The Enhancement of Reusability of Course Content and Scenarios in Unified e-Learning Environment for Schools

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Abstract: With the expansion of e-learning, the understanding and evaluation of already created e-learning environments is becoming an extremely important issue. One way to dealing with the problem is analysis of case studies, i.e. already created environments, from the reuse perspective. The paper presents a general framework and model to assess UNITE, the unified e-learning environment for schools, from the reuse perspective. UNITE is the e-learning environment of the ongoing EU project (FP6 IST-26964, 2006-2008, http://www.unite-ist.org/). UNITE assets are described using feature diagrams (FDs) telling us about the internal structure of UNITE; representing relationships among the compound and atomic features, thus enhancing better transparency of UNITE and in this way empowering reuse. The factors of UNITE influential to reuse with some concrete results are also presented. We provide analysis aiming to extract from the model the relevant information of two kinds: (1) which is influential to reuse in a positive sense, i.e., enhancing reuse (e.g., application of meta-design methodology for the scenarios description, classification of subjects in metadata, use of content management tools (e.g., Course editor, Metadata editor), multi-linguistic approach, international and local collaboration between teachers and students in e-learning scenario implementation and delivery, and methodological support, etc.) and (2) which is hindering reuse (e. g., age of the students, differences in national syllabus and national educational programmes, language, cultural and communication problems). Despite of some limitations of FDs, we found this notation useful because it allows the explicit representation of various aspects of the complex system (i.e., UNITE) focusing on variability of features and possible relationships and constraints. We focus on the aspects such as evaluation of the UNITE platform including tools, scenarios and content variability.

Keywords: Computer supported learning, e-learning environment development, meta-design, mobile learning, reusability

1. Introduction

Today e-learning is a normal practice in a variety of corporative and governmental organizations, including universities and secondary schools world-wide. With the expansion of e-learning, the understanding and evaluation of already created e-learning environments is becoming an extremely important issue. As e-learning environments relate not only to technology but also relate to many other factors (e.g., pedagogical, organizational, social, etc.), the evaluation of efficiency of such environments is indeed a very complex problem. One way to dealing with the problem is analysis and evaluation of case studies (i.e., the already created environments or their constituents) from the reuse perspective. A motivation of the reuse-based approach is as follows: if created e-learning assets within an environment are reusable and we can in somewhat way to measure the extent of their reusability, either quantitatively or qualitatively, then one can reason about efficiency of the environment per se.

The aim of this paper is, using the introduced general framework and a model, to assess UNITE, the unified e-learning environment for schools, from the reuse perspective. UNITE is the e-learning environment of the EU project (FP6 IST-26964, 2006-2008, http://www.unite-ist.org/) based on three technologies: Microcosmos (e-learning management, Extreme Media Solutions Ltd.), MTS-Infopool (content management of SCORM-compliant courses, Fraunhofer-Institut für Graphische Datenverarbeitung) and m-learning (Cambridge Training and Development). The distinction of the project is the evaluation of sustainability and degree of deployment of project's results through the creation of the UNITE network of schools (NoS). Physically, the NoS consists of 14 schools from 10 European countries with 46 teachers and 512 pupils involved in the project. The NoS provides a social and environmental basis for the investigation and validation of the UNITE framework, i.e., the technological platform, the pedagogical models (Granić 2007, Cukusic 2008), and the e-learning scenarios (Zoakou 2007) that are created, integrated, populated and used in the UNITE schools. Thus the above stated features are enough to provide the evaluation for reusability.

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In this paper, we describe: 1) a framework reuse-based analysis and evaluation of e-learning environments, which is independent of the environment; 2) a feature-based model that describes dependences of reusable assets within the given e-learning environment and 3) with the help of the model, evaluation of reusability of the assets by analyzing critical factors which enhance and those which hinder reuse.

