

**Master Thesis**

**Analyzing Patterns for Reusing Web  
Teaching Materials**

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### **Abstract**

The Web has become the ultimate medium for information exchange amongst people by providing a wealth of digital educational resources which are readily available in numerous subject areas. This abundance of educational resources has led to an increased number of open content initiatives and an increase in the reuse and sharing of teaching materials all over the world, especially in the past few years. Teachers are able to reuse and prepare new tailor-made materials by adapting existing ones in order to create more effective learning experience for their students and improve the quality of their teaching practice.

However, current initiatives, in expanding the culture of sharing and reusing, have met with limited success because of the following problems.

**The presence of a wide range of e-learning products using different platforms** makes content sharing and composition between e-learning systems difficult. Sometimes, specific formats of teaching materials are inaccessible for modification and manipulation since they require the use of special software tools.

**The lack of available educational resources in minority languages for K-12 educational level**, besides the absence of affordable technical infrastructures and trained staff still stand in the way of developing countries' ability to move forward. The *UNESCO's Universal Declaration on Cultural Diversity (2001)* strives to decrease the dominance of the English language on the Web by encouraging mother-tongue teaching thereby promoting freedom of expression, media pluralism, multilingualism, and equal access to art, scientific and technological knowledge.

**The presence of technology-push solutions** which focus on resolving technical aspects like developing system interoperability specifications and metadata standards fail to understand teacher needs based on their behavior and practices for a successful adoption of these solutions.

The pattern language approach, which originally emerged in architecture in the 1970s and has since gained momentum and acceptance across diverse fields and disciplines, aims to capture expert knowledge to provide core solutions to recurring problems in our environment. It has only recently emerged in the field of education and e-learning and existing projects and initiatives focus on resolving problems within a pedagogical and learning environment context.

In order to solve previously stated problems, a user-centric approach is adopted in this thesis, together with the pattern language approach. A teacher survey carried out in Bosnia and Herzegovina with the aim of gaining a perspective of underlying barriers and motivators in reusing teaching materials, search strategies, selection criteria, and adaptations of existing Web teaching materials was used in developing a pattern language for reusing Web teaching materials. The resulting pattern language, which offers solutions to problems such as choosing, designing, editing, and sequencing teaching materials, is the first of its kind in this domain. Each individually-created pattern provides an explicit user workflow, which is further translated into system-user workflow interactions and dialogues for modeling workflow based applications that provide more user-friendly systems, tools and possible educational Web services.

The main contribution of this research is the ***creation of a pattern language for reusing Web teaching materials*** which is not meant to capture “complete wisdom”, as it is the first of its kind, but rather to provide a solid basis for future research and development of both new patterns, and user-centric systems that can support essential functionalities in reusing teaching materials found on the Web. The developed pattern language also enables discussions with the pattern community concerning possible improvements and future work.

The ultimate goal is to further encourage research towards a multilingual learning resource system, the “*eLearning Grid*”, which will enable educators to use Web service technologies to efficiently search, reuse, and translate existing teaching materials and to make new ones.

## Analyzing Patterns for Reusing Web Teaching Materials

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# Chapter 1 Introduction

*“In five years, the best education will come from the Web.”*(Bill Gates, 2010)

In today’s information and technology-enhanced era, the Web has become the ultimate medium for information exchange and communication amongst people. The wealth of educational materials and resources readily available on the Web, in numerous subject areas has greatly influenced the shape of today’s education, affecting both learning and teaching activities alike. Therefore, it is not surprising that nowadays teachers rarely rely only on non-digital resources such as books to conduct their classes.

However, creating new digital materials is not an easy task. Anyone who has had to do so from scratch knows how time consuming and labor intensive it can be, even with the existence of detailed curriculum descriptions and lesson plans.

In addition to a growing number of obligations and responsibilities, teachers are pressed for time to quickly and efficiently create new teaching materials for their upcoming classes, in order to move on to other tasks at hand.

As a result, the educational community has become highly dependent on reusing existing Web teaching materials and adapting them to create their own tailor-made materials which best suit their needs and student groups. In doing so, teachers have been able to increase their overall productivity by saving time, improving their teaching practice by staying up-to-date with their corresponding subject area, and improving the learning experience for their students while keeping the levels of motivation and interest high.

In practice, texts, videos, images and slides are reused by following these steps:

1. finding good resources relevant to the topic and student group
2. selecting specific parts to be reused in the creation of new material, such as images, slides, sections of a video or audio files
3. defining content sequence in newly created material
4. publishing and/or distributing newly-created material.

Publishing and distributing newly-created materials is most often done by relying on PowerPoint presentations because of the practicality of delivering instruction and generating hard-copies.

The idea of reusing and adapting resources may seem simple, even trivial, but in practice it can prove to be a challenging task for teachers of different profiles. Here is an example of why this is often the case.

Although the *UNESCO's Universal Declaration on Cultural Diversity (2001)* is working on decreasing the English language dominance on the Web by encouraging mother-tongue teaching and equal access to knowledge, the majority of educational materials currently available are still in English. If a teacher is looking for materials in his native language, e.g. Bosnian, he faces the possibility of finding no relevant search results for a particular topic. Sometimes, even if he is lucky to find materials in his native language, these may not be accessible or be in a desired format and level, and are therefore useless. If English materials are used, provided that the teacher is fluent in English, a lot of time and effort needs to be put into translating these materials, since machine translations are rarely perfect.

On another note, not all teachers have the luxury of accessing vast amounts of teaching resources on the Web due to the absence of existing technological infrastructures, which mainly target developing countries and remote areas. Even today, many teachers remain uncomfortable with using information communication technologies and are reluctant to adopt any new methods into their teaching practice.

A number of open content initiatives and projects have been introduced in the last few years to enhance and expand the culture of reusing and sharing of teaching materials within the worldwide educational community, but have unfortunately met with limited success. Reasons for this are as follows:

**The presence of a wide range of e-learning products using different platforms** makes content sharing and composition between e-learning systems difficult. Often specific formats of teaching materials are inaccessible for modification and manipulation since they require the use of special software tools.

**The presence of technology-push solutions** which focus on resolving technical aspects, like developing system interoperability specifications and technical and metadata standards, fail to understand teacher needs based on their behavior and practices for a successful adoption of these solutions.

**The lack of available educational resources in minority languages for K-12 educational level**, besides the absence of affordable technical infrastructures and trained staff, still stand in the way of developing countries' ability to move forward.

In order to tackle the above problems, a user-centric approach is adopted in this thesis, as current technologically-focused initiatives fail to understand the real issues and barriers teachers face in reusing Web teaching materials, based on their practices and behaviors for a successful adoption and exploitation of proposed technological solutions. In light of this, a K-12 teacher survey was carried out in Bosnia and Herzegovina with the aim of gaining a perspective of underlying barriers and motivators in reusing teaching materials, search strategies, selection criteria, and adaptations of existing Web teaching materials.

Along with the user-centric approach, this thesis adopts the pattern language approach, which has been adopted by many fields and disciplines since its first introduction in architecture to help ordinary people design and improve their living spaces. Carefully extracted survey observations and findings were used in the development of a pattern language for reusing Web teaching materials, whose goal is to provide a solution for teachers not only in choosing, designing, editing, and sequencing teaching materials, but also in providing guidance for designers in designing more user-centric tools and systems with necessary user-driven functionalities. This type of a pattern language is currently missing in the field of education and e-learning as existing pattern initiatives do not share a unique focus and interest. Each individually created pattern, in the pattern language, is used to provide an explicit user workflow which further helps teachers to visually follow and distinguish a necessary sequence of steps in reusing potential Web teaching materials. Furthermore, these can be translated into system-user workflow interactions and dialogues for modeling workflow-based applications that provide more user-friendly systems, tools and

possibly educational Web services.

The remainder of the thesis is presented as follows.

*Chapter Two, “Background”*, presents the impact of ICTs on our society and educational systems, the significance of reusing educational materials, as well as the issues developing countries are struggling with in order to bridge the gap of the digital divide.

*Chapter Three, “Patterns and Pattern Languages”* reviews the basic concepts of patterns and pattern languages. It also outlines the importance and significance of the pattern language approach, which has been gaining momentum and popularity across many different fields and disciplines since its introduction in the late 1970s.

*Chapter Four, “A Pattern Language for Reusing Web Teaching Materials”* presents the research methodology adopted for the formation of the pattern language, data collection and analysis, as well as the formed pattern categories and pattern language itself.

*Chapter Five, “Conclusion”*, presents the conclusions of this thesis. It also suggests future research that may be extended upon the completed work.

## Chapter 2 Background

This Chapter sheds light on the importance of including and promoting the use of ICTs in education as well as the underlying issues facing developing countries as they struggle to bridge the gap of the digital divide, which has resulted in some countries being information-rich and others information-poor. The reasons for reusing available teaching materials on the Web are outlined which set the foundations for the work and research being carried out.

*“Background”* is divided in the following three main Sections:

- **Section 2.1 “Bridging the Digital Divide”** presents the concept of the digital divide and the obstacles developing countries are facing in setting up necessary technical infrastructures for the inclusion in the information super highway.
- **Section 2.2 “The Impact of ICTs on Education”** provides an overview of the importance and opportunities ICTs provide especially in relation to education. The example of Bosnia and Herzegovina is discussed in detail.
- **Section 2.3 “Current Approaches in Reusing Educational Materials for Teaching and Learning”** gives an overview of the current approaches and initiatives in reusing Web teaching materials.

### 2.1 Bridging the Digital Divide

A decade ago, a connection to the Web was a relatively rare commodity. Nowadays, almost two billion people [] worldwide are connected to the Web, taking advantage of the largest human knowledge repository, as a result of rapid progressions of information communication technologies (ICTs). ICTs have managed to change the very essence of our lives and have also improved the quality of education.

The gap between those who benefit from ICTs and those who cannot, better known as the digital divide, has been attributed mostly to financial and socio-economic factors, affecting less economically developed countries.

As an example, Africa which accounts for about 15% of the world’s population has only 11% of its population connected to the Web while North America which

accounts for about 5% of the world's population has 77% of its population connected to the Web as of 2010.

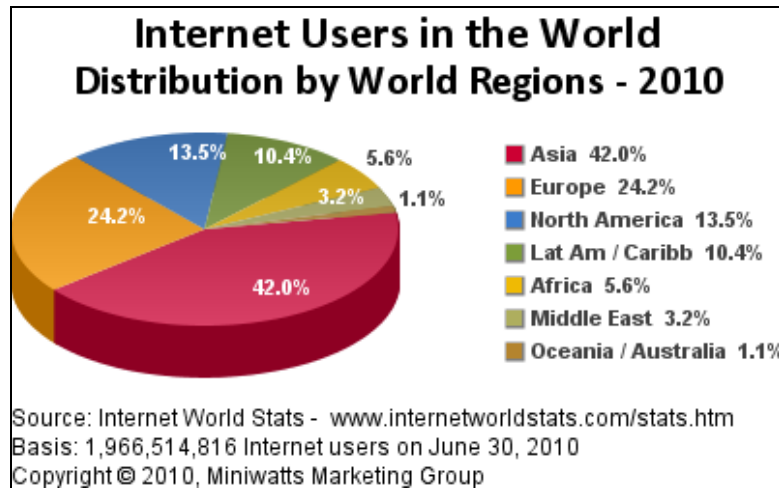


Fig.1: *World Internet Users Distribution by World Regions for 2010*

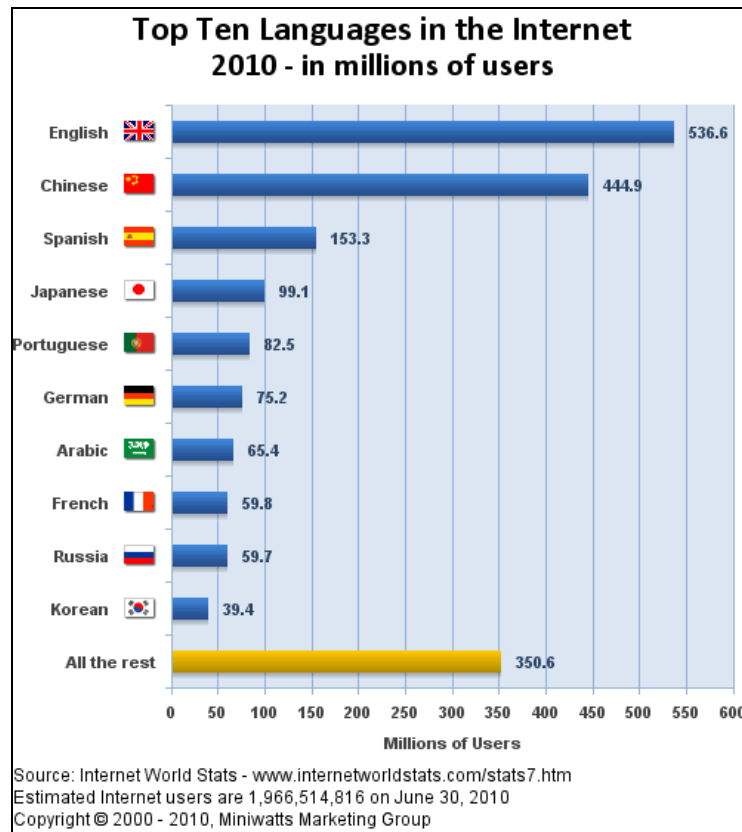
It is therefore not surprising that the concentration of access to ICTs is in North America, Europe and the Northern Asia Pacific area while access in southern regions of the globe including Africa, rural India and south Asia is rather limited.

The poorer nations overburdened by debt, disease, and ignorance are the least likely to invest in ICTs as the startup costs and expenses of setting up and maintaining technical infrastructures are limited to resources needed for essential human survival. This is unfortunate as ICTs have the potential for increasing the access to and improving the quality of education by offering unprecedented opportunities.

In reality, the problem of the digital divide is not only of technical nature, but of multiple dimensions. As Keniston [] distinguished, the digital divide affects four social divisions:

- those who are rich and powerful and those who are not
- those who speak English and those who do not
- those who live in technically well-established regions and those who do not
- those who are technically savvy and those who are not.

As noted above, one of the challenges in the distribution of ICTs and the narrowing of the digital divide is the so called language barrier.



*Fig.2 Top 10 Languages in the internet in millions of users*

According to statistics, the English language is by far the most dominating force on the Web. Although the reasons for its dominance are complex, it can be said that they have been brought about by the imperialism, economic and political importance of English-speaking countries.

By the year 2000, only 20% of all Web sites in the world were in languages other than English, and most of these were in Japanese, German, French, Spanish, Portuguese, and Chinese. But in larger regions of Africa, India, and south Asia, less than 10% of people are English-literate while the rest, more than two billion, speak languages that are sparsely represented on the Web. Because of this language barrier the majority of people in these regions have little use for ICTs and the Web, even if the necessary technical infrastructures existed.

It is these demographic differences that affect whether certain countries are

information-rich or information-poor, resulting in their inclusion or exclusion from full participation in the information age.

## **2.2 The Impact of ICTs on Education**

The overall impact of ICTs on the worldwide educational trends and activities has been more than remarkable.

Electronic learning or better known as e-learning, which refers to teaching and learning activities involving the diverse use of ICTs, has gained great popularity for providing and sharing knowledge all over the world. As a result, teachers and learners alike no longer have to rely only on printed materials and physical media stored in libraries. With the Web, a wealth of educational materials in almost all subjects and media varieties can be accessed from anywhere and at any time by an unlimited number of people.

With the spread of ICTs and available resources on the Web, it is not surprising that the role of teachers has slowly been changing. Teachers are encouraged to incorporate ICTs into their class instructions since they allow diverse ways of presenting materials thereby maintaining student interests' high and promoting lifelong learning. However, researchers have identified several internal and external barriers to the adoption of ICTs in classroom instruction, which include teachers' attitudes and willingness, their workload, the availability and accessibility of hardware and software, staff development, and institutional and technical support. All these factors are interrelated.

One of the key factors preventing teachers from applying ICTs to teaching is their lack of computer literacy, which would require time to learn in addition to the time required for lesson material preparation. Although the increasing availability of computer equipment in schools offers easy access to computer resources, many teachers fail to alter existing patterns of teaching.

The lack of software designed specifically for instruction might be one of the major reasons for the continued lack of willingness to use ICTs. The strong emphasis on the learner's perspective in recent years has led to many software products for teaching which focus on students' learning needs instead of facilitating teachers' instructional design. Hence, teachers themselves have

benefited relatively little from such developments. The software for “integrating technology into instruction” is therefore needed by teachers to leverage ICTs with minimal effort. Moreover, through such software, the burden of lesson preparation would be lightened, and thus teachers would be better motivated to apply ICTs in their teaching. If the ultimate goal of integrating ICTs in instruction is in order to make technology an integral part of classroom functions, then the design and application of software for instructional purposes is an essential step.

In addition, the creation of e-learning materials is not an easy task, in terms of both time and money. Moreover, the growth of e-learning is directly related to the degree of access to ICTs, which puts developed countries in a far better position than developing ones. But in order to truly promote and expand the use of ICTs in developing countries, provide equal educational opportunities in the world and preserve cultural identities, it is necessary to provide educational resources not only in English but in other less well represented languages as emphasized by the *UNESCO’s Universal Declaration on Cultural Diversity (2001)* in encouraging mother tongue teaching as the right of all children. These goals can best be achieved by reusing, translating and sharing existing educational materials found on the Web, as government funds and budgets of developing countries are limited. The educational community and individual teachers must be encouraged to reuse and share teaching materials with each other as much as possible, to bring about a positive change in their own communities and provide a brighter future for the coming generations.

