Quality factors for knowledge repository: based on e-Quality project

Emma Kusztina[1], Oleg Zaikin[2], Magdalena Ciszczyk[3], Ryszard Tadeusiewicz[4]

[1,2,3] Szczecin University of Technology, Faculty of Computer Science and Information Technology, Szczecin, Poland, {ekushtina, ozaikine, mciszczyk}@wi.ps.pl. [4] AGH – University of Science and Technology, Cracow, Poland, rtad@agh.edu.pl.

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1. EXECUTIVE SUMMARY

The article presents a summary of theoretical discussions and practical experiments regarding the development of a repository as a new element of the educational organization management system in ODL conditions. The concept of creating a knowledge repository in an educational organization was already described by the authors in a series of articles presented in previous **EUNIS** conferences.

1.1. Background

For the purpose of discussing practical applications authors used the results of the **e-Quality** project (e-Quality: Quality implementation in open and distance learning in a multicultural European environment, the Socrates/Minerva European Union Project, 2003–2006).

The presented method of creating a repository is based on the combination of two approaches: the **process** and the **ontological** one, and should be used in each educational situation defined by a vector (study subject, education goal, group of students).

1.2. Alternatives

According to the process approach, creating the repository can be described as a set of separate sub-processes. Each sub-process is described by its inputs/outputs and personal role controlling. Afterwards, the quality of the organization process as a whole can be evaluated. According to the ontological approach, the content of didactic materials is described as a semantic net and divided into a sequence of Learning Objects. This allows the quality of didactic material's content to be evaluated by each user.

1.3. Conclusions

Using both approaches allows **defining quality factors of the didactic material** as a final-product. These factors include:
- compatibility of the didactic materials structure with a specified educational situation (an example for the speciality of Production Management and Engineering);
- completeness of the repository resources according to the speciality profile;
- monitoring the rate of competences acquired during the student's self-learning process according to the developed procedure (a Java application);
- ability to use a non-commercial platform (Moodle).

2. GOALS AND PRINCIPLES OF EDUCATIONAL EXPERIENCE QUALITY ANALYSIS IN ODL CONDITION

2.1. Analysis of the e-Quality project results

One of the main research areas within the domain of open and distance learning (ODL) is the quality issue (European Quality Observatory, 2008), (McGorry, 2004). It has been discussed, among others, in the frames of the international project e-Quality: Quality implementation in open and distance learning in a multicultural European environment, which was financed by UE funds of Socrates/Minerva Program (e-Quality, 2003-2006).

The following universities participated in the project: European Universitary Pole of Montpellier and Languedoc-Roussillon (France, coordinator), University Montpellier 2 (France), Open University of Catalonia (Spain), University of Tampere (Finland), Szczecin University of Technology (Poland), University of Applied Sciences Valais (Switzerland), Lausanne University (Switzerland).

The main goals of the project were the following:
- Developing standards for creating didactic materials and for managing the distance learning environment while maintaining concordance with the quality criteria.
- Establishing a net of ODL specialists trained in the quality issue.
- Defining a system of standardized concept definitions for the distance learning process.

The starting point for the research conducted in the project was a comparative analysis of the higher education situation in countries of the participants, which became the base for determining existing factors blocking the introduction of quality in higher education institutions. It turned out, that amongst the distinguished 13 most essential blocking factors eight directly concern: problems with formulating the quality criterion and developing appropriate documents for this purpose, integration of existing, national systems of quality with new requirements resulting from globalization of the education services market.

The Best Practice Database (BPD) was recognized as a crucial element of the quality assessment system in education. Its task is to enable saving and sharing best practices connected to individual processes of educational organizations, including distance learning processes. A set of data describing a university's experience in giving classes in ODL mode was considered a BPD unit. This set includes: the name of the university, subject.topic, the set of didactic and organizational materials, the number of students participating in the education process. The main task of BPD was to validate each university's interpretation of the ODL idea and to compare the correctness of preparing the processes and procedures which consist for the entire education process in ODL conditions.

It turned out to be the BPD advantage, that it was an instrument of estimating the scale of ODL application at universities in the EU countries and that it demonstrated the diversity of attempts at understanding the quality with reference to ODL. Analysis of BPD assumptions showed that the problem of education quality at universities in ODL conditions has not been analyzed yet as a multi-level university management system which consist in:
1. organizing administrative processes, which is connected to defining new user roles and to giving a new shape and role to didactic materials.
2. the process of preparing didactic materials according to the standards' requirements.
3. leading the personalized student lifecycle.

