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Departamento de Engenharia Electrotécnica e de Computadores

Customisable e-Training Programmes based on Trainees Profiles

By

Diogo Miguel Frias de Figueiredo

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Ricardo Luís Rosa Jardim-Gonçalves

João Filipe dos Santos Sarraipa

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ABSTRACT

Online training (e-training) is a major driver to promote the development of competencies and knowledge in enterprises. A lack of customizable e-training programmes based on trainees' profiles and of continuous maintenance of the training materials prevents the sustainability of industrial training deployment. This dissertation presents a training strategy and a methodology for building training courses with the purpose to provide a trainee oriented industrial training development. The training strategy intends to facilitate the management of all the training components and tasks to be able to build a training structure focused in a specific planned objective. The methodology for building e-training courses proposes to create customizable training materials in an easier way, enabling various organizations to participate actively on its production.

Additionally a customisable training programme framework is presented. It is supported by a compliant ontology-based model able to support adaptable training contents, orchestration service, facilitating the efficiency and acceptance of the e-training programmes delivery.

KEYWORDS

The keywords of this dissertation are: *Customizable e-training Programmes, Knowledge Representation, Ontology, e-training Course Development Methodology*

RESUMO

A formação “online” (“e-training”) tem sido um factor fundamental no desenvolvimento de conhecimento e competências nas empresas. A sustentabilidade da formação é vital para o seu sucesso e depende da manutenção dos materiais de formação disponíveis e do desenvolvimento de novos materiais. È neste âmbito que esta dissertação apresenta uma estratégia de formação e uma metodologia para a criação de cursos de formação focalizados nos perfis dos formandos. A estratégia de formação que aqui se mostra tenciona facilitar a gestão de todos os componentes de formação de modo a permitir a criação de uma estrutura de formação focada num objectivo específico. A metodologia apresentada propõe a criação de materiais formativos de uma forma eficiente, permitindo várias organizações participarem activamente na produção dos mesmos.

Aliada á metodologia, é também apresentada uma solução que permite a customização de programas de formação, suportada por um modelo baseado numa ontologia. A solução permite a orquestração de materiais formativos de acordo com as necessidades do utilizador, facilitando a eficiência e posterior aceitação da formação “online”.

PALAVRAS-CHAVE

As palavras-chave desta dissertação são: Programas de ‘e-training’ costumizáveis, Representação de Conhecimento, Ontologia, Metodologia de Desenvolvimento de Cursos de ‘e-training’.

TABLE OF ACRONYMS

ADDIE	Analysis, Design, Development, Implementation, Evaluation
ADL	Advanced Distributed Learning
AICC	Aviation Industry CBT (Computer Based Training) Committee
API	Application Programming Interface
CAM	Content Aggregation Model
CTO	Chief Technical Officer
EU	European Union
HR	Human Resources
HTML	HyperText Markup Language
IDEF0	Integration Definition for Function Modeling
IEEE	Institute of Electrical and Electronics Engineers
IPR	Intellectual Property Rights
ISD	Instruction System Development
IT	Information Technology
JSP	Java Server Pages
JVM	Java Virtual Machine
KISS	Keep it Short and Simple
LCMS	Learning Content Management System
LMS	Learning Management System
LO	Learning Object
LOM	Learning Object Metadata
MOODLE	Modular Object Oriented Developmental Learning Environment
OWL	Web Ontology Language
PDK	Programming Development Kit
PPT	Microsoft PowerPoint
QTI	Question and Test Interoperability
RDF	Resource Description Framework
RTD	Research & Technical Development
SCO	SCORM Learning Object
SCORM	Sharable Content Object Reference Model

SME’s	Small and Medium Enterprises
SN	Sequencing and Navigation
SS	Simple Sequencing
TC	Training Course
TiCW	Training in Collaborative Working
TM	Training Module
W3C	World Wide Web Consortium
WebCT	Web Course Tools
XML	Extensible Markup Language

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1. INTRODUCTION

As the economy turns more to a knowledge based-industry, keeping all the members of an organization up to date is becoming an increasing challenge. With the rise of e-Learning, the continuous training is now possible and online industrial training is a major driver to promote the development of competencies and knowledge in organizations.

A lack of a continuous maintenance of the training materials prevents the sustainability of industrial training deployment [21]. The delivery of skills needed for their business by using e-learning has, objectively many advantages over conventional training delivery techniques. Delivery costs are considerably lower and staff will not be off site while training. Downtime is minimized and productivity maintained. [4]

From the start of e-Learning it was assumed that the managers of small and medium enterprises (SME's) would recognize that e-Learning could help deliver just in time training at the working place. Although there is a need for continuous staff training (updating professional knowledge and skills) and that e-Learning is identified as a relative low cost solution compared to standard training.

Research carried out in several European and national projects reveals that e-Learning isn't that much applied in small and medium sized companies (SME's) [1]. E-Learning is still used mainly in big companies, where there is sufficient knowledge and resources to develop and implement sustainable training strategies. Only the IT sector and a few more others use regularly e-Learning, but unfortunately the few activities undertaken by SME's usually are of rather poor quality [2] and consequently the effect of the training doesn't often reach the desired outcome.

One possible solution is to involve SME's into sharing knowledge and collaboration by building communities of practice and to develop business-oriented models of training to meet their needs [12]. Also, by delivering content in small pieces over time as part of a large process, corresponding to the needs of SME staff for faster learning in the context of their work, it would be interesting to, by creating a simple application based on a training development methodology, serve several SME's in the training of non private knowledge.

Despite setbacks in the past, mostly caused by exaggerated expectations and inappropriate approaches and products, e-learning is still considered as a key for the solution of the Human Resources (HR) and training problems of European SMEs. To work towards sustainable learning strategies, however, e-learning has to be embedded in intelligent and adequate "mixtures" of different learning methods and technologies [3].

Human resources and training for achieving business competence, particularly e-competence, represents factors on which competitive advantages are going to be built. E-Learning can further contribute to the achievement of such competences and at the same time can meet the pronounced needs for flexibility in SME's. It is important, however, to design effective models and lines of intervention to help SME's to build participative suitable models of training i.e. within communities of practice. [12]

1.1. Motivation

On the level of European policies, e-learning is seen as one of the prerequisites to achieve the Lisbon objectives: "by facilitating knowledge and skills acquisition, by providing flexible learning opportunities for students and citizens, personalizing learning and by creating new collaborative learning opportunities. E-learning could become an efficient and cost effective tool for fostering workforce development and it can lead to cost savings through better utilization of a user's time, efficiencies in personnel resources in institutions providing education and training as well as reductions in physical requirements" [19][54][4].

The Internet has been growing exponentially, and thus, the information within. Courses and training programs available followed the Internet growth, making it harder to identify the adequate course or program for a specific profile. Allowing the possibility of automatically identifying courses and programs relevant to a certain topic, and customized to a user profile is relevant to anyone who seeks training, and thus, it will help the development and adoption of e-learning.

This is in line with the Lisbon Treaty, where one of its goals is that EU should "… become the most competitive and dynamic knowledge-based economy in the world…", for that it is needed active support for the development and adoption of e-learning throughout Europe [28][3].

1.2. Research Method

For this dissertation, the research method adopted was the classical research method that is described as the following:

Figure 1.1 – Classical research methodology [76]

The classical research method is based on the 7 steps:

1. Research question / Problem: This step is the most important for a research, because it is in this step that is defined the 'area of interest'. Even though the research statement is not declarative like a hypothesis, the research question must be targeted in a way that its study is feasible and there is possibility of being confirmed or refuted. Typically there are several other questions to complement and narrow the focus of the main research question. The research question is defined in section 1.3.

2. Background / Observation: The Background / Observation are based on the study of prior work on the subject. The work done previously and other topics that related to the subject at hand are studied, not only for better understanding of the topic, but also to distinguish the previous work from the one being developed and its impact. Studying the state of the art is then a really important step and it's advised to read the literature review, projects, and several types of documents (reading materials with high newness and low reliability and crossing then with high reliability and low newness). With a better understanding of the prior work done in the area, several iterations can be done between steps 1 and 2, in order to better focus on the development of something of interest. The Background / Observation are extended throughout sections 2, 2.2, 3 and 4.

3. Formulate hypothesis: Formulating a hypothesis is defining the expectations of the project at hand. The hypothesis serves to bring clarity, specificity and focus to the research problem and define the desirable outcomes. The formulate hypothesis step can be found in section 1.5.

4. Design experiment: This step includes all the detailed planning of the experimental phase. This phase is usually composed by the design of a prototype or systems architecture and since the research outcome needs to be measurable, in this phase it's also needed to develop a plan for validation which can be replicated by others in a feasible way. The theoretical design is defined in section 4.2 and the proof-of-concept implementation is defined in section 5.

5. Test hypothesis / Collect data: This step is required for evaluating the hypothesis proposed and to evaluate the outcomes of the system / architecture designed. It should be created a test battery to identify the maximum variety of results. The Test hypothesis / Collect data step is defined in section 5.2.1.

6. Interpret / Analyze results: The Interpret / Analyze results step takes place after all tests were done and the data output is collected. In order to interpret and analyze the results, if applicable, it is suggested that qualitative and quantitative data analysis should be applied to the results. With a detailed analyses of the outcomes it can lead to a weakening of the confidence of the hypothesis, but this should not be interpreted has a failure, but rather a way to improve the original approach with a new expertise on the subject.

When positive results are obtained, it is possible to consider the future research and provide recommendations. Discussion regarding literature, research objectives and questions should be taken into account, and draw conclusions out of it. Interpretation / Analysis results from the implementation can be found in section 5.2.2.

7. Publish findings: With solid results, either in line of the original hypothesis or against it, it should result in a contribution to the scientific community. Accordingly to the type of research, scientific papers should be written to present intermediate results (e.g. in conferences), consolidated results (e.g. in journals) and finalized with a dissertation about the hypothesis. The scientific validation and hypothesis verification is found in section 5.2.3

1.3. Research Problem and Question(s)

- How to improve e-training acceptance in the industry?
    - How to improve e-training development?
    - Is it possible to generate automatically a course depending on the profile of a trainee?
        - Can a knowledge base be a catalyst to reach such objective?

1.4. Background Observation

Finding time for training is difficult. And the more senior the trainee the more he or she will find it difficult to allocate time for personal development. This is particularly true of senior practitioners in the professions such as the law, accountancy and engineering, etc.

Despite the recognition that training is a necessary component of successful development, it is difficult to allocate the requisite amount budget; and it is axiomatic that poor training is worse than no training.[22]

When a suitable training partner is found, the location or timetable often does not fit the immediate requirements. It is extremely common that training is identified as part of the appraisal process but suitable courses usually are not available for several weeks or even months. This can lead to demotivation and even to the loss of a collaborator under certain circumstances.[9]

The biggest problem in selecting a suitable training is the question of measuring how much of the learned material is actually retained by course delegates after they return to the workplace. Most studies imply that the rate of retention is frighteningly low. But with e-training, because delegates can learn in their own time and at their own pace, they do much better than when they are on formal training courses.

On the other hand, having a just in time training availability, providing the trainee with tools that allow him/her to use it whenever he/she wants is proving to be a major advantage in delivering trainings. Not only is more cost effective, by not having a trainer physically present, but the trainee can control the pace of learning, according to his/her learning methods, and even allowing the trainee to focus on what the trainee really needs, even allowing to take the lesson more than once. [26]

By allowing the creation of courses based on the user profile / interests, individuals seeking training on a specific topic would have the possibility of learning about relevant topics in their positions without the need of a trainer, saving in time and funds, and avoiding following courses that aren't relevant for the user needs.

1.5. Hypothesis

By implementing an architecture for the description and categorization of training components, it would be possible to automatically adapt a training programme accordingly to the user needs and profile. The training programme customization needs knowledge reasoning techniques based on Ontologies described in OWL.

1.6. Dissertation Outline

In the current section the context and needs that this contribution in focused on are presented, evidencing the need for a solution in the e-learning industry, the automatic generation of courses according to the user needs and profile.

Next in Chapter 2 are presented several basic concepts relevant within this dissertation. The Chapters 3 and 4.1 act as the state of the art review. Firstly it is presented several training methodologies that are used to create courses, Chapter 3 addresses the study of e-learning standards and applications and the Chapter 4.1 presents ontology's as a potential solution. In each chapter is found a brief conclusion about the topic studied.

In Chapter 4.2 is presented a training development system that allows a rapid development of courses and training materials. Chapter 5 refers the experimental developments taken for achieving the final objectives.

Chapter 5.2 presents the implementation testing and hypothesis validation. A demonstrator of the implementation was adopted by the CoSpaces Project and is presented and discussed. Finally in chapter 6 the conclusions and future work are presented.

2. BASIC CONCEPTS AND METHODOLOGIES IN E-TRAINING DEVELOPMENT

2.1. Basic Concepts:

For better understanding of this document, the author presents in this section referenced definitions of key concepts relevant within this dissertation.

2.1.1. Learning, E-Learning

Learning is acquiring new knowledge, behaviours, skills, values or preferences, and it may involve processing different types of information. Learning functions can be performed by different brain learning processes, which depend on the mental capacities of the learning subject/agent, the type of knowledge which has to be acquitted, as well as on the socio-cognitive and environmental circumstances. [6]

It is understand that learning is the absorption of knowledge about a particular subject. From this, it is possible to define and understand what e-learning is.

A usual accepted definition for e-learning is: The delivery of a learning, training or education program by electronic means. E-learning involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material. [7]

2.1.2. Training, E-Training

Training is the act of teaching someone how to do something, such as a job, or teaching the skills and attitudes that will have a direct impact on job performance, such as operations, human resources policies, or management and leadership. [5]

Like in learning and e-learning, the definition of e-training is closely related to training. E-training is a term that is used to describe a number of techniques that use computer technology to deliver instructional material to trainees. [21]

E-training is usually understood as e-learning, the author finds it relevant to distinguish them. The core idea is the same, to pass on knowledge, but in training the knowledge is more task-oriented (e.g. know to do, how to use, how to install).

Overall, and with the increasing focus of E-learning on knowledge-era workplace issues, and of e-learning on real-world contexts, we can expect to see a convergence of models (e-learning and e-training) as they both attempt to achieve similar kinds of outcomes (e.g. higher-order thinking) but in different contexts and with differing degrees of generalization or specificity. [10] For now, e-training is seen as a sub-category of e-learning, a term used for industry training.

2.1.3. Web – based training

A web-based training delivery method allows the course participants to extend the training time-span according to their needs and within a specific personal time allocation by accessing the materials via a browser or a network-connected application. By depending on general access to the course material, connectivity, performance and availability demands are also relevant issues to the training deployment.

With this delivery method each learner is able to execute the content in a preferred approach, e.g. always displaying examples of a certain learning topic first, as is the case of an example-oriented strategy. The learning objectives achieved can be validated by built-in assessments that allow electronic marks through the evaluation. Web-based training offers the highest flexibility but also the need for additional discipline since the organization of the learning process is controlled by the user. Thus, the learner can be focused and concentrated to make a profitable use of learning materials.[67]

2.1.4. Virtual Classrooms

Virtual classrooms are an alternative training delivery that has to be supported by a specific platform. It provides many of the advantages of the classroom training without the constraint of a fixed location. The participants join the course via web-based training or related technologies. This means that the participants are not required to come to a particular training location but must possess the necessary technical environment to participate. Since this delivery method requires fast internet access it is only suitable for those persons who have access to such a connection. This means that it is more appropriate for smaller target groups and not for large-area dissemination. Virtual training has a higher demand on the performance and availability of the platform than the administrative use for classroom training. [67]

2.1.5. Blended Learning

This type of training delivery is characterized by a combination of all training delivery types. It combines the various forms of web-based training with more traditional forms, such as classroom training. A typical example of this would be a combination of technology-based materials and face-to-face sessions used together to deliver instruction. [67]

2.1.6. Training Structure

In this chapter it will be described the four categories of the training structure, with a top to bottom perspective. Starting from the training curriculum, training programmes, training courses and training modules, these are the four identifiable categories within the training structure. Below is a brief description of these categories.

2.1.6.1. Training Curriculum

A training curriculum is the set of related instructional elements and content offers in a given field of study [37].

It's designed to establish the underpinning that is to be used to frame down training course elements. There could be several training curriculum areas, and each usually has at least one course defined with its direct contents of such area. Nevertheless there are some training topics that are used by other areas, so it is usual to find courses that exist in several training curriculums. Such relations give some complexity to the classification of these training elements.[67]

A dynamic training curriculum is one where at least one curriculum element does not have an associated training course, as opposed to fixed and variable curriculum types. By modularization, designating the number of stand-alone curricular units as the required elements of a training programme enables such dynamism of design. The dynamic training curriculum is therefore flexible, learner-centric and competency-based. This conceptual framework holds instructional elements (modules and materials) by focusing on atomic competences and skills within established domains.[38]

2.1.6.2. Training Programme

A Training Programme is a significant long-term training activity which comprises a set of courses.[36]

It's a construct conceived for training in specific skills focusing on a given target audience and using a selected delivery approach. Reference training programmes are those that are designed for reference target audiences (especially relevant within a given training environment) and that serve as orientation for targeted training execution. [38]

The main difference between a training curriculum and a training programme is that a training programme is designed to develop specific skills, and the training curriculum embraces all the fields of area of study. It is usual to find several training programmes within a particular training curriculum.

2.1.6.3. Training Courses

A training course is an ordered process or succession of a number of lectures dealing with a subject. [68] It is conceived in a way that meets the specific desires and expectations of a determined target audience.[67] A training course is divided in several modules, accordingly to the topics that are addressed.

2.1.6.4. Training Modules

A training module is a small piece of a training course with a very clear objective.[67]

Several modules of the same topic area are grouped together to form a training course, but by orchestrating several training modules it is possible to build a dynamic curriculum that is specially adapted to specific characteristics of the target audience profiles and skills. [67]

2.2. Methodologies in E-training Development

Closely related to the type of training and tools used, are the methodologies used for training development. In this section the author presents a brief overview of the main training development methodologies that are used at the moment.

Methodologies establish the set of working methods that guide development processes, thus streamlining activities by providing the set of practices, procedures and rules that steers progress towards goals. [38] In this section is presented an overview of relevant methodologies in e-training development.

2.2.1. ADDIE

The ADDIE Model is a widely used model, and it also serves as a base model for several other training methodologies. These other systems use ADDIE as a generic model, typically with minor changes. There are probably over 100 different variations of the generic ADDIE model. [56]

ADDIE stands for Analysis Design, Development Implementation, and Evaluation. The acronym represents also the order in which is advisable to build the model, and each step has an outcome that feeds the subsequent step. [56]

Below is the order of the ADDIE model and a short description of each stage: [56][58][58]

Analysis --> Design --> Development --> Implementation --> Evaluation

- **Analysis**: During analysis, the designer identifies the learning problem, the goals and objectives, the audience's needs, existing knowledge, and any other relevant characteristics. Analysis also considers the learning environment, any constraints, the delivery options, and the timeline for the project. There are also defined performance measurement indicators for the tasks to be trained and an outline of the budget.
- **Design**: A systematic process of specifying learning objectives. Detailed storyboards and prototypes are often made, and the look and feel, graphic design, user-interface and content are determined here. Other than identifying and list the learning steps required to perform the task, it is also developed performance tests to show mastery of the tasks to be trained. Also it is listed the entry behaviours that the learner must demonstrate prior to training.
- **Development**: The actual creation (production) of the content and learning

materials based on the Design phase by listing all activities that will help the students learn the task, selecting the delivery methods such as handouts, videos, etc. While developing the instructional courseware, it is also reviewed the existing material to avoid explaining the same twice.