In short, it can be concluded, that in order to narrow the digital divide for the 5 billion people across the world who are not connected to the Web, it is not just a matter of setting up and maintaining necessary technical infrastructures. Many other factors must be addressed in addition to this by individuals and respective governments; promoting the use of ICTs, expanding the number of represented minority languages on the Web and increasing the number of available high-quality educational materials by reusing existing ones, thereby improving the literacy and technical skills of society as a whole.

### 2.2.1 The Case of Bosnia and Herzegovina

Bosnia and Herzegovina (BiH), a small country in Southern Europe, is better known to the wider international community for the brutal armed conflict that took place in the early 1990s, as a result of the dissolution of Yugoslavia.

The war and post-war environment in BiH left it struggling far behind its neighboring countries in the Balkans. Damaged infrastructure and the digital divide affected both ordinary life and its ability to compete in the regional and global markets.

To help understand how difficult and challenging it is to make changes on the country level, it is necessary to provide a short overview of how the government is structured.

The territory of BiH covers two entities that have their own governments, parliaments and ministries; the Federation of Bosnia and Herzegovina (FBiH) and the Republika Srpska (RS), along with an internationally supervised Brcko District. These have been established by the Dayton Agreement back in 1995, to guarantee that all three major groups (Muslim, Serb and Croat) were equally represented. The government consists of a tripartite presidency, the Council of Ministers and the Parliamentary Assembly. In FBiH alone, there is an additional administrative level of ten cantons. The presence of so many levels of government, which respond to the post-war situation and political interests, tends to create inefficiency in bringing about quick changes for the benefit of BiH society.

Back in 2000, only 0.2% of the population was using the Web. Since then, over the span of 10 years, the situation has significantly improved and the percentage of the population accessing the Web nowadays is a staggering 31%.

Year	Users	Population	% of Population
2000	7,000	4,339,600	0.2%
2002	100,000	4,452,876	2.2%
2006	806,400	4,568,399	17.5%
2007	950,000	4,672,165	20.3%
2010	1,441,000	4,621,598	31.2%

Table 1: Web usage and population statistics

But, in comparison with the population percentages of other European countries, BiH still has the lowest figures as seen in Fig.3.

Even with the ongoing systemic changes and efforts to harmonize standards with those of EU, the current set of laws is not focused on promoting an information society and the use of ICTs in primary and secondary schools. It is therefore not surprising that the quantity of educational materials and resources available in native languages of FBiH is very low. Students and teachers alike need to be English literate in order to take advantage of educational opportunities that the Web has to offer.

<b>Internet Usage in Europe</b>					
<b>EUROPE</b>	<b>Population ( 2010 Est )</b>	<b>Internet Users, Latest Data</b>	<b>Penetration (% Population)</b>	<b>User Growth (2000-2010)</b>	<b>% Users Europe</b>
<a href="#">Albania</a>	2,986,952	1,300,000	43.5 %	51,900.0 %	0.3 %
<a href="#">Andorra</a>	84,525	67,200	79.5 %	1,244.0 %	0.0 %
<a href="#">Austria</a>	8,214,160	6,143,600	74.8 %	192.6 %	1.3 %
<a href="#">Belarus</a>	9,612,632	4,436,800	46.2 %	2,364.9 %	0.9 %
<a href="#">Belgium</a>	10,423,493	8,113,200	77.8 %	305.7 %	1.7 %
<a href="#">Bosnia-Herzegovina</a>	4,621,598	1,441,000	31.2 %	20,485.7 %	0.3 %
<a href="#">Bulgaria</a>	7,148,785	3,395,000	47.5 %	689.5 %	0.7 %
<a href="#">Croatia</a>	4,486,881	2,244,400	50.0 %	1,022.2 %	0.5 %
<a href="#">Cyprus</a>	1,102,677	433,800	39.3 %	261.5 %	0.1 %
<a href="#">Czech Republic</a>	10,201,707	6,680,800	65.5 %	568.1 %	1.4 %
<a href="#">Denmark</a>	5,515,575	4,750,500	86.1 %	143.6 %	1.0 %

Fig.3: Internet usage in Europe, 2010

The number of primary and secondary schools in FBiH, which provide education to nearly half a million students, amounts to 596.

The e-Readiness Assessment Report for 2005 (UNDP, 2006) showed that while 64% of primary and secondary schools had a computer lab, only 43% had Internet access mainly obtained via dial-up. As one of the basic indicators of ICT usage within educational institutions, the number of students per computer was a staggering 57 students for every computer in primary and secondary schools.

According to data provided by the World Bank, BiH spent about 2.7% of its GDP on basic education and 1.4% on secondary education. Almost 90% of this budget was spent on teachers' salaries, which left very few or no resources for investments in educational development.

Since 2005, the educational sector has taken major steps forward, particularly in regard to the student computer ratio in primary and secondary schools. Therefore, the e-Readiness Assessment Report for 2009 showed a significant improvement, from 57 to 26 in the students per computer figure. The situation in secondary schools is even better; 16 students per computer compared to 35. The percentage of primary and elementary schools with a computer lab increased from 64% in 2005 to 73% in 2009, with an Internet connection in 90% of them in 2009 via ADSL.

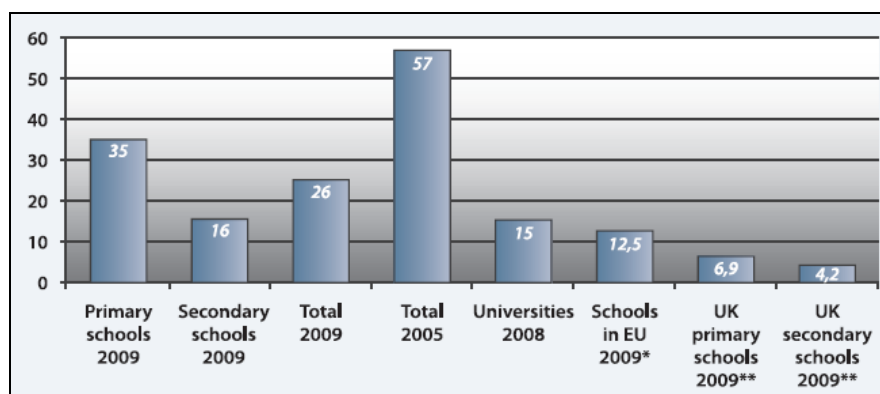


Fig.4: Number of students per computer

Although the statistics are encouraging for BiH, ICTs are hardly being incorporated by teachers on a daily basis in their classroom instructions. The available school computers are mainly used for computing classes, checking emails and accessing entertainment and social media sites. In addition, the majority of teachers are either reluctant to include ICTs in their teaching practice or lack technical skills to use them, besides the deficiency of suitable educational resources in official languages of FBiH. This leaves even enthusiastic young teachers discouraged, as they lack confidence in translating and reusing English materials on their own for which they will not receive proper recognition or compensation.

For ICTs to have a more meaningful effect on the FBiH educational system, focus needs to be shifted on expanding the number of high-quality materials in official languages of FBiH, training and motivating teachers to collaborate, reuse, share and incorporate such materials into classroom

instruction. These efforts would lead to educational and economic growth of the country, from which everyone in FBiH could prosper from.

### **2.3 Current Approaches in Reusing Educational Materials for Teaching and Learning**

In order to address difficulties in creating new digital materials for educational purposes and benefit from economies of scale, numerous international initiatives have been funded to investigate ways in which they can be developed, shared and reused by teachers and learners around the world. Behind these initiatives lies a vision in which reusable resources also known as learning objects could bring about a new currency of exchange within the learning economy. Learning objects, produced by teachers and students themselves, would be stored in digital repositories, where they could easily be accessed, recombined and reused within online courses. In an ideal world, these resources would be designed so that they could be adapted to fit different educational models, subject areas and levels of study.

The idea of creating digital educational resources with the express purpose of reuse, which refers to the action of taking an existing piece of content with the purpose of creating new one different from the original content, has been around since the early 1990s. Some of the benefits for reusing educational resources have been identified as:

- *The reuse of digital materials can enable reduction of costs.*  
The design and implementation of high-quality educational materials is expensive, so reusing them targets to reduce expenses especially since digital media can be distributed and reproduced economically.
- *The sharing of digital materials can lead to improvements in educational quality.*

Exchange and reuse of digital materials facilitates collaboration among educators, so that each participant contributes with their own specific knowledge and skills, which in turn can provide a base for a community that is dedicated to designing best practices based on educational experiences.

- *The distribution of digital materials is connected to the distribution of educational expertise.*

Digital materials could provide the formalization of knowledge about teaching and learning and in turn support educators to translate educational theories and qualified principles.

- *The universal access to digital materials will lead to educational growth.*

Once the reuse of digital materials is easy and cheap, the expansion of education without additional costs will be made possible.

A number of initiatives have been attempting to provide the technology to support the practice of publication and reuse; metadata standards and specifications like IEEE Learning Object Metadata (LOM) have been developed to enable content description as well as resource purpose so that they can be accurately located. Learning object repositories (LORs) have been developed in which to store resources and their metadata. Content packaging specifications such as IMS-CP have been developed in order to enable interoperability and the transfer of sets of interlinked files in a manner that allows them to be unpacked on another server and runtime engines such as SCORM RTE (sharable content object reference model-runtime environment) and IMS-LD (learning design) have been developed that allow quite complex sequencing of users through sets of resources.

In addition to the development of technical infrastructures, various funding bodies have supported programs and projects with the objective of creating enough open content to spread the practice of reuse. Institutions such as MIT, with their OpenCourseWare have pioneered in providing some of their course materials for free. The OpenCourseWare Consortium is now a collaboration of more than 200 higher education institutions and associated organizations from around the world creating a body of open educational content using a shared model.

However, in spite of all these initiatives, the concept of reusable learning objects has not achieved critical mass uptake, as it has hardly registered with the average educator. Significant evidence exists to support that there is no lack of interest in reusing, but that the built infrastructure to support reuse is not

appropriate for the needs of the work-a-day educators. [11] But, because unlimited access to educational resources leads to economic growth as skilled and employable citizens create wealth, it is important for reuse and sharing to become a common practice among teachers. This would also ensure that educational resources multiplied easily which would mean that there would be enough education for all.

## Chapter 3 Patterns and Pattern Languages

The purpose of Chapter 3 is not only to provide an introduction to patterns and the importance of the pattern language approach which have greatly influenced the direction and scope of this research, but also to lay down the foundations for Chapter 4.

Special emphasis will be placed on architecture, as the field where patterns and the pattern language approach originated back in the late 1970s, as well as on Christopher Alexander who is regarded as the father of patterns.

Even with the approach gaining momentum and popularity across many different fields and disciplines over the years, the focus will be on pedagogy and e-learning, as they provide valuable insight and relevance for developing patterns related to this thesis.

***“Patterns and Pattern Languages”*** is divided in the following four main Sections:

- ***Section 3.1 “Pattern Basics”*** presents an introduction to the definition of patterns, an overview of the essential pattern elements and a description of the main phases of a pattern life-cycle.
- ***Section 3.2 “Pattern Language”*** introduces the concept of a pattern language and how it helps in resolving complex situations and processes.
- ***Section 3.3 “Patterns in Diverse Fields”*** provides an overview of the pattern language approach in different fields, such as architecture, pedagogy and e-learning, which are relevant to this thesis.
- ***Section 3.4 “The Pattern Language Approach”*** gives an overview of the importance and significance of the pattern language approach that all the pattern adopting fields and disciplines can benefit from.

### 3.1 Pattern Basics

#### 3.1.1 Definition

The term “*pattern*” originated as an architectural concept and was first introduced by Christopher Alexander and his colleagues in the late 1970s to mean a recurring problem-solution pair which can be observed under a variety

of conditions [1].

A pattern is about best practice, i.e. it is about a particular class of a problem paired with a type of a solution that has endured the test of time, proving to be a good and insightful way of tackling that problem.

A pattern does not only document a recurring problem-solution pair within a given context, but it includes the binding rationale behind both the problem and the solution.

It can therefore be said that patterns represent a method of capturing expert knowledge on best practices.

### 3.1.2 Pattern Elements

Patterns are written in natural language and are therefore easy to understand. A lot of different formats exist but there is a certain agreement on the mandatory elements of a pattern[8]:

*“A pattern has to be identified by its name. A pattern describes a solution to a problem occurring in a certain context. Forces describe the trade-offs that must be considered when applying the pattern. In addition there are several other elements that can be used to describe a pattern.”*

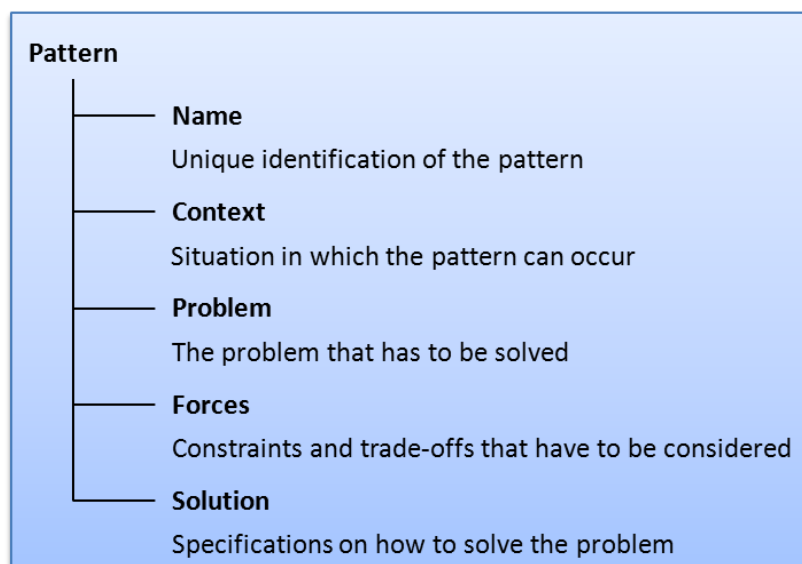


Fig.5: Essential elements of a pattern

### 3.1.3 Pattern Life-Cycle

Writing patterns does not only capture experience and knowledge, but also

contributes to it. It is important to note that patterns are found and not invented.

Each pattern goes through a number of phases in its life-cycle that begins with experience and expert knowledge in a certain problem domain, which enables the resolution of complex problems by relating new situations to those previously successfully solved.

Problems and their solutions are then abstracted and decomposed in common situations to specify single or a number of related patterns. Writing patterns is not easy, but further contributes to understanding procedures and interactions, especially when it comes to complex structures and situations.

After patterns are published, they are ready for selection and application through pattern users to solve real-world problems. In order for users to understand how to use them, authors of most pattern approaches provide guidance and concrete examples.

Depending on the changing environment and findings of the problem domain, some patterns need to be updated or replaced to reflect those changes.

Therefore, existing patterns need to be frequently updated and modified, new ones added, and outdated ones removed. When new patterns are added, they need to be integrated into existing ones by defining their relationships and organization.

The described pattern life-cycle model is shown in Fig.6.

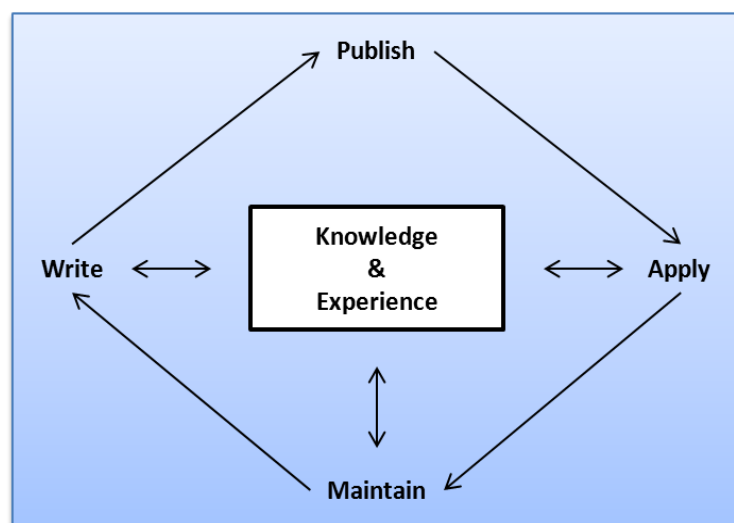


Fig.6: The pattern life-cycle

## **3.2 Pattern Languages**

The term “*pattern language*” was proposed by Christopher Alexander in his first book, “*The Timeless Way of Building*”, where he remarks:

*“A pattern language gives each person who uses it, the power to create an infinite variety of new and unique buildings, just as his ordinary language gives him the power to create an infinite variety of sentences.”*

*“The structure of the language is created by the network of connections among individual patterns: and the language lives, or not, as a totality, to the degree these patterns form a whole.”*

*“Each pattern then, depends both on the smaller patterns it contains and on the larger patterns within which it is contained.”*

Individual patterns can be a good solution for smaller, fine grained problems but linking related patterns is useful in addressing more complex processes in a step-by-step approach. Therefore, the set of patterns working together is called a pattern language.

A pattern language includes rules and guidelines which explain how and when to apply its patterns to solve a problem that is larger than any individual pattern can solve. These rules and guidelines suggest the order and granularity of applying each pattern in the language.

Ideally, a good pattern language is generative.

## **3.3 Patterns in Diverse Fields**

### **3.3.1 Patterns in Architecture**

Patterns originally emerged in the field of architecture back in the late 1970s, in a series of books published by Christopher Alexander and his colleagues with the intent to provide ordinary people with a set of conceptual resources they could use in creating and improving their neighborhoods and living spaces, whose construction was dominated by architects and town planners.