Building an appropriate information system, working in the network environment, in frames of which the quality management process will be realized is essential for the needs of the multi-level system.

2.2. Interpretation of the education process as a production process

The concept of a quality management subsystem within the information system supporting the educational organization management allows for using the existing quality control methodologies (table 1). The specificity of implementing the ODL idea as part of educational organization functioning results in the possibility to consider this implementation as a production process.

Table 1. Stages of implementation of the methodologies of quality control in ODL

Educational process as a production process	Organizational structure of educational organization	Methodologies of quality control of education organization functioning, based on:
innovative	research subject: group of functional units	process approach: 1. for each process input and output is determined 2. process is multi-domain oriented 3. localization of each process (or group o processes) within one unit of new organization structure
ill formalized	structure units based on technological principles	game and scenario theory: 1. communication between process participants 2. cooperation of specialists, who prepare content 3. preparation and standardization of competence sets

Considering the education process as a production one requires:

- introducing innovations into the organizational structure,
- creating functional units connected by common technological principles.

This allows to precisely determine the roles and required competences of specialists, who are responsible for the content of didactic materials.

Consideration of all stages presented in table 1 gives the possibility to analyze the quality issue of the distinguished tasks connected to the final product creation: (1) planning, (2) administration, (3) assessment and evaluation, (4) production of didactic materials and (5) student support. Roles were assigned to each of these tasks, characterizing actions and required competences, that one should take to achieve the intended goal. The prepared set of roles (table 2) is a result of compromises and in the majority of the educational systems requires adaptation to existing conditions.

Table 2. Main tasks in distance learning and roles assigned to them (Zaikin, Różewski, 2005)

Task	Exemplary roles
Education planning	Education process regulations manager Education process content creator
Education administration (management)	Education process administrator Coordinator Technical administrator Consultant
Education results assessment and evaluation	Students evaluator Developer
Didactic materials production	Didactic materials designer Didactic materials creator Audio-video specialist
Student support	Pedagogical support Technological support Tutor

Each of these roles in the Learning Management Systems (LMS) and learning content management system (LCMS) can be described with the help of the RUP (Rational Unified Process) standard. Although this standard, in its primary application, serves for planning and management of projects connected to creating and implementing different types of software (Henderson-Sellers et al.,2001), it was used in the e-Quality project to describe roles with the help of the following structure:<role, activity, artifact, additional elements>, where

- role - is entrenched in the ODL idea and in the local educational system,
- activity – a set of actions performed by the specified role, which are essential in the motivation process for achieving the determined goal, e.g. planning the structure of didactic materials,
- artifacts - things created by humans; an especially essential artifact is information about the way the information itself was/is produced, modified and used by particular processes,

- additional elements – supplementary elements, which do not participate directly in the process, e.g. guides.

When analyzing the main processes in distance learning together with their assigned roles, two processes become especially important: the process of preparing didactic materials and the student support process, as it is these two, that decide about the quality of education within each educational organization. These processes have different nature (table 3), however, as an analysis performed by the e-Quality project consortium has shown, finding common views regarding the issue of these processes performance quality is going to be a starting point for formulating quality norms for the entire teaching-learning process.

Table 3. Comparison of the student support process and the didactic materials preparation process (Zaikin, Różewski, 2005)

Process features	Didactic materials preparation process	Student support
Purpose	Orientation on the product	Orientation on the client
Production type	Unit production	Mass/wholesale production
Character	Deterministic	Random
Ways of modeling	Gantt charts	Simulation
Criterion type	Ill formalized criterion	Quantitative criterion

In distance learning the process of preparing didactic materials gains special significance on account of the lack of a direct contact with the teacher. Didactic materials become the intermediary between a source of information and the cognitive process of a student. The student, thanks to the didactic materials, discovers knowledge on his own, trying to create appropriate (correct) mental structures in his mind. The process of didactic materials preparation is oriented on intangible production, meaning that as sub-product/final product the material is prepared in a digital form (Korytkowski, Zaikin, 2004). Each created material is prepared in order to meet the assumed requirements of a certain course. The teacher playing the role of the knowledge engineer and the expert in the frames of the course of study designs the conceptual model of the course using existing monographs, textbooks and articles and his own knowledge about the relevant field. According to the SCORM standard presenting didactic materials to students requires distinguishing Learning Objects, determining their sequence and finding a computer environment which will play the role of the knowledge repository (SCORM, 2004), (Kushtina, 2006). Therefore, the quality of the process of preparing didactic materials requires considering such quality features as: usefulness (ergonomic aspect), competence (information aspect), as well as structuralism (cognitive aspect).