- **Implementation**: During implementation, the goal is to develop a procedure for training the learner and the teacher. Materials are delivered or distributed to the students group. After delivery, the effectiveness of the training materials is evaluated.
- **Evaluation**: This phase consists of a formative and a summative evaluation. Formative evaluation is presented in each stage of the ADDIE process. Summative evaluation consists in tests designed for criterion-related referenced items and providing opportunities for feedback from the users. Revisions are made as necessary. In this phase it is reviewed and evaluated each passed phase (Analysis, Design, Development and Implementation), to ensure that the training in development will accomplish its objectives.
- The ADDIE model has been criticized by some as being too systematic, that is, too linear, too inflexible, too constraining, and even too time-consuming to implement. As an alternative to the systematic approach, there are a variety of systemic design models that emphasize a more holistic, iterative approach to the development of the training. Rather than developing the instruction in phases, the entire development team works together from the start to rapidly build modules, which can be tested with the student audience, and then revised based on their feedback. [56]

The systemic approach to development has many advantages when it comes to the creation of technology-based training. To create engaging metaphors or themes, artists and writers work together in a process that validates the creative approach with students early in the development cycle. Programmers and designers garner agreement as to which learning activities are both effective as well as possible, given the constraints of the client's computers or network.

Despite these advantages, there are practical challenges with a purely systemic design approach in the management of resources. In most cases, training programs must be developed under a fixed -- and often limited -- budget and schedule. While it is very easy to allocate people and time to each step, it is harder to plan deliverables when there are no distinct steps in the process. The holistic approach begs the questions, "How many iterations, and time, will it take to finish the program?" "Do the contributions made by programmers and artists in the design phase, who have no formal background in instruction, warrant the extra time required and additional compensation for this time?" [58]These are all considerations that need to be taken into account in designing a purely systemic training development methodology based on the ADDIE model.

2.2.2. Dick and Carey Systems Approach Model

Another well-known instructional design model is The Dick and Carey Systems Approach Model. The model was originally published in 1978 by Walter Dick and Lou Carey in their book entitled "The Systematic Design of Instruction".

Dick and Carey made a significant contribution to the instructional design field by championing a systems view of instruction as opposed to viewing instruction as a sum of isolated parts. The model addresses instruction as an entire system, focusing on the interrelationship between context, content, learning and instruction. According to Dick and Carey, components such as the instructor, learners, materials, instructional activities, delivery system, and performance environments interact with each other and work together to bring about the desired student learning outcomes. [59]

The Dick and Carey Design Model describe all the phases of an iterative process that starts by identifying instructional goals and ends with summative evaluation. This model is applicable as shown below.

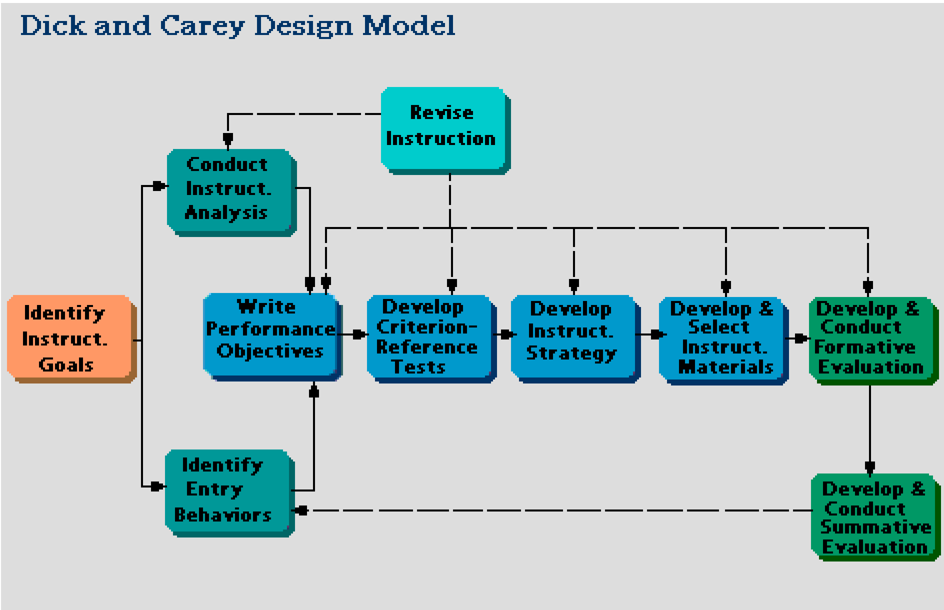


Figure 2.1 – Flow chart of the Dick and Carey Design Model [59]

The Dick and Carey Design Model Next is composed by 9 base steps, presented below:

1) **Instructional Goal**: Desirable state of affairs by 'Instruction Needs Analysis': Analysis of a discrepancy between an instructional goal and the present state of affairs or a personal perception of needs.

2) **Instructional Analysis**: Its purpose is to determine the skills involved in reaching a goal. In this step it's made an analysis from which it is build a list of steps and skills that should be followed in order to correctly reach the objectives defined in the previous step.

3) **Entry Behaviours and Learner Characteristics**. The purpose of this step is to determine which of the required enabling skills the learners need to bring to the learning task. Intellectual skills and abilities such as verbal comprehension and spatial orientation as well as traits of personality are examples of common requirements.

4) **Performance Objectives**. Its purpose is to translate the needs and goals into specific and detailed objective functions, determining whether the instruction is related to its goals or not. The lesson planning is focused on appropriate conditions of learning and measuring the development performance by assisting learners in their study efforts.

5) **Criterion-Referenced Test Items**. Purpose: To diagnose individual possessions of the necessary prerequisites for learning new skills in order to check the results of student learning during the process of a lesson. In this step it is also provided documents of student's progress for parents or administrators that are useful in evaluating the instructional system itself (Formative / Summative evaluation).

6) **Instructional Strategy**. Purpose: To outline how instructional activities will relate to the accomplishment of the objectives. It is advisable to create tasks reflected in the objectives and increase the effectiveness of teaching strategies by choosing the appropriate delivering system.

7) **Instructional Materials.** Purpose: To select printed or other media intended to convey events of instruction. Use of existing materials when it is possible or evaluating the need for the development of new materials.

8) **Formative Evaluation**. Purpose: To provide data for revising and improving instructional materials. To revise the instruction in order to make it as effective as possible for larger number of students.

9) **Summative Evaluation**. Purpose: To study the effectiveness of system as a

whole conducted after the system has passed through its formative stage Small scale/ Large Scale Short period/ Long period. [59]

2.2.3. Training Development Methodology (Target Wise)

Training Development Methodology is a method designed to build trainings that improve the performance of employees and train customers on using products and services. This training development methodology is widely used, and consists on the following steps [63]:

1) **Needs Analysis**:

In this step the training development project is analyzed and the training needs are identified by investigating:

- The needs, competencies, preferences and other characteristics (e.g. language skills, cultural differences) of the target audience that the training solution must be tailored to.
- The characteristics of the target audience's environment that may affect the design of the training solution.
- The skills, knowledge and/or attitudes that must be improved or trained. Based on this data, it's developed the learning objectives that describe what learners should be able to do or know after they have completed the training. It's also identified the types of training materials that will be most effective in meeting these learning objectives (e.g. Web-based training, instructor-led training, virtual classroom training [i.e. instructor-led training delivered via Internet using videoconferencing tools], video, audio, and job aids such as quick reference guides or checklists).

2) **Design Phase**:

Based on the outcome of the Needs Analysis, it's made the design of the training materials that need to be created. Depending on the type of training material, this design consists of the following:

- A course curriculum (list of the courses including course titles, high-level course goals, and course types that will be developed).
- For each course, a course outline shows the structure of the course (modules, topics, subtopics, learning objectives, learner activities).
- For each course, the design of the training content, e.g. storyboards, audio

scripts, video scripts, instructor and student manuals and PowerPoint presentations for instructor-led or virtual classroom training, job aids like quick reference guides and checklists.

- For each type of course that will be developed, a prototype module showing the course type's look and feel, navigation, instructional design, and level and type of interactivity.

3) **Development Phase**:

Based on the outcomes of the Needs Analysis and Design phases, it's developed the actual training materials – e.g. Web-based course, audio and video recordings, quick reference guides, and final draft instructor and student guides – that will be provided to the learners. This phase will also encompass a pilot test of the developed training materials. Based on the test feedback, final changes will be made to the training materials.

4) **Deployment Phase**:

In this phase of the training development methodology it's deployed the training materials that were created in the Development phase. This deployment may include activities like:

Web-based training, audio or video recordings:

- Burning Web-based training courses, audio or video recordings on CD-ROM or DVD
- Uploading Web-based courses, audio or video recordings to a network server
- Storing Web-based courses in a Learning Content Management System (LCMS)

5) **Quality Assurance**:

At the end of every phase of the training development methodology the deliverables resulting from the phase will undergo a quality check as a form of a review.

2.2.4. Conclusions

It is important to have a methodology that allows several entities to collaborate on the developing of the training curriculum, so that more easily the methodologies could be integrated within a SME's. It is possible to have such integration if an e-training course building methodology considers an inter-organizational interaction in producing and sharing training materials, using known tools to facilitate the development of web based courses. [21]

The ADDIE methodology is a very efficient and elegant methodology for e-training development. The author considers that a methodology based on the ADDIE methodology and tailored to the inter-organizational interaction and development of web based courses can be a more interesting approach in solving the SME's needs because of its documentation, usage by other entities, content organization and the methodology implemented and the potential of scaling a solution to involve other features.

3. E-LEARNING STANDARDS OVERVIEW

Specifications and standards in e-learning enable different independent assets of learning to coexist for effective and better learning outcomes and also support properties like durability, accessibility, scalability etc. [12]

Many organizations like IMS, IEEE, ARIADNE, and AICC are making standards in the field of e-learning and most of the standards made by them are becoming the de facto standards in e-learning. These organizations are working on different aspects, like LOM [44] with tagging learning content by IEEE, QTI for question and testing interoperability by IMS etc. SCORM from ADL initiative adopted and adapted many specifications and standards from other organization to deal with different aspects of e-learning simultaneously. [12]

These technologies have typically been applied in ad hoc and divergent forms: Innumerable courses, course components and systems for managing and delivering them have been developed independently of one another, often at great expense.[13]

Although there has been an effort in reducing costs in the creation of courses, by improving the platforms in order to decrease the number of teachers and content creators, there is still a major struggle in reusing materials, because contents which were developed in proprietary formats may not include the core data, so it's not easy to recover the contents with all the information associated with the original content.[12]

As in any industry, this rapidly evolution of Standards comes parallel to the manufacture of new products. Initially, the design and other facilities become propriety of the manufacturing company but in case of non satisfaction of the user needs, industry comes up with common standards. Presently, all indicators show that we are in a transition period of standards in e-learning. [12]

There is still some work to be done towards the creation of common standards. Several reasons can be identified as the main cause of the slow adoption of standards, like the fact that standards are very young. So the organizations responsible for creating them are not yet sure about the standards, changing drastically between versions; and the fact that most of the standards are complex to a common institution person dealing with the e-learning content and tools. The task of creating a standard in an emerging field like e-learning is difficult, it's like trying to hit a moving target that itself is changing constantly. [12] [13]

At the moment there are innumerous standards and different variations of them, below is presented a description of the most common, and the ones that the author finds relevant for the development of this dissertation and implementation. It is relevant to explain that the objective of the implementation is to automatically create a list of courses to be followed, and not to create a binding-standard of another standard.

3.1. IEEE-LOM

In this section is presented the IEEE Standard for Learning Object Metadata. A widely used standard in e-learning and its usage is still growing. But first, for a better understanding of the LOM, and the process in general, let's study some guidelines in the construction of learning objects.

3.1.1. Guidelines in Learning Objects creation

A Learning Object is any grouping of materials that is structured in a meaningful way and is tied to an education objective. In the creation of a Learning Object, the author should consider how it relates to other existing Learning Objects and other educational materials available in the platform. [15]

Associating Metadata, which is information about the Learning Object itself (as opposed to the information in the Leaning Object that is part of the learning experience), is useful because that is how search engines within the platform can locate and identify the Learning Objects.

Finally there are some key-words to keep in mind when creating the Learning Object: *Interoperable*, making it possible to work with other Learning Objects and with Learning Management Systems; *Reusable*, allowing others the use of the objects created, even in different ways that firstly the object was designed for; *Discoverable*, adding the information needed for quick and easy discovery so it can be found by other developer; and *Durable*, by using the latest metadata standards so the lifespan long.[15]

3.1.2. Introduction to IEEE LOM

Metadata is the information about an object, be it physical or digital. As the number of objects grows exponentially and our needs for learning expand equally dramatically, the lack of information or metadata about objects' places a critical and fundamental constraint on our ability to discover, manage, and use objects. This standard addresses this problem by defining a structure for interoperable descriptions of learning objects.[14]

Content metadata deals with tagging the content such that it can be used for managing, locating and evaluating the content. Learning objects are any entity digital or non-digital, which can be used, re-used and referenced during e-learning. Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning. [12]

Synchronization across organizations for defining standards of common interfaces across different concerns is one of the biggest problem in defining the Standards and Specification. It seems very encouraging that this specification is used by Content Aggregation Model (CAM) of SCORM (specification).[12]

The Learning Object Metadata (LOM) is widely accepted and implemented in its current form, and its further standardization brings with it risks of significant revision or even outright rejection. Consequently it has been agreed by many stakeholders that stabilizing and supporting the standard in its present form is currently more important that in further standardization. As a further result, the LOM will not be subjected to further incremental revisions and minor changes.[13]

3.1.3. IEEE LOM Standard Overview

IEEE LOM is a multi-part standard that specifies Learning Object Metadata. The Standard Overview specifies a conceptual data schema that defines the structure of a metadata instance for a learning object. It is defined as any entity – digital or non-digital- that may be used for learning, education, or training. A Learning Object describes relevant characteristics of content to which it applies such characteristics may be grouped in general, life cycle, metadata, educational, among others.[14]

LOM comprises a hierarchy of elements. At the first level there are nine categories, each of which contains sub-elements. These sub-elements may be simple elements that hold data, or can be aggregated with other elements, containing further sub-elements. Each element semantics is determined by its context, depending on the parent or container element in the hierarchy and other elements in the same container. For example, the various *Description* elements (1.4, 5.10, 6.3, 7.2.2, 8.3 and 9.3) derive their context from their parent element. In addition, description element 9.3 also takes its context from the value of element 9.1 *Purpose* in the same instance of *Classification*. [16]

IEEE LOM defines a Basic Metadata Structure that has several data elements grouped into categories. The data elements within the Metadata structure describe the Learning Object and are grouped into categories. LOM v1.0 base scheme (Figure 4.1) consists of nine categories that are as follow: a) The general category groups the general information that describes the learning object as a whole; b) The lifecycle category groups the features related to the history and current state of this learning object and those who have affected this learning object during its evolution; c)The meta-metadata category groups information about the metadata instance itself (rather than the learning object that the metadata instance describes); d) The technical category groups the technical requirements and technical characteristics of the learning object; e) The educational category groups the educational and pedagogic characteristics of the learning object; f) The rights category groups the intellectual property rights and conditions of use for the learning object; g) The relation category groups features that define the relationship between the learning object and other related learning objects; h) The annotation category provides comments on the educational use of the learning object and provides information on when and by whom the comments were created; i) The classification category describes this learning object in relation to a particular classification system. [14]

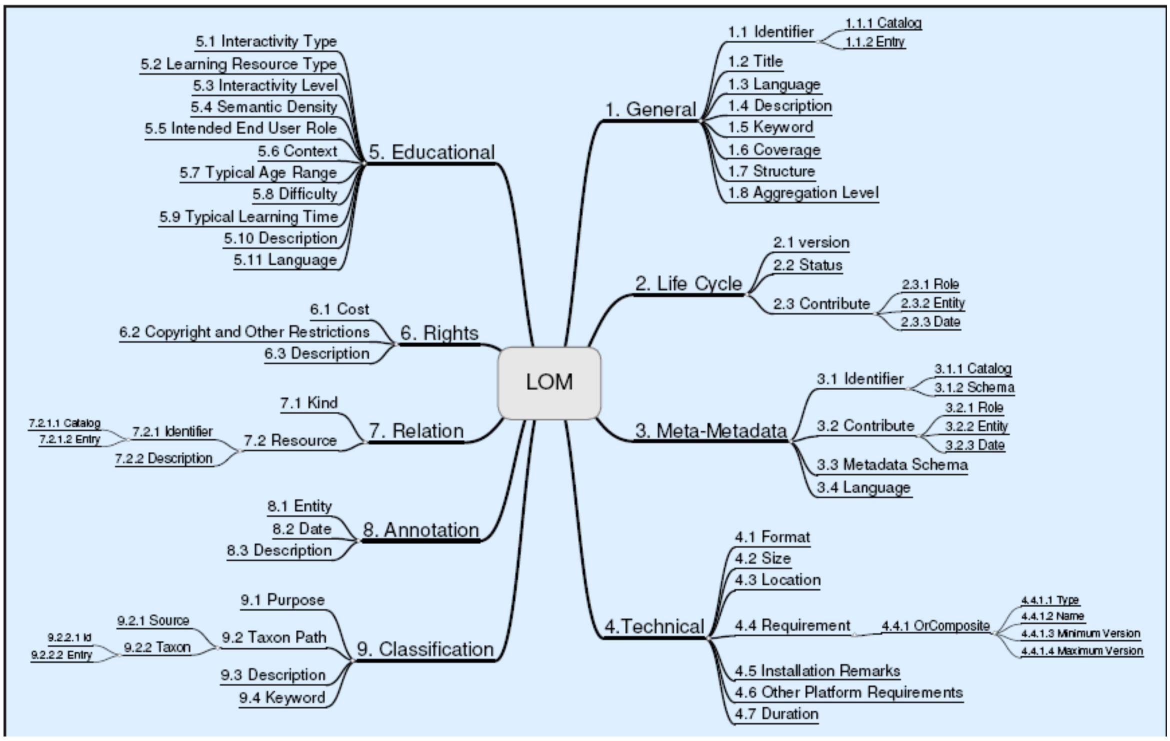


Figure 3.1 – LOM base scheme [16]

The data model specifies that some elements may be repeated either individually or as a group, for example: although the elements 9.3 (*Description*) and 9.1 (*Purpose*) can only occur once within each instance of the Classification container element, the Classification element may be repeated thus allowing many descriptions for different purposes. [16]

The data model also specifies the value space and data type for each of the simple data elements. The value space defines the restrictions, if any, on the data that can be entered for that element. For many elements, the value space allows any string of Unicode character to be entered, whereas other elements entries must be drawn from a declared list or must be in a specified format (e.g. date and language codes). Some element data types simply allow a string of characters to be entered, and others comprise two parts, as described below: LangString items contain Language and String parts, allowing the same information to be recorded in multiple languages; Vocabulary items are constrained in such a way that their entries have to be chosen from a controlled list of terms - composed of Source-Value pairs - with the Source containing the name of the list of terms being used and the Value containing the chosen term; DateTime and Duration items contain one part that allows the date or duration to be given in a machine readable format, and a second that allows a description of the date or duration (for example “mid summer, 1968”). [16]

When implementing the LOM as a data or service provider, it is not necessary to support all the elements in the data model, nor need the LOM data model limit the information which may be provided. The creation of an application profile allows a community of users to specify which elements and vocabularies they will use. Elements from the LOM may be dropped and elements from other metadata schemas may be brought in; likewise, the vocabularies in the LOM may be supplemented with values appropriate to that community. [60]

3.2. IMS Simple Sequencing

IMS Simple Sequencing allows several interesting actions in the e-leaning platforms such as SCORM, thus, IMS Simple Packaging and Sequencing is briefly described in this chapter.