In his second and best known book in the trilogy, “*A Pattern Language: Towns, Buildings, Construction*”[1], Alexander developed the idea of a structured template, a pattern, characterized as:

*“Each pattern describes a problem which occurs over and over again in*

*our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.”*

*(Alexander et al., 1977)*

The central aspect of Alexander’s definition is the recurring problem in our environment, whose solution is concrete enough to allow real problems to be solved but abstract enough to avoid solving only specifically observed problems.

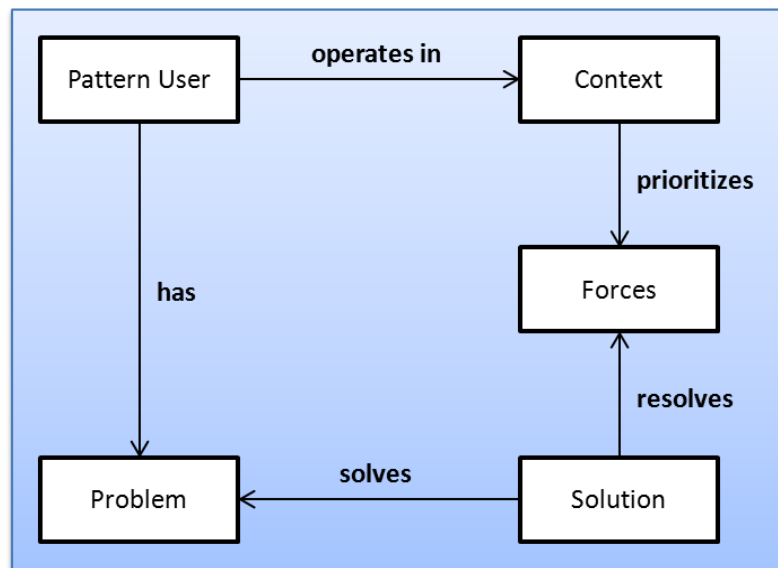


Fig.7: Relationships between pattern elements

The book provides 253 patterns that document knowledge of designing towns, buildings, and construction, and although all patterns are written in the same way, they address quite different levels of urban design.

The Alexandrian patterns are divided into three levels [1]:

1. *Towns* which comprise 94 global or large patterns, describing the layout of whole towns and communities
2. *Buildings* which consist of 110 patterns that can be applied on groups of buildings and individual buildings
3. *Construction* which comprises 49 patterns that show in detail how to build the buildings.

Each Alexandrian pattern, regardless of its level, is composed of eight elements in the following format:

- i. *Title*: displaying the pattern name
- ii. *Picture*: depicting the end archetypal product of the pattern
- iii. *Introductory paragraph*: explaining the context of the pattern and a description of the problem which the pattern is designed to solve
- iv. *Headline (in bold type)*: stating the essence of the problem
- v. *Body of the problem*: describing the empirical background of the pattern, evidence for its validity, and the different ways the pattern can be used
- vi. *Solution (in bold type)*: providing precise instructions of physical and social relationships required to solve the stated problem in the stated context
- vii. *Diagram*: depicting the solution in the form of a diagram with labels to indicate main components
- viii. *Related patterns*: closing paragraph relating the pattern to other smaller patterns which are needed for its completion and embellishment.

An example of the “Agricultural Valleys” [1] pattern is shown in Fig.8.

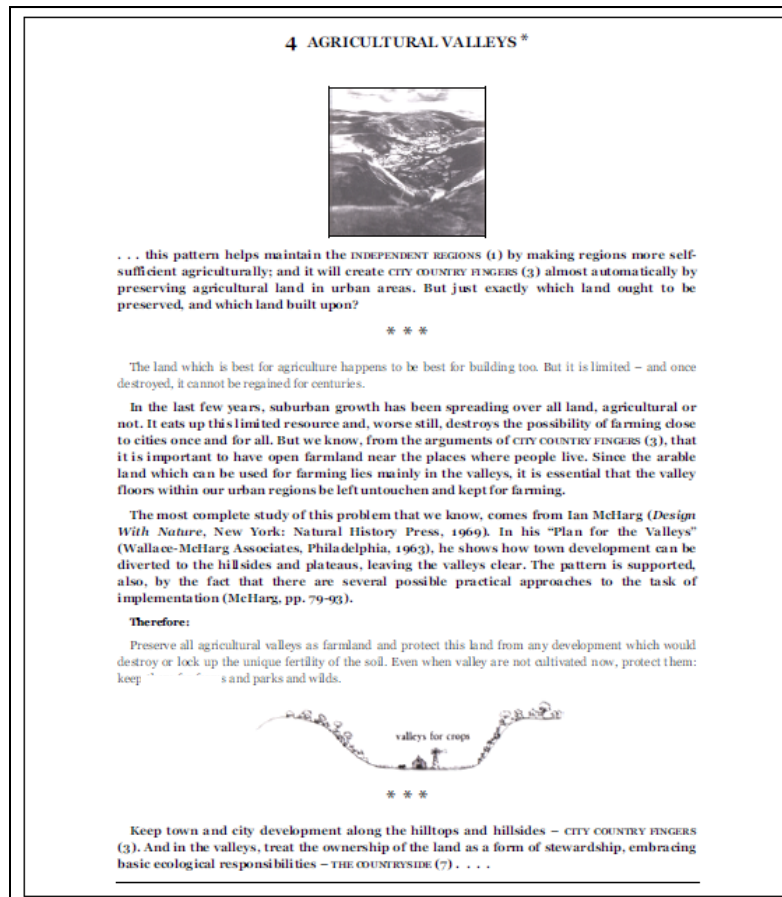


Fig.8: Example of an Alexandrian pattern

Since their introduction in the late 1970s, patterns have gained popularity and momentum across diverse fields including computer science, software engineering, human-computer interactions, and most recently in education and e-learning.

### **3.3.2 Patterns in Pedagogy**

The use of patterns is still new to the field of education and with the widespread misconception that professionals with good technical skills and subject matter know how to teach, it is not surprising that the educational community needs time to include patterns as an everyday tool.

Patterns in pedagogy, or better known as pedagogical patterns, are targeted at education to provide best teaching practices by capturing expert experience, both in academia and industry. For those new to teaching, pedagogical patterns offer a way to receive guidance and wisdom passed on by experienced teachers.

According to Bergin (2001):

*“The intent of pedagogical patterns is to capture the essence of the practice in a compact form that can be easily communicated to those who need the knowledge. Presenting this information in a coherent and accessible form can mean the difference between every new instructor needing to relearn what is known by senior faculty and easy transference of knowledge of teaching within the community.”*

Pedagogical patterns, like all other patterns, do not have a single standard form, but instead, different authors who use different forms by adding or omitting some optional elements.

A pedagogical pattern usually starts out with an instructor who has found an effective way to teach a specific concept. The pattern is written by abstracting the problem, the context, the forces that act upon the problem, the solution and the rationale for and consequences of using that solution [Mes98]. The pattern author then offers it for review by sending it to colleagues and/or posting it on the Web.

An example of a pedagogical pattern is shown in Fig.9.

## 5 Do you remember?

*Progress, far from consisting in change, depends on retentiveness...Those who cannot remember the past are condemned to fulfill it.*

George Santayana, *Life of Reason*

### Problem

How do you recapture what was learned days before?

### Forces

You want to repeat what the participants have learned so far, but you would also like to know how well they understood it.

Although things are sometimes complex, often they are more likely to be understood if a student uses her own words to explain the concepts to somebody else.

### Solution

Provide a short exercise where the students have to express the topics in their own terms.

- Vocabulary Exercise: Write the key terms which have been used so far on the white board. Each participant can pick one, so each explains one term.
- Questionnaire: Give the participants two or three questions, which cover what has been learned so far and which they have to discuss in small teams, for example in pairs.
- Mini project: Give the participants a very small problem to solve, which covers most of the topics.

### Discussion

It is essential for the *Questionnaire* that the questions are not too easy, so the participants have to discuss a possible answer and perhaps assemble an example for their solution.

The challenge when using the *Mini Project* is to find a project, that is really tiny. You don't want to spend too much time; you just want to review the concepts.

Fig.9: Pedagogical pattern “Do you remember”

The *Pedagogical Patterns Project (PPP)* is a worldwide network of authors, working on collecting many types of patterns to help teachers teach, by offering the know-how of experienced instructors and to help students learn. Individuals from more than twelve different countries contribute successful practices for pedagogical concerns such as planning and conducting a short course, teaching various techniques such as abstraction, helping learners work in teams, conducting peer review sessions, developing a course in computer science, and increasing the efficiency of class lectures.

### **3.3.3 Patterns in e-learning**

Even though the pattern language approach has been adopted by many different fields and disciplines, the field of e-learning has been lagging until recently.

Recently, more and more projects as well as efforts have emerged, but they do not share a unique focus or interest. Patterns from other fields and disciplines have also proven to be useful in the design of e-learning.

Some current proposals are related to the design of e-learning software systems.

One of the most well-known is the *E-LEN* project which was started in Norway in 2003. The scope of the project was to create a network of e-learning centers and organizations in the learning technologies, as well as to develop and publish pedagogically informed technology for effective e-learning experiences through the use of patterns.

Some of the initial concepts and aspects achieved are:

- Integration of pedagogical approaches with hypermedia design patterns, as well as a taxonomy of design patterns of adaptive hypermedia
- Implementation of wizards to guide e-learning system administrators in configuring the instantiation of pedagogical patterns
- Definition of organizational patterns for developing and implementing e-learning centers within institutions
- Theoretical investigation of pattern mining and identification in the collaborative learning domain.

Another well-known project is the *Educational Environment Modeling Language (E<sup>2</sup>ML)* for supporting the design of educational environments. It provides comprehensive documentation of the instructional design process by defining learning goals and modeling action diagrams as well as overview diagrams of the whole design.

Some of the aims of the project are:

- Facilitating communication among all involved in the educational design process.

- Supporting the derivation of requirements that have to be met by e-learning tools
- Supporting quality assessment during the setup stage of an e-learning environment by providing decision support for management decisions
- Providing a diagnostic toolkit for supporting redesign of existing educational environments.

<b>Case Studies In-Depth Analysis</b>		R1
Students (all, single)		20h
Being able to use the institution description schema + can apply organizational theory concepts	Complete understanding of one institution	G3 G4
Using email + Using MS Word (basics)	-	G5
One online case study	Final Report (10 p.)	
View all materials of a case study's and analyze it with the course concepts. Ask the A for questions. Write the report following the report guidelines. (20h)		
[anywhere]		
Online case studies (CS)		
Syllabus		

Fig.10: Example of  $E^2ML$  pattern, “Case Studies In-Depth Analysis”

Another set of proposals is concerned with the design of good educational practices, but not directly involving the use of technology. These works are related to educational theories and instructional disciplines. The proposals include patterns for: classroom education, study groups, seminars, running of a course, and pedagogical patterns that initiated the *Pedagogical Patterns Project (PPP)* described in *Section 3.3.2*.

Finally, there are proposals devoted to the design of good e-learning materials which propose an approach to assist designers of e-learning experiences.

One such proposal is the E-Dilema<sup>3</sup> European project which aims to assist in the selection and design of learning objects.

There are many other projects and initiatives such as the *Pointer* and *TELL* projects developed to spread the use of patterns in the field of e-learning, but they will not be covered in this thesis. What is common to all of them is the type of patterns used and proposed.

In general, there are two main types of patterns distinguished in e-learning:

- *Patterns for analysis* (aka *patterns of interaction / patterns of behavior*) which deal with analyzing the usage of e-learning systems in training or academic contexts, so as to help teachers to constantly improve them, and
- *Patterns for design* which are devoted to the design of e-learning systems.

### **3.4 The Pattern Language Approach**

It is important to identify the significance and relevance of the pattern language approach to the work and contribution of this thesis.

As observed by Alexander:

*“It allows you to write down good ideas in a way that can be discussed, shared, modified, and so forth. So, it is a really useful vehicle of communication.”*

Because patterns are contextual and capture a wealth of knowledge, experience, and resources they can be easily shared, adapted, and applied by those who use them. They can also address human behaviors and organizational issues.

A good pattern language provides enough detail to be useful, but not so much that it becomes too complex for it to be understood and implemented. Therefore, generally speaking, the pattern language approach helps to:

- Solve real-world problems
- Capture domain expertise
- Document design decisions and rationale
- Reuse the wisdom and experience of master practitioners
- Convey expert insight to novices
- Form a shared vocabulary for problem-solving discussion.

# Chapter 4 A Pattern Language for Reusing Web Teaching Materials

This Chapter presents the developed pattern language for reusing Web teaching materials which is not intended to capture the “ultimate wisdom” of reusing Web teaching materials’ practice. Rather, its current form aims to provide a starting point for discussions with the pattern community, exchange of ideas and further research in the domain.

*“Pattern Language for Reusing Web Teaching Materials”* is divided into the following five main Sections:

- **Section 4.1 “Methodology”** provides an overview of the research approach in collecting patterns towards a pattern language for reusing Web teaching materials.
- **Section 4.2 “Use Case”** presents the use case scenario, contents and workflow derived during the creation process.
- **Section 4.3 “K-12 Teacher Survey in Bosnia and Herzegovina”** presents the survey carried out among K-12 teachers with detailed observations and findings collected through data analysis.
- **Section 4.4 “Developing Individual Patterns”** provides an overview of the iterative process in forming individual patterns based on the observations obtained from **Section 4.2**. Pattern forms used to represent different aspects of reusing Web teaching materials are presented along with detailed examples of individual patterns and the rationale behind them.
- **Section 4.5 “Formulating a Pattern Language”** presents the formed pattern language for reusing Web teaching materials, which aims to help novice users and designers in reusing existing materials and designing more user-centric tools and systems.
- **Section 4.6 “Developing Pattern based Workflows”** describes how user and system-user based workflows have been derived from individual patterns to help designers in designing more user-centric tools, systems,

and applications which provide the necessary functionalities.

**Section 4.7 “Using Patterns for User-Centric Tools”** describes how the formed pattern language can be used as a lingua franca between teachers and designers in creation of more user-centric tools.

**Section 4.8 “Future Work”** discusses possible directions of extending the completed work.

## **4.1 Methodology**

It seems clear that current technologically focused initiatives which strive to resolve aspects like system interoperability specifications and technical and metadata standards, have met limited success in expanding the worldwide culture of sharing and reusing of Web teaching materials. This is mainly because little effort has been invested in understanding the actual teacher needs and practices for a successful adoption of proposed technological solutions. Too much energy is directed into pushing new state-of-the-art products, which unfortunately end up being unexploited to their full potential.

Since the technology-push approach is not enough on its own to further expand the culture of sharing and reusing, the approach adopted and presented in this thesis is user-centric. Personal experience in teaching Mathematics at the high school level in Bosnia and Herzegovina brings along with it firsthand knowledge in what teachers face on a daily basis and how important it is to quickly create new captivating teaching materials for upcoming classes and move on to other tasks and obligations at hand, but is not enough to paint the complete picture. This is why a use-case was initially created for research purposes with the aim to not only confirm the fact that the creation of new teaching materials is time consuming, but also to document exact steps and efforts needed to compose new materials from existing ones on the Web. Following the use-case, a K-12 teacher survey and interviews were conducted in Bosnia and Herzegovina with the intention of obtaining a deeper understanding of the real issues regarding barriers and motivators that other fellow teachers face, as well as their attitudes and practices in reusing digital materials.

Along with the user-centric approach, the pattern language approach is used

as a proven method in diverse fields and disciplines to enable reuse of expert experience in solving recurring problems under specific contexts. As mentioned in *Chapter 3*, current pattern initiatives in e-learning do not share a unique focus or interest and as such, no pattern language for reusing Web teaching materials exists which covers all related aspects necessary for successful reuse; tasks, tools, system and community specifications. Observations and practices obtained from data analysis of teacher interviews have been used as a foundation for the formed pattern language presented in *Section 4.4*.

## 4.2 Use-Case

The following scenario was used for the use-case of created mathematical materials, shown in Fig.11:

- a K-12 Bosnian Mathematics teacher needs to develop a new lesson plan within two hours for tomorrow's class
- search, browse, and reuse existing materials on the Web
- translate, modify, and assemble a new lesson plan
- contents include a combination of text, images, videos and audio files on a slide
- new lesson plan presented as a slideshow.

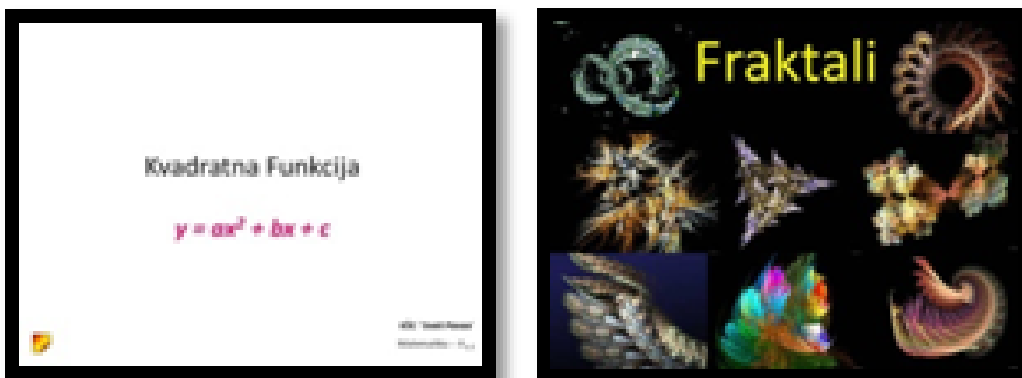


Fig.11: Created use case materials available at <http://www.ai.soc.i.kyoto-u.ac.jp/~nadia/home.htm>

Adding contents to a new lesson plan for the topic of quadratic function and fractals for Grade 10 level proved neither easy nor time efficient since no matching results were found in Bosnian for the grade level intended and

therefore had to be first translated from English and then modified. Special attention had to be paid to the use of correct terminology of different concepts translated into Bosnian language. For manipulation of media contents which were added to the lesson plan, different programs found freely on the Web including *Visual Slideshow* and *X2X Free Video Trim* had to be downloaded.