The student support process, which concerns such activities as help offered to the student in solving task problems or pedagogic support, presents another view at the quality idea. The support bases on a personal infrastructure and software-hardware equipment of the student. The discussed process is oriented on the student (customer), who contacts a certain service in a random moment of time and is occupies it for a random period of time. In such case, environment activity effectiveness is a crucial quality criterion. It can be calculated through analysis of appropriate times and costs (e.g. total time, when students demand access to resources). Assessing quality indicators of such type requires an optimization model for a closed network consisting of servers (educational services): teacher, course, administration and students (Zaikine et al., 2000)

The final result of education - competence obtained by the student - depends on the quality of both processes, while the quality of student support depends also on the quality of didactic materials (e.g. time and amount of consultations and trainings). It is possible to interpret the main criterion of ODL system functioning in the context of assuring functioning quality of individual sub-processes which: maximize meeting independent demands regarding time and student education mode, minimize differences with the traditional education environment and maximize the possibility of obtaining a certificate of achieved education results.

The above statements are a source of a new view at the development and distribution of didactic materials. The concept of the Best Practice Database containing, on one hand, the description of the problem that was to be solved and, on the other hand, the solution of the problem with a

commentary regarding its effectiveness and possible future applications can be consider as a scheme and prototype of a knowledge repository for education needs.

3. REPOSITORY AS A KNOWLEDGE EXCHANGE MECHANISM

Knowledge repository, especially in distance learning mode, is a crucial element for proper functioning of the education process. The repository is a tool enabling cooperation between the student and the teacher. It is designed for modeling philosophical, scientific, scientific-technical, scientific-technological state of a chosen knowledge domain (Kushtina, 2006). In the repository Learning Objects are stored, built as a result of portioning a given domain knowledge into pieces. Elements of the repository are dynamically powered, changing their semantic depth depending on education goals. However, these dynamics creates a new, difficult task for the teacher. For although there exist information systems that can be used as an environment for knowledge repository realization, in which LOs are distributed and communication between the education process participants is possible, looking for a way of automation of the ill formalized content creation process lies in the hands of the repository authors.

The process of automation requires the preparation of LO to be examined at two levels (figure 1):

1. Level one - LO is a non-dividable physical unit with a defined structure of its content.
2. Level two – a set of LOs covering a certain scope of knowledge, according to the specified educational situation.

3.1. Requirements for knowledge repository construction

On the market there exist many solutions meant for storing and sharing didactic materials, users administration, reporting and communication with students. It is possible to use different commercial tools for the needs of distance learning (Oracle I-Learning (Oracle iLearning, 2008), WebCT Vista (WebCT Vista, 2008), LMS – WBTServer (LMS – WBTserver, 2008), Claroline (Claroline, 2008), etc.), as well as Open Source instruments, the source code of which is available for exploration by each user accepting the use principles (Moodle (Moodle, 2008)).

From the financial point of view, for the needs of education the Moodle platform (Modular Object-Oriented Dynamic Learning Environment), which is an LMS type solution, is often used. The modular structure of Moodle guarantees flexibility in creation of courses and including didactic materials within them. Adding new modules and modernization of the already existing ones is widely applied and implemented, and enables the system to work in accordance with users expectations. The entire platform is provided with security mechanisms, which, on the user's side, are manifested in the form different access rights to didactic content.

Moodle's architecture allows for its adaptation to repository needs in harmony with cognitive principles. However, the process of filling the repository with content is a complex one, based on a criterion consisting of two components: number of didactic materials in each topic and complexity of tasks. In other words, the person responsible for the content of the repository should make sure that each of the topics and discussed problems is developed at different complexity levels, as well as that there is no significant disproportion between the content of tasks for different topics.

This approach classifies the management process of didactic materials preparation and their sequence establishment as a component of four basic management functions: planning, organizing, motivating and controlling. Realization of these functions allows for developing the structure of the knowledge repository reference model (figure 1).