3.2.1. Introduction IMS SS

The IMS is a consortium formed by almost 200 commercial, governmental and other entities. Currently, the IMS has some 80 contributing members, a significant number of which are American and British commercial entities, but which also include universities and federal governmental agencies. [13]

The IMS Simple Sequencing Specification defines a method for representing the intended behaviour of an authored learning experience such that any learning technology system (LTS) can sequence discrete learning activities in a consistent way.[12]

IMS SS declares the relative order in which electronic learning activities are to be presented to a learner and the conditions under which a resource is selected, delivered, or skipped during presentation. [17]

IMS SS is labelled as simple because the specification considers only a limited number of common sequencing strategies, not because the specification itself is simple.[17] It relies on the concept of learning activities, such as content or test questions. Activities are associated with other activities into a hierarchy, resulting in an activity tree. A parent activity and its children are referred to as a cluster of activities.[17]

3.2.2. IMS Overview

The Simple Sequencing model is intended to provide base level support for sequencing learning activities. It is purposely neutral with regard to models of pedagogy and the use of instructional strategies, but it describes only fairly simple behaviours' in order to limit the specification and especially conformance verification to a manageable scope. Below are described the main concepts used in IMS SS.[18]

- **Conceptual Model**

Sequencing occurs within a conceptual runtime environment which translates navigation events into navigation requests to the sequencing engine. Results of sequencing are then used to modify or create the user interface which the learner sees. This model is intended to give enough background to an implementer to understand how the Simple Sequencing Specification can fit into a complete delivery environment.[18]

- **Scope**

The Simple Sequencing Specification addresses a small but productive segment of the entire problem space for learning content sequencing. The IMS Simple Sequencing Specification relies on the concept of learning activities. A learning activity may be loosely described as an instructional event or events embedded in a content resource, or as an aggregation of activities that eventually resolve to discreet content resources with their contained instructional events. [18]

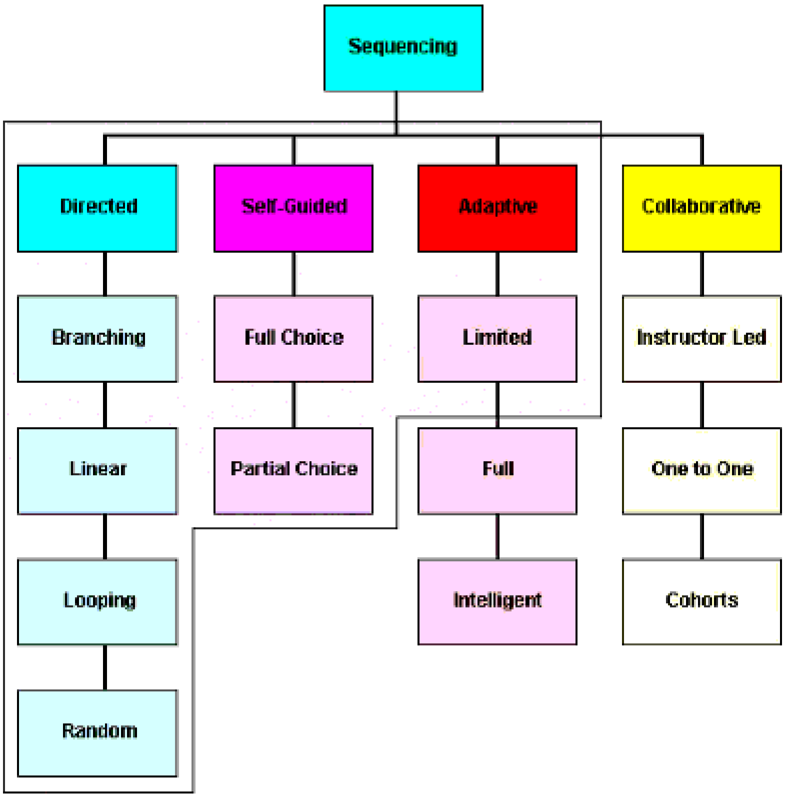


Figure 3.2 – IMS SS Scope

- **Learning Activity**

A Learning Activity is a pedagogically neutral unit of instruction, knowledge, assessment, etc. It can have sub-activities and may be nested to an arbitrarily deep level. Each activity may have a tracking status associated for each learner that is assigned to experience the activity. Activities can be attempted any number of times, or the number can be specified. They can be suspended, abandoned, exited normally, etc. All activities are performed within the context of a parent activity. [18]

- **Activity Tree**

The activities managed through Simple Sequencing are arranged as an activity tree (Figure 4.3). LMS sequencing behaviour is described in terms of traversing the nodes of the tree to determine which activity to deliver to the learner. Each node in this tree is an activity. The tree is not necessarily balanced and its branches are not necessarily of equal length. There is an implicit containment hierarchy in the tree. For example, activity AB is said to be part of activity A. Activity ABCA is part of activity ABC which is part of activity AB. You can assign any conceptual label you want to those activities. For example, one could say that A is a course, AA a lesson, and AAA a step in that lesson. Another implementer may define A as a curriculum, AA as an assigned task, and AAA as a lesson.[18]

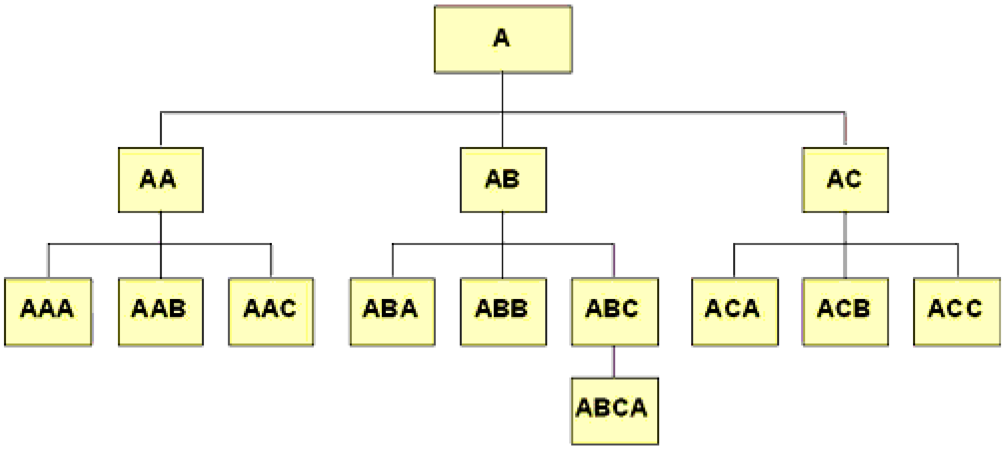


Figure 3.3 – IMS SS Activity Tree

The Simple Sequencing Specification defines the canonical traversal of the activity tree as pre-order traversal. Using the example in Figure 4.3, this means that, starting from A, the traversal would go to AA, then AAA, then AAB, then AAC, then AB, then ABA, etc. Note that the reverse pre-order traversal is not just a mirror image of the forward pre-order traversal. Using the example in Figure 4.3 again, the precedent of AC is ABCA, not AB.

The default traversal path can be modified through the association of sequencing rules created by a learning designer. Traversal is triggered by a sequencing request, which in turn is triggered by the learner through navigational events or by the delivery system itself. Sequencing rules are evaluated at runtime and can be conditional based on tracking status. Activities are always delivered one at a time and may have auxiliary resources associated with them. [18]

In IMS the activity tree can be represented as an organization element in the IMS Content Packaging Specification. The top level activity is the organization itself, and each node in the tree is an item in the organization. However, the Simple Sequencing Specification itself makes no assumptions about packaging of the learning content. The same Simple Sequencing behaviours and rules defined in this overview could be used for content that is assembled and managed dynamically by an intelligent tutoring system, for example. [18]

- **Activity Resources**

A content resource may be associated with any node in the activity tree that is a leaf node. This means that the delivery of an activity involves the delivery of the content resource.

The Simple Sequencing Specification assumes that some content resources may be able to communicate results, and others not. For example, a resource may be a "dumb" document or HTML page, or it may be a SCO as defined in SCORM. Simple Sequencing assumes that some results that map to the status data model defined in the specification; however, it does not define how to communicate the data. There can be different ways to do this, all of which would work with Simple Sequencing. Therefore, how a content resource can communicate results must be defined elsewhere.

If no content resource is associated with a leaf node, Simple Sequencing does not specify any particular behaviour. This is an example of an undefined behaviour, which is outside the scope of the Simple Sequencing Specification. [18]

- **Activity Clusters**

Simple Sequencing rules are associated with clusters of activity nodes. In Simple Sequencing, the term cluster refers to a single node and its immediate children. The scope of a particular rule never extends beyond the cluster. For example, many rules govern how to handle the sub-activities in a cluster, or rollup the result of the sub-activities in a cluster. Those rules are associated with the parent node in the cluster. Other rules are associated with a specific activity and do not affect its children. [18]

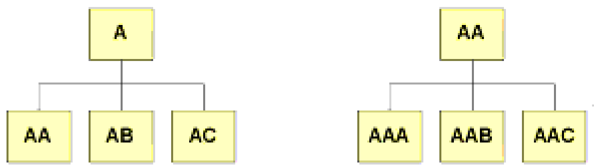


Figure 3.4 – IMS SS Activity Clusters

- **Navigation Control Modes**

Unless otherwise specified, a learner is allowed to choose any sub-activity in a cluster, but a guided flow through the cluster can also be specified. Flowing through a cluster as a learner continues from activity to activity delivers each of the sub-activities in the cluster, one after the other, as shown in Figure 4.4. The rule that governs whether such guided flow is enabled is associated with the parent node in the cluster. If the sub-activities are leaf nodes with an associated content resource, the flow of sequencing will deliver each of these content resources, one after the other.[18]

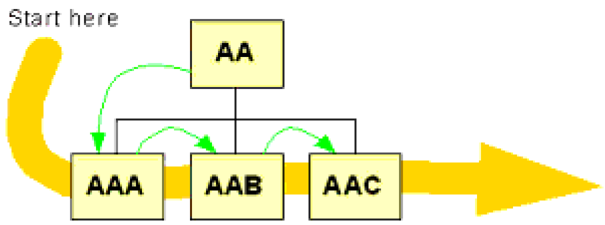


Figure 3.5 – IMS SS Navigation Control Nodes

The basic control modes that govern this behaviour are choice and flow, each of which can be enabled or disabled. If choice is disabled, the user is not allowed to choose but must follow the defined flow. If flow is enabled, the user is guided through the activities according to the structure of the tree. Both can be enabled at the same time, in which case the user can choose any activity, but can also be guided. However, both cannot be disabled at the same time.[18]

The same control modes can be specified for all the clusters in an activity tree, or they can be different for different clusters. For example, the learner may be guided by flow through a sequence of exercises within which she is free to choose different practice items.

- **Rule-based Sequencing – Conditional Rules**

Complex navigation behaviours may be achieved by assigning rules to different nodes at different levels of nesting. Figure 4.5 shows how the traversal of the tree as the user continues from activity to activity when flow is enabled can be affected by rules. In this example, specific nodes have a rule that specifies that they should be skipped under certain conditions. To each cluster is given a rule called "control mode" that enables flowing through its children, and specific nodes are given a conditional rule that states that it should be skipped.

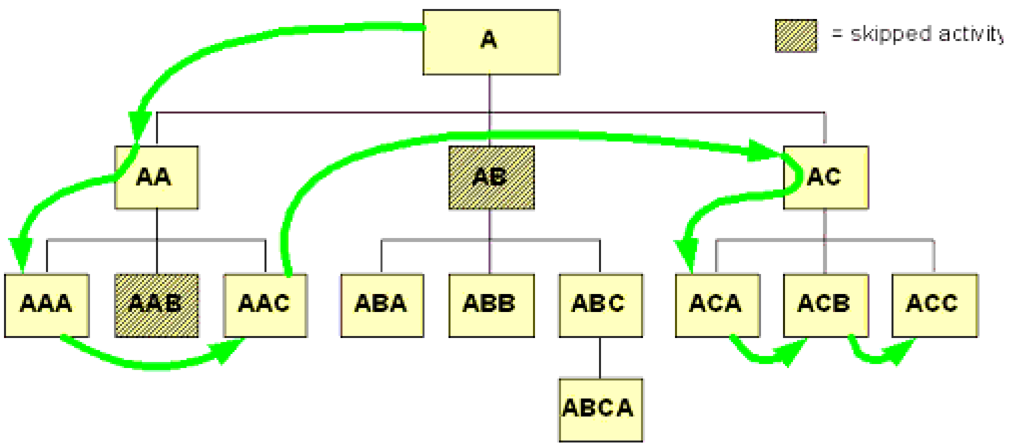


Figure 3.6 – IMS SS Rule Bases Sequencing

Many of the conditional rules defined in Simple Sequencing are based on data collected by tracking the results of activities. When an activity contains sub-activities, in other words when it is the parent node in an activity cluster, the results of the sub-activities are rolled up into summary results for the cluster. This is not always desirable. For example, whether a learner succeeded in a free practice should not affect the result of a course. Rollups can be controlled in two ways. One way is by the assignment of rollup rules to a cluster, as shown in Figure 4.6. The other way is by "tagging" a particular sub-activity to specify it should not be included in rollups. [18]

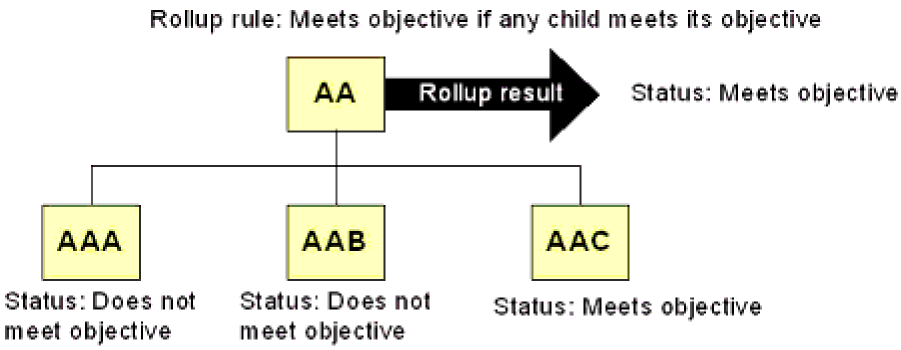


Figure 3.7 – IMS SS Rule Bases Sequencing assignment rollup rules

The IMS Simple Sequencing it's very well documented and established. Although its design limits some interaction, it supports the majority of the sequencing needs of the e-learning methods, so it's a standard to take in consideration. For more information about the IMS SS, please refer to:

IMS Simple Sequencing Best Practice and Implementation Guide - Version 1.0: This document provides an overview and describes how the IMS Simple Sequencing Information Model and XML Binding can be applied to specific types of interoperability scenarios. This is the best place to start, but also contains very technical reading. [18]

IMS Simple Sequencing Information and Behaviour Model - Version 1.0. This document describes the data structures in detail, technical reading. [56]

IMS Simple Sequencing XML Binding - Version 1.0. This document describes how to encode the sequencing objects in XML and provides the corresponding XML schema; Technical Manual to be consulted together with the previous documents. [77]

3.3. SCORM

The Sharable Content Object Reference Model (SCORM, a specification of the ADL

Initiative) is considered to be a collection of standards and specifications for e-learning. By borrowing from previous work of other specifications and standards from other organizations, it was putted together a model to creating and deploying e-learning with a mentality oriented to a strong server supporting the solution. [12]

For the purpose of this dissertation SCORM was studied as a solution for the problem that this dissertation wants to solve. Although it was decided that SCORM wasn't going to be used, studying its design was very interesting and helpful for the development of the implementation.

3.3.1. Introduction

SCORM 2004 is the evolution of the underlying standards and specifications. In the most recent version (SCORM 2004), it has been introduced the sequencing, which is a set of rules that specifies the order in which a learner may experience content objects. Below are presented the main standards and specifications that SCORM adopted:

1. IEEE Data Model for Content Object Communications
2. IEEE ECMAScript Application Programming Interface for Content to Runtime Services Communication
3. IEEE Learning Object Metadata (LOM)
4. IEEE Extensible Mark-up Language (XML) Schema Binding for Learning Object metadata Data Model
5. IMS Content Packaging
6. IMS Simple Sequencing [12]

SCORM encapsulates these specifications in three broad categories as follows:

1. Content Aggregation Model

It represents a learning strategy for designers and implementers of instruction to aggregate learning resources for the purpose of delivering a desired learning experience. There are two terms mostly used in Content Aggregation Model: Item and SCO. Example of Items in SCORM is standalone text file, media file etc. SCO are collection items which are treated as a unit for the LMSs.

2. Runtime Environment

It gives details of the requirements for launching content objects, establishing communication between LMSs and SCOs, and managing the tracking information that can be communicated between SCOs and LMSs.

3. Sequencing and Navigation

It is based on the IMS Simple Sequencing (SS) Specification. It also describes how learner and system initiated navigation events can be triggered and processed.[12]

From the three categories presented, it was decided to study both Content Aggregation Model and the Sequencing and Navigation. The Runtime Environment was considered of no use for this project. Below is presented an overview of the Content Aggregation Model (CAM) and Sequencing and Navigation (SN).

3.3.2. CAM Overview

The SCORM CAM represents a learning-taxonomy of neutral means for designers and implements an instruction that aggregates learning resources for the purpose of delivering the desired learning experience. A learning resource is any representation of information that is used in a learning experience. Learning experiences consist of activities that are supported by electronic or non-electronic learning resources.

One activity in the process of creating and delivering learning experiences involves the creation, discovery, and gathering together, or aggregation, of simple assets into more complex learning resources and then organizing the resources into a predefined sequence of delivery. The SCORM CAM supports this process and is made up of the following:

• **Content Model**: Nomenclature defining the content components of a learning experience.

• **Content Packaging**: Defines how to represent the intended behaviour of a learning experience (content structure) and how to aggregate activities of learning resources for movement between different environments (content packaging).

• **Metadata**: A mechanism for describing specific instances of the components of the content model.

• **Sequencing and Navigation**: A rule-based model defining a set of rules that describe the intended sequence and ordering of activities. The activities may or may not reference learning resources to be delivered to the learner. [20]

A content package contains two major components:

• A special XML document describing the content structure and associated resources of the package called the manifest file (imsmanifest.xml). A manifest is required to be present at the root of the content package. Below there is a brief overview of the contents of the manifest file.

• The content (i.e., physical files) making up the content package. [20]

A manifest is an XML document that contains a structured inventory of the content of a package. If the content package is intended for delivery to an end user, the manifest also contains information about how the content is organized. The scope of a manifest is elastic. A manifest can describe part of a course that can stand by itself outside of the context of a course (an “instructional object”), an entire course, a collection of courses, or just a collection of content that is to be shipped from one system to another. When packaging a collection of courses, such a content package would typically have to be disaggregated in order to be delivered to learners in a practical LMS run-time system. At this point there is no consensus or standard on how to publish a very large or very complex package in a practical LMS, because different LMS systems and repositories use different methods to represent or store the learning content to deliver to learners. The general rule is that a package always contains a single top-level manifest that may contain one or more (sub)manifests. The top-level manifest always describes the package. Any nested (sub)manifests describe the content at the level at which the (sub)manifest is scoped, such as course, instructional object or other. [20]

The manifest is composed of four major sections:

1. **Metadata**: Data describing the content package as a whole.

2. **Organizations**: Contains the content structure or organization of the learning resources making up a stand-alone unit or units of instruction. A definition of sequencing intent can be associated with the content structure.

3. **Resources**: Defines the learning resources bundled in the content package.