The overall process took more than the original scenario designated, but a workflow depicted in Fig.12 was derived based on the steps taken:

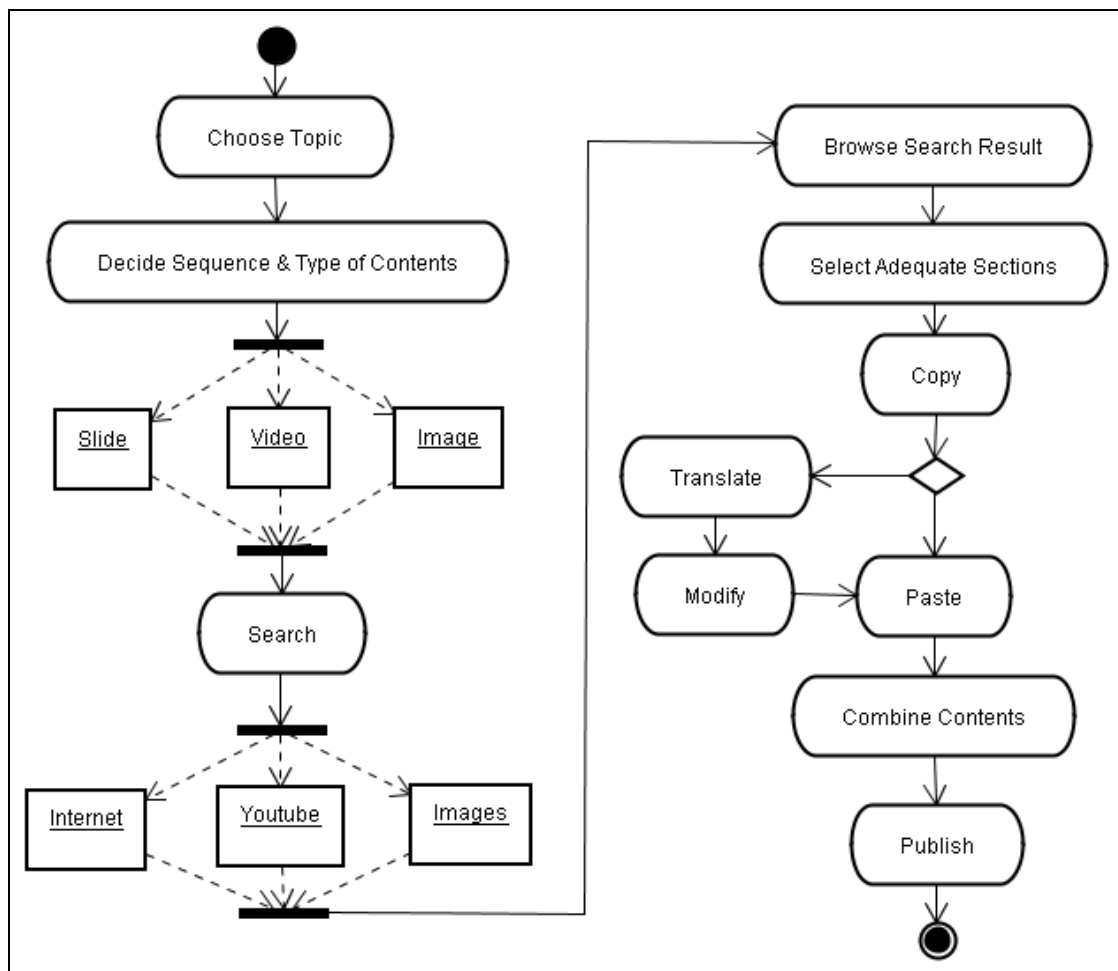


Fig.12: Use case workflow process

Following the created use case, as previously mentioned, a K-12 teacher survey and interviews were conducted in Bosnia and Herzegovina with the aim of obtaining a deeper understanding of what other fellow teachers face in adopting the practice of reusing Web teaching materials. The survey and its

findings are given in the next *Section*.

### 4.3 K-12 Teacher Survey in Bosnia and Herzegovina

Since little is truly known about the actual teacher attitudes and practices in creating new teaching materials from existing ones on the Web, a survey was conducted in Bosnia and Herzegovina amongst twenty K-12 teachers, mainly teaching Mathematics, for research purposes.



Fig.13: Teacher interviewees

The survey is qualitative in nature and is based on data gathered in face-to-face interviews with teachers at their respective teaching posts. The interviewee demographics are shown in Table 2.

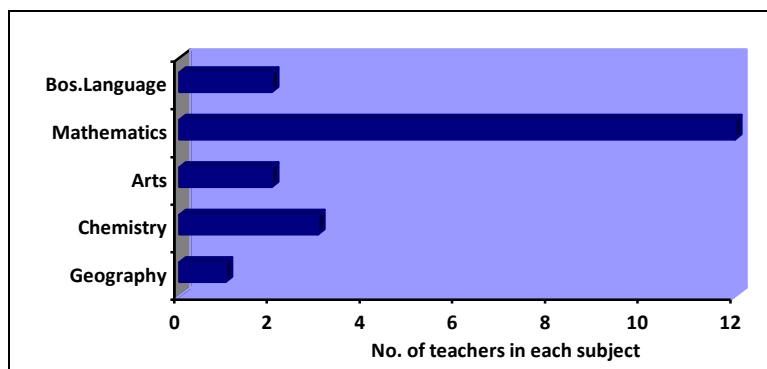


Fig.14: Distribution of interviewees according to subject area

The interviewee sample was mainly dominated by Mathematics teachers, although other subject area teachers were interviewed. Fig.14 illustrates the number of interviewees per subject area.

<b>Interviewee</b>	<b>Subject Area</b>	<b>Age</b>	<b>Gender</b>	<b>Grade Level Taught</b>	<b>Teaching Experience (years)</b>	<b>No. of Students</b>
Teacher(T1)	Mathematics	29	M	9-12	5	25
Teacher(T2)	Mathematics	28	F	5-8	3	22
Teacher(T3)	Geography	33	F	9-12	8	25
Teacher(T4)	Mathematics	37	M	9-12	10	21
Teacher(T5)	Arts	36	F	9-12	12	25
Teacher(T6)	Mathematics	28	F	5-8	4	20
Teacher(T7)	Mathematics	31	F	9-12	7	24
Teacher(T8)	Chemistry	37	F	5-8	11	23
Teacher(T9)	Mathematics	48	F	9-12	23	21
Teacher(T10)	Chemistry	33	F	9-12	9	23
Teacher(T11)	Mathematics	29	F	9-12	4	21
Teacher(T12)	Mathematics	33	M	9-12	8	24
Teacher(T13)	Arts	54	F	5-8	21	25
Teacher(T14)	Mathematics	29	F	9-12	5	22
Teacher(T15)	Chemistry	31	M	9-12	6	21
Teacher(T16)	Bosnian Language	32	F	9-12	8	27
Teacher(T17)	Mathematics	55	F	5-8	28	22
Teacher(T18)	Mathematics	32	M	9-12	7	27
Teacher(T19)	Bosnian Language	39	F	5-8	15	25
Teacher(T20)	Mathematics	26	F	9-12	2	22

Table 2: Interviewee demographics

The main focus of the survey and interviews conducted is related to:

- motivators for reusing digital teaching resources
- barriers for reusing digital teaching resources
- search strategies and selection criteria of digital teaching resources
- adaptations and reuse of digital teaching resources
- desired functionalities and tools.

#### **4.3.1 Data Analysis**

Once the interviews were completed, data collected was independently analyzed and the main findings are presented below.

Overall, teachers feel that easy access to an abundance of teaching resources on the Web increases their productivity by saving time since it is much easier than performing manual search of non-digital resources like books. Some of the comments about the benefits resulting from using Web materials include:

*“They are more up-to-date than any of the books we use.” (T1)*

*“My favorite thing about the Web is how quickly I can access images to use.” (T15)*

*“It’s all available on the Web.” (T3)*

Interviewees mentioned that using Web materials improves the quality of their teaching practice by helping them increase subject matter expertise and technological literacy. As one teacher commented:

*“Sometimes, explanations given in the book are insufficient. Luckily, I am able to find better ways on the Web given by other teachers. This allows me to stay current within my subject area.” (T14)*

A number of comments were received about Web digital materials empowering the learning experience for students by generating and maintaining interest and motivation at high levels. In regards to this, Web resources were also used to enhance existing classroom activities or provide supplementary information to students. One received comment states:

*“Teaching solely out of textbooks, that’s ancient history. No student wants to be in such a boring class anymore.” (T10)*

Interviewees identified barriers in reusing materials, which were primarily related to lack of technological infrastructures in their respective schools, restrictions in accessing quality reliable materials without paying a fee, grade inappropriate materials which were either too simple or too advanced, and very few resources in Bosnian which discouraged them at times. There are also quite a few teachers out there who are not willing to adopt modern methods and approaches in their teaching practice. Interviewees noted:

*“For me to be able to bring something new and refreshing to my students, I*

*need to go home, spend free time searching and creating new lesson plans and materials, ask the administration for a projector and show the materials on my own personal PC. It's just a big hassle, but I still do it.” (T2)*

*“So many times I found great YouTube videos and interactive exercises to supplement concepts I was teaching, but couldn't use them since they were in English. Sure kids learn English in school, but it's too advanced for them to follow math terminology.” (T18)*

*“Hmmm, I don't see what the big fuss is all about. I have been teaching for so many years without the fancy technology, why start now?” (T17)*

When it came to teachers' willingness to share materials they personally created or reused, only 20% of interviewees were reluctant to do so. The other 80% were enthusiastic about sharing materials and possibly influencing new ideas that could help students to better grasp subject matter. They all preferred the idea of choosing with whom to share their materials. A few received comments include:

*“I have a few colleagues I have been good with for the past few years. We help each other out by swapping classes, we even share lesson plans at times.” (T11)*

*“Sure I am willing to share, but only with those who want to share with me. An eye for an eye.” (T12)*

*“It's only fair that I shared my materials, if I am going to be reusing someone else's.” (T14)*

*“Whatever I find that I can download, I am going to reuse.” (T4)*

On another note, teachers mainly relied on usual search engines like *Yahoo* and *Google* to find materials and resources they were interested in reusing. They mentioned that filtering search engine results was time consuming and a frustrating process, especially since materials were very rarely found in Bosnian as the source language. Depending on how much time they had at their disposal, they would either start a broad search quest and review a number of materials, or target a specific search for the exact topic they were looking for. The majority placed emphasis on accessing teacher sites built by, or for, teachers with indexed topic materials, which enabled them to see what

other teachers in their domain were using and to gain new ideas and approaches in their own teaching practice. Different types of materials were searched, depending on teachers' preferences that usually ranged from finding PowerPoint slides to images and videos of real-world examples, interactive exercises, etc. Related corresponding quotes include:

*"I have a few teacher sites I discovered on my own and which a fellow colleague recommended. Since then, they are my first preference when I need to find something."* (T6)

*"I aim for slides which I can use to teach a new lesson...it's so much more captivating than telling students to open their books which have not changed since the 90s and have been passed from one student generation to the next."* (T7)

*"I found a major mistake in one of the materials I was using. Oops! Luckily I saw it before going to class. Now, I always make sure to double check."* (T20)

When it comes to modifications and adaptations necessary for reusing Web teaching materials, adaptations were mainly performed in changing the layout and design, translating content and modifying its level of difficulty, as well as reorganizing contents in a preferred sequence. As one teacher notes:

*"Whenever I use something, I need to change the given problems and exercises. I have my own stack of math problems which are more suitable for my students."* (T1)

During the interviews, teachers made several suggestions in regards to what tools and functions they would appreciate having at their disposal when composing new materials from existing ones. These are summarized as:

- provide access to teacher oriented sites with accurate and reliable materials
- access resources with indexed and categorized contents by grade level, subject area and language
- download resources in a common format compatible with MS processors
- manipulate video length and subtitles
- translate materials quickly and easily
- decide who to share reused materials with.

Overall, although barriers exist in reusing Web teaching materials, interviewees showed eagerness to go through the trouble and include them in their teaching practice as a way not only to empower students' learning experience, but also their own expertise and quality of teaching .

#### **4.3.2 Limitations**

The teacher survey carried out for the purpose of this research has the following limitations:

- small scale survey
- participant selection
- participant distribution.

First of all, the small number of teachers interviewed in person was restricted by time and distance constraints. As such, it is not possible to generalize observations to all teachers in Bosnia and Herzegovina as well as other developing countries. A more rigorous survey should involve a randomly selected sample of teachers across different developing countries who vary in terms of comfort of using information technology, the Web, and reusing teaching materials created by others.

Second of all, some teachers participating in the survey volunteered on the basis of acquaintance and past contact. As such, the survey data may be subject to bias, with participants overstating the value of sharing and reusing existing teaching materials.

Finally, the teachers participating in the survey did not cover the whole region of Bosnia and Herzegovina. As such, the survey data may not represent the general attitude and practices of all teachers in Bosnia and Herzegovina.

Although limitations exist, the observations and findings obtained through the small scale survey provide preliminary insights into teacher practices, behaviors, and attitudes towards sharing and reusing Web teaching materials.

#### **4.4 Developing Individual Patterns**

In order to develop individual patterns, teacher practices and behaviors were documented after thorough analysis of the data set obtained from the survey presented in *Section 4.3*. The iterative process used is illustrated in Fig.15.

Once the teacher practices and behaviors were extracted and generalized, a first version of initial patterns was roughly formalized to represent the basic ideas of practices in reusing digital materials found on the Web that could assist non-expert users.

In the second step, initial patterns were refined through an in-lab workshop which led to improved patterns.

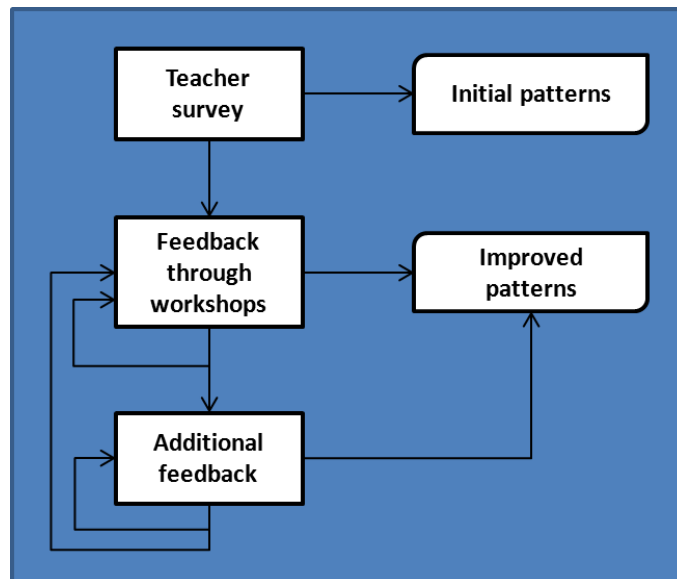


Fig.15: Pattern development process

For each pattern, situations were determined in which solutions provided by patterns have been successfully applied. Some patterns were modified more than once, through several iterations, by obtaining feedback from different in-lab individuals and faculty members.

In the third step, patterns were presented in a research paper [4] for the CSCW 2011 conference for which additional feedback was obtained from an assigned reviewer.

It is therefore important to mention that the developed patterns are not the reflection of the personal opinions of the author.

#### 4.4.1 Pattern Categories

Individual patterns had to be categorized in order to cover all related aspects necessary for successful reuse of Web teaching materials; tasks, tools, system, and community interactions. This is why patterns were divided into the

following categories:

- *Tasks performed by teachers*: describes activities users have to perform while pursuing a goal of reusing existing Web materials. It also provides an insight for designers and system developers into the essential functionalities that must be provided by a system or platform.
- *Tools required for content manipulation*: describes what type of functionalities and features tools must have for successful content manipulation.
- *Interactions within teacher community*: describes possible user and community collaborations within the system environment.
- *Interactions with system environment*: describes the design and functionalities of the system environment supporting the reuse of Web materials, desirable usability attributes and user interface preferences.

These created categories will also help in managing patterns, as their number increases to a larger extent.

#### 4.4.2 Pattern Format

As mentioned in *Chapter 3*, a lot of different pattern formats exist depending on the field and discipline they are being developed for. Some pattern authors even decide not to take a fixed format at all [Martin Fowler, 96].

Because a fixed format increases readability and understandability, a common modified version of the Alexandrian pattern, shown in Table 3, was used in the formation of patterns for reusing Web teaching materials. This decision fell on the best fit, following a review of the different pattern formats proposed so far.