The paper is organized as follows. Section 2 analyzes related works and reusability issues in e-learning. Section 3 presents a general framework for reuse-based analysis of e-learning environments. Section 4 describes a model based on using feature diagrams for representing reusable assets in the UNITE e-learning framework. Section 5 delivers a case study of the implementation of the model and analysis of factors influential to reuse. Section 6 presents the evaluation and discussion on the topics. Finally, Section 7 ends with conclusions.

2. Related works and reusability in e-learning domain

We categorize basic related works into three research streams: 1) approaches that deal with e-learning environments at schools; 2) analysis of reuse-based strategies for e-learning within the meta-design approach; 3) reusability of e-learning content and scenarios.

Stream 1 There are many announcements on tools and systems that are dedicated for e-learning at schools. Examples are Blackboard (http://www.blackboard.com), Moodle (http://moodle.com), ILIAS (ILIAS http://www.ilias.uni-koeln.de/ios/index-e.html), Atutor (http://www.atutor.ca), Claroline (http://www.claroline.net). As the development of the large software system is a complex process that, in general, requires several iterations until the produced system fulfils requirements of the intended user community, social aspects are as important as technical ones (Nikolova et al. 2007).

Stream 2 For supporting a wide variety of e-learning systems a flexible framework is required, which is adaptable to the learning content and knowledge processes that are not static, but evolve dynamically over time. Such a framework has to describe a wide range of evolutionary changes that can be supported in the system itself by empowering the users to participate in setup, customization, and evolution of the system, thus bringing users domain expertise into the system. In this context, G. Fischer and E. Giaccardi propose the idea of meta-design, where social creativity can be supported by innovative computer systems that allow all users to contribute to framing and solving design problems collaboratively and act as designers (Fischer and Giaccardi 2004). For socio-technical systems to effectively support collaborative design, they must adequately address not only the problem situations, but also the collaborative activity surrounding the problem (Fischer 2007).

Niederée et al. describe taxonomies that are a well-established instrument for organizing and accessing resources in Information, Content and Knowledge Management (ICKM) systems. Taxonomies contribute to a common understanding and an improved communication in the user community by fostering the development and usage of a shared vocabulary. Authors present a meta-design framework for systematically supporting the user in the setup, customization and evolution of Web-based ICKM system instances, which is based on a model-based domain construction approach (Niederée et al. 2002).

The need for effective methods to capture, represent and communicate design knowledge remains pressing. High level principles, such as those provided by constructivism, are not sufficient in themselves. T. Boyle provides the concept of Patterns for Learning (PALs) (Boyle 2000). These are re-usable design patterns that can be applied in the development of computer supported learning environments. The paper discusses how PALs may be extracted to capture and represent design knowledge. It is argued that these re-usable design patterns provide a productive currency for meta-design, the theoretical discourse about design.

D. Kaplan, J.Youm & D. Shaenfield describe the design for a meta-authoring tool capable of generating domain-specific learning activity across a variety of instructional designs. MetaTool supports a collaborative authoring of instructional technology and facilitate research into how, when and why certain sets of instructional design components are educationally effective in particular contexts. The end result is an open architecture developed using an object-oriented methodology and participatory design that is modifiable and extendable (Kaplan, Youm & Shaenfield 2003).

The use of metadata is an instrument enhancing reuse. R. Or-Bach discusses considerable efforts in the computer-mediated learning field towards standardization of metadata elements to facilitate a common method for identifying, searching and retrieving learning objects. There are ongoing debates regarding the issues of granularity of learning objects and the vocabulary in learning object metadata schemas (Or-Bach 2004).

Maule, R. (2001) presents a conceptual model and content framework to aid in the linkage of cognitive variables, to the meta-cognitive attributes of those variables, and related metadata for the design of the presentation media. Instructional designers seeking to provide mediated instruction to target specific learning strategies, in specific target markets, or for specific individuals, may use the framework to help align the design elements comprising the instructional presentation, with the meta-cognitive learning styles of the target population, with the cognitive variables governing the subject matter presentation.

