organisation, availability of instructors, and budget for training means. The strength of this methodology is that all these factors are discussed early in the ID process, first at a global level, and later in more detail. These factors together with guidelines from instructional theory served as input for discussions about potential learning activities and learning means later on.

During the discussions on learning goals, one of the participants emphasised the importance of a model that should allow us to design a generic structure that provides an explicit representation of relations between the learning content modules in the training domain. This modular structure provided a basis for discussing the different training configurations that were required. These configurations were defined according to (1) the function profiles[3] that needs to be trained for, and (2) the type of learning content the learner needs to acquire during the learning process. The resulting structure is generic and applicable to all parts of the training domain.

The results of the discussions were documented, and in between the workshops, the assumptions, arguments and decisions were reviewed by the participants themselves as well as other stakeholders in the organizations (Janssen, Boot, and Verstegen, in press). In this way consensus has been reached about the ID and we developed a suitable solution accepted by all participants, an ID template for the F16 maintenance training. As an example, we applied the template on a small but representative part of the domain in order to create a detailed technical design. Finally, a last iterative cycle has been conducted in a meeting with the steering committee in order to check assumptions, recognize bottlenecks, validate decisions and discuss products.

RESULTS

The study resulted in a generic ID template for the training and a detailed specification of a small part of the training. Because it was impossible to predefine the whole course structure, we focussed on one aspect of the course: the supportive information. Together with the participants we described all aspects in this component which can be used as a blueprint for the other aspects of the course.

The resulting ID template is a specification of the learning content modules that the training should be composed of, matching the modules in the generic

[3] A function profile is a structured description of the characteristics, required competence level, and training needs of a target group.

structure. The generic structure is represented in a table (see figure 2). The depth levels (represented as columns) are based on the function profiles that need to be trained for. The time line (represented as rows) corresponds to the sequences in which the modules will be arranged in the final training.

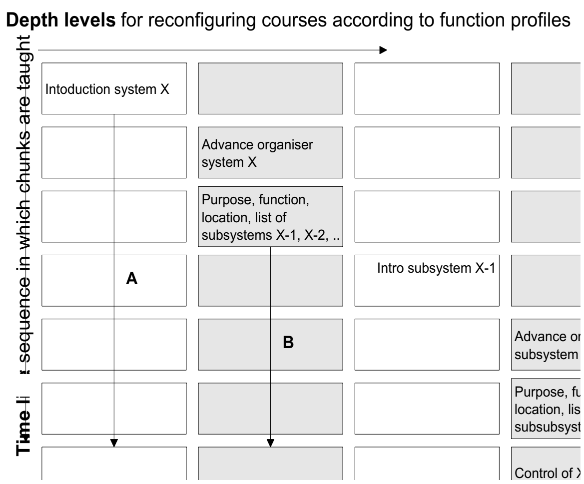

Figure 2. **Part of the modular structure**

Courses can be rearranged by removing column(s) from the table, to flexibly arrange different course for different audiences. Example audiences are the primary target audience, the F16 maintenance engineers; and a secondary target audience, F16 pilots in training. Whereas the maintenance engineers need deep understanding of the F16 systems (e.g. to find a fault in the system); the pilots only need superficial knowledge of the systems (e.g. to describe an error notified during a flight). For each of these audiences, the competence level that needs to be trained for is described in function profiles, on which the required arrangement of learning content modules can be based. To support reuse of learning content in both training configurations, the learning content modules are divided in depth levels. Following the example, the learning modules in the first column (A in figure 2) provide a general background to the learner and will be arranged in training configurations for both groups. The modules in the second column (B in figure 2) provide additional learning content and will only be arranged in training configurations for the primary learner group.

For each module, the learning goals, the learning activities, the learning means, and a scenario to give an example of the learning process for the particular module are specified.
The selection of learning goals is based upon covering all knowledge, skills and attitude aspects in task performance. The selection of learning activities is based upon supporting optimal learning processes by means of active engagement with meaningful learning tasks. Main principles that have been applied are to make theory lessons (more) task-oriented and to provide only that theory that is really required for good task performance (Just Enough [JE] and Just in Time [JIT] principles). In the final learning solution, a basic assumption was to apply computer-based training[4] wherever possible. For the theoretical learning activities the participants choose computer-based as well as computer-assisted training[5] methods. For exercises the participants chose for computer-based and emulation training[6]. Except for the rehearsal training, it was decided that the computer-based training will always be supplied with (online) instructor assistance and a paper-based text book.

The following aspects of the ID template are very important:

- The ID template provides a fixed structure to force consistent detail specification of the ID for all parts of the training.
- The ID template provides an algorithm for how to arrange the learning content modules in different configurations.
- The ID template provides information about the instructional intentions of a module.

During the detail specification we found that the ID template supported the modularization of the training into smaller, independent modules, whilst still maintaining a strong relation with the different type of learning goals. This seems to be the result of explicit descriptions of the relations between the learning content modules in the modular structure.

CONCLUSION

The main conclusion of this study is that the development of a generic ID template seems to support the ID process for modular training design. Instead of specifying the learning content modules independently, the template provides an heuristic for specifying them in relation to other modules in the training, supporting consistent application of the instructional strategy throughout the training, resulting in a coherent learning environment. Moreover, it supports SMEs in creating detail specifications with minimal involvement of (expensive) ID experts.

Regarding to the ID process, we learned that co-operation of a group of people reflecting the work floor

[4] Computer-based training refers to student-led learning using the computer.
[5] Computer-assisted training refers to instructor-led learning with assistance of the computer.
[6] An emulation is a simulation of the real system with some additional feedback.

is an effective way to gain insight in all important factors and in the end to create consensus amongst the stakeholders. In some situations it appeared helpful to split up in smaller groups to discuss things independently and then to make joint decisions afterwards. Because the SME input is very important in the ID process for competence-based training, individual interviews sometimes appear more fruitful to gather in depth domain information. Although this process requires high time investments in early stages of the ID process, it eventually leads to return on investment due to the increased effectiveness resulting from a valid product. Moreover, the intense cooperation during the ID process appears to support mutual understanding and communication between and within (levels of) the Air Forces.

NEXT PHASE

In the next phase of this study, SMEs will use the ID template and apply it to all parts of the training package to create a detailed technical design. This phase will cover a detailed modularization of the whole training package (with appropriate metadata), a detailed ID in which all learning activities are described and all learning means are specified, and insight in the possible roles and possibilities of the learners, instructors and administrators. Finally, the ID will have to be implemented in both organisations.

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