Name	Unique identification of the pattern
Intent	A short overview what the pattern is about
Context	The situation in which the pattern occurs
Problem	The problem that has to be solved
Forces	The trade-offs that have to be considered
Solution	Description of how to solve the problem
Consequences	The positive and negative consequences of performing the solution
Relate Patterns	Other patterns related to this particular pattern in some way

Table 3: Pattern format for individual patterns

#### 4.4.3 Example of a Pattern

Now, let's take a closer look at one of the individual patterns shown in Fig.16.

Nowadays, although a wealth of educational resources can be found on the Web, it can be challenging and at times difficult to select the best material or reference amongst so many.

Since there are no filters on the Web regarding what is posted, it is necessary for teachers to develop skills to evaluate what they find. Extra time and effort must be devoted in assessing the quality and accuracy of information presented in different materials. This can include looking at qualifications of the author and cross-references, or reading recommendations by other users. The copyright statements and/or license agreements must also be carefully checked before reusing any materials.

The *Accuracy Pattern* provides guidance for non-expert users in checking the quality and accuracy of information presented in teaching materials they may be interested in reusing.

Accuracy	Content accuracy of teaching materials on the Web
Intent	Determine content accuracy in existing teaching materials on the Web
Context	The Web offers a wide range of information that can be frequently updated, easily accessed and downloaded. However, anyone can post contents since there is no quality control on the Web. Therefore, educators need to check the accuracy of contents in teaching materials.
Problem	How to determine accuracy and reliability of teaching materials?
Forces	<ul style="list-style-type: none"> <li>• Teaching content is provided by an unknown and unreliable online source</li> <li>• Need expert knowledge in the subject domain to determine content accuracy of teaching materials</li> <li>• Need to distinguish the presence of political, ideological, cultural, religious, institutional, or personal biases</li> </ul>
Solution	<p>Information on the Web undergoes no process of evaluation and therefore no quality assurance exists. Generally, information created by government (.gov) / educational institutions (.edu) is considered the most reliable. Before teachers decide to reuse contents of existing materials they must critically inspect whether the information presented is accurate, comprehensive, credible and objective.</p> <p>The following steps will help teachers decide if the information in teaching materials is worthwhile:</p> <ol style="list-style-type: none"> <li>1. Identify the name of individual/group/institution that created contents of a teaching material. Reliable materials should state the name of their author.</li> <li>2. Identify any contact information supplied. Reliable materials should provide a way for others to contact authors, to ask questions and/or debate about any information found in the material.</li> <li>3. Identify author's purpose or motivation behind the material. Reliable sources should be objective in presenting content information.</li> <li>4. Identify the source of any facts mentioned. Reliable materials should reference published or unpublished sources of facts found in them.</li> <li>5. Look for any links provided to related sources of information regarding covered topics. Reliable materials should contain information that can be verified by other sources and materials.</li> <li>6. Identify the date of the last content modification. Reliable contents should be up-to-date. This may vary according to the type of educational field/subject.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>• Accurate informational contents for students in teaching materials</li> <li>• Any new changes/breakthroughs in the corresponding field of covered concepts and topics must be updated in new teaching materials to keep them accurate</li> </ul>
Related Patterns	Search, Translation, Reusing Web Teaching Materials Patterns

Fig.16: The *Accuracy Pattern*

Because of space constraints, only the essential pattern elements are presented.

### **Name**

Accuracy pattern

### **Context**

The Web offers a wide range of information that can be frequently updated, easily accessed and downloaded. However, anyone can post content since there is no quality control on the Web. Therefore, educators need to check the accuracy of content in teaching materials.

### **Problem**

How to determine accuracy and reliability of teaching materials?

### **Forces**

- Teaching content may be provided by an unknown and unreliable online source.
- Need expertise and knowledge in the domain to determine content accuracy of a teaching material.
- Need to distinguish the presence of political, ideological, cultural, religious, institutional, or personal biases.

### **Solution**

Information on the Web undergoes no process of evaluation and therefore no quality assurance exists. Generally, information created by government (.gov) / educational institutions (.edu) is considered the most reliable. Before teachers decide to reuse contents of existing materials they must critically inspect whether the information presented is accurate, comprehensive, credible, and objective.

The following steps will help teachers decide if the information in teaching materials is worthwhile:

1. Identify the name of the individual/group/institution that created contents of a teaching material. Reliable material should state the name of its author.
2. Identify the source of any facts mentioned. Reliable materials should reference published or unpublished sources of facts found in them.
3. Identify any contact information supplied. Reliable materials should provide a way for others to contact authors, to ask questions and/or debate about any information found in the material.

4. Identify author's purpose or motivation behind the material. Reliable sources should be objective in presenting content information.
5. Identify the date of the last content modification. Reliable contents should be up-to-date. This may vary according to the type of educational field.
6. Look for any links provided to related sources of information regarding covered topics. Reliable materials should contain information that can be verified by other sources and materials.

#### 4.5 Formulating a Pattern Language

A pattern language consisting of 28 patterns has been developed to communicate practices and processes in reusing Web teaching materials, which will provide a good starting place for future research in both development of new patterns and designs of user-centric systems supporting the necessary functionalities for reusing Web teaching materials.

The pattern language consisting of individually formed patterns, shown in Fig.17, aims to:

- support non-experts in reusing Web teaching materials
- support designers in creating user-centric systems, with teachers as the main end users in mind.

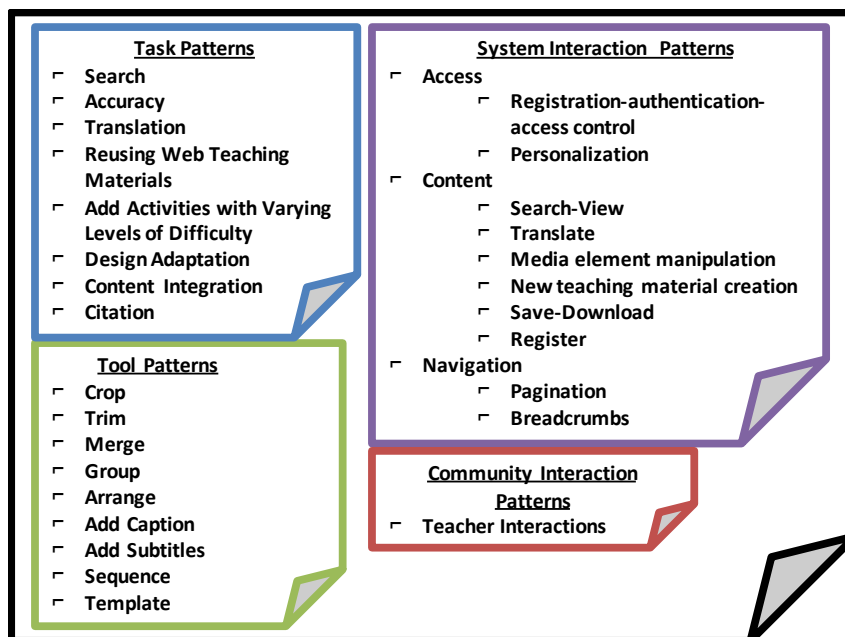


Fig.17: A pattern language for reusing Web teaching materials

## 4.6 Developing Pattern-based Workflows

### 4.6.1 User Workflows

A workflow consists of a sequence of connected steps and as such is like a roadmap. Each workflow provides visual representation of the necessary steps needed for a completion of a particular process.

It is this aspect which makes workflows so useful, by helping people discover what steps they need to carry out in order to complete a particular task or process.

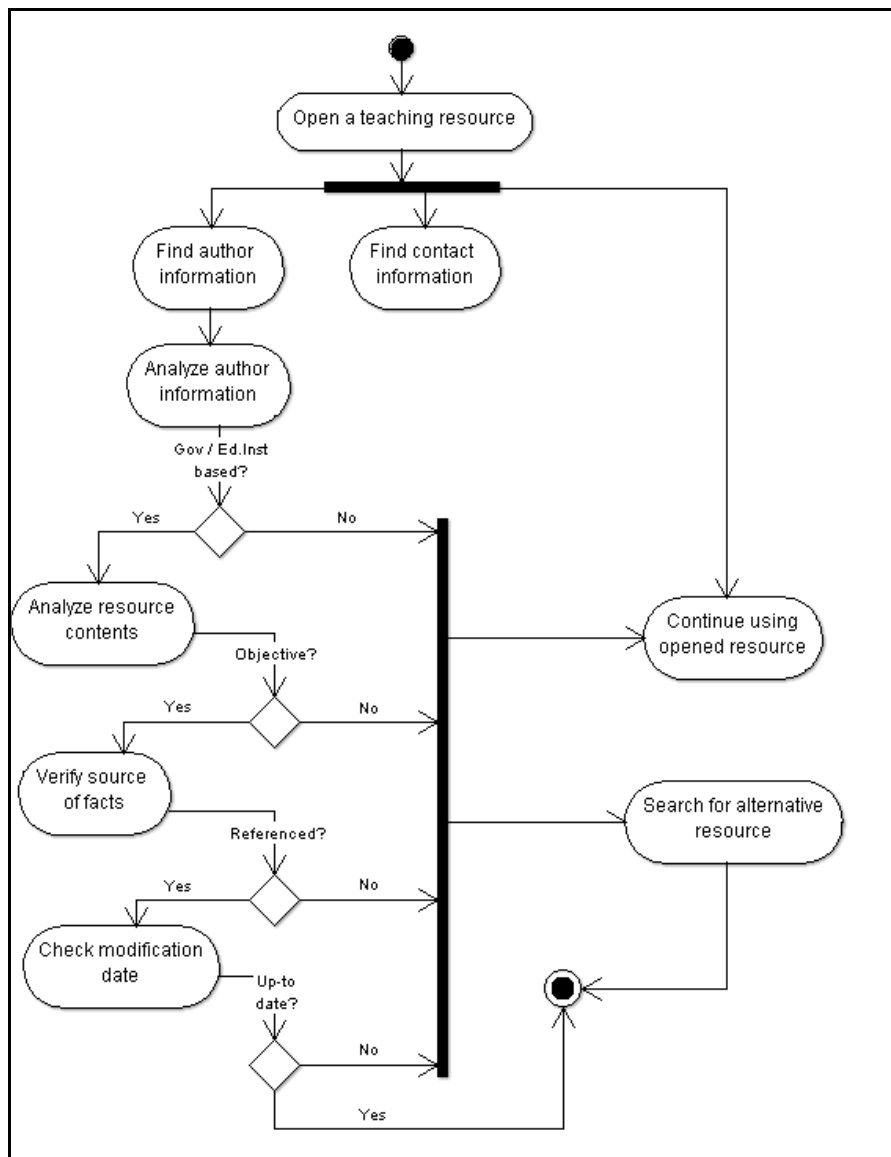


Fig.18: User workflow derived from the Accuracy Pattern

For this reason, specific individual pattern in the “tasks performed by

teachers” category has been used to explicitly derive a user workflow that documents all the necessary steps in reusing Web teaching materials. This provides an even clearer guidance for teachers, especially technology non-experts, in successfully reusing materials they may be interested in.

As a continuation of the *Accuracy Pattern* example, the above Fig.18 depicts the derived user workflow.

#### 4.6.2 System-User Workflows

Going a step further, each user workflow was translated into system-user workflows.

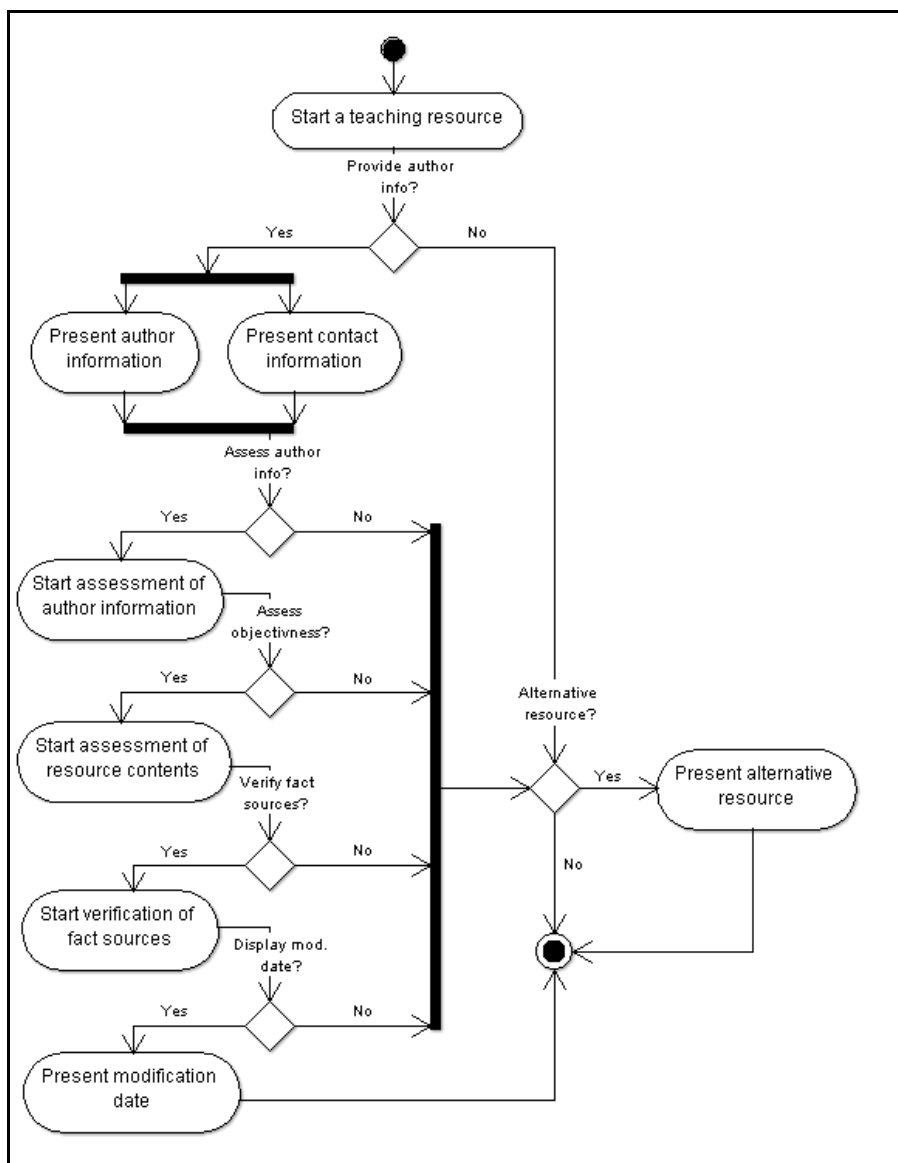


Fig.19: System-user workflow based on the *Accuracy Pattern*

The main purpose of doing so is to provide explicit description of interactions between a system and its users that designers can extract in proposing future system designs based on user driven functionalities.

The above Fig.19 depicts the system-user interaction workflow based on the *Accuracy Pattern*.

#### **4.7 Using Patterns for User-Centric Tools**

A natural question that arises is whether pattern languages can actually advance active user participation from teachers in the design of user-centric tools.

When it comes to architecture, pattern languages were originally developed as tools to support participatory design. In a series of case-studies, Alexander *et al.* described the participatory processes that he sought to develop [1]. Key elements of these processes were:

1. Removal of the separation of roles between designing a building and realizing it on site, which in Alexander's view, made it impossible to ensure that the building was sensitive to local contingencies. Instead, a new role of 'architect builder' was introduced, responsible for both assisting the users in design and coordinating building activity on site.
2. The architect builder introduced the users to the patterns in order to support localized control of design. The whole user group addressed patterns covering large-scale issues, such as the relative positions of buildings. As the design progressed, sub-groups considered smaller scale details that particularly affected them. The groups or individuals were asked to consider the patterns, criticize and adapt them to their own situations, and to use them to develop their own designs.
3. When developing designs, users were encouraged to use sketches, and to pace and mark out their designs on the ground where building was to take place. This was important to help them visualize the effect their proposals, in the specific context.
4. Within the building process, Alexander sought to use approaches that supported what he called 'gradual stiffening'. This approach sought to avoid

the drawbacks of premature commitment in design, by permitting late adaptations to designs.

As there has been a growing interest in using patterns and pattern languages in the design of interactive system in the past few years, contribution of user participation in the design of interactive systems was examined in participatory design [10]. For this purpose two pattern languages were developed, each one dealing with a specific class of websites. The first language addressed the design of travel websites and was developed by selecting previously published patterns addressing the general issue of interactive systems design, and adapting them to reflect the specific functions and needs of a travel websites. This language was used in seven simulated design exercises, in which different users were asked to develop paper prototypes. The users ranged in experience from retired teachers with no experience of using the Web to trainee Web designers. At the start of the session, users were told that following the patterns was not compulsory, and that the illustrations were examples only and not definitive best practices. After each session, users were interviewed about reactions to the exercise and to the pattern language. The second language addressed the design of a Web-based learning resource, covering both pedagogical and interface design issues. This language was used in six simulated design exercises to develop paper prototypes, and in three further extended studies, in which initially developed designs were further developed by working through iterations of static HTML and dynamic Web designs. All users were lecturers or students, or both, with some experience of Web usage, but from a range of academic disciplines. Results of these investigations suggest that pattern languages can be useful in supporting participatory design activities with the overall positive user response in using patterns as sound design guidelines [10].

From these participatory processes we can conclude that patterns can be used as a possible “lingua franca” for designers and teachers in applying patterns and derived workflows as superior guidelines to support design practice in real design activities.