Stream 3 Sommaruga proposes an approach to the creation of re-usable and adaptable learning content objects. The RUC prototype demonstrates how starting from the same basic content it is possible to produce three different results: a synthetic presentation in the form of slides, a detailed presentation in the form of scientific report, and an assessment presentation in the form of test. The use of the XML technology allows content structures to be defined at different levels of abstraction and content to be separated from presentation. Therefore the same content can be adapted to different pedagogical contexts. By focusing on the definition of structures for learning content objects, the RUC prototype can give a significant contribution to the SCORM standard to further increase reusability and adaptability at a lower level of granularity (Sommaruga 2004).

Pferdt, F. & Dilger, B. focus upon the concept of the reusability of learning objects. In their point of view a dilemma occurs through the different perspectives of the technological and educational discipline involved. The paper offers ideas from an educational perspective and shows three approaches which allow get out of the dilemma situation (Pferdt & Dilger 2006).

Strijker analyses the use of databases assigning resources to users with changing access rights and raises the following issues: How will the information be presented to the right users? How can resources be reused for different audiences and how should access rights be provided? Who has the right to change? Who can read it and who is owner of the objects in a resource base (Strijker 2000).

This short study shows that reusability in e-learning has many aspects and they should be thoroughly studied in some well-established manner. In the further discussion, we provide a framework and a model to evaluate reusability aspects in e-learning environments.

3. A framework for reuse-based analysis of e-learning environments

The need for such a framework is motivated by the fact that 1) reusability and e-learning are two sides of the same coin; 2) any project and its results (e.g., e-learning environment) should be founded on a well-defined framework (i.e., integration and use of technology, pedagogy, and e-learning scenarios within some network of organizational structure (e.g., departments, schools, etc.). The framework we suggest includes the following items:

- A1) Identification of the scope (boundaries) of reusability and levels within the scope;
- A2) Identification of reusability aspects to be considered; and
- A3) Introduction of some measures to evaluate reusability for each aspect.

A1.Boundaries of reuse is pre-specified by the scope of the organizational structure within which the e-learning environment is exploited (in our case by NoS). There are three levels within the network: internal for each school; national and international.

A2.Three aspects are important to deal with reusability in e-learning: technical, non-technical and pedagogy-related ones. The latter includes content, scenarios and pedagogical approaches used to deliver the content. Of course, pedagogy-related aspects are non-technical aspects, but we suggest considering them separately because of their importance for learning (e-learning). By doing so, we see a difference between reuse in software engineering (where only technical and non-technical aspects are under consideration (Lim 1997) and reuse in e-learning.

By technical reusability in e-learning we mean a) various kinds of tools used to support e-learning, which may include documentation (e.g., guidelines, instructions, etc.) saved in a repository, repositories per se and their managing software, software that support compositional, representative and generative aspects (e.g., editors, composers, generators, etc.), conventional tools integrated into e-learning environment (including HW, OS and Web); b) mode of the use of tools and devices (e.g., computers, internet, mobile devices, etc.).

By non-technical reusability in e-learning domain we mean standardization initiatives, Intellectual property protection, dissemination (knowledge transferring), organizational, managerial, economical, financial, social aspects (e.g., teachers and students motivation, communication between various shareholders, etc.).

We hope that this framework describes the general understanding of reusability in the e-learning and it can be used in various e-learning environments. The most crucial part of the framework is of how to measure and evaluate the extent of reusability. The measures should be considered separately for each aspect and can be expressed either quantitatively or qualitatively. However, some measures may be common for different reusability aspects e.g., number of users, frequency of usage (scenarios, tools, and software), scope of the content, scope of the scenarios used, scope of usages (scenarios, content) in the mode 'use-as-is', scope of usage with modification, etc.
As reusability has many dimensions, it is very difficult to encounter the possible measures in general. Below we present those that were applied to evaluate reusability within the UNITE environment.

A3. Measures are subdivided into three categories as follows.

Measures for pedagogy-based reusability include the following items:

- Scope of the content (scenarios) used without changes (except translation to other language)
- Scope of content adaptation
- Scope of the use of scenarios and content for m-leaning
- Teachers', students', experts' opinion about scenarios and content
- Number of different languages used to deliver the content
- Number of places (outside classrooms) where scenarios were used
- Measures and procedures applied to validation of content and scenarios.