4. **(sub)Manifest(s):** Describes any logically nested units of instruction (which can be treated as stand-alone units). [20]

The content organization should not be confused with the physical structure of the content package, or with the structure of the manifest itself. For example, the files in a content package are often organized in a hierarchy of folders, but that structure in itself cannot tell the user of a content package how to use the content of the package. The purpose of the content organization is to provide the content developer with the means to specify cohesive units of instruction that use collections of learning resources. Such a unit of instruction is a hierarchy of learning activities, for which specific behaviours and rules may be prescribed in such a way that this activity structure and the associated behaviours can be reproduced in any SCORM conformant LMS environment. [20]

3.3.3. SN Overview

Parts of the SCORM SN book are based on the IMS Simple Sequencing (SS) Specification [1] which defines a method for representing the intended behaviour of an authored learning experience such that any LMS will sequence discrete learning activities consistently. SCORM Sequencing depends on a defined structure of learning activities of the activity tree; a defined sequencing strategy, the sequencing definition model; and the application of defined behaviour to external and system triggered events, SCORM sequencing behaviours. [20]

The SCORM SN book does not impose requirements on the type or style of the user interface presented to a learner at run-time, including any user interface devices for navigation or accessing auxiliary services. The nature of the user interface and the mechanisms for interaction between the learner and the LMS are intentionally unspecified. Issues such as look and feel, presentation style and placement of user interface devices or controls are outside the scope of SCORM. Various recommendations are provided to help reducing interpretation of the SCORM navigation model until a formal navigation (and presentation) specification or standard is developed. However, an LMS is required to provide user interface devices that trigger navigation events and the processing would result in the identification of a deliverable content object. [20]

A content structure diagram is a common tool used by the instructional design community to describe the hierarchical relationship of a learning experience. IMS SS defines and uses a similar concept called an Activity Tree to describe a structure of learning activities. The activity tree allows the SCORM SN model to describe informational and processing requirements such as sequencing algorithms and behaviours in an implementation independent manner. [20]

It is anticipated, but not required, that systems implementing sequencing will have an internal proprietary representation of the activity tree, which may or may not be a tree data structure.

SCORM does not define when or how an activity tree is created within an LMS. In addition, SCORM does not require that an activity tree ever be a static structure. Implementations are free to dynamically alter the structure of an activity tree and the sequencing information applied to activities in the activity tree as they see fit, so long as the Sequencing Definition Model and Sequencing Behaviours are adhered to. If an implementation chooses to dynamically modify an activity tree while a learner is interacting with content objects associated with its activities, it is recommended that the LMS does so in a manner that does not disrupt the current learner experience. Again, it is not the intention of

SCORM to mandate how authoring tools and LMS's implement activity trees, or how instructional design methodologies are to be modified to focus on an activity tree. Rather, an activity tree is a general term that represents an instance of hierarchical learning activities and the corresponding sequencing information for the interoperable application of specified sequencing behaviours. [20]

It is known that SCORM strongly recommends the use of the IEEE LOM for describing SCORM Content Model Components. [20] By having several files for each module, there is the issue of replicating data, because each module has files that can be used in other modules. SCORM allows the creation of dependencies that by enabling the reuse of those files, shrinking down the total size of a course. Although this solution seems interesting, it brings with it a serious issue, the requirement of, whenever data of a module is changed all the files within its dependency must be changed as well, making each change in a course something to be considered and analyzed.

SCORM is a solution for organizations with a considered amount of resources, from universities to large companies. For smaller organizations and companies that only want to provide simple presentations without evaluation, for the purpose training, SCORM based solutions tend to, by offering much more configuration possibilities, not be that appealing because they are costly and complex to implement.

3.4. Learning Management Systems

In this chapter is presented a brief description of what a LMS is and a summary of the more popular Learning Management Systems. For more information about the LMS's studied, use the references given.

3.4.1. Definition

A LMS, Learning Management System, is an implemented computer system on Internet/Intranet servers that takes care of the following basic activities:

- Users' management. The system must allow the entrance to users with different profiles, for instance: the teacher, the student and the system administrator.
- Administrative management of the virtual courses. It is made a tracking of the student, storing all and each one of the activities the student develops with the tool. For example, the evaluations carried out by the students to fix the assimilation degree of the contents of the courses are one of the most important

administrative tasks.

- Management of the communication tools. With this component it's possible to establish communication among the different system actors. These communication tools can be forums, e-mail, videoconference, chat, etc. [64]

3.4.2. Current LMS's

Since time and efficiency are becoming more relevant, it is needed a training delivery that is both independent of time and location, such as web-based courseware that the learner can access ubiquitously, at anytime and anywhere, i.e. e-training. Learning Management Systems (LMS) are trying to respond to the challenge, incorporating more and more functionalities in management and development of training. Although, such grow in functionalities available to build e-training materials implicates an augment of the complexity to produce them. Commercial LMS are costly, difficult to handle and to maintain; they have made little impact within SME's and they are not sustainable. [21]

Among many others, BlackBoard and MOODLE are two well-known web-based learning management systems, one being a commercial LMS and the other open source, respectively. Comparative results show that Blackboard is better than MOODLE. Blackboard offers greater flexibility in designing the curriculum and study schedules as well as many useful communication and discussion features to facilitate active participation for instructors and students. It also provides flexible assessment and grading functions. Non-features such as costs and quality of services rendered by vendors have not been considerate. In terms of costs MOODLE is superior to Blackboard because it is free. However, freeware usually have weaknesses in terms of technical support.[64] Although MOODLE isn't as good as its competitors, it's the most popular among the academic community, with many universities using it as its LMS and with a strong community supporting, it is evolving rapidly.

3.4.2.1. Moodle

Moodle stands for Modular Object Oriented Developmental Learning Environment [MOODLE], and it is a well known and widely used learning management system. Moodle is, though, more than a Content Management System, since it provides support for learning activities. It is described as a Course Management System because its central concept is a Course and, therefore, it manages courses and all the participants and resources associated with a course.[66]

Moodle is able to handle the standard features of a course and its associated settings, such as users, roles, resources, common site navigation, etc. It allows the creation of courses from scratch, but it also allows other information packages to be imported and used (e.g. SCORM, Content). Moodle's overall design aims to account for educational principles and pedagogical and learning theories, but its pedagogical expressiveness regarding some features is limited, e.g. adaptive learning flow and adaptive content. [66]

3.4.2.2. Blackboard

Blackboard is a commercial LMS and one of the more relevant within the course management space. In 1998, Blackboard LLC merged with Course Info LLC, a small course management software provider that originated at Cornell University. Over the years, Blackboard has grown exponentially and has acquired several other companies, most notably, WebCT in 2006. Blackboard offers numerous products, but their flagship one is the Blackboard Academic Suite, containing the content management system known as the Blackboard Learning System. [78]

Blackboard is a great course management system. In general students learn, instructors instruct and the software has everything needed. Each iteration of blackboard gets slightly easier to maintain and easier to upgrade. But Blackboard is still big and expensive. It generally takes a small team of people keep the application update, and for large implementations can take more. [79]

3.5. Conclusions

SCORM, aggregates, among others, the IEEE-LOM and IMS SS standards, and it's a complete package that allows the implementation of a very rich and interactive LMS over its description. Moodle is an example of a technology that uses SCORM and allows the creation of courses and training materials. But, by being based on a complex and academic-focused solution, the process of developing materials is more exhaustive then what the industry typically requires. The process is then, bound to be subject of inefficiencies. [21]

Knowing that it isn't always needed a complex platform for delivering training it can be interesting to use a trimmed version of the standards studied in order to address the needs of the implementation of this dissertation.

4. Training Organization

In this chapter is described the Organization of Training Knowledge, based on Ontologies. Also it is described the training strategy for developing a course.

4.1. Organization of Training Knowledge

In computer and information science, ontology is a technical term denoting an artefact that is designed for a purpose, which is to enable the modelling of knowledge about some domain, real or imagined.[31]

In this section ontologies are studied from a perspective that could be interesting to explore for the implementation procedure.

4.1.1. Ontology use

"An ontology is a formal explicit specification of a shared conceptualization for a domain of interest" [21] It includes a vocabulary of terms, and some specification of their meaning. This includes definitions and an indication of how concepts are related, which imposes a structure on the domain and constrains the interpretations of terms. Ontologies formally define the semantics of concepts and their relations for a specific domain.[26]

Ontologies are used by people, databases and applications that need to share information where its domains are specific to an area of knowledge. They include definitions of basic concepts used and understood by people and computers, to that information; it's possible to add relations between its concepts for allowing the organization by domains. [34]

The ontology captures the instructional function of a learning resource, in other words, its "essence" from a teaching/learning perspective, an aspect not yet covered by learning object metadata standards.[23]

An ontology expresses a common understanding of a domain that serves as a basis of communication between people or systems. The need for Ontologies has been widely recognized therefore the author will only summarize some expected benefits. In education, widespread appliance of such a shared instructional vocabulary offers advantages for teachers and learners. A more accurate search for learning resources, made possible by the explicit instructional function, leads to better reuse and less duplication, hence faster authoring of curriculums. By seeking instructionally appropriated learning material, learners can bridge knowledge gaps more efficiently.[23]

In order to address this issue several authors suggest that Ontologies can be used to describe LO's content, thus providing LO's with a new dimension of reusability – content reusability. Ontologies for e-learning are different in the following aspects: content – what the learning material is about, context – in which form a topic is presented, and structure – as learning material does not appear in isolation.[24]

Valuable information can be gained by mining metadata of educational resources. However, if the mined data is annotated using IEEE Learning Objects and Metadata standard (LOM), then significant pedagogical information is missing. While LOM and SCORM provide a framework for the representation and processing of the metadata, they fall short in including the needed semantic density for more specific pedagogical tracking. Using a pedagogical ontology will provide a higher level of decision support analysis and mining, based in qualitative issues like: the pedagogic methodologies used the collaborative degree of activities or the understanding expressed in the assessments. [25]

The development and use of conceptual models in learning has been a research topic of the learning sciences for many years. While the earlier works focused on the individual learner, the collaborative use of conceptual models has become a research field in its own later on. Despite the ongoing interest in the use of conceptual models for learning, there is a lack of theoretical as well as empirical work regarding the role of ontologies in collaborative learning and knowledge creation. [26]

4.1.2. Social Ontologies (Folksonomies)

According to the most cited definition of the Semantic Web literature, ontology is an explicit specification of the conceptualization of a domain [2], thus, an ontology is engineered by –but often for- members of a domain by explicating a reality as a set of agreed upon terms and logically-founded constraints on their use. [27]

Ontologies are enabling technology for the Semantic Web. They are a means for people to state what they mean by the terms used in data that they might generate, share, or consume. Recently an emergent concept is growing in the Semantic Web called Folksonomies, they arise from data about how people associate terms with content that they generate, share, or consume. [27]

Ontologies created for the social dimension face a problem with the dynamic of the community itself, with members leaving and entering and with their commitments changing; a new consensus may shape up invalidating the knowledge codified in the ontology. To address this problem of an ontology drift, several authors expect that the individual interactions of a large number of rational agents would lead to global effects that could be observed as semantics. Ontologies would thus become an emergent effect of the system as opposed to be a fixed, limited contract of the majority. Although this solution is more scalable and easily maintainable, only exists an agreement that covers the basic conditions under which emergence would take place. [27]

Folksonomy (from folk and taxonomy) is a neologism for a practice of collaborative categorization using freely chosen keywords. The idea of a folksonomy is to allow the users to describe a set of shared objects with a set of keywords of their own choice. The interesting observation is that when users (folks) do their tagging in a public space, the collection of their keyword/value associations becomes a useful source of data in the aggregate, hence the term “folksonomy”, the labelling of lots of things by people in a social context. [27]

It is important to note that in terms of knowledge representation, the set of keywords cannot even be considered as vocabularies. The set of rules is not fixed, in fact, the users form no explicit agreement at all about the use of words, and also important is that there is no one-to-one correspondence between concepts and keywords. Notice that it is not always possible for the users to express a complex concept with a single keyword and thus they may use more than one tag to express the concept association that the item brings up in them. [27]

In contrast with taxonomies, that limit the dimensions along which one can make distinctions, and local choices at the leaves are constrained by global categorizations in branches, folksonomies are massively dimensional and there is no global consistency imposed by current practice. Things are easy to tag, there is no wrong answer, and the emergent patterns give insight into collective attention. [27]

This attack on “ontology” is a top down categorization as a way of finding and organizing information and the praise for folksonomy is really the observation that we now have an entirely new source of data for finding and organizing information: user participation. For the task of finding information, taxonomies are too rigid and purely text-based search is too weak, tags introduce distributed human intelligence into the system. [27]

4.1.3. Training Organization using an Ontology

An ontology can be used to represent a training knowledge base, facilitating the categorization of its elements and subsequently reasoning over it. Below is presented an illustration of a training system. This model was built in Protégé and follows the approach used in this dissertation.

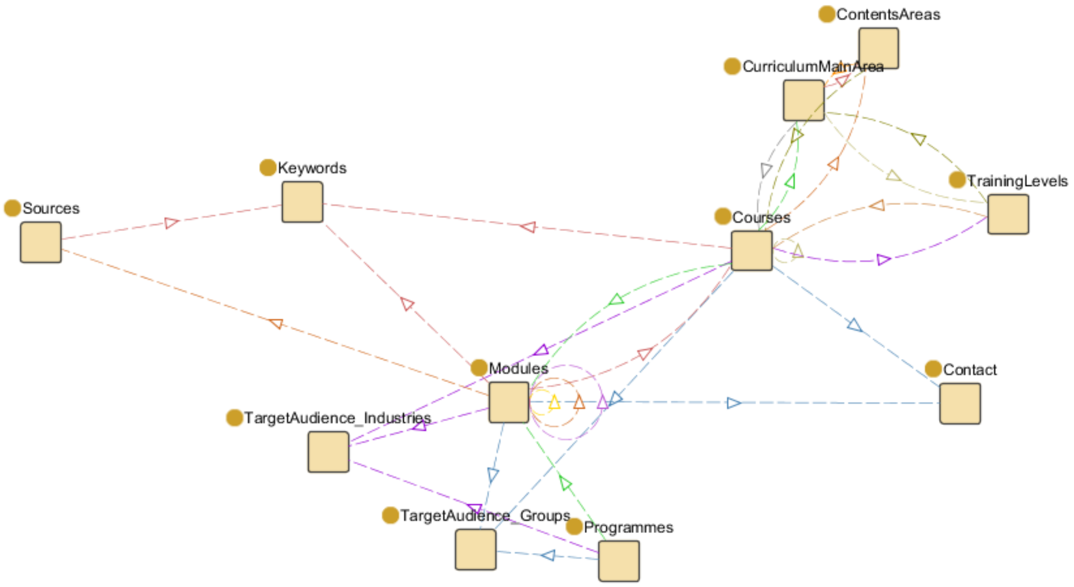


Figure 4.1 – Relationship structure of the Training System Knowledge Base. Each colour represents a different property linking the concepts. Example: each Module has a set of Keywords, the property linking it is: hasKeywords.

In such model (Figure 5.1) each training Module has several concepts associated, the Sources concept contains information about the sources referred in the Module, Contact includes the contact information of the author of a Module or Course and Keywords that contain a list of all relevant keywords needed for describing the contents of the Module. A Course, other than Contacts and Modules that contain the course also includes Keywords (that include Keywords inherited from its Modules) and belongs to a Curriculum Main Area that is divided by Content Areas and Training Levels. Each Module and Course has a Target Audience Group and a Target Audience Industry, for defining the profile of the user. Finally, a Programme is defined for a specific profile, e.g. Target Audience Industry and Target Audience Group as has a set of modules.

4.1.4. Conclusions

What is more important than a specific ontology is the more general notion that techniques of Semantic Web, such as formal specification of structured data and reasoning across disparate data sources, can apply to the Social Web. Tagging data offers an interesting window into the intersection of formal reasoning and semi structured data with context-dependent semantics. [27]

The use of keywords to describe the topics addressed in a module, for example, is a derivative of a folksonomy focused in a training scenario. Other forms of tagging, like the connections between modules, courses, keywords, content areas, and levels, are, in essence the same as the example given. This notion is interesting and provides an opportunity to use folksonomies concepts and functionalities to improve the reasoning of the implementation.

4.2. An Approach to Industrial e-training

Nowadays with the globalisation phenomenon, companies are pushed to improve its strategies towards deconstruction and a focus on core competencies, giving rise to the concept of distributed virtual enterprises [51].To reach such competencies, personal knowledge and other intellectual capital assets serve vital functions within the enterprise [40]. Thus, there is an increase demand of workers flexibility and consequently a constant need of delivering training to them [41].

Distributed virtual enterprises are alliances of organisations that come together to share skills or core competencies and resources in order to better respond to business opportunities [42]. In accordance with this Hamburg et al. stated [43] that a possible solution is to involve SME's into sharing knowledge and collaboration by building communities of practice and to develop business-oriented models of training to meet their needs.

The author in this section refers to a training strategy and a common methodology of building e-training courses with the purpose to organise how the training is managed, enabling at the same time, organizations to collaborate in developing it.

Since time and efficiency are becoming more relevant, it is needed a training delivery that is both independent of time and location, such as web-based courseware that the learner can access ubiquitously, at anytime and anywhere, i.e. e-training. Learning Management Systems (LMS) are trying to respond to the challenge, incorporating more and more functionalities in management and development of training. Although, such growth in functionalities available to build e-training materials implicates an augment of the complexity to produce them. Commercial LMS are costly, difficult to handle and to maintain; they have made little impact within SME's and are not sustainable. [43]

Most of the literature about e-learning stills presents analysis that shows the failure of e-learning especially in industry. These analysis brings up critical factors, which can be grouped as follows [48]: Initial Design Issues; Focus on technology and not on instructional design; Lack of understanding, that specific e-learning tasks have to correspond to the existing competencies as well as the present and future work tasks of learners; Issues of user-friendliness and interactivity; Problems with production, distribution, long term management and evaluation of e-learning courses.

By presenting an e-training course building methodology, based on the ADDIE methodology studied in chapter 2, that considers an inter-organizational interaction in producing shared training materials and using known tools to facilitate the development of web based courses, the author intends to contribute to solve the issues regarding the e-training development and usage. The next two sections address the two mentioned cases respectively.

4.2.1. A Training Strategy as a System

This training development (based on ADDIE model) is to be supported on a proper methodology in order to ensure the accomplishment of the goals through a rational and logical path. The methodology encloses two phases: development and quality check. The development phase defines a clear set of steps for defining modules since early conception, until the development of training materials; quality check phase focuses on quality management/assurance of materials.[50]

A Training Strategy pursuit to define in what way the training objectives could be accomplished, and be represented as a system in the sense that encloses a set of interrelated components working together towards the training process. Thus, in order to define each small step on the pursuit of training delivery, it was deeply defined each of such systems' components.

Thus, a training system can be designed based on the Integration Definition for Function Modelling (IDEF0) standard structure. IDEF0 is a method intended to model the decisions, actions, and activities of an organization or system. This standard structure comprises a system based on inputs, outputs with feedback, controls and mechanisms of a determined function [44].