Therefore, in order to mimic Alexander’s process and apply the formed pattern language for reusing Web teaching materials, design sessions could be

arranged in which a designer whose role would be that of a facilitator could be asked to work with teachers in developing a design of a tool or a system that would best fit their needs when it comes to reusing and sharing Web materials. The designer would guide and assist the teacher design group and encourage them to get involved by actively creating paper prototypes. Teachers would be encouraged to sketch their own ideas, and to make notes about features they would like to include in the design based on the patterns, but also asked questions to make them think and let them justify their choices.

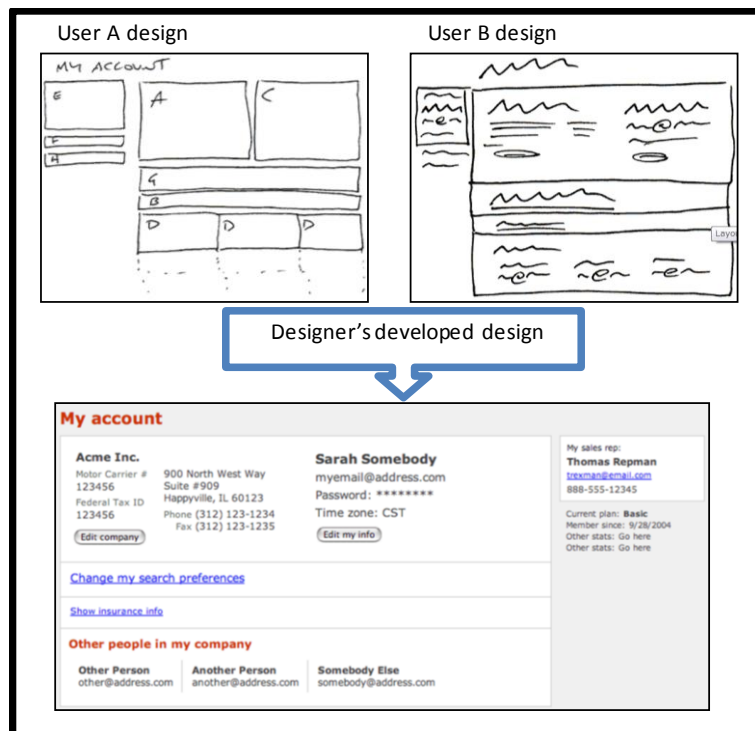


Fig.20: Developed designs based on sessions between users and designers

Later on, the designer would be involved in an iterative development process, beginning with paper prototypes and sketches, moving through mockups of the designs using Web authoring tools towards finished products.

## 4.8 Future Work

From the very beginning, the aim of this research has been towards a bigger and more ambitious goal; to lay the foundation towards building a multilingual learning resource system using Web service technologies which would enable educators to easily access and reuse unlimited number of educational resources.

As covered in *Section 4.7*, design sessions should be set up between designers and different profiled teachers to help build a complete multilingual learning resource system supporting reuse and sharing of Web teaching materials. Prototypes of the system would then have to go through different tests such as usability, functionalities, etc.

Being a multilingual resource system, it would contribute in reducing the imbalance of content availability in minority languages, especially for the K-12 educational level, as well as in further expanding the culture of sharing and reusing.

The system would take advantage of machine translators provided by the Language Grid project [3] and collaboration tools provide by the Language Grid Toolbox [3] to support the multilingual facet of resources and communication among the diverse teacher community.

A model of such a system supporting necessary user driven functionalities is illustrated in Fig.21.

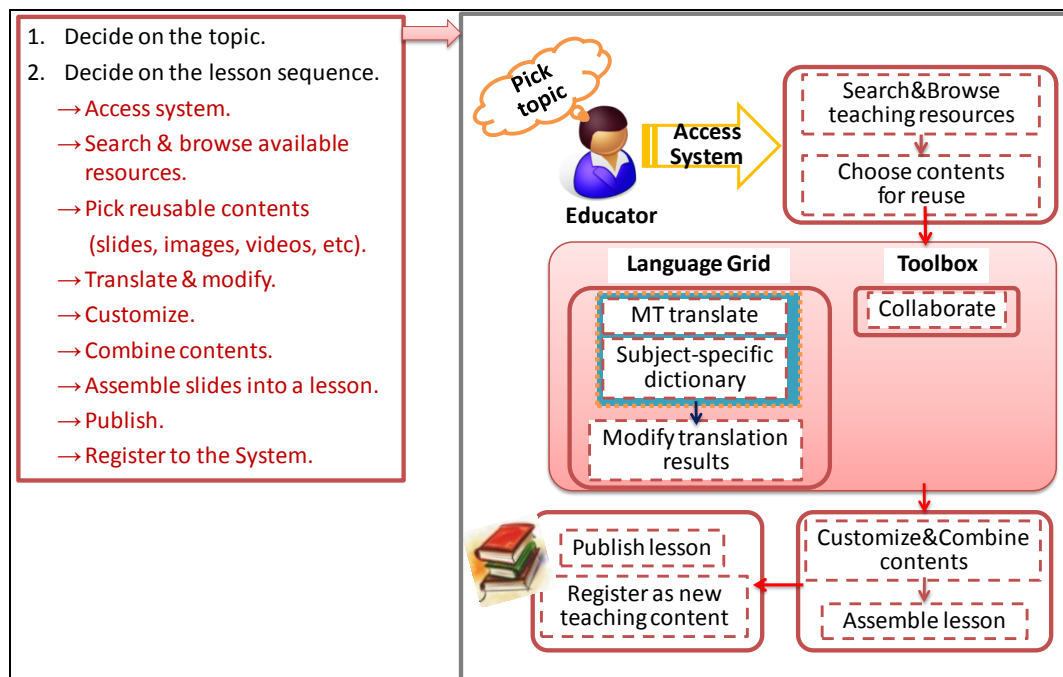


Fig.21: Model of multilingual resource system

Each teaching material would be represented as a resource and wrapped as a service with different media element types and handling different levels of

granularity, similar to that of the Language Grid. The user generated metadata level would allow users to add information about resources like topic, author, date of creation and editing, etc.

As the amount of teaching materials would grow, a search function using classic keyword-based would not be enough or effective for efficient queries. Therefore, the search function would need the presence of content metadata formalized through various ontologies to refine search queries.

## Chapter 5 Conclusion

In today's fast paced world, as teachers are pressed with time and a growing number of responsibilities, it is crucial for them to be able to quickly and efficiently create new teaching materials for their upcoming classes and move on to other tasks at hand.

A logical solution resides in relying on today's information and technology enhanced era, by taking advantage of information communication technologies and vast amounts of educational resources readily available on the Web.

For the culture of sharing and reusing of Web teaching materials to make a real lasting impression on the worldwide educational community, current open content initiatives and projects need to look beyond technological issues and ways to resolve them. Energy needs to be focused in trying to understand end users' practices and behaviors for a successful adoption and improvement of existing technological solutions.

This is why a user-centric approach has been adopted throughout this thesis with the aim of addressing real issues and teacher practices involved in reusing teaching materials found on the Web by conducting teacher interviews and survey, which designers can use to their advantage in creating useful and fully exploited user-centric tools, applications and systems that will support all the necessary functionalities.

In order to supplement the user-centric approach, this thesis has also adopted the pattern language approach which has been adopted by so many diverse fields and domains over the years, as a proven method to share expertise knowledge and solve real world problems. A pattern language consisting of 28 patterns which addresses different aspects necessary for successful reuse of Web teaching materials like tasks, tools, system and community interactions was developed.

Therefore, the main contribution of this thesis is the ***development of a pattern language for reusing Web teaching materials***, which is currently missing in the field of education and e-learning. The main goal of this language is to provide teachers with solutions in choosing, designing, editing

and sequencing teaching materials, but it also enables:

- discussions within the pattern community
- creation of new patterns in the pattern language
- discussions between real end users and designers
- design of user-centric tools and systems
- creation of a foundation for future work towards a service oriented multilingual learning resource system.

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# Appendix: Patterns

## A.1 Task Patterns

### A.1.1 Search Pattern

<b>Search</b>	<b>Search the Web for teaching materials</b>
Intent	Perform an efficient search for Web teaching materials on a specific topic
Context	Searching for specific information on the Web can be difficult and time consuming. Advanced Web search techniques, compatible with most search engines, help narrow search results to match context and format of search queries.
Problem	How to perform an efficient search for Web teaching materials on a specific topic?
Forces	<ul style="list-style-type: none"> <li>• Search engines cover a small percentage of all the available information on the Web</li> <li>• Different search engines provide different search results for the same query</li> </ul>
Solution	<p>The Web provides vast amounts of information and educational materials in numerous subject areas. To be able to take advantage of what Web has to offer, search is often conducted. In order to efficiently conduct search in as less time as possible teachers should adopt the following steps:</p> <ol style="list-style-type: none"> <li>1. Before starting a Web search, it is necessary to break down the topic into separate concepts.</li> <li>2. Once the concepts are identified, a list of search terms describing each concept should be made.</li> <li>3. Access a Web search engine such as Google or Yahoo.</li> <li>4. Decide which advanced search method best suits individual preferences if direct link to a teaching material is not known:             <ol style="list-style-type: none"> <li>4.1. <i>Boolean search</i> uses the logical relationships (AND, OR, NOT) among search terms. AND enables a two word search for finding materials that contain both search terms. A variation is to use the (+) sign before the word without spaces. OR conjunction is mostly used to search for synonyms, enabling either of the search terms to be returned. NOT conjunction is used to retrieve information that excludes a particular search term. A variation is to use the (-) in front of the search term so as to exclude it. Combined AND OR search enables more complex search by combining the logic of both conjunctions.</li> <li>4.2. <i>Phrase search</i> is useful when search terms appear naturally in the context of a phrase. In order to do so, the phrase must be enclosed with double quotes.</li> <li>4.3. <i>Natural language search</i> enables normal questions or sentences to be used as a search query without the worry of Boolean logic.</li> </ol> </li> <li>5. Once search is complete, browse results with the most relevance.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>• It takes practice to decide which search method best suits individual preferences</li> <li>• Sifting and organizing numerous search results can be time consuming</li> <li>• Discovery of relevant materials for reuse that contain a specific topic or media format</li> </ul>
Related Patterns	Translation, Accuracy Patterns

### A.1.2 Accuracy Pattern

Accuracy	Content accuracy of teaching materials on the Web
Intent	Determine content accuracy in existing teaching materials on the Web
Context	The Web offers a wide range of information that can be frequently updated, easily accessed and downloaded. However, anyone can post contents since there is no quality control on the Web. Therefore, educators need to check the accuracy of contents in teaching materials.
Problem	How to determine accuracy and reliability of teaching materials?
Forces	<ul style="list-style-type: none"> <li>• Teaching content is provided by an unknown and unreliable online source</li> <li>• Need expert knowledge in the subject domain to determine content accuracy of teaching materials</li> <li>• Need to distinguish the presence of political, ideological, cultural, religious, institutional, or personal biases</li> </ul>
Solution	<p>Information on the Web undergoes no process of evaluation and therefore no quality assurance exists. Generally, information created by government (.gov) / educational institutions (.edu) is considered the most reliable. Before teachers decide to reuse contents of existing materials they must critically inspect whether the information presented is accurate, comprehensive, credible and objective.</p> <p>The following steps will help teachers decide if the information in teaching materials is worthwhile:</p> <ol style="list-style-type: none"> <li>1. Identify the name of individual/group/institution that created contents of a teaching material. Reliable materials should state the name of their author.</li> <li>2. Identify any contact information supplied. Reliable materials should provide a way for others to contact authors, to ask questions and/or debate about any information found in the material.</li> <li>3. Identify author's purpose or motivation behind the material. Reliable sources should be objective in presenting content information.</li> <li>4. Identify the source of any facts mentioned. Reliable materials should reference published or unpublished sources of facts found in them.</li> <li>5. Look for any links provided to related sources of information regarding covered topics. Reliable materials should contain information that can be verified by other sources and materials.</li> <li>6. Identify the date of the last content modification. Reliable contents should be up-to-date. This may vary according to the type of educational field/subject.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>• Accurate informational contents for students in teaching materials</li> <li>• Any new changes/breakthroughs in the corresponding field of covered concepts and topics must be updated in new teaching materials to keep them accurate</li> </ul>
Related Patterns	Search, Translation, Reusing Web Teaching Materials Patterns

### A.1.3 Translation Pattern

Translation	Composition of multilingual teaching materials
Intent	Compose teaching materials in different languages
Context	Teaching materials are provided in one language. To obtain versions in other languages, the original version has to be translated.
Problem	How to translate teaching materials from one language to another?
Forces	<ul style="list-style-type: none"> <li>• Teaching materials are provided in a language not understood by the teacher or target student group</li> <li>• Translation is necessary to create multilingual versions understood by target student groups</li> <li>• Knowledge required regarding which source language materials are presented in</li> <li>• Different machine translators are more suitable for certain pairs of languages than for others</li> <li>• Evaluation of translation accuracy</li> </ul>
Solution	<p>In order to translate materials, it is necessary to perform translations either manually or using machine translators. If a teacher is multilingual, material translation can be done manually or assistance from other persons/teachers within the community can be asked. If translation is done with the help of another person, domain specific concepts and materials' context should be provided to allow better translation quality.</p> <p>On the other hand machine translators can be used, but they still cover a small number of language pairs and require human revisions. These revisions must be performed by experts who fully understand the context of domain specific terms.</p> <p>Required steps for translation are:</p> <ol style="list-style-type: none"> <li>1. Enable sections of teaching materials for translation either by human or machine translators.</li> <li>2. Identify the source and target language pairs.</li> <li>3. If a machine translator is used, choose the best translator available for the language pair.</li> <li>4. Translate chosen sections.</li> <li>5. Revise translations.</li> <li>6. Add translated parts to replace original sections in the teaching material.</li> <li>7. Resize translated parts to fit in the design layout.</li> <li>8. Re-arrange translated parts to fit in the design layout.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>• Multilingual teaching materials available</li> <li>• Length of the original and translated sections may differ</li> <li>• Any changes in the original material must be updated in the translated version</li> </ul>
Related Patterns	Search, Accuracy, Design Adaptation, Reusing Web Teaching Materials Patterns

### A.1.4 Reusing Web Teaching Materials Pattern

<b>Reusing Web Teaching Materials</b>	<b>Reuse existing teaching materials to meet personalized requirements</b>
Intent	Reuse existing materials to fit individual teachers' preferences
Context	Creating teaching materials from scratch is time consuming and it's highly unlikely that a perfect teaching material is authored by someone else as a result of different teaching styles and approaches. One way to save time is by reusing available Web materials and adapting them to fit individual needs and usage scenarios. Reusing refers to using only specific sections or using the complete teaching material.
Problem	How to reuse existing teaching materials to fit personalized teaching requirements?
Forces	<ul style="list-style-type: none"> <li>• Some material formats require special software tools for manipulation</li> <li>• Some materials are inaccessible for reuse and manipulation</li> <li>• Reusing and adapting materials is time consuming</li> </ul>
Solution	<p>It is necessary to define what requirements must be met in reusing chosen Web materials so that they best fit individual preferences.</p> <p>Important steps for reusing materials and their contents should include the following:</p> <ol style="list-style-type: none"> <li>1. Check curriculum requirements.</li> <li>2. Check learning and teaching objectives.</li> <li>3. Decide teaching style/instructional strategies.</li> <li>4. Translate chosen material sections to target language, if necessary.</li> <li>5. Adapt the level of difficulty and material duration, if necessary.</li> <li>6. Set up a desired sequence of material sections.</li> <li>7. Carefully define sequence of known and new concepts.</li> <li>8. Change material design layout, if necessary.</li> <li>9. Transform created material into several different formats, if possible.</li> <li>10. Enable hard-copy distribution and reference materials.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>• Obtain materials which fit individual teachers' requirements</li> <li>• Adaptions need to be individually performed</li> </ul>
Related Patterns	Accuracy, Translation, Add Activities with Varying Levels of Difficulty, Design Adaptation, Patterns

### A.1.5 Add Activities with Varying Levels of Difficulty Pattern

Add Activities with Varying Levels of Difficulty	<b>Compose teaching materials with diverse activities to suit differing student levels</b>
Intent	Compose teaching materials with diverse activities that support different levels of difficulty within a student group
Context	In every student group there are students with differing levels of skills and abilities. After an introductory lesson, intermediate lessons provide activities/exercises to check the level of understanding about covered topics. Successful and effective teaching materials contain activities that engage and motivate all students, and provide challenging questions for more advanced students. Attention needs to be given to students with limitations caused by disabilities.
Problem	How to compose materials with activities that fit different student needs and abilities within a single student group?
Forces	<ul style="list-style-type: none"> <li>• Chosen teaching materials for reuse do not contain activities suitable for all students</li> <li>• Chosen materials are not suitable for students with disabilities</li> <li>• Composing several versions of chosen materials is time consuming</li> </ul>
Solution	<p>Before starting to create materials by adapting existing ones, teachers must be well informed about individual students and whether there are any limitations and/or disabilities. A balance must be found on how to cover different levels by providing a range of activities.</p> <p>Steps required are:</p> <ol style="list-style-type: none"> <li>1. Find out about any limitations/disabilities among students.</li> <li>2. Check curriculum requirements for the chosen topic.</li> <li>3. Check learning objectives.</li> <li>4. Choose a teaching strategy.</li> <li>5. Check chosen materials for relevant limitations.</li> <li>6. Adapt materials by creating several versions.</li> <li>7. Add activities/exercises with different levels of difficulty to evenly cover topics' minimum requirements and more.</li> <li>8. Decide on a fair assessment and evaluation criteria.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>• Created materials covering all student levels equally</li> <li>• Creating materials with differing levels requires teachers time and effort</li> </ul>
Related Patterns	Reusing Web Teaching Materials, Design Adaptation Patterns