Measures for technical reusability of UNITE tools include:

- Reusability of documents (guidelines, quality measured by degree of structuring, completeness, conciseness, use of templates);
- Reusability of software (easiness of use (how much integration of helps, prompts), intuitive interfaces, level of automation, quality of software)
- Reusability of information pool (UNITE repository, how separation of concerns are implemented, how easily a user can storage items, of how effective search of information is, etc.)
- Size of the repository for one user
- Number of eLearning standards applied (SCORM)
- Complexity, taxonomy of content and metadata
- Number, quality of features that are supported by the developed tools
- Representation formalism for knowledge sharing and dissemination
- Of how integration of various aspects are supported by the UNITE editor (course editor)

Measures for non-technical reusability. Though for this kind of reusability can be applied various measures, we restrict ourselves by providing specific measures used in UNITE for social-economics evaluation such as:

- Readiness index of a school to be involved in the project (at the beginning of the project)
- Teachers courses (in the 18 month of the project)
- Readiness index of a school to use the environment (after the end of UNITE).

In general, the scope of usability of UNITE is the integration of various reusability aspects.

4. Model for description of reusability in UNITE e-learning framework

We analyze the e-learning from the perspective of engineering, therefore we composed the common model of the UNITE framework. This model can be viewed as a specialization and instantiation of the framework described in Section 3. To represent the model, we used Feature Diagrams (FDs) (see Figure 1) for representing results of analysis, i.e. UNITE e-learning environment, because FDs are simple and allow expressing non-functional aspects too. Our goal is to take into account variability of features (e.g., web-based and mobile tools, scenarios, content etc.) Our efforts have concentrated on the evaluation of the UNITE platform including scenarios and content variability.