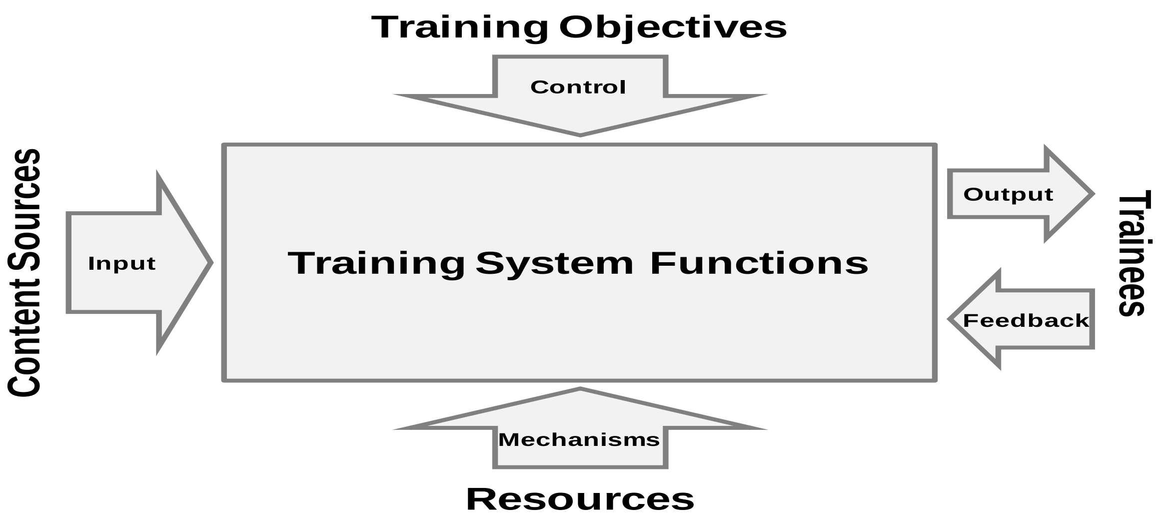


Figure 4.2 – Training System Overview

The training system has as inputs, contents on the training objectives main themes. It has mechanisms able to supply resources for training materials development and delivery; and an entry control composed of the training principles which will conduct the system to the defined focus. Finally, it has the output which in this case is the training delivery to the trainees. Trainees communicate back to system to provide essential feedback on performance and quality of training, thus enabling adaptation and change towards excellence. Such training system elements are described in the following sections.

4.2.1.1. Training System Inputs

The inputs of the training system are composed by the content sources. The objective of this section is to detail the methodology and the structure to be used for content collection. Two main sources of contents have been identified: internal and external. Internal contents come from project activities; the main purpose of having an identification of the internal sources is for internal governance of the contents used to produce training materials. External contents come from external sources to the involved organizations. The idea of having an identification of the external sources is mainly about intellectual property rights, and to facilitate trainees to follow to the training materials sources.

4.2.1.2. Training System Control

Training should follow an outcome-based approach where focus and drive are set on the specific outcomes of the training delivery towards a valuable and effective training experience. Clear objectives are defined, where a set of eight sound training principles are clearly identified to control the overall training system development and deployment (top of Figure 2).

The Dynamic Training Curriculum principle defines that a curriculum is the set of related instructional elements and content offers in a given field of study [46][47].A dynamic curriculum is a curriculum composed by training modules, which could be orchestrated to build adapted courses to specific characteristics, as target audience profiles and skills.

The Reference Training Courses and Programs are to be conceived in a way that meet the specific desires and expectations of a determined target audience. Effective Training Implementation addresses how training execution should be carefully planned in order to generate the envisioned impact.

The Methodology-based Development principle establishes how the training development should be supported by a proper methodology in order to ensure quality management/assurance of materials accomplishing and its goals through a rational and logical path.

The Valuable Marketing and Communication principle addresses how Marketing and Communication are important vehicles to reach targeted audiences and promote awareness of topics and value of the training services. Only with Appropriate Technological Infrastructures that will host and support training delivery is possible to realize the foreseen goals of the training services.

Accountable Training Activities is a principle that refers how an outcome-based approach to training focused on the results of delivery is supported by accountability.

And finally, Intellectual Property Rights principle that addresses how the training consortium should have a clear agreement on IPR for exploitation of developed training materials.

4.2.1.3. Training System Outputs

The training system outputs are based on two elements: the training execution and the training marketing. Training execution needs of an appropriated marketing to reach the target trainees. On the other hand the trainees are invited to provide a feedback in order to have a continuous training improvement.

Training Execution ensures that the training is offered in a most flexible way to meet the different needs of trainees in order to achieve the desired results. The Marketing/Promotion essential goal is to create and sustain interest in Training, and to promote the Training Services. The identification of the real interests of potential learners, ascertained through target audience analysis, is also vital for creating a product that meets the needs of customers. A focus on what the customer wants is essential to successful marketing. At the same time, this customer-orientation must also be balanced with the training objectives. Feedback mechanisms are intended to adapt, revise or re-plan the training execution in the various dimensions (curriculum, programmes, contents, etc) and are mainly implemented through feedback questionnaires.

4.2.1.4. Training System Mechanisms

The training system mechanisms are assets that facilitate training execution. For each particular training course, these assets are assembled by the trainers themselves to provide training, e-learning infrastructures as a vehicle to training delivery, and methodologies which provide directives for training development.

Trainers are expected to be able to properly identify and determine training requirements for each session [48]. Such work will require a specific design of the courses and programs – including evaluation schemes – according to each target group. The e-learning infrastructure’s main requisite is to make possible the delivery of virtual classroom and web-based training, and to give directions related to available presential classrooms events.

4.2.1.5. Training System Functions

The training system presented is rooted in a well-established Instruction System Development (ISD) approach, commonly referred as ADDIE [49]. The acronym stands for the five key phases/functions contained in the model – Analysis, Design, Development, Implementation and Evaluation. The approach is especially relevant for the envisioned training system due to being simple, reliable, supporting self-adjustment and applicable to a broad range of training needs [50].

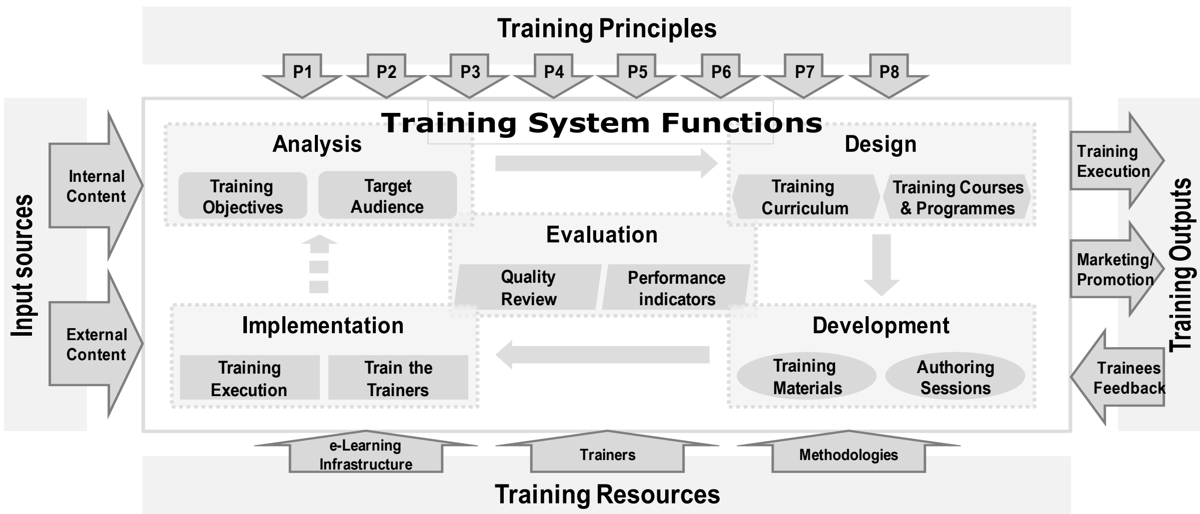


Figure 4.3 – Training System detailed view

In the following it is presented in detail the Training system functions (central area of Figure 2). Such functions represent each step of the activities, actions, processes, and operations that embody the training system and which have been used as a guide to the strategy and plan definition of the work needed to conceive, develop and implement training activities.

The **Analysis** phase determines training needs (e.g. analyze learner characteristics, task to be learned, etc) and expresses them as information that is useful for training development. The ISD model requires that training fulfil specific needs. This is done through the generation and evaluation of such analysis elements as training objectives and target groups analysis.

The **Design** phase is the ISD planning stage. Its purpose is to transform relevant content into concise, behavioural objectives, creating the instructional “blueprint” that will direct the development of all training materials, tests, and methods. Training requirements, target groups and outcomes identified during analysis are here mapped into goals and objectives, constituting the training courses, training curriculum and programmes.

The **Development** phase translates design specifications into training materials. Using the objectives, instructional approach, and input selections from design phase, the development activity produces instructional materials for both trainers and trainees, and evaluation instruments. Moreover, and in order to reach a superior level on training materials, it is needed to train the authors on how they should develop the training objects in such a way that they exist in a format able to be deployed in an infrastructure which is capable to support various training forms and types.

The **Implementation** phase focuses on details of training delivery/execution, as training of trainees and logistical arrangements. Work focuses on scheduling a training place, preparing an agenda, defining appropriate marketing, setting up the training environment instructional materials, ensuring delivery of a training session able to captures trainees' interest.

The **Evaluation** phase ensures that training-under-development stays on track, safeguarding achievement of training goals and analyzing system performance. A quality review process based on decisions and revisions for future course iterations can be made after evaluating the strengths and weaknesses in a completed training programme, thus ensuring achievement of desired goals. In each execution it is asked the trainees feedback concerning, e.g. materials quality, trainers performance, etc. This information is used for constant improvement of the training system.

4.2.2. E-Training Course's Development Methodology

Closely linked with the way how a course is developed is the technology that supports it, and knowing that it isn't always needed a complex platform for delivering training [42]. There are several technologies and methodologies that allow the creation of courses and training materials for the industry, but they are mostly academic-focused solutions where the process of building courses and materials it's more exhaustive then what the industry typically requires. This process it's bound to be subject of inefficiencies brought by the using of academic-focused technology in industrial training.

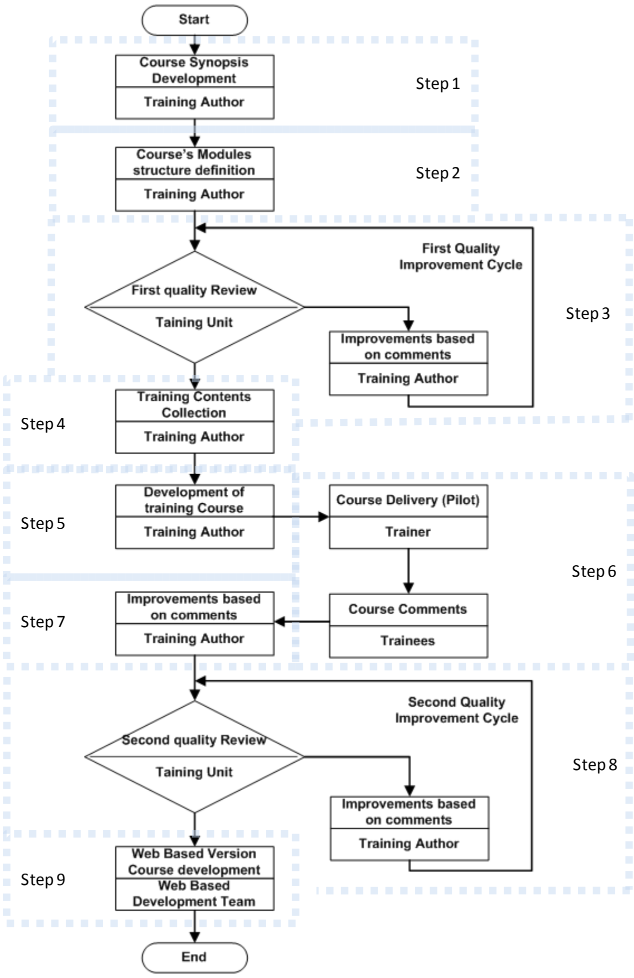


Figure 4.4 – An e-training course building methodology

This proposal has been validated as a potential solution for improving the efficiency in developing e-training courses within partners in European projects as in CoSpaces [51], where the exchange of information results in a need of constant training between the several parts involved, by structuring the training developing procedure.

The presented Course Development Methodology is composed by 9 steps (Figure 6.3)

1) Course Synopsis Development

What should students know, understand, and be able to do? This step considers the goals and identifies the learning objectives. Essential learning objectives represent the personal knowledge at the deepest level. It should be written a declarative statement for the essential understanding that will result from the training and should be written an essential question that this training course might address. It should be considered questions that point to big ideas and promote a deep and essential understanding. Essential questions that frame and guide the course must be formulated with the objective of focusing the unit knowledge (e.g. - What ideas or concepts of this topic will the focus on in this unit? What ideas underlie this topic? A really interesting thing, which adds value to the unit, can be a hook to a big idea. It helps the user to make links to other ideas, disciplines or domains of knowledge).

After having such questions delineated, it is defined the requirements of the course as well as the first concepts about this element of study. These concepts together in a specific order build the course synopsis template:

Title - This includes Training Course's acronym plus its title.

Narrative summary - This presents a summary of the Training Course (TC), and its highlights.

Target Groups - This presents the target groups for who the TC was defined.

Target Industries - This denotes the target industries which the TC uses as reference for examples/demonstrations.

Objectives - This denotes the training objectives of the TC.

Student requirements - Any specific student requirements are stated in this section (e.g. recommended precedence; previous students' knowledge).

Technical requirements - Any specific technical requirements (e.g. personal computer and/or specific software installed).

Recommended Precedence - Any course which the trainee should follow before attending this one.

Estimated time - Duration of the TC.

Modules – This presents the training modules which this TC is composed by.

Contact person - Contact person for the TC.

Skills – Know - Skills to be acquired related to the knowing and understanding (Theoretical knowledge of a field; the capacity to know and understand).

Skills – Do - Skills to be acquired related to the knowing how to act (Practical and operational application of knowledge to certain situations; be able to accomplish).

Skills – Be - Skills to be acquired related to the knowing how to be (Values such as an integral element of the way of perceiving and living with others and in a social context).

2) Course's Modules Structure Definition

The modules are organized and structured around the courses questions. Assessments inform the teacher and the learner about learner progress and at the same time, contributes to the learning process. A structure with assessments included is a good approach for producing an interactive course. Thus each module should have at least one assessment question. A training course could be composed by small training objects – the Training Modules (TM). For each TM is needed to define topics that are described in the course synopsis template (presented in step 4). However there is a difference between the course synopsis template and the module synopsis template. The field 'Modules' of the courses synopsis template is exchanged by the 'Input field content' in the module synopsis template. Input Content – This presents the input content sources used as relevant and essential for development of the module template contents.

3) First Quality Improvement Cycle

In this step the training unit members are invited to see and comment the structure of the courses. If there is agreement, the training course development could pass to the next step, if not the training course author should update the work developed in order to fulfill the comments received. This process is repeated until there is an agreement.

4) Training Contents Collection

Two main sources of contents have been identified: internal and external. Internal contents come from involved organizations, while external contents come from external sources, such as conferences, publications, books, etc.

The selected training content for each course is to be described in the “Input Content” field of each module/course synopsis.

5) Development of Training Courses contents

In this step the authors develop the training materials. To facilitate this process, the proposal methodology defined that the training materials should be in a PPT basis, since it is one of the most common tools used to present information. The training course materials main components to be developed by an author are:

Slides. Slides with a balanced level between text and figures/animations are desired. The most appellative they could be, more attention from the audience, they will take. [50]

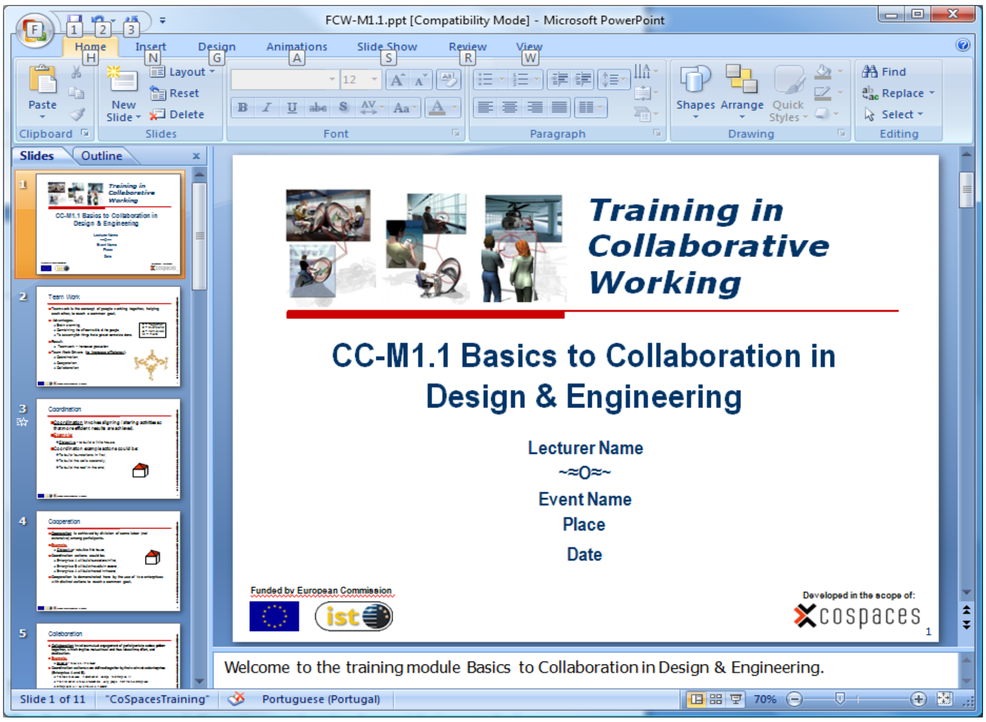


Figure 4.5 – Training courses slides

Narrative Text. The narrative text is one of the most important components of a training course. It gives to the trainees the possibility of following the trainers' thoughts about a specific slide. When the training material reaches a stable version, the narrative text will be converted in voice for the web version of the course.

Handouts. Handouts are informative or educational material given to the learner. Handouts can comprise copies of the slides, explicative notes about each slide and any other material that is handed out to the learner. This is a simple print method of training slides which has narrative text in.

Evaluation. It is a document with questions and answers for learners. In case of Web-based trainings these have been implemented as online tests enable the learner to check learning progress and consolidate skills and knowledge. These tests are the ones mentioned in the step2.

For quality purposes it was identified a set of guidelines which training authors should follow:

Identification – Title, narrative summary and proposed objectives are considered appropriate to the training unit content and goals and the overall ambition of the Training Module/Course (Training Element) within the training curriculum.

Adequacy - Adequacy and sufficiency of the training content to meet the proposed skills and objectives of the training element.

Suitability - Training Element appropriateness for its target audience. Suitability of Students and Technical requirements appropriated for this training element.

Clearness - The Training Element content is comprehensive and helps learners to understand the concepts being presented. Narrative text exists and is well written and contains no spelling, grammar, or punctuation errors. Semantic is correct. Clarity of textual definitions, examples, assessment questions, etc.

Enthusiasm - Ability to motivate the interest and involvement of the identified target groups in the learning process.

Visual design - Clarity of animations, graphical models and illustrations. Have a good balance of the slides concerning the text and images.

References - Training Element includes the appropriate references in the training content. Input content of the TU description is filled accordingly.

Evaluation - Some questions and answers for the learners are developed. It is mandatory for each TM to have at least one question and its related answer.

Duration - Duration of the Training Element is in accordance with the “Estimated time” section in the synopsis template.

Template - Training material follows the common agreed style. Slides are according to the common template with the copyright notices, if needed.

6) Course Delivery (Pilot)

Course delivery is the stage where a course is delivered with the main objective of performing high level training on its subject. Pilot delivery is the stage related to the first time that the course is delivered. In all of these situations, the trainees are requested to comment about the course. These comments will be used, if necessary, to improve the course.

7) Improvement based on comments from Course Delivery

In this step the authors make the improvement of the training course materials based on the feedback gave by the trainees in the step before.

8) Second quality improvement cycle

This step comprises a quality procedure on the training materials developed. This is the last quality improvement cycle, which its main objective is to approve the course before publishing it.