### A.1.6 Design Adaptation Pattern

<b>Design Adaptation</b>	<b>Adapt the design of teaching materials to meet personalized preferences</b>
Intent	Adapt the design of teaching materials to fit teachers' individual preferences
Context	Effective teaching materials manage to capture students' interest levels and keep them high. In order to create effective materials, besides subject matter, teachers must pay attention to content design since they highly influence students' perception. As numerous designs exist, it is important to adapt design layouts for different student groups and teaching styles.
Problem	How to adapt the design layout for different teaching materials?
Forces	<ul style="list-style-type: none"> <li>• Design consists of many elements including background images, colors, fonts, etc.</li> <li>• Changing elements in an applied style template requires changing one element at a time</li> <li>• Choosing the right design layout takes practice</li> </ul>
Solution	<p>Many different elements come into play in the design layout and style. Design adaptations involve replacing, changing and rearranging different elements such as images, text boxes, etc. Sometimes, adaptations will involve only graphics, and at other times attention needs to be paid to correcting the length of translated texts to fit in the design layout.</p> <p>Some useful steps in successfully adapting the design layouts include:</p> <ol style="list-style-type: none"> <li>1. Replace existing background graphics.</li> <li>2. Delete existing background graphics.</li> <li>3. Add additional background graphics.</li> <li>4. Apply different style templates and background colors.</li> <li>5. Resize text boxes if necessary.</li> <li>6. Rearrange text boxes, images, etc.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>• Adapting the design layout can be time consuming</li> <li>• The design layout of contents is adapted to fit teachers preferences and student group</li> </ul>
Related Patterns	Reusing Web Teaching Materials, Add Activities with Varying Levels of Difficulty, Content Integration, Crop, Trim, Add Caption, Add Subtitles Patterns

### A.1.7 Content Integration Pattern

<b>Content Integration</b>	<b>Integrate contents from reused Web teaching materials</b>
Intent	Combine contents from reused materials into a new teaching material
Context	Creating new teaching materials by reusing existing ones on the Web, involves pedagogical and technical know-how. Attention needs to be focused on covering required learning and teaching objectives, as well as knowing how to combine different media content types all at once.
Problem	How to combine different media type contents into a single teaching material?
Forces	<ul style="list-style-type: none"> <li>Integrating contents from different materials requires pedagogical and technical expertise</li> <li>Integrating contents on the same topic in a particular sequence may differ from teacher to teacher</li> </ul>
Solution	<p>Teachers must be very skilled in integrating different media contents to create an effective teaching material from existing materials on the Web. Careful consideration must be placed on structuring materials according to curriculum requirements, learning and pedagogical objectives since this enforces the teaching-learning process. Once the goals and objectives of a material are determined, the order of contents can be decided, so that the arrangement of concepts complies with curriculum requirements.</p> <p>An all-purpose tool such as MS PowerPoint can be useful to teachers for combining different media content types all at once and presenting them as a teaching material. Images, text, audio and video files can be imported and manipulated quite easily.</p>
Consequences	<ul style="list-style-type: none"> <li>New teaching material created</li> <li>Integrating contents can be time consuming and requires practice</li> <li>Integrating contents in a particular sequence may not prove</li> </ul>
Related Patterns	Citation, Design Adaptation, Merge, Group, Arrange, Sequence, Template Patterns

### A.1.8 Citation Pattern

<b>Citation</b>	<b>Cite sources in teaching materials</b>
Intent	Determine when it is necessary to cite sources in a newly composed teaching material
Context	Teachers tend to be confused in deciding when it is necessary to cite sources of information and facts they reuse.
Problem	How to decide when and which sources to cite?
Forces	<ul style="list-style-type: none"> <li>Some teachers are not willing to cite sources of their information</li> <li>It is not always easy to cite or refer to original sources posted online since anyone can publish contents on the Web</li> </ul>
Solution	<p>Teachers do not always need to cite sources of information and facts they end up using in their teaching materials. It is not necessary to cite sources in case when information regarding common knowledge is used, nor when citations of specific sections have already been provided.</p> <p>Here are a few guidelines when citations or references are typically needed:</p> <ol style="list-style-type: none"> <li>If created teaching contents refer to information that is not commonly known.</li> <li>If contents contain information that results from a scientific study.</li> <li>If contents contain sections directly quoted from other sources including multimedia.</li> <li>If teaching contents incorporate contradictory claims from conflicting research studies.</li> <li>If teaching contents contain specific sections of events that have been documented or presented elsewhere.</li> </ol>
Consequences	<ul style="list-style-type: none"> <li>Provide thorough citations and references of sources in teaching materials</li> <li>If too many sources need to be cited, it can be time consuming for teachers</li> </ul>
Related Patterns	Content Integration Pattern

## A.2 Tool Patterns required for content manipulation

### A.2.1 Template Pattern

<b>Template</b>	<b>Provide templates for creating new teaching materials</b>
Intent	Provide different style templates for creating new teaching materials
Context	Different design templates fit different teacher preferences, teaching styles and objectives. Sometimes, the need to create contents of the same design arises.
Problem	What design templates should be available to teachers?
Forces	<ul style="list-style-type: none"> <li>• Too many design templates to choose from</li> <li>• Time consuming to decide on an appropriate design layout</li> </ul>
Solution	Provide a list of different effective design templates for teachers to choose from, if they wish to. They should be able to choose a blank template and create their own design style layout.
Consequences	<ul style="list-style-type: none"> <li>• An abundance of design templates for teachers to choose from</li> </ul>
Related Patterns	Group, Merge, Sequence, Content Integration Patterns

### A.2.2 Crop Pattern

<b>Crop</b>	<b>Crop an image</b>
Intent	Provide a tool for cropping images
Context	Teachers should manipulate images by altering their size, borders, shape, angle, etc.
Problem	How can teachers easily crop images without the use of advanced software tools??
Forces	<ul style="list-style-type: none"> <li>• Many different commercial software tools are available</li> </ul>
Solution	Crop tool should be easy to use and should provide a number of options for altering images. These options should include alteration of image size, borders, shape, angle, etc.
Consequences	<ul style="list-style-type: none"> <li>• Cropped image ready to be used with other media elements in a new teaching material</li> </ul>
Related Patterns	Arrange, Trim, Translate, Design Adaptation Patterns

### A.2.3 Trim Pattern

<b>Trim</b>	<b>Trim a video file</b>
Intent	Provide a tool for trimming video files
Context	Trimming tool should allow teachers to set the starting and ending point and therefore cut out irrelevant sections.
Problem	How can teachers easily trim sections of a video without the use of advanced software tools?
Forces	<ul style="list-style-type: none"> <li>• Many different commercial software tools are available</li> </ul>
Solution	Teachers should be provided with an easy to use tool that enables them to choose the starting and ending points of a video. They should also be able to preview it before using the modified version of the video.
Consequences	<ul style="list-style-type: none"> <li>• Personalized duration and sections of the initial video ready to be used</li> </ul>
Related Patterns	Arrange, Crop, Translate, Design Adaptation Patterns

### A.2.4 Merge Pattern

<b>Merge</b>	<b>Merge two slides into one</b>
Intent	Provide a tool that enables two slides to be merged into one
Context	Slides of different design layouts can be merged into a predefined design layout
Problem	How should teachers easily merge two slides with different layouts into one?
Forces	<ul style="list-style-type: none"> <li>Abundance of design layouts to choose</li> </ul>
Solution	Merge chosen slides into a single one by choosing its design layout from a list of possible predefined designs. All elements of initial slides become components of the newly created merging slide.
Consequences	<ul style="list-style-type: none"> <li>The result is a single slide with a chosen design layout</li> </ul>
Related Patterns	Group, Sequence, Trim, Add Captions, Add Subtitles, Translation, Crop, Content Integration Patterns

### A.2.5 Add Captions Pattern

<b>Add Captions</b>	<b>Add multilingual captions to images</b>
Intent	Provide a tool that enables adding multilingual captions to images
Context	Teachers should take advantage of captions to label different images in their materials.
Problem	How can teachers easily add captions to images?
Forces	<ul style="list-style-type: none"> <li>Many commercial software tools exist</li> </ul>
Solution	Adding a caption should be made available once an image is in use. Captions should be restricted to images only. The caption should be written in a provided text box whose position can be altered by teachers according to their preference.
Consequences	<ul style="list-style-type: none"> <li>An image with appropriate caption set by the user.</li> </ul>
Related Patterns	Arrange, Crop, Translation, Design Adaptation Patterns

### A.2.6 Add Subtitles Pattern

<b>Add Subtitles</b>	<b>Add multilingual subtitles to video files</b>
Intent	Provide a tool that enables adding multilingual subtitles to video files
Context	Teachers should be able to add subtitles to a sequence of vide frames
Problem	How can teachers easily add subtitles to videos?
Forces	<ul style="list-style-type: none"> <li>Many commercial software tools exist</li> <li>Timing subtitles to coincide with video frames is time consuming</li> </ul>
Solution	Adding subtitles should be made available once a video is in use. Subtitles should be restricted to videos only. The subtitles should have the option of editing, timing, displaying and hiding.
Consequences	<ul style="list-style-type: none"> <li>Video with corresponding subtitles in the target language which coincide with the sequence of video frames</li> </ul>
Related Patterns	Arrange, Trim, Translation, Design Adaptation Patterns

### A.2.7 Group Pattern

<b>Group</b>	<b>Group different media elements together</b>
Intent	Provide a tool that enables different media elements to be grouped together
Context	Media elements should be chosen in such a way that their physical, logical, or temporal properties match when grouped.
Problem	How should teachers combine media elements?
Forces	<ul style="list-style-type: none"> <li>• Requires technical know-how</li> <li>• Grouping media elements can be time consuming</li> </ul>
Solution	Place media elements together on a slide. The grouping determines which properties must be matched for elements to be assembled together. If there is a need to extract an element from the composite one, remove the grouping and the element will be available for extraction.
Consequences	<ul style="list-style-type: none"> <li>• The result is a composite element composed of different media elements (text, image, video, audio files)</li> <li>• All combined elements become components of teaching material</li> </ul>
Related Patterns	Arrange, Merge, Trim, Add Captions, Add Subtitles, Crop, Design Adaptation Patterns

### A.2.8 Arrange Pattern

<b>Arrange</b>	<b>Arrange media elements in different locations</b>
Intent	Provide a tool that enables media element arrangement in different locations
Context	Arranging media elements in different locations on the slide should match teacher's preferences.
Problem	How can teachers easily arrange media elements on a slide?
Forces	<ul style="list-style-type: none"> <li>• Arranging elements is time consuming</li> </ul>
Solution	Provide drag and drop movement of media elements into different locations on the slide that match the movement motion of the teacher.
Consequences	<ul style="list-style-type: none"> <li>• A slide with arranged media elements in desired locations within the slide</li> </ul>
Related Patterns	Group, Design Adaptation Patterns


### A.2.9 Sequence Pattern

<b>Sequence</b>	<b>Sequence contents and slides in a coherent manner</b>
Intent	Provide a tool that enables easy sequencing of contents and slides
Context	All slides or contents should be organized according to a partial order.
Problem	How should teachers sequence a collection of slides or contents to create a coherent presentation or module?
Forces	<ul style="list-style-type: none"> <li>• Time consuming process</li> <li>• Requires pedagogical and technical skills</li> </ul>
Solution	Plan a presentation or module by organizing slides or contents into a partial order. Then, define the delivery method. The choice of presented slides can be made during the planning or delivery stage.
Consequences	<ul style="list-style-type: none"> <li>• Selection of slides matching logical and temporal properties are serialized and shown in a sequence</li> </ul>
Related Patterns	Content Integration Pattern

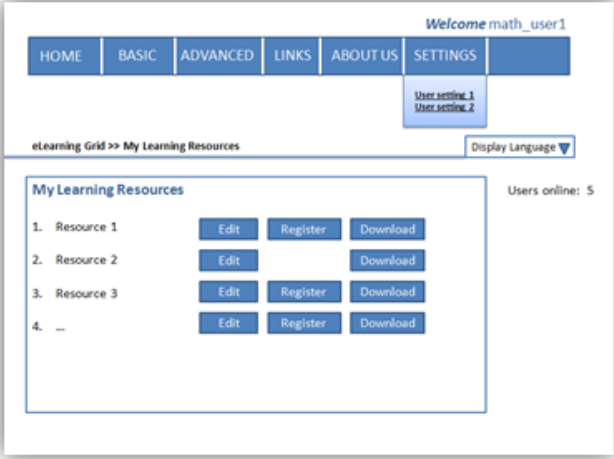
## A.3 System Environment Interaction Patterns

### A.3.1 Access Patterns

#### A.3.1.1 Registration-authentication-access control Pattern

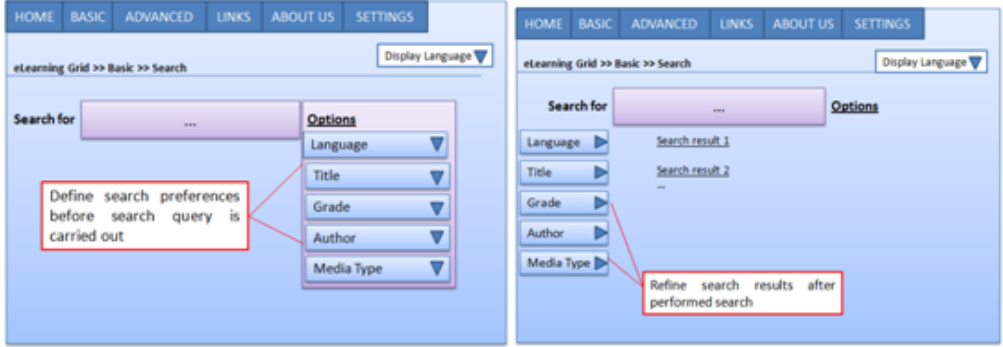
<b>Registration-authentication-Access control</b>	<b>Register and access the system</b>
Intent	Provide a system function that enables registration and access to personal account
Context	<p>There are different user roles within the system and therefore different access rights need to be assigned.</p> <p>Guests have limited access rights, as unregistered users, to available teaching resources.</p> <p>Teachers, as registered users, are able to sign in and personalize their account settings (language, etc.) besides having extensive teaching resource privileges.</p> <p>Administrators have full permissions over the entire system and set the default settings.</p>
Problem	How should different users' access rights be effectively managed?
Forces	<ul style="list-style-type: none"> <li>• Build a complete system that supports multiple functions</li> </ul>
Solution	Provide a standard registration mechanism for every user. Users may register themselves through a Web interface or submit a request for registration to the administrators. Every user has a specific role: Guest, Teacher. Develop a database with user data and provide a mechanism for user authentication.
Consequences	
Related Patterns	Personalization Pattern

### A.3.1.2 Personalization Pattern

<b>Personalization</b>	<b>Personalize settings of the system environment</b>
Intent	Provide a system function that enables personalization of different settings
Context	According to user login information or the lack of, corresponding access rights, settings and privileges are available for viewing or change. Registered users; teachers, are able to access their saved / registered teaching resources. They may choose to view/edit/register/download a specific teaching resource from a list of their saved resources.
Problem	How should individual user settings be set?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	Provide a personalization service for all registered users which customizes their setting preferences. Through this service all users should enter the system through an initial login page, and once they are authenticated, they should be presented with all their saved settings and a list of “my teaching resources”.
Consequences	 <p>The screenshot shows a web application interface for a user named 'math_user1'. At the top, there is a navigation menu with buttons for HOME, BASIC, ADVANCED, LINKS, ABOUT US, and SETTINGS. A 'Welcome math_user1' message is displayed in the top right. Below the navigation, there is a breadcrumb trail 'eLearning Grid &gt;&gt; My Learning Resources' and a 'Display Language' dropdown menu. The main content area is titled 'My Learning Resources' and contains a list of four resources. Each resource has three buttons: 'Edit', 'Register', and 'Download'. The first resource is 'Resource 1', the second is 'Resource 2', the third is 'Resource 3', and the fourth is represented by an ellipsis. In the top right corner of the main content area, it says 'Users online: 5'.</p>
Related Patterns	Registration-authentication-access control Pattern

## A.3.2 Content Patterns

### A.3.2.1 Search-View Pattern

<b>Search-View</b>	<b>Search and view different teaching materials and resources</b>
Intent	Provide a system function that enables searching and viewing of materials and resources
Context	Sometimes there is an abundance of teaching resources and materials for a particular topic or subject, which results in users spending a lot of time in browsing them. Yet, users do not want to spend a lot of time searching, but gain access quickly and efficiently. There needs to be a difference between general Web search and system search for users, otherwise there is no benefits for users to use the system.
Problem	How should users effectively search through teaching resources and materials without wasting too much time?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	The system should have a search function powered by adding Dublin Core metadata and LOM (learning object metadata) to registered teaching resources. This would enable users to narrow their search and efficiently find different types of teaching resources relevant to their search inquiry in order to build a lesson/course.
Consequences	
Related Patterns	Translate, Save-Download Patterns