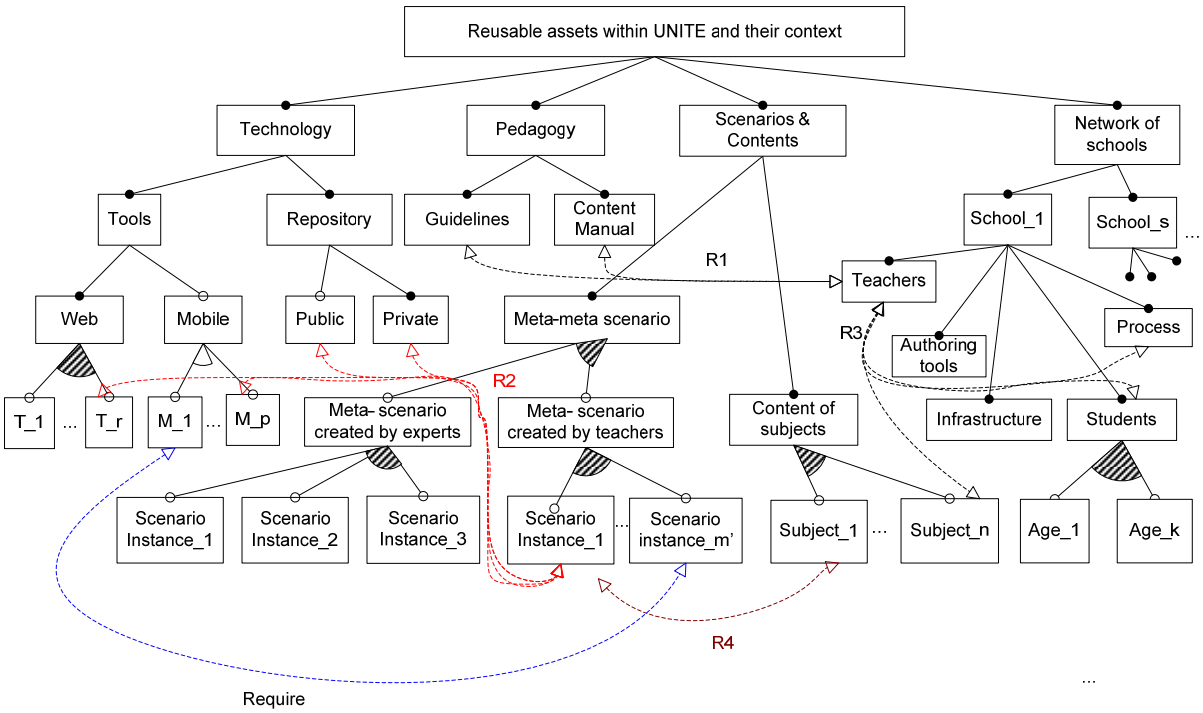

Figure 1: Feature diagram as a model for representing UNITE reusable assets and their relationships

A conventional FD [Kang et al, 1998; Schobbens et al, 2006] is a tree-like directed acyclic graph, in which the root represents the initial concept (also referred to as domain), intermediate nodes represent compound features, and leaves represent non-decomposable atomic features that may have values (aka variants); branches represent the parent-child relationships among compound features or among compound features and atomic features. Furthermore, some additional relationships such as constraints (e.g., <require>, <mutual exclusion>, etc.) between leaves derived from different parents are identified.

FDs are a graphical notation. Features are denoted by boxes. Features differ in types. There are mandatory, optional and alternative feature types. Mandatory feature is the one which always is selected (it is marked by a black circle above its box). Optional feature is the one which may be selected or not. Alternative feature is the one which is selected depending on some alternative (condition). Both are marked by a white circle above its box (see Figure1). The white arc means that only one optional feature can be selected while interpreting the model. The darken arc means that any number of optional features can be selected.

The following features such as web-based tools (abstractly denoted as T_1,…, T_r) , mobile-based tools (denoted as M_1,…,M_p), scenario instances developed by experts (Instance_1, _2 and _3), scenario instances developed by teachers (Instance_1, _2,…, _m), Subjects (_1,…, _n), student ages (age_1, …, age_k) are atomic features.

The most crucial part of the model is relationships among atomic features. They are specified as R1 (teacher uses Guidelines and Content manual developed by UNITE experts), R2 (scenarios instances & scenario content created using tools are stored in the public or private repository), R3 (teacher has students and subjects connected via the learning process), R4 (content of the subject implements a

scenario). Also the model delivers some constrains, e.g.: scenario instance_m requires mobile tool M_1; students are not allowed to create scenarios (this constraint is not shown in Figure 1). The concrete description of realization of some relationships is presented in the Section 5.

Benefits of the introduced model are as follows: a) it describes hierarchy of features thus telling us about the internal structure of UNITE; b) it describes the parent-child relationships among the compound features, thus enhancing better understanding of UNITE and in this way empowering reuse; c) it describes the relationships between atomic features, thus tending to represent functional dependencies of UNITE.

5. Some relationships of UNITE features and their reusability: A case study

We analyse the implemented relationships with reuse in mind. Table 1 presents the scope of reuse (i.e., NoS) and some characteristics of NoS. Table 2 summarizes web-based and mobile tools, pedagogical guidelines and manuals in national languages, i.e. multi-linguistic interfaces that enhance reuse.

Table 1: Quantitative characteristics of the network of schools participated in the project

Some quantitative characteristics of the NoS	Amount
Countries: Bulgaria (BG), Croatia (HR), Cyprus(CY), United Kingdom (UK), Germany (DE), Greece (GR), Latvia (LT), Lithuania (LT), Malta (ML), Slovenia (SLO)	10
Number of schools	14
Number of teachers participated	46
Number of pupils in age 11-19 years involved	512
Number of classes participated	26
Number of e-scenarios implemented in schools	40
Average number of hours spent by one teacher for scenario implementation	42
Number of national languages for scenarios and content (all except Malta & Cyprus)	8
Number of metadata were added into the repository of learning objects	254

Table 2: Use of multi-linguistic approach to enhance reuse of *UNITE tools* (relationships R1 & R2)