9) Web based version development

In this step the power-point of the courses presentation is transformed into an interactive Flash course with the possibility to add narration voices to each slide. After this, it is only a matter of deploying the package built in a Learning Management System (e-learning infrastructure) or in an html server (since the chosen tool produce the package to run as a normal html page), in order to have a web-based course (e-training course).

There are several tools to aid in this effort; nevertheless there are two that were already tested by the CoSpaces training. For the narrative voice it was used the TextAloud tool [51], a software that converts text to voice. Then it was used the Articulate [53] tool for an easy e-learning course production. Articulate is one of the most recognized rapid e-learning software and e-learning authoring tool available. The figure 4.6 has an example of a CoSpaces e-training course in a flash based course. It facilitates between various functionalities to produce various kinds of assessments, which are very useful for auto evaluation by the trainees. [50]

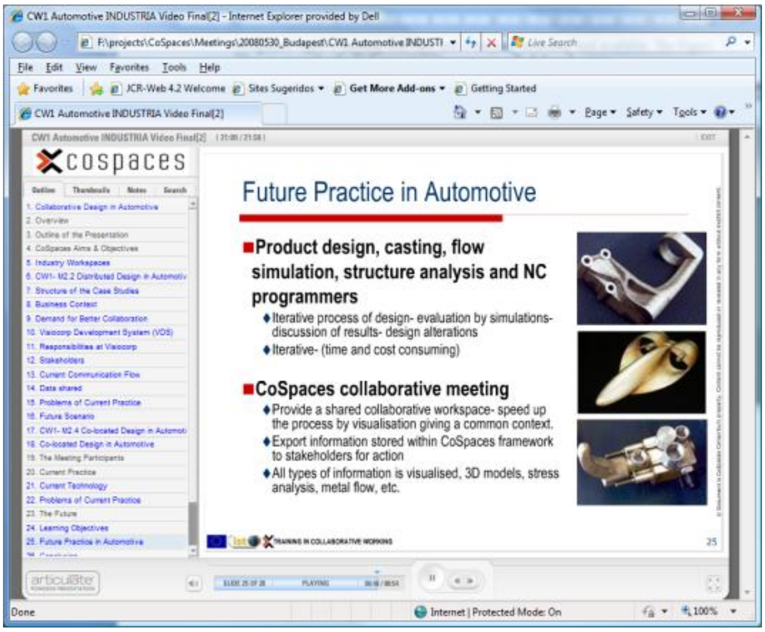


Figure 4.6 – Web based course (in Flash)

However the author stated that it's possible to increase the efficiency of creating industry-focused training courses, through a process, which do not need authors adapting them. Their future work will be focused in the automatic creation of industry focused training courses. With information in the courses/modules synopsis templates, authors believe that a training course could be automatically generated through appropriate reasoning on it. Thus, an automatic orchestration of courses based on the profile characteristics of the trainee is a goal to pursuit.

5. PROOF-OF-CONCEPT IMPLEMENTATION, TESTING AND VALIDATION

In this section the Proof-of-Concept Implementation is described as well as it's testing and validation.

5.1. Proof – of – Concept Implementation

This section describes the implementation, the automatic orchestration of modules and courses in order to provide a learning experience according to each user needs.

In the development phase several standards and methodologies were taken into consideration, but because this is a case study aiming to confirm the possibility of automatic creation of courses, throughout the implementation several simplifications were made in other to try to keep the focus of the objective. In the future it is possible to adapt this implementation in order meet the requirements of the standards studied.

5.1.1. Technologies used

Before explaining the architecture of the implementation, it is presented a brief study of the technologies used and the reasons behind each selection.

5.1.1.1. OWL / Protégé

OWL (Web Ontology Language) is one of the languages for knowledge representation. OWL uses formal semantics and RDF/XML-based serializations, like many other languages of the Semantic Web. [80]

OWL is supported by the World Wide Web Consortium (W3C) and with the growing interest by academic and commercial entities, it has been updated to its 2.0 version, know as OWL 2, with development in the areas of syntaxes, semantics and profiles. [81]

For a better implementation it is advisable to use an OWL Editor because the specifications and used fields are complex and extensive. Protégé is a free and open source ontology editor and knowledge-base framework that supports the two main ways of modelling ontology's via the Protégé-Frames and Protégé-OWL editors. Protégé is based on Java, and by providing a plug-and-play environment makes it a flexible base for rapid prototyping and application development. The Protégé Programming Development Kit (PDK) includes, among other API's, an OWL API that extends the core API to provide access to

OWL ontologies. PDK includes a set of libraries that allows Java to do several operations on the OWL Language, like reading, editing classes and properties, among others.[82]

At the moment, Protégé only supports Java and there is no known intention of adding new supports, forcing the adoption of Java for facilitating the development.

5.1.1.2. JAVA

Java is a flexible technology that allows developers to create software that is independent of the platform where it will run. It also allows multi-threading programs that run in Web browsers and Web Services, and combine Java objects between applications. Java is, at the same time, a high-level object oriented programming language, and this software developed must run on every hardware that has installed a Java Virtual Machine (JVM). For this, Java is compiled to byte code instead of directly to platform-specific machine code. [83]

Other than the fact that Java is a very interesting technology, the adoption of Java on this project was also influenced by the lack of support for other languages by Protégé (that only provides an API for Java).

5.1.1.3. Web Services

Web services were created to allow the sharing of a service with the world. Usually a web service converts a normal application into a web application, with the sharing of applications functions on the internet. By publishing those services, they will be ready to be consumed by anyone. Web services are used also for data exchange between different network platforms, programming languages, operating systems or different hardware systems and allow applications made in different languages and/or different operating systems to link their data. [84]

5.1.1.4. JAVA Server Pages

Java Server Pages (JSP) technology allows a fast and simple way of creation of dynamic web content. A JSP file is usually composed by HTML or XML code mixed with tags and scriptlets written in the Java programming language. This file also allows a web server to dynamically add content to HTML pages before they are sent to a requesting browser. [85]

Using Java for development of the project, Java Server Pages is the natural solution for implementing a Web Site for purpose of validation.

5.1.2. Architecture

In order to create the implementation, a simple architecture has been developed using the tools and technologies mentioned before. The architecture is depicted in the figure bellow as well as the existing interactions.

The figure is composed by three different parts:

- The Training Orchestration Server
- The JSP files used for interface
- Server with the flash videos

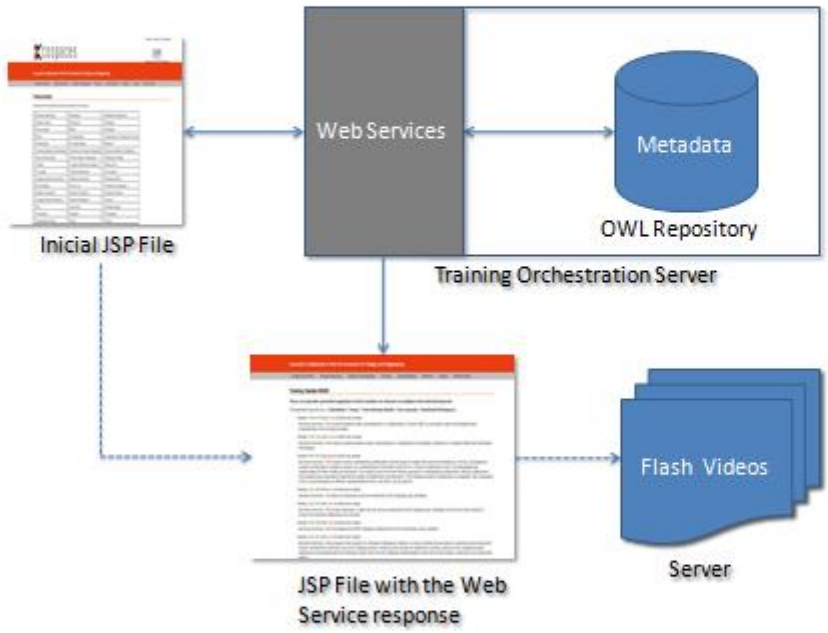


Figure 5.1 – Implementation Architecture

With this architecture a user is able to retrieve an automatic orchestrated course that is built accordingly to its needs. After connecting to the web service of the Training Orchestration Server in order to fetch the available keywords and target audiences, the user selects and sends to the web service the intended fields of search. By reasoning over the Metadata of the Training Systems Modelling existing in the OWL Repository, it is generated a list of modules suggested to be followed and the answer replied and presented in the final JSP file. The response includes all the links to the modules suggested, that can be consulted in another server.

To develop this concept, it was used data from the CoSpaces project, and its Training in Collaborative Working (TiCW), all the information was modeled and its presented in the following section.

5.1.2.1. Training System Modelling

The Training System Knowledge Base was built in Protégé and uses data from the CoSpaces Project and its Training in Collaborative Working (TiCW) for constructing a functional demonstrator. The model design is referred in section 5.3 and the illustration of its implementation can be found in the Figure 7.2

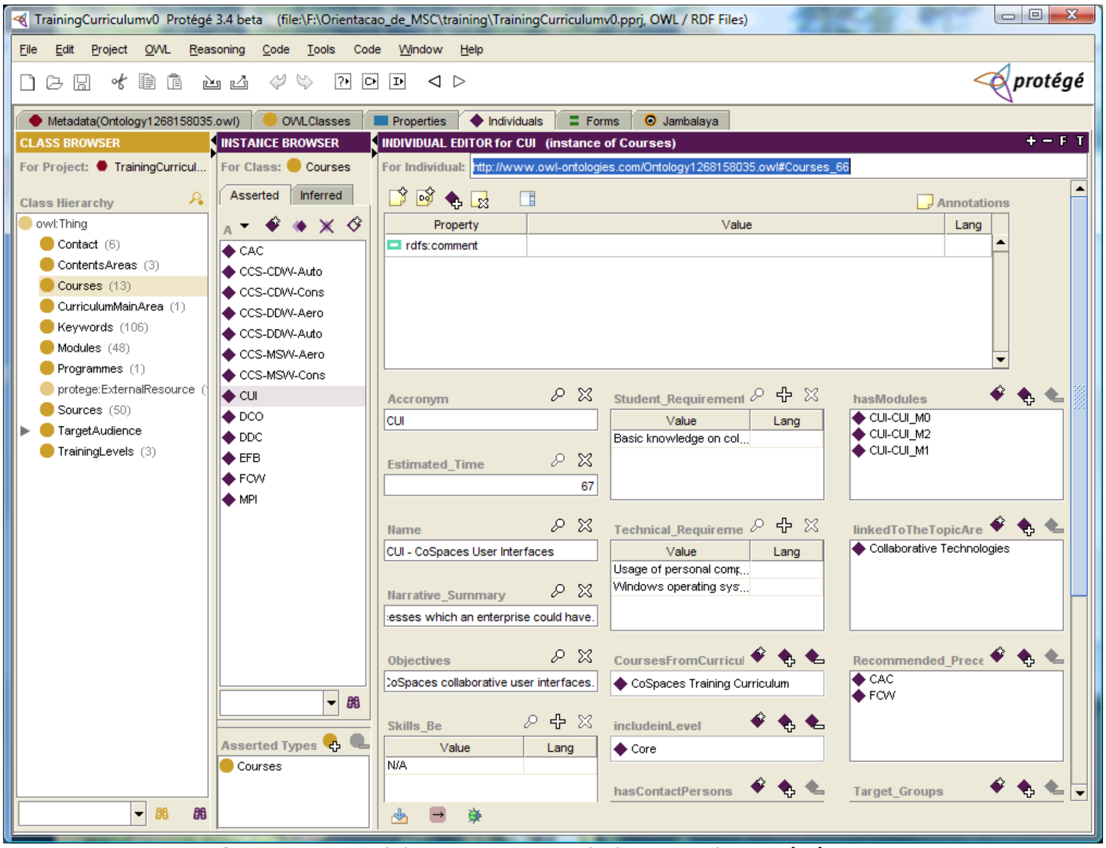


Figure 5.2 – Training System Knowledge Base in Protégé

The model provides an easy comprehension and management of the whole system by adopting a visual knowledge modelling approach for reasoning and inspection based on Protégé. The figure above presents the knowledge related to one of the modelled courses – the CUI course using Protégé. It is shown that the CUI course has 3 modules, and it is linked to the curriculum topic area Collaborative Technologies. The recommended precedence's and the level of training on which the CUI course belongs are also in the model, among other relevant concepts.

5.1.2.2. Automatic orchestration of e-training programmes

As stated above, the automatic orchestration aims to automatic generate courses according to its user needs.

The implementation generates adaptable courses with content originally developed for static courses. By having a training curriculum matrix, it was possible to reason over it and generates an order in which the courses will be ordered. With the recommended precedence's field in modules and courses, it was possible to complement the generation of a course according to the user needs by suggesting other courses / modules that are considered relevant for the better understanding of the topics of interest.

As input for reasoning over the model, the implementation uses all the keywords and target audiences that are present in the model. First, it was developed a demonstrator that only uses keywords as input and later was developed a version where the target audiences are cross-matched with the selected keywords for refining the orchestration. Next are presented a brief overview of the two steps in the implementation.

Keywords

Being the module the atom element of the model, all its associated keywords will be inherited by the course(s) that belongs to. So, by backtracking all the keywords that the user as chosen, the application will identify the modules that contain the selected keywords and, as explained above, all its recommended precedence's.

After adding all the modules that will be presented, it is needed to reason over the model to generate an order on which they will be presented. Here is where the training curriculum matrix is vital, to proper organize the course that will be generated for the user.

Target Audience & Keywords

With the adding of the Target Audience concept to the selection, all the modules / courses that weren't identified as relevant for the target audience selected will be taken out of the course generated for the user.

5.1.3. Considerations and remarks

During the implementation, they were made several considerations in order to simplify the construction of the application and its features in order, not only to keep the project within its time frame but more importantly to keep the final application simple, without generating complexity to none of its intervenients.

With the complete training system model was possible to identify several ways of increasing the search fields available for the user as well as the creation of filters were the user, for example, could select only courses / modules from a specific level of the training system.

5.2. Implementation Testing and Hypothesis Validation

The implementation was tested in a European Commission Project, the CoSpaces Project. The final conclusions of the project and other considerations were used for the purpose of validation the implementation.

From a general point of view, it could be stated that the objective of this work is essentially the automatic orchestration of courses according to the user needs and its profile. For that, it was needed to implement a model of training, in this case, the Training in Collaborative Working inserted in the CoSpaces Project. All the data about courses, modules and other concepts was gathered from the TiCW, and the model created reflected key aspects of the TiCW.

The methodology suggested to be used was vital to keep the focus of the implementation, and the author always kept in mind the KISS principle (Keep It Short and Simple) for modelling the system and implementing it. With this, it was possible to build in the time frame projected a working – proof of concept that, as stated, was used by the CoSpaces project.

5.2.1. CoSpaces UseCase

The CoSpaces project is a European Commission founded project that addresses three scientific and technological objectives:

- Evaluate collaboration at individual, team and enterprise levels, and develop collaboration models emphasizing applications of problem solving, creativity, participatory and knowledge based design in innovative collaborative work environments;
- Create an innovative distributed software framework that will support easy creation of collaborative work environments for distributed knowledge workers and teams in collaborative design and engineering tasks;
- Validate the distributed software framework for creating different classes of collaborative working styles required for collaborative design and engineering in the Aerospace, Automotive and Construction sectors.

For more information about CoSpaces, refer to [86]

5.2.1.1. Training in Collaborative Working (TiCW)

Training in Collaborative Working defined within CoSpaces Project is aimed at generating an impact on selected target groups, by allowing trainees to understand common issues directly related with Collaborative Working especially focusing on the Collaborative Working Environments pragmatics. TiCW is mainly focused on delivering effective training for industrialists in order to raise awareness and develop skills on collaborative technologies and to enable the uptake of the technologies developed within the project. [86][73]

Within TiCW there are several concepts that were used for the model implementation. In the next sections are presented the concepts as described in the CoSpaces Project and were used as a base for the OWL model.

Note that the Training Programme concept was inserted in the model for future improvements where the automatic orchestration could be also reason over the several training programmes. All the training programmes are available in a web basis at: [86].

5.2.1.2. Target Groups

TiCW, by targeting anybody from any kind of enterprise or academia institution that is concerned with collaboration issues, TiCW segmented its groups into two high-level groups: Industrialist and Researchers & Academics. Inside the industrialists groups were identified four main groups: BM – Business Managers; EM – Engineer Managers; PT – Project Teams; and IT – IT Specialists. Additionally to this, the target industrial sectors considered were: Aerospace, Construction and Automotive. [73]

Bellow is presented a short description found on TiCW of each of the groups within Industrialist’s main group and the Researchers & Academics main group. For each Industrialist’s main group there is a corresponding Training Programme that can be consulted in [73].

BM (Business Managers)

This group of people are the managers of business within the organizations (either CEO or unit managers) and that have the role of managing the business and the ultimate power of decision to adopt the solution. Business Managers have little time and always expected to get short and sharp messages. Thus, TiCW reaches this people with focused training in the real value and impact of the collaborative solutions from a business perspective. [73]

EM (Engineer Managers)

These are the professionals, specialized in the management that is required to successfully lead engineering personnel and projects, who have some decision power/influence on the technologies and collaborative approaches to be adopted in the organization for performing design and engineering product development. Engineering Managers normally expect training on the value of the technology (both from business and functional perspective) and specifics on how to deploy such technology in the organization. TiCW addresses EM needs having training related to collaborative technologies specially focused in change management associated to the deployment of such technologies in organizations. [73]

PT (Project Teams)

Project Teams are composed by Project Managers and/or Designers & Engineers (D&E) that perform at project level. Project Teams expect training on actually using the technology for design and engineering working especially focused on the functions based on relevant and meaningful use-cases. TiCW addresses this group demands by having training focused in “as-is” and “to be” use-cases accomplished with its related demonstrators, and also aggregated with its used technology analysis. [73]

IT (IT Specialists)

IT specialists (CTO and other IT personnel) are responsible for setting-up and maintaining the IT infrastructure for supporting D&E project tasks. IT Specialists expect to understand the technological components of the collaborative solutions and receive training on its usability, configuration and maintenance procedures. For this TiCW have particular courses on technology usability accomplished by such technology use cases demonstrators. [73]

RA (Researchers & Academics)

Researches and Academics are people that mainly want to search for specific information about topics rather than follow standard training programmes. Researchers and academics expect to have available in a meaningful and searchable form the materials for prompt usage within their research work or in their training programmes or educational curricula. TiCW address this target audience providing a service able to generate and adapt training programme to be focused in their desired topic needs. [73]

TiCW, as stated above, uses the implementation of this dissertation as its adaptive training generation, and, by modelling several target audiences groups and industries, it was possible to automatically orchestrate a training course based on specific topic.