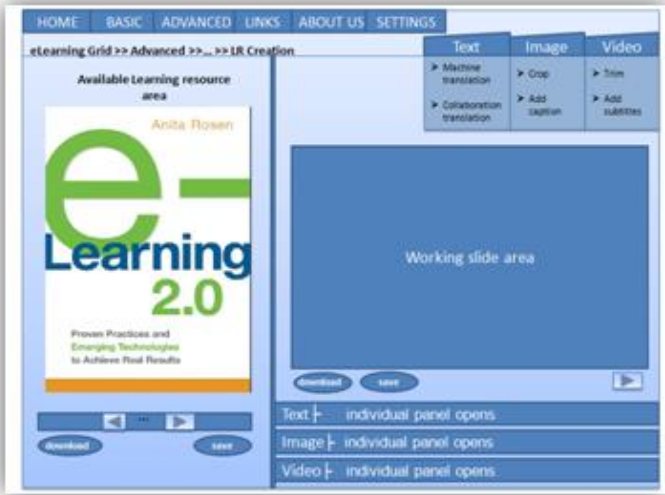
### A.3.2.2 Translate Pattern

<b>Translate</b>	<b>Translate teaching materials and resources into many languages</b>
Intent	Provide a system function that enables translation of materials and resources into many languages
Context	Available resources through the system should be available in multiple languages for different users. If there are resources currently unavailable in the target language, users should be able to translate them.
Problem	How should users easily and quickly translate teaching resources into different languages?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	Different translation services should be available. Registered users should be able to translate different types of media elements according to their preference by accessing "Advanced" service, while unregistered users should be allowed to translate only text as a "Basic" service through the Language Grid.
Consequences	<ul style="list-style-type: none"> <li>Translated materials and resources into desired languages</li> </ul>
Related Patterns	Registration-authentication-access, Search-View, New teaching material creation Patterns

### A.3.2.3 Media element manipulation Pattern

<b>Media element manipulation</b>	<b>Media element manipulation environment</b>
Intent	Provide a system function that enables manipulation of media elements
Context	Registered users should be able to view teaching resources through the system and decide which parts, media elements they want to reuse to create personalized teaching resources. In order to do so different media manipulation tools are required.
Problem	How should registered users easily modify media elements to create new teaching resources?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	Manipulation tools need to be developed which allow users to modify text, images, and videos. These should include trimming of videos and adding subtitles; cropping of images and adding of captions.
Consequences	Successfully completed media element manipulation
Related Patterns	Registration-authentication-access, Search-View, Translate Patterns


### A.3.2.4 New teaching material creation Pattern

<b>New teaching material creation</b>	<b>Create new teaching materials</b>
Intent	Provide a system function that enables creation of new teaching materials
Context	Easy-to-use tools for creating, assembling and modifying teaching resources so that users don't have to spend a lot of time and effort. In this way, users can easily perform generic activities and reuse some design templates.
Problem	How should users be assisted in creating new teaching materials?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	Provide users with appropriate tools for creating learning resources, assembling and modifying them.
Consequences	
Related Patterns	Search-View, Translate, Media element manipulation, Save-Download, Register Patterns

### A.3.2.5 Save-Download Pattern

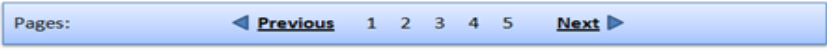
<b>Save-Download</b>	<b>Save and download a teaching material</b>
Intent	Provide a system function that enables saving and downloading of materials
Context	Registered users have the option of saving/downloading available teaching resources which they obtain through search queries, but also their newly created teaching materials.
Problem	How should users easily save/download available and newly created teaching materials?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	Registered users should have options available by clicking on the appropriate save/download buttons according to whether the teaching resources are user created or already available.
Consequences	<ul style="list-style-type: none"> <li>Saving and downloading desired materials and resources</li> </ul>
Related Patterns	Search-View, New teaching material creation

### A.3.2.2 Register Pattern

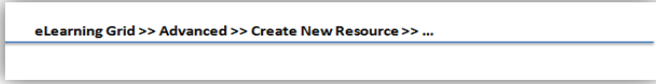
<b>Register</b>	<b>Register a new teaching material</b>
Intent	Provide a system function that enables easy registration of new materials
Context	Registered users should be able to register newly created teaching materials, once they are saved in their individual teaching resources.
Problem	How should users easily register newly created teaching materials?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	Teachers should be able to save their newly created materials, and from <b>“My Teaching Resources”</b> register them, if they choose to. Registration option should be available only for resources which have been saved and not registered up to that point. The option should be dimmed / invisible if the resource is already registered by the user.
Consequences	
Related Patterns	New teaching material creation, Save-Download Patterns

## A.3.3 Navigation Patterns

### A.3.3.1 Pagination Pattern

<b>Pagination</b>	<b>Pagination controls for multiple pages</b>
Intent	Provide a system function that enables pagination
Context	Sometimes when users search for particular teaching resources, search contains many results which cannot fit in a single page, but need to be displayed over several pages.
Problem	How should users view multiple page search results?
Forces	<ul style="list-style-type: none"> <li>Build a complete system that supports multiple functions</li> </ul>
Solution	Break the complete search item dataset into smaller sequential parts and display these on separate sequential pages. Provide pagination controls to browse from page to page. Allow users to browse previous and next pages, as well as first and last by providing links to such actions.
Consequences	
Related Patterns	Breadcrumbs Pattern

### A.3.3.2 Breadcrumbs Pattern

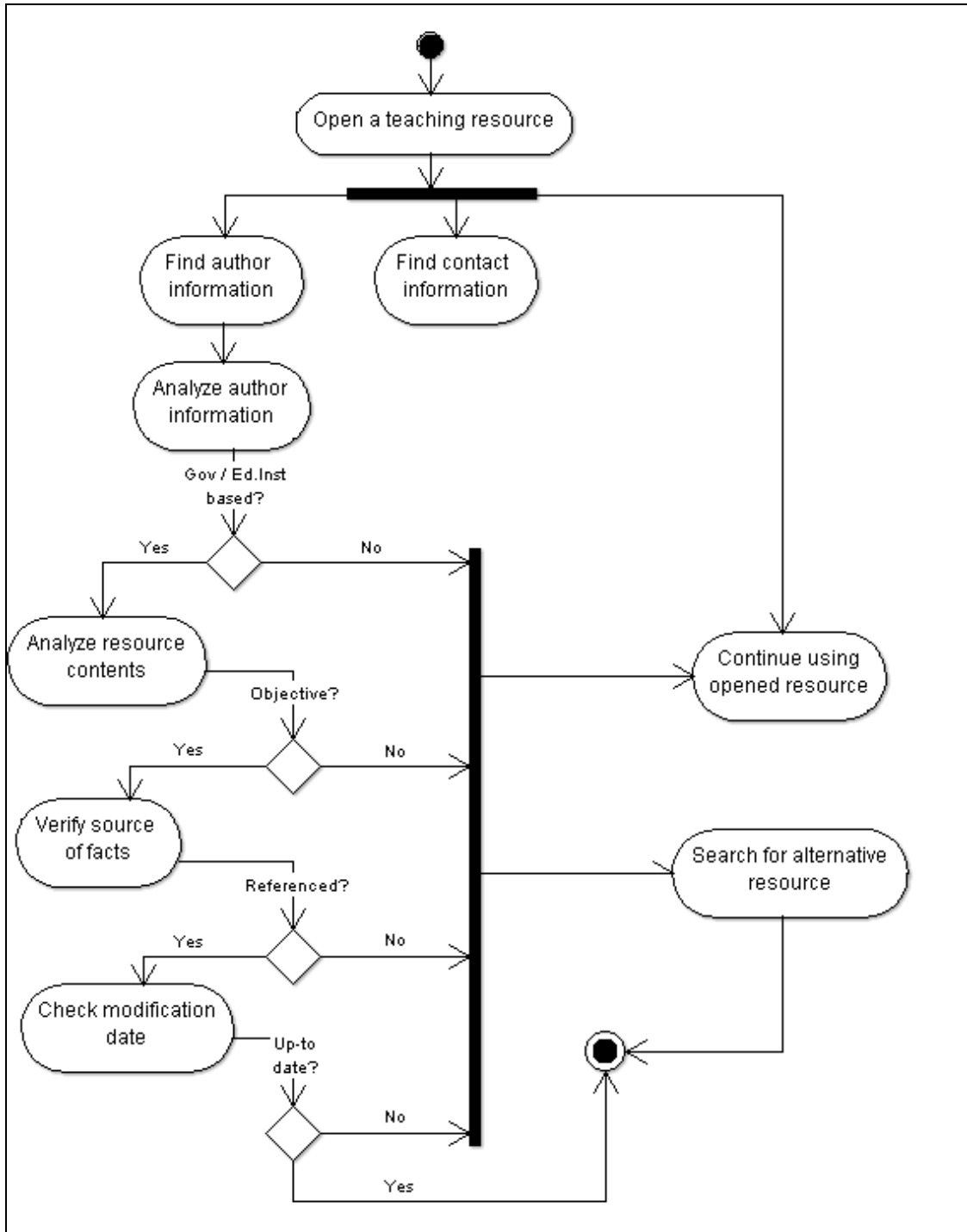
<b>Breadcrumbs</b>	<b>Breadcrumbs displaying user location</b>
Intent	Provide a system function that enables users to know their location
Context	Breadcrumbs show users where they are in a site's hierarchy; making the structure of a website more easily understood.
Problem	How should users know their location?
Forces	<ul style="list-style-type: none"> <li>Building a complete system that supports multiple functions</li> </ul>
Solution	Show labels of sections in the hierarchical path that leads to the viewed page. Each label of the higher level subsections have links that lead to the respective section of the site. The label of the current page should be at the end of the breadcrumb and is not linked.
Consequences	
Related Patterns	Pagination Pattern

## A.4 Community Interaction Patterns

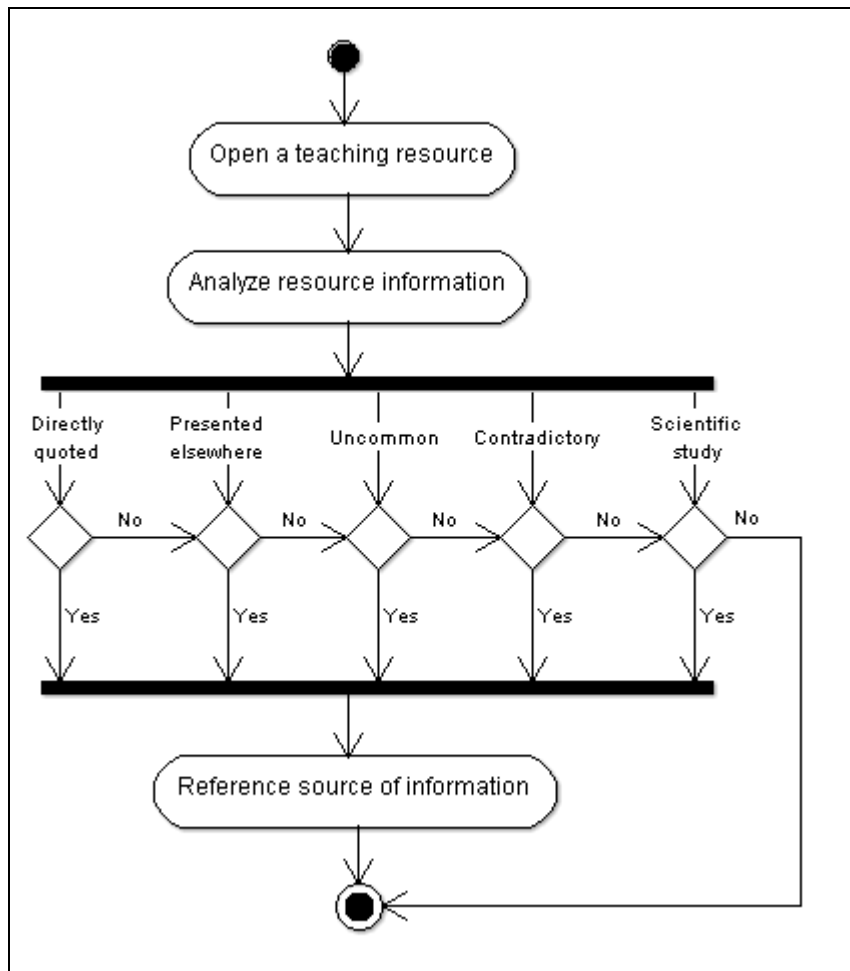
<b>Community Interaction</b>	<b>Establish an active community of educators</b>
Intent	Create a community that enhances sharing of educational materials
Context	Web technology supports building of communities to develop and exchange knowledge or innovative ideas in a particular domain of interest or practice.
Problem	How to create a community of educators that supports exchange of knowledge and materials?
Forces	<ul style="list-style-type: none"> <li>• Time and differing locations prevent people from meeting</li> <li>• Different organizational structures prevent people from jointly elaborating knowledge</li> </ul>
Solution	<p>Technical systems or components like newsgroups, chat, wikis, etc. can be used to enhance communication, question and answer dialogues and the exchange of educational materials among educators. Therefore, relations emerge between members with similar interests on a common topic.</p> <p>Members of a community should be shown various properties of participation, like who is present in the collaborations space, each member's level of activity, history of activity, what tasks they are working on and the level of completion. This tends to establish trust within a community, which leads to a more active and collaborative environment.</p> <p>A statement or icon that reminds members of why they are collaborating in the first place serves as a good reminder which stimulates trust within the community.</p>
Consequences	<ul style="list-style-type: none"> <li>• Members of a community are informally bound</li> <li>• People enjoy novel experiences and viewpoints</li> <li>• There are no guarantees of community members' support</li> <li>• Active community for material sharing</li> </ul>
Related Patterns	Search, Accuracy, Translation, Add Activities with Varying Levels of Difficulty Patterns

## A.5 User Workflows

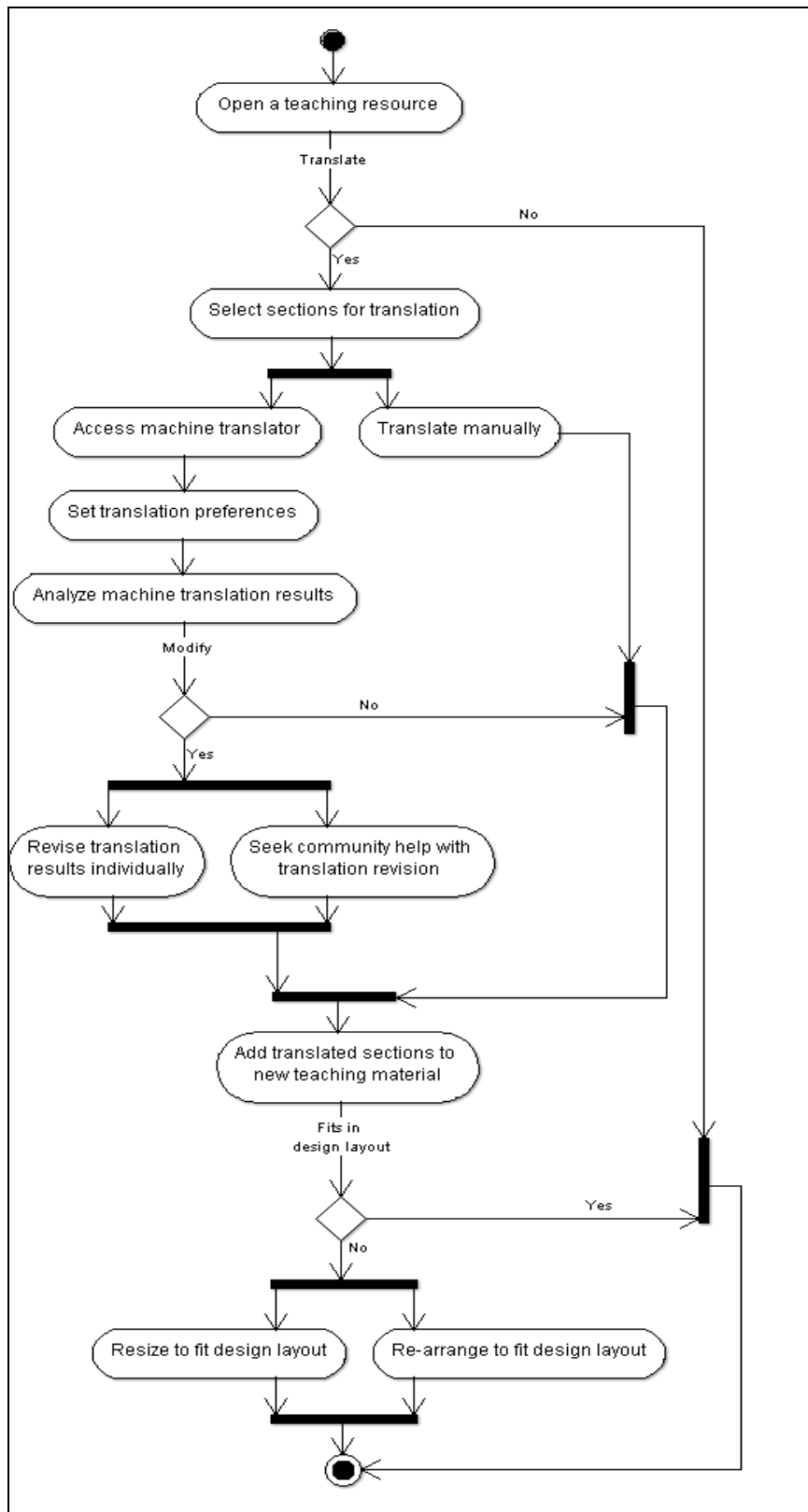
### A.5.1 Accuracy Pattern derived user workflow



### A.5.2 Citation Pattern derived user workflow



### A.5.3 Translation Pattern derived user workflow



**A.5.4 Add Activities with Varying Levels of Difficulty Pattern derived user workflow**