UNITE tool or guideline	Languages						Number
Interface of platform	EN	GR	DE		LT	HR	5
Course Editor	EN	GR	DE		LT	HR	5
Mediaboard	EN	GR	DE		LT	HR	5
PPC authoring tool	EN	GR	DE		LT	HR	5
PPC player	EN	GR	DE		LT	HR	5
SMS authoring tool	EN	GR	DE		LT	HR	5
Evaluation forms	EN	GR	DE	BG		HR	5
Platform guides	EN	GR	DE	BG		HR	5
Pedagogy guides	EN		DE	BG		HR	4

Table 3 represents relationships R2 among the following authoring tools that were provided for teachers for the content development:

- Text processors: Unite tools (Course editor, Metadata editor, HTML editor), PowerPoint, Word, FrontPage, Dreamweaver, Acrobat.
- Subject specific: Excel, MathCad, Pocketslide, Access.
- Image makers: Photoshop, Paint, IrfanView.
- Video makers: Movie maker, Flash.

Examples of specific UNITE e-learning scenarios created, implemented and delivered by teachers: Geography and History – Historical heritage of Trbovlje; Ecosystem; The human being: Nutrition and digestion; Social Sciences: Youth crime; Teenage Well-being - Student Research Project; Elective course scenario: 'Wonderful World of Inventions'; English – Famous Authors (Zoakou et al, 2007).

Table 3: *Tools* used by teachers and students in UNITE scenarios implementation (relationship R2)

Authoring tools	School country: GR	No. of sch.: DE	BG	SLO	UK	LT	LT	CY	ML	HR	
Text processors	x	x	x	x	x	x	x	x	x	x	10
Subject specific					x	x	x	x	x	x	5
Image makers			x	x			x		x		4
Video makers	x					x	x		x		4

Table 4 describes where and for what purpose mobile devices were used by students in e-learning scenarios outside the classroom (in library, in museum, in factory, etc.) (Relationship R3).

Table 4: Places where students have performed learning activities

Places were students performed activities	School country: BG	CY	HR	DE	GR	LV	LT	ML	SSLO	UK	No. of sch.
School	x	x	x	x	x	x	x	x	x		9
At home	x		x	x		x	x	x		x	7
Outside (to take pictures, to play learning games, to answer quizzes 'on move')	x	x	x		x	x	x	x	x	x	9

The content can not easily be re-used due to the fact that teachers are not from the same domain and the domain is not really generic (like science). Table 5 presents a controlled vocabulary of metadata, classification of subjects in metadata in order to enhance reuse:

Table 5: Characteristics of pedagogy-based reusability (categories of metadata) for content and scenarios reuse in UNITE (R4 relationship)

Metadata category	School country: BG	CY	HR	DE	GR	LV	LT	ML	SLO	UK	No. of sub.
Biological Sciences	1			1							2
Economics and Social Science			1							1	2
Humanities			1								1
Languages, Linguistics and Cultures	1	2		2	1	1	1	2	1		11
Mathematical and Computing Sciences	1	1	2	4		2	2	2	1		15
Physical Sciences	2	1	2		1			2	1		9
No. of subjects per country	5	3	6	7	2	3	3	6	4	1	40

The UNITE e-learning scenario template (meta-meta scenario) created by experts and based on JISC template (JISC, 2004) is used by teachers as creators of meta-scenario. Table 6 illustrates scenarios created using the UNITE template and different content in English that was translated into national languages to enhance reuse.

Table 6: Enhancing reuse of *UNITE learning resources* through the use of multi-linguistic approach

E-learning resources	Languages								Number
E-learning scenario description	EN		DE	BG		HR	LV		5
Learning content	EN	GR	DE	BG	LT	HR	LV	SLO	8

Factors that hinder reuse of e-learning resources (ITC, English, Environmental scenarios and content) are the ages of pupils. Characteristics of UNITE NoS relationship R3 is presented in Figure 2.