To give an example, a professor might want to search for training materials on collaboration models. Though TiCW addresses this topic, how could one then locate the right combination of materials to meet a specific set of requirements? The implementation has a knowledge base that maintains associations between all training modules, materials and the rationale behind them, and this enables one to exploit them and to build customized training programmes. Trainee researchers/academics can then follow a set of training modules that have been sequenced in a specific order, according to the course number and training level defined in the curriculum, to facilitate their acquisition of a pre-defined set of competences, according to their needs. [73]

5.2.1.3. Training Curriculum

The training curriculum has been designed in order to establish the underpinning that is to be used to frame down training courses and, subsequently, the automatic orchestration of courses. The curriculum on collaborative working follows an integrative structure established over two dimensional axes: horizontally, training levels; and vertically, reference content areas. The figure bellow illustrates how the TiCW Curriculum as the training levels classified in three stages:

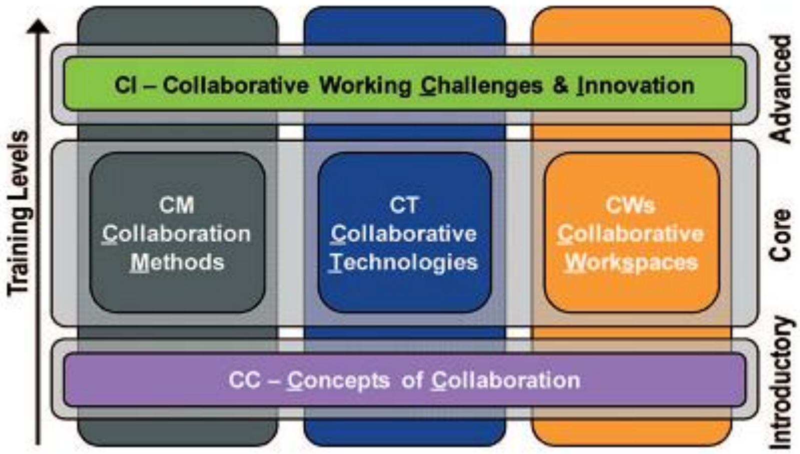


Figure 5.3 – TiCW Curriculum

1) **Introductory** level, with the objective to endow trainees with the basis about the curriculum areas and to ensure a common knowledge level amongst all;
2) **Core** level, which aggregates training elements that establish the in-depth knowledge, understanding and skills that are central to the curriculum areas;
3) **Advanced** level, combining training elements focusing on advanced topics that provide enhanced comprehension of specific knowledge areas related to

collaborative knowledge areas related to collaborative working pragmatics. [73]

The curriculum content areas have been defined upon reference subjects that represent the fundamental dimensions of collaborative working pragmatics: ‘Collaboration Methods’, ‘Collaborative Technologies’ and ‘Collaborative Workspaces’. In conjunction to these areas there are two more that are related to the introductory and advanced levels of the curriculum which are designated by ‘Concepts of Collaboration’ and ‘Collaborative Working Challenges & Innovation’ areas respectively. [73]Which are briefly presented bellow.

Concepts of Collaboration (CC) - The CC area aggregates training materials related to the essential concepts of Collaborative Working. It encloses a basic knowledge support that includes elements such as concepts and terminologies, related to collaborative working and collaborative workspaces. CC extends throughout the Collaboration Methods, Collaborative Technologies and Collaborative Workspaces, and has the FCW as its only course.

Collaboration Methods (CM) - The CM area is aimed at establishing the fundamental and applied understanding of collaboration and its manifestations between individuals and engineering teams, as competences on the human-factors of collaboration are essential for comprehension of the interactions and patterns at collaborative engineering in order to guide the design/evaluation of technologies and workspaces. CM area has the MPI and DDC courses.

Collaborative Technologies (CT) - The CT area relates to technologies that support Collaborative Working, aiming to provide trainees with technological competences and skills on developing support to ease creation and use of collaborative workspaces for seamless, stable and natural collaboration of distributed workers and teams. In CT can be found the CUI and CAC courses.

Collaborative Workspaces (CWs) - The CWs area focuses on knowledge and specific aspects related to collaborative workspaces, based on meaningful case studies. Three generic classes of workspaces have been considered distributed workspaces, co-located workspaces and knowledge-supported mobile workspace within three reference industries automotive, construction and aerospace. The CWs area has the CCS course.

Collaborative Working Challenges & Innovation (CI) - The CI area focuses on challenges in deploying CoSpaces technologies to industry and in motivating the collaboration in D&E through innovative solutions, demonstrating the potential value that it could afford to businesses and networks of engineering organizations.CI extends throughout the Collaboration Methods, Collaborative Technologies and Collaborative Workspaces and has the EFB and DCO courses. [73]

In order to have a better idea of what kind of contents are expected in each course and what is its role in the overall training, the courses were categorized in the curriculum structure as it is shown in the figure bellow.

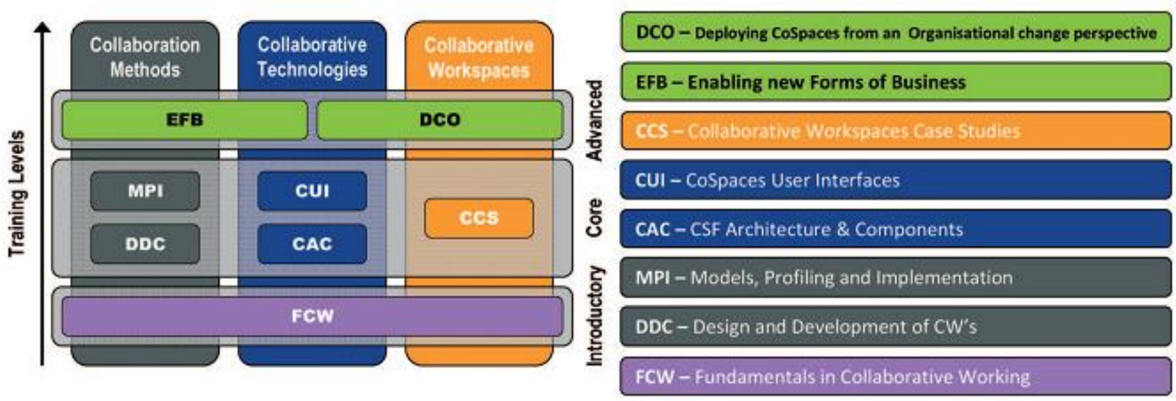


Figure 5.4 – TiCW Curriculum with detailed courses

By establishing a matrix of courses, the curriculum creation allows the prioritizing of courses based on its training level and content area. It is therefore vital for the automatic orchestration of courses, because without a matrix, the correct organization would be a greater challenge.

5.2.1.4. Training Courses

Together with the regular courses description, all the courses are also introduced with its curriculum position (training level & content area) and industrial directive. Bellow are described each course followed by an illustration of the existing modules of it.

In order to better clarify the kind of information that a course uses, take into account the complete example of the FCW course and modules in the annexes, section 11.1.1. This course belongs to the introductory level of the TiCW curriculum. For the complete description of all courses and modules, refer to [74][86]

Course FCW - Fundamentals in Collaborative Working

Fundamentals in Collaborative Working course (Introductory level) has the main objective to endow the students with the basics and scope of Collaborative Working. It is designed as an introduction to any participant in the CoSpaces training curriculum.

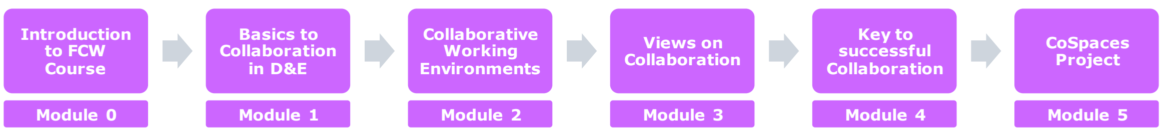


Figure 5.5 – FCW Course Module's structure [74]

Course EFB - Enabling new Forms of Business

Enabling New Forms of Business course (Advanced level) focuses on the business aspects of using collaboration and collaborative technologies. The main target of this course are Business Managers (although also of interest for Engineering Managers) to provide the business view and value of the solution in the application domain.

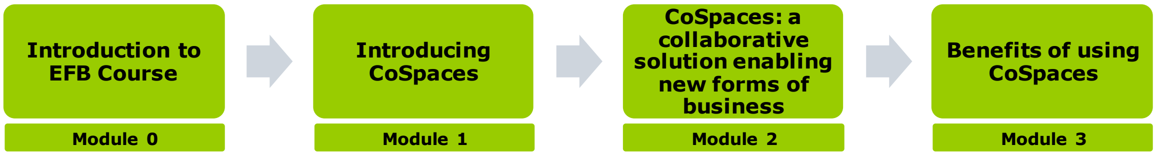


Figure 5.6 – EFB Course Module's structure [74]

Course DCO – Deploying CoSpaces from an Organizational Change Perspective

Deployment of CoSpaces in Organisations course (Advanced level) is focused on the deployment of CoSpaces Collaborative Technologies in organizations. The main targets of this course are Engineering Managers in order to provide the insights on how to deploy the solution in the organization to support collaborative design and engineering related tasks.

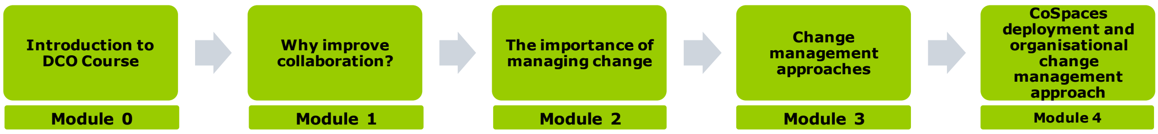


Figure 5.7 – DCO Course Module's structure [74]

Course CCS - Collaborative Workspaces Case Studies

Collaborative Workspaces Case Studies course (Core level) focuses on specific and meaningful cases studies of collaborative workspaces in design and engineering domains. It has six possible cases (co-located in construction, co-located in automotive, distributed in aerospace, distributed in automotive, mobile in aerospace, mobile in construction) and goes from the explanation of the case study to the actual demonstration (role-based hands-on demo, when environment permits, or a more passive demonstration, e.g. video). It provides a contextualized (meaningful application in specific sector) view of the use and value of the approach and solution.

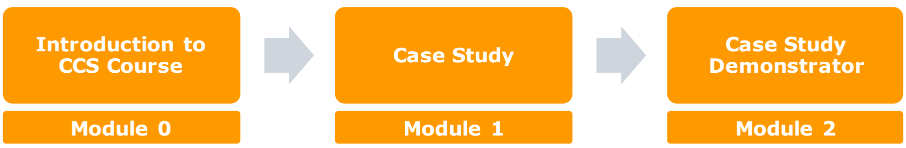


Figure 5.8 – CCS Course Module's structure [74]

Course DDC - Design and Development of Collaborative Workspace

Design and Development of Collaborative Workspaces course (Core level) consists of four main topics (Living Labs and RTD; user requirements; evaluation of collaborative workspaces; design guidance for collaborative workspaces) and focuses on the aspects related to the design and development of collaborative workspaces. The focus of this course is for industry professionals involved in research and development projects related to the design and development of CW.

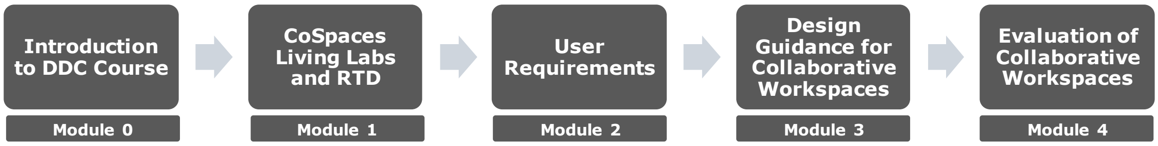


Figure 5.9 – DDC Course Module's structure [74]

Course MPI - Models, Profiling and Implementation

Models, Profiling and Implementation course (Core level) focuses mainly on the aspects of collaboration modelling, collaboration profiling and change management. This course is targeted at Engineering Management professionals but also for Project Teams.

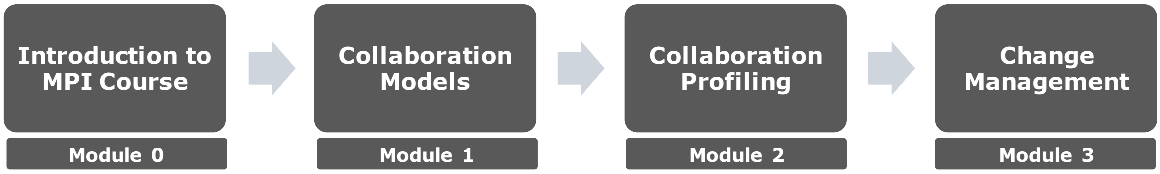


Figure 5.10 – MPI Course Module's structure [74]

Course CAC - CSF Architecture and Components

CSF Architecture and Components course (Core level) focuses on the Architecture and Components of the CoSpaces Software Framework. The course is especially targeting the IT specialists groups for providing the understanding on the CSF parts and relations as the way to understand its functional aspects and properties.

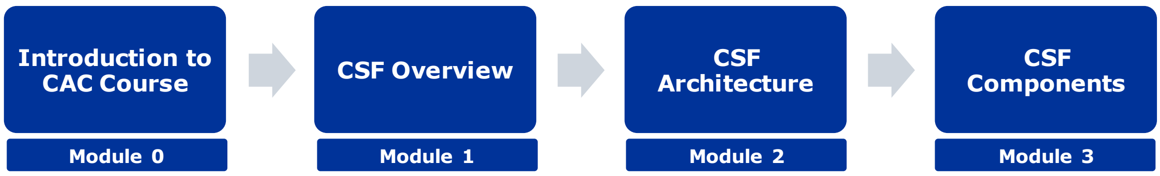


Figure 5.11 – CAC Course Module's structure [74]

Course CUI - CoSpaces User Interfaces

CoSpaces User Interfaces course (Core level) presents details on how to install the frameworks and components as well as the details on its usage from the end-users perspective. It provides training on the setup, installation, configuration and on the how to use aspects related to the CoSpaces User Interfaces, addressing IT specialists' knowledge and competence needs.

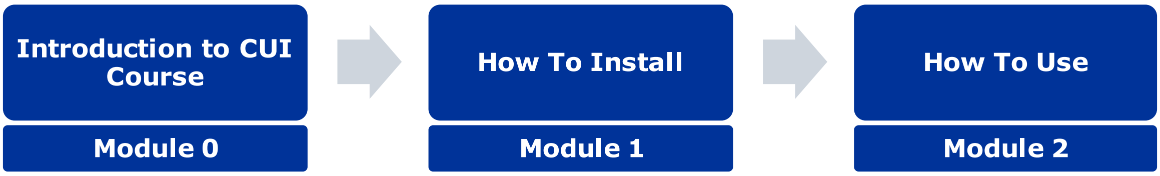


Figure 5.12 – CUI Course Module's structure [74]

By analyzing all the information available of the courses, it is clear that, for reusing purposes it is important to include the maximum amount of information of each course in the model.

5.2.1.5. Training Modules

The modules are the atom unit of the model. They are, as seen above, indexed for each course, and from that to the rest of the high level model concepts. For example, each module has associated keywords that will be used for discovering all modules, modules with precedence, courses, and so on. For an example of the modules synopsis within a course, refer to the section 11.1 in the annexes, please refer to [75] to consult the entire existing module's synopsis.

The modules are deliverable via a flash video imbued in a web server created. Simply by accessing the link of the desired module, the user will start its learning experience with the possibility of pausing and retaking the lesson at any time. The figure below illustrates the interface for the navigation within a module.

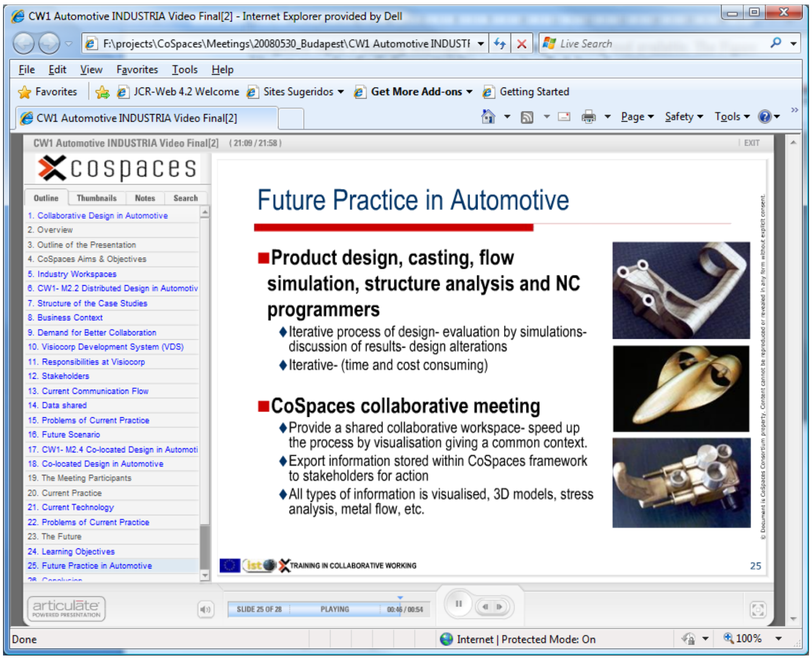


Figure 5.13 – Example of module in flash

For each module there is a corresponding flash video, and subsequently a link to access it. By providing a set of links to a user, he/she will easy navigate though them and gather knowledge about the selected topics.

Like the case of the training courses, with the training modules complete descriptions and analyses it was possible to identify the fields that would be relevant to the implementation and cross reference them to concepts from e-learning standards. With this action it was identified not only that it would be possible to automatic orchestrate courses, but also limitations and future improvements.

5.2.2. CoSpaces Adaptable Training Programme Service

For validation and integration within the CoSpaces project, it was created a JSP web page that, via webservices, requests a generated course according to the user needs. The web page with the list of modules suggested is presented with the name of each module, a short description and a link to the flash video of the respective module.

For example, the user selects the keywords that he/she is interested in, and after clicking 'Generate' it will appear a web page with all the modules relevant for the selection. For illustration of this process, refer to the section 5.2.

In this section is presented the part of the CoSpaces Project that addressed the implementation of this project, and how it was used.

The Adaptable Training Programme Service uses the knowledge base constructed for the CoSpaces training system. It was defined to be used for governance of the system and to be used for specific reasoning operations. Thus, in that sense, through such reasoning operations it was built this service. The following figure shows the structure of such a knowledge base. [74]

The service, as described above, is available a web page on the CoSpaces web site.

The application can be found in the following web site: www.cospaces.org/training/training_programmes.htm.

In the Researchers & Academics section it can be found the link to the web page created to be client of the web service built to create the automatic generated courses.