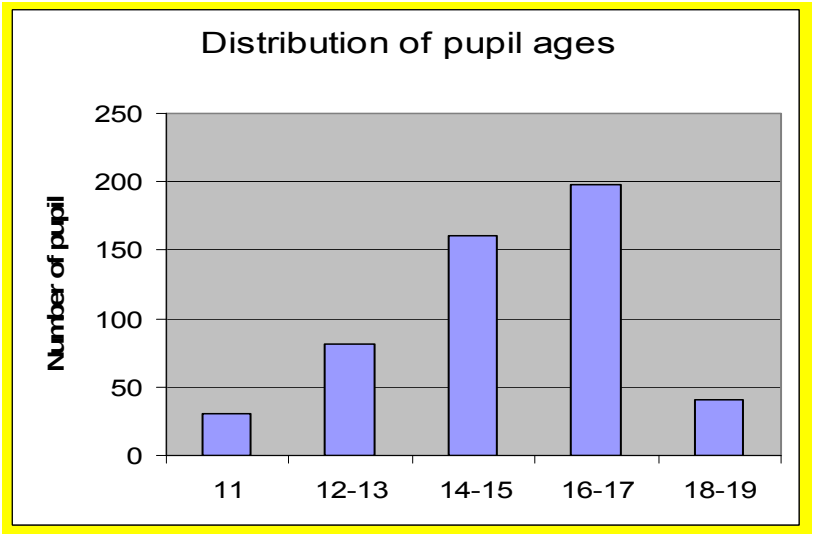

Figure 2: Content reuse: Ages of pupils as hindering factor of reuse

Table 6 and Figure 3 describe other characteristics of the non-technical reusability, such as international collaboration in e-learning.

Table 6: International collaboration in e-learning scenario implementation and delivery

	Name of the scenario			
Scenario	ICT in education	English language	Environmental	Student project
Collaboration type	Teachers	Teachers	Teachers	Teachers & students
School country	Bulgaria, Croatia, Lithuania, Slovenia	Germany, Malta	Cyprus, Greece	Lithuania, Croatia, England

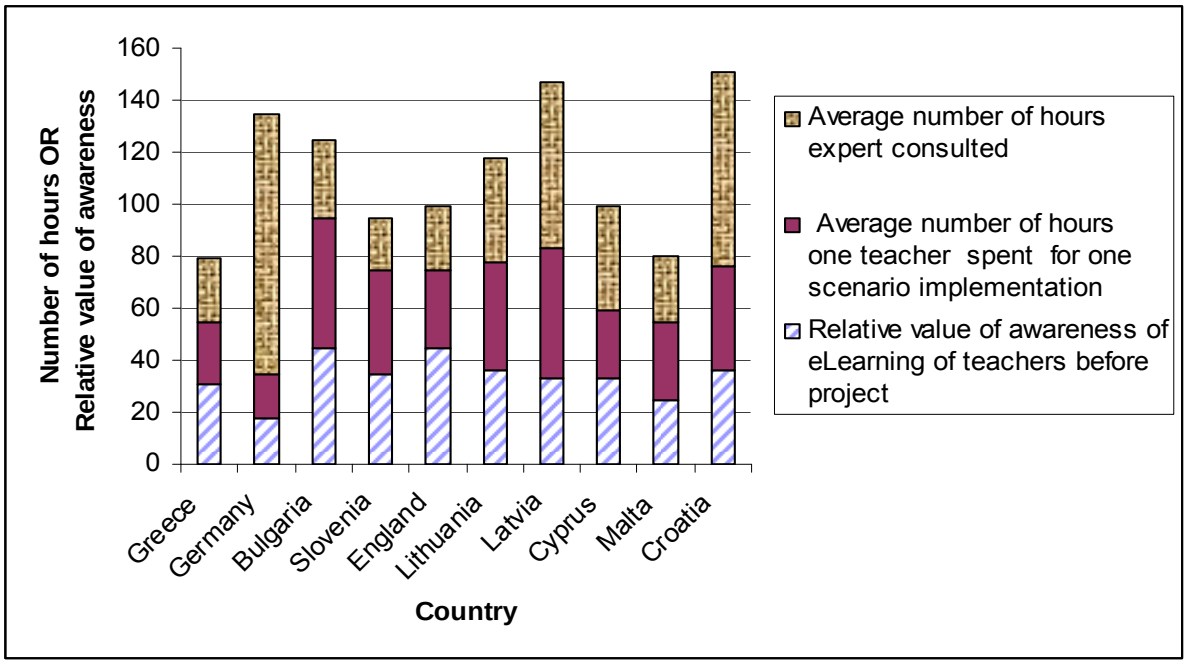

Figure 3: Interdependence of the efforts (hours spent) of teacher and his consultant in the process of implementation of the scenario and teacher awareness of e-learning in different schools

6. Summary, evaluation and discussion

We have suggested an environment-independent framework for analysis of a given e-learning environment to evaluate it from the reuse viewpoint. Although reusability in e-learning is recognized as a very important issue which is analyzed in a variety of different contexts, this is done usually in ad

hoc manner. Our contribution is a systematic framework enabling analysis, understanding and evaluation of the e-learning environment at a higher abstraction level, thus enhancing reusability. Within the framework, we have also presented a model as a case study to describe the structure and functionality of the concrete e-learning environment UNITE, the unified e-learning environment for schools implemented for European network of schools. The model represents essential characteristics of the environment, which are described and modelled using the feature concept and represented using feature diagrams. The feature–based model contains a feature hierarchy where intermediate nodes describe compound UNITE features under consideration and leaves represent atomic features. From the reuse perspective compound features and their derivatives, i.e., atomic features are categorized as pedagogy-related, technology-related and non-technical ones. The benefit of the model is the explicit representation of relationships among various kinds of atomic features, thus enhancing understanding and promoting reuse.

As it has been shown in (Štuikys et al, 2008A and 2008B), feature diagrams have much wider capabilities for e-learning domain because such a formalism is influential for reusability in various aspects (e.g., methodological, component-based and generative reuse). However, feature diagrams have also some limitations: in literature there are some discrepancies in syntactic representation of feature diagrams, the lack of tools that support semi-automatic drawing of diagrams; it also seems that relationships at a higher level are too abstract for practical use and we need to represent them at a lower level (e.g., using tables as it is done in our case study); furthermore, the e-learning community is yet not prepared to use feature diagrams at a wider extent.). Despite of those limitations of FDs, we found this notation useful because it allows also the explicit representation of various aspects of the complex system (i.e., UNITE in our case) focusing on variability of features and possible relationships and constraints.

We have identified factors that are enhancing reuse and those that are hindering reuse. Enhancing factors are: a well-defined pedagogical model for e-learning and m-learning, including guidelines for teachers, administrative support, generality and adaptability of scenarios (pedagogical ones); characteristics and capabilities of tools in the whole (technical aspects); the early involvement of teachers in the process, including such activities as participation in requirements for UNITE platform statement, training courses, participation in all phases of validation and acting as designers (e.g., development by teachers own scenarios and content); high-level managing and planning, multi-linguistic approach applied in the use of scenarios and content (non-technical reuse aspects that should be treated as the implementation of meta-design concepts); and finally the integration and coordination of all above stated.

As we have identified from our case study, factors that hinder reuse are: cultural differences in different countries, language barriers, students' ages, differences in curricula, motivating and self-motivating of using content developed by others.

7. Conclusions

Reusability of e-learning content has many dimensions; however, they can be categorized into three categories: pedagogical, technical and non-technical. It is impossible to discriminate the importance of each category separately: for general assessment, they should be considered in the whole, but for analysis and investigation purposes they are to be first measured and then evaluated separately. To do so we have proposed a general framework and a model for evaluation of reusability aspects and presented a case study to analyze the UNITE e-learning environment from reuse perspective. What is needed to further enhancement of reusability of the e-learning content is a more effective educational design by combining a number of resources designed; new policies and processes in schools, which support the culture of collaborative work environment and enable the recognition of this form of work.

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