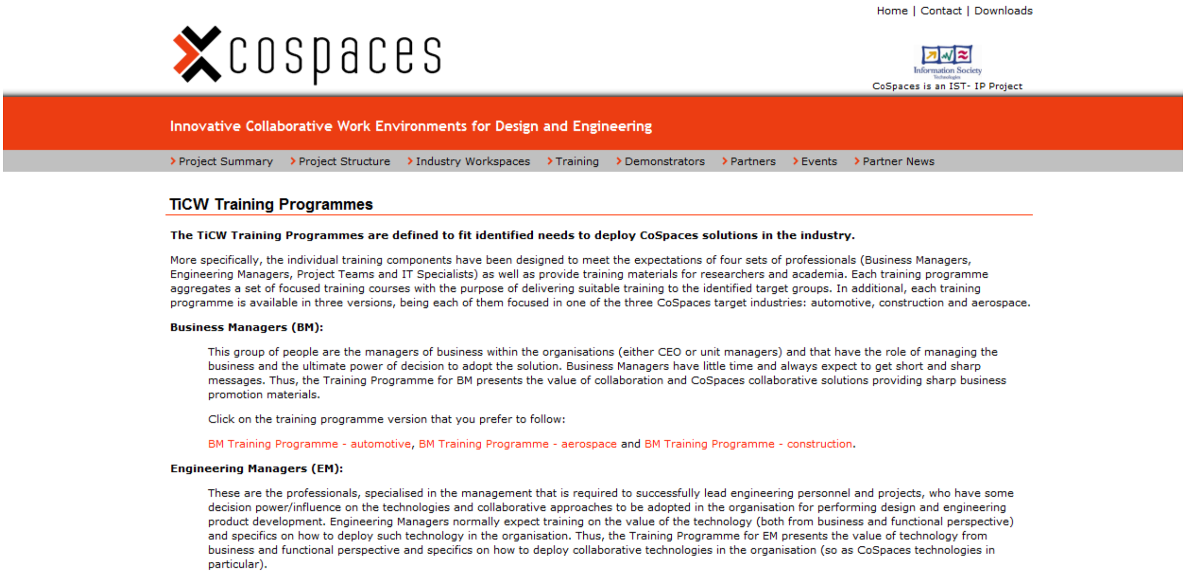


Figure 5.14 – TiCW User interface – Part1

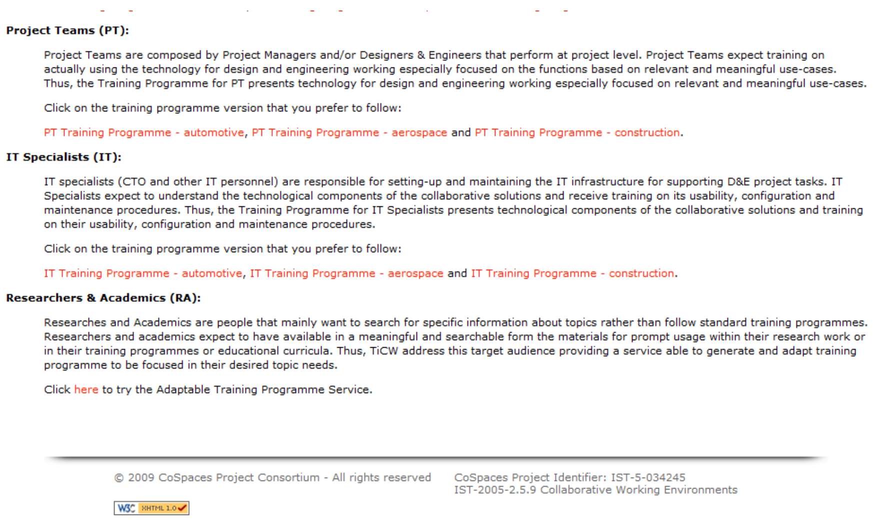
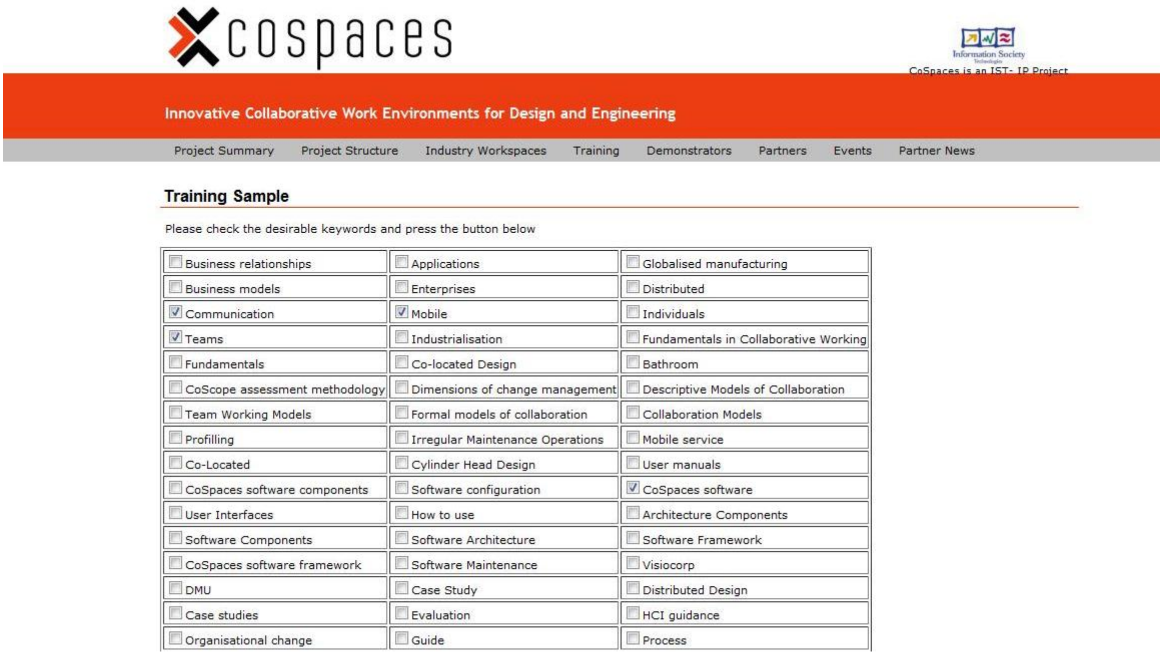


Figure 5.15 – TiCW User interface – Part2

After following the link it is firstly presented to the user a list of all the available keywords. The user can select the ones that he/she could be interested in. After a submission, a training programme is prompted on the fly, adapted to the choice. A list of training modules is then presented. With such a list, the trainee could follow a training programme adapted to his/her interests. The following presents an example [73]

The Figure 8.14 bellow illustrates the first step: the user select a set of concepts. In this case, the concepts are: ‘Communication’; ‘Teams’, Mobile and ‘CoSpaces Software’.



Business relationships	Applications	Globalised manufacturing
Business models	Enterprises	Distributed
Communication	Mobile	Individuals
Teams	Industrialisation	Fundamentals in Collaborative Working
Fundamentals	Co-located Design	Bathroom
CoScope assessment methodology	Dimensions of change management	Descriptive Models of Collaboration
Team Working Models	Formal models of collaboration	Collaboration Models
Profilling	Irregular Maintenance Operations	Mobile service
Co-Located	Cylinder Head Design	User manuals
CoSpaces software components	Software configuration	CoSpaces software
User Interfaces	How to use	Architecture Components
Software Components	Software Architecture	Software Framework
CoSpaces software framework	Software Maintenance	Visiocorp
DMU	Case Study	Distributed Design
Case studies	Evaluation	HCI guidance
Organisational change	Guide	Process

Figure 5.16 – CoSpaces Training Keywords List

After pressing the available button, a suggested training programme is displayed. It is composed by all the modules that contain the selected keywords and the recommended precedence's of them. This suggested training programme presents the modules ordered accordingly to a pre-determined sequence, resulting from the position of the modules in its course and the course in the curriculum. Thus, the trainee will start with the more basic training modules and progress to the more advanced ones. The result is displayed in the figure bellow. [73]

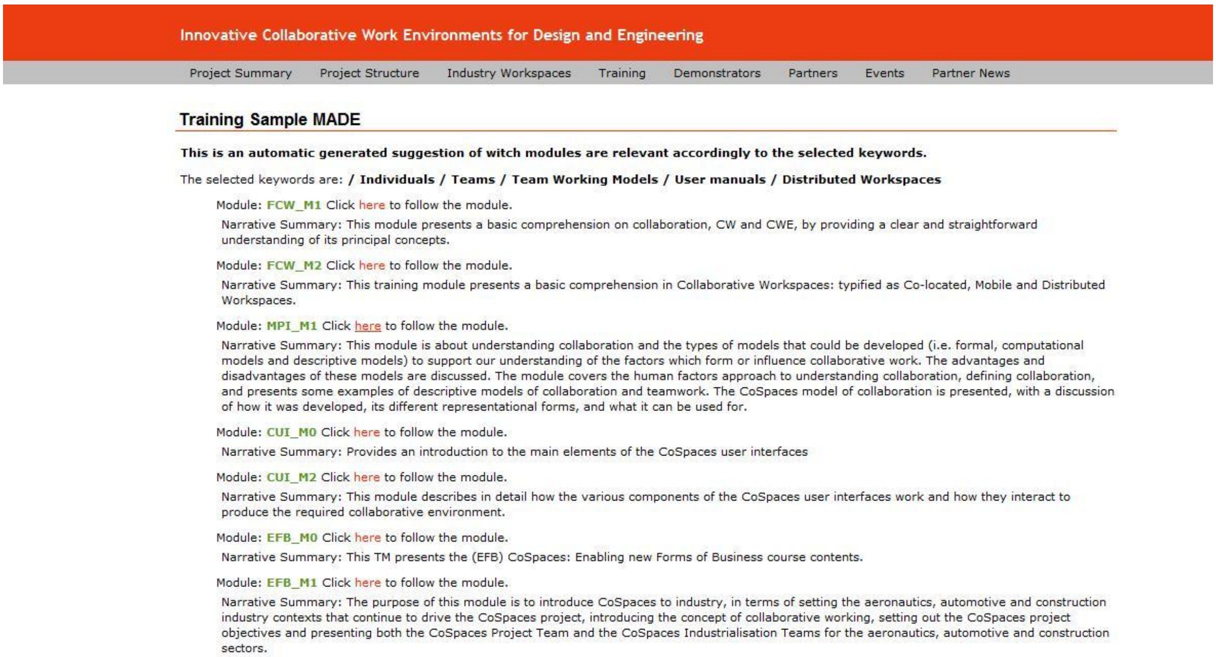


Figure 5.17 – Example of an adaptable training programme composition

On this sample, the trainee will follow respectively the modules: FCW_M1; FCW_M2; MPI_M1; CUI_M0; CUI_M2; EFB_M0 and EFB_M1. All the modules are presented with their short description. These modules are available in a flash based format (same format as the developed courses and programmes). [73]

The demonstrator was considered a success among the CoSpaces Project and the sentence: “Tangible efforts on training aspects & materials have been done”, referring to the training part of the CoSpaces Project where the demonstrator of this dissertation was inserted, is found in the final review report. [75]

In the CoSpaces Project it was also referred the demonstrator as a functionality available: “In additional there is an extra functionality that is focused in defining adaptable training programmes on the fly. Such functionality is dedicated to Researchers & Academics people needs, since they mostly prefer to have training focused in a specific research topic rather than have a profile dedicated training programme.”[73]

5.2.3. Dissemination and Hypothesis Validation

The usage in the CoSpaces Project proves that it is possible to improve e-training development with such application and intentional validation with the publication of the paper: [Sarraipa J., Figueiredo D., Maló P. and Jardim-Gonçales R.; “An Inter-Organisational approach to Industrial e-Training”; The Summer 4th International Conference on Knowledge Generation, Communication and Management: KGCM 2010] supports the dissemination procedure.

Concerning the research question, the author gave evidence that it is possible to automatically generate a course depending on the profile of a trainee and its needs with the usage of a knowledge base system. In line with the hypothesis of this dissertation, by modelling the training system model in an OWL ontology it was possible to implement an architecture for the description and categorization of training components.

The implementation of an automatic orchestration of courses according to the user needs together with the suggested methodology, allows a capable development of training courses and materials. Thus, conceding a significant flexibility in e-training development, deployment and reuse of the materials available. These factors lead to an easier maintenance of the training system as well as downsizing costs, which are key factors in the e-training acceptance of industry.

6. CONCLUSIONS AND FUTURE WORK

This dissertation proposes a methodology for a simple and faster way of developing content training materials, courses and programmes, which was published in the paper [21]. Furthermore, it was developed a demonstrator that enables the generation of adapted courses according to the trainee profile, or/and through a specific topic.

The platform developed to enable the automatic generation of the mentioned adapted courses, is constituted by a set of services that uses reasoning mechanisms over a knowledge model, represented by an ontology, which represents all the training curriculum elements involved, such as topics, modules, courses, profiles, etc. Such reasoning supports the creation of adapted courses specified by the choosing of specific topics (keywords) or/and by the trainee profile. The demonstrator was built under the European funded CoSpaces Project, which received a remarkable positive feedback from its reviewers. Thus, it can be stated that such demonstrator was a success. For this purpose the author recognizes and thanks the CoSpaces Project for the great connection that his Master Thesis had with the project and also recognizes the importance of the CoSpaces training contents access availability.

In additional, the author analysed that training courses should use the standards (e.g. SCORM) as guidelines. However the solution didn't use SCORM because it would require a more complex modulation with the insertion of fields within the model that aren't relevant to the demonstrator. Throughout the implementation the author analyzed with caution each development in order to keep a balance between the simplicity of use, the functionalities that the application would take and the possibility that in the future the implementation could be turned into a SCORM complaint application.

Regarding the future work, the base concepts existing in SCORM are present in the implementation, and it is possible, by increasing the complexity of the model, to build a SCORM complaint solution. For example, with the adoption of the IMS Simple Sequencing (one of the standards used by SCORM), it will be possible to 'jump' between modules and generate courses where the trainee would proceed to a more advanced part of the course accordingly to his/her assessment. It can also be possible to insert the application in a LMS like MOODLE. For that, several functionalities such as improving the dynamism in keywords selection can be added. In this example, a trainee could receive recommendations on topics that colleagues from the same class are also taking.

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8. ANNEXES

8.1. Course and Modules Synopsis Example

8.1.1. Fundamentals in Collaborative Working (FCW) Course Synopsis

FCW Course's Synopsis	
Title	Fundamentals in Collaborative Working
Narrative Summary	The course FCW main objective is to endow students with the basics and scope of Collaborative Working (CW). It is designed as an introduction to any participant to concepts of collaboration, collaborative workspaces and ICT-enabled CWE. The course also provides insights on collaboration from an industry perspective and the key elements to successful collaboration. CoSpaces is presented at the end as the way forward.
Keywords	Fundamentals; Collaboration; Collaborative Working; CWE
Target Group(s)	All
Target Industries	All
Objectives	This course main objective is to endow the students with the basics and scope of Collaborative Working and Collaborative Engineering.
Student Requirements	None
Technical Requirements	None
Recommended Precedence	None
Estimated Time	50 minutes
Modules	Introduction to FCW Course; Basics to Collaboration in D&E; Collaborative Working Environments; Views on Collaboration; Key to successful Collaboration; CoSpaces Project;
Contact Person	Pedro Maló, UNINOVA, Portugal – pmm@uninova.pt
Hard skills - Know	Basics definitions about collaboration in Designer & Engineering; Historical basis of Workspaces; Overview on the actual stage of collaborative working in the CoSpaces industrial sectors, and the barriers that could appear in the move to the collaborative working; Key solutions to improve collaborative working; CoSpaces project can provide solutions to improve collaborative working.
Skills – Do	Confront own current working environments against future ambitions in

	view of collaboration needs, possibilities and barriers.
Skills – Be	Be open to get in ideas related to collaborative working.

8.1.2. Module 0 - Introduction to FCW Course

Title	Introduction to the FCW Course
Narrative Summary	This training module presents the (FCW) Fundamentals in Collaborative Working course contents.
Keywords	Introduction; Fundamentals in Collaborative Working; FCW
Target Group(s)	All
Target Industries	All
Objectives	This TM main objective is to endow the students with the main topics of this course.
Student Requirements	None
Technical Requirements	None
Recommended Precedence	None
Estimated Time	1 minute
Input Content	D66; D104
Contact Person	João Sarraipa, UNINOVA, Portugal – jfss@uninova.pt
Hard skills - Know	Introductory information to the FCW Course
Skills – Do	N/A
Skills – Be	N/A

8.1.3. Module 1 - Basics on Collaboration and Definitions

Title	Basics on Collaboration and Definitions
Narrative Summary	This module presents a basic comprehension on collaboration, CW and CWE, by providing a clear and straightforward understanding of its principal concepts.
Keywords	Basics; Collaboration; Definitions
Target Group(s)	All
Target Industries	All
Objectives	Provide basic knowledge about Collaboration and its definitions/concepts
Student Requirements	None
Technical	None

Requirements	
Recommended Precedence	None
Estimated Time	10 minutes
Input Content	CoSpaces D3_D4; Article 'Concept of collaboration (2008)' Camarinha-Matos, L.M., Afsarmanesh, H.;
Contact Person	Pedro Maló, UNINOVA, Portugal – pmm@uninova.pt
Hard skills - Know	Basic concepts and ideas of Collaboration, CW and CWE
Skills – Do	N/A
Skills – Be	N/A

8.1.4. Module 2 - Collaborative Working Environments

Title	Collaborative Working Environments
Narrative Summary	This training module presents a basic comprehension in Collaborative Workspaces: typified as Co-located, Mobile and Distributed Workspaces.
Keywords	Collaborative Workspaces; CWE; Co-located Workspaces; Mobile Workspaces; Distributed Workspaces;
Target Group(s)	All
Target Industries	All
Objectives	Provide knowledge about Collaborative Working Environments (CWE).
Student Requirements	None
Technical Requirements	None
Recommended Precedence	Module 1 – "Basics to Collaboration in Design & Engineering"
Estimated Time	6 minutes
Input Content	CoSpaces D1; Jarmo Suominen, Professor UIAH/MIT (2005) - "demand or desire"; and Future_workspaces Roadmap Summary, project (IST-2001-38346).
Contact Person	João Sarraipa, UNINOVA, Portugal – jfss@uninova.pt
Hard skills - Know	Historical overview of Workspaces; Types of Collaborative Working Environments and its characteristics;
Skills – Do	N/A
Skills – Be	N/A

8.1.5. Module 3 - Views on Collaboration

Title	Views on Collaboration
Narrative Summary	This module provides insight views on collaboration set around the three reference industries for CoSpaces: Construction; Automotive and Aerospace.
Keywords	Collaboration; Construction; Automotive; Aerospace.
Target Group(s)	All
Target Industries	All
Objectives	Endow students with the comprehension on the generic (to all industries) and specific (to automotive, aerospace and construction) views and needs in respect to collaboration, collaborative design and engineering and associated opportunities, challenges and risks.
Student Requirements	None
Technical Requirements	None
Recommended Precedence	Module 2 – "Collaborative Working Environments"
Estimated Time	40 minutes
Input Content	CoSpaces D1; CoSpaces D5; eBusiness Watch Reports
Contact Person	João Sarraipa, UNINOVA, Portugal – jfss@uninova.pt
Hard skills - Know	Collaboration views from manufacturing industries; Collaboration views from Automotive; Collaboration view from Aerospace; Collaboration view from Construction.
Skills – Do	N/A
Skills – Be	N/A

8.1.6. Module 4 - Key to successful Collaboration

Title	Key to successful Collaboration
Narrative Summary	The training module explores into the key element that make collaboration a success. It stresses the need to focus on a human-centred approach to collaboration as the way for fruitful and all-inclusive collaboration processes. Then it addresses collaborative technologies as the underpinning technological support for collaboration and collaborative processes.
Keywords	Success; Collaboration; Collaborative technologies

Target Group(s)	All
Target Industries	All
Objectives	
Student Requirements	None
Technical Requirements	None
Recommended Precedence	Module 3 - Views on Collaboration
Estimated Time	10 minutes
Input Content	CoSpaces DoW; CoSpaces D5;
Contact Person	Pedro Maló, UNINOVA, Portugal – pmm@uninova.pt
Hard skills - Know	Overall comprehension about the key elements for a successful collaboration; General understanding of the concept of human-centred collaboration; Broad notions on collaborative technologies concepts and types.
Skills – Do	N/A
Skills – Be	N/A

8.1.7. Module 5 - Cospaces Project

Title	CoSpaces Project
Narrative Summary	This training module gives an introduction to the CoSpaces Project emphasizing what the industry people could get from it. The TM focuses on aspects of the CoSpaces project such as project objectives, relevance, industrial impact, validation workspaces, real innovation and delivering value.
Keywords	CoSpaces Project; Collaborative Workspaces;
Target Group(s)	All
Target Industries	All
Objectives	Provide information about what Industry and researchers could get from the CoSpaces project.
Student Requirements	None
Technical Requirements	None
Recommended Precedence	Module 4 - Key to Successful Collaboration
Estimated Time	10 minutes
Input Content	CoSpaces DoW; CoSpaces D29; CoSpaces D69;
Contact Person	Pedro Maló, UNINOVA, Portugal – pmm@uninova.pt

Hard skills - Know	CoSpaces project objectives, relevance, industrial impact, validation workspaces, real innovation and value delivery.
Skills – Do	N/A
Skills – Be	N/A