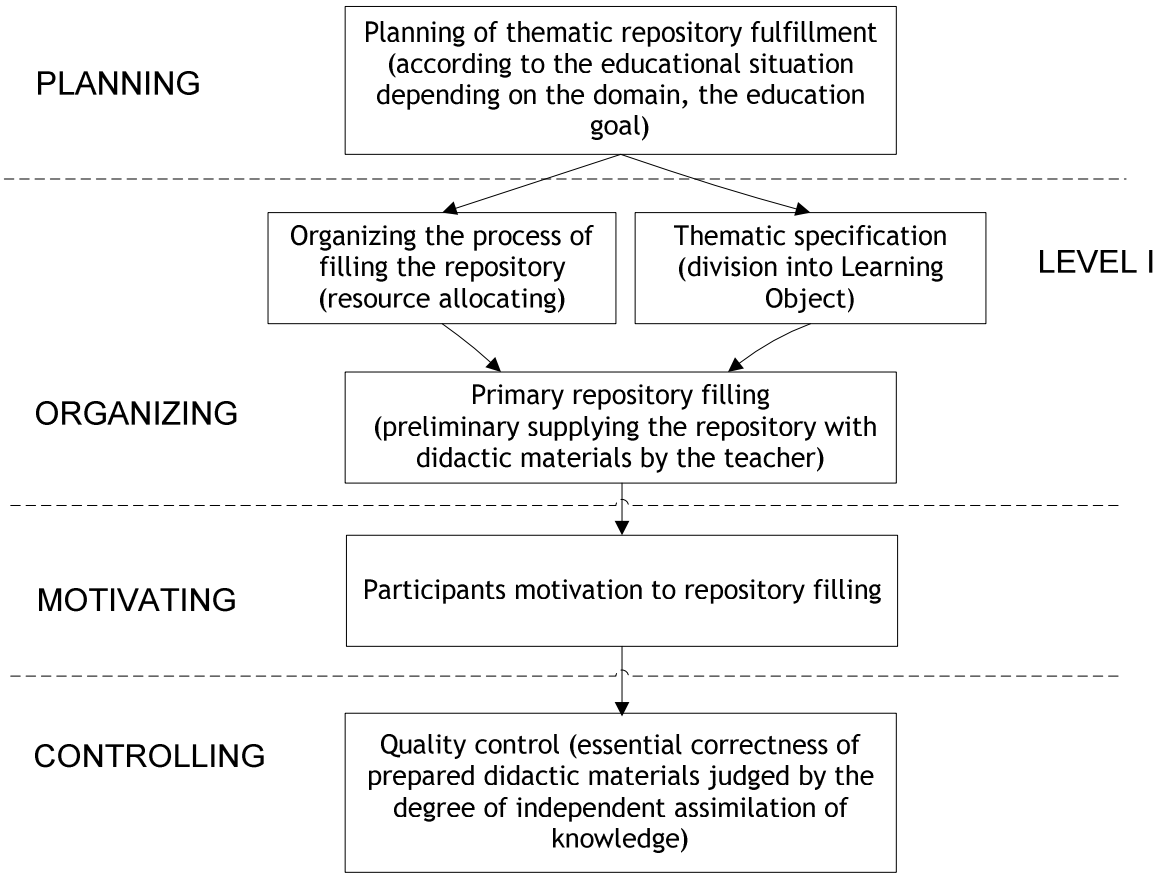

Figure 1. Stages of the knowledge repository development process

In the structure of the knowledge repository reference model the planning process concerns defining the proportion between individual forms of classes and their topics and directly depends on the specified educational situation. It includes in its scope determining the way of distributing these materials and the proportions of theoretical and procedural knowledge.

Organizing is a complex process, which consists of:
a) allocating resources (personal, equipment, etc.),
b) defining roles of the education process participants (functional dependencies, tasks for users),
c) portioning knowledge into the form of Learning Objects (LO),
d) primary repository filling.

Motivation of the education process participants is connected to stimulating their behavior for needs of preparing didactic materials. In other words, motivating is about supporting human activity in such a way that one directly participates in creating the repository. In order to achieve this it is necessary to develop a motivation model which will consist of student motivation function and teacher motivation function. The motivation model assumes existence of such a scenario of influences between the student and the teacher, where student's involvement increases during realization of tasks and thus the repository is expanded by new tasks and their new solution (Kusztina et al., 2008).

Controlling concerns assessment of the correctness of didactic materials preparation. Firstly, the degree of independent assimilation of knowledge included in the repository is evaluated. On this basis, it is possible to draw conclusions regarding whether the developed LO is suitable for individual, independent work of students. Secondly, the assessment is performed by a domain expert, what assures reliability and credibility of the didactic material. The control stage is essential for eliminating mistakes, making corrections, as well as for strengthening the motivation function.

3.2. Thematic specification as an element of repository completeness

A problem especially important from the point of view of quality and assuring completeness of the education process is the problem of thematic specification, which is a crucial element in case of the development of a Learning Object sequence (figure 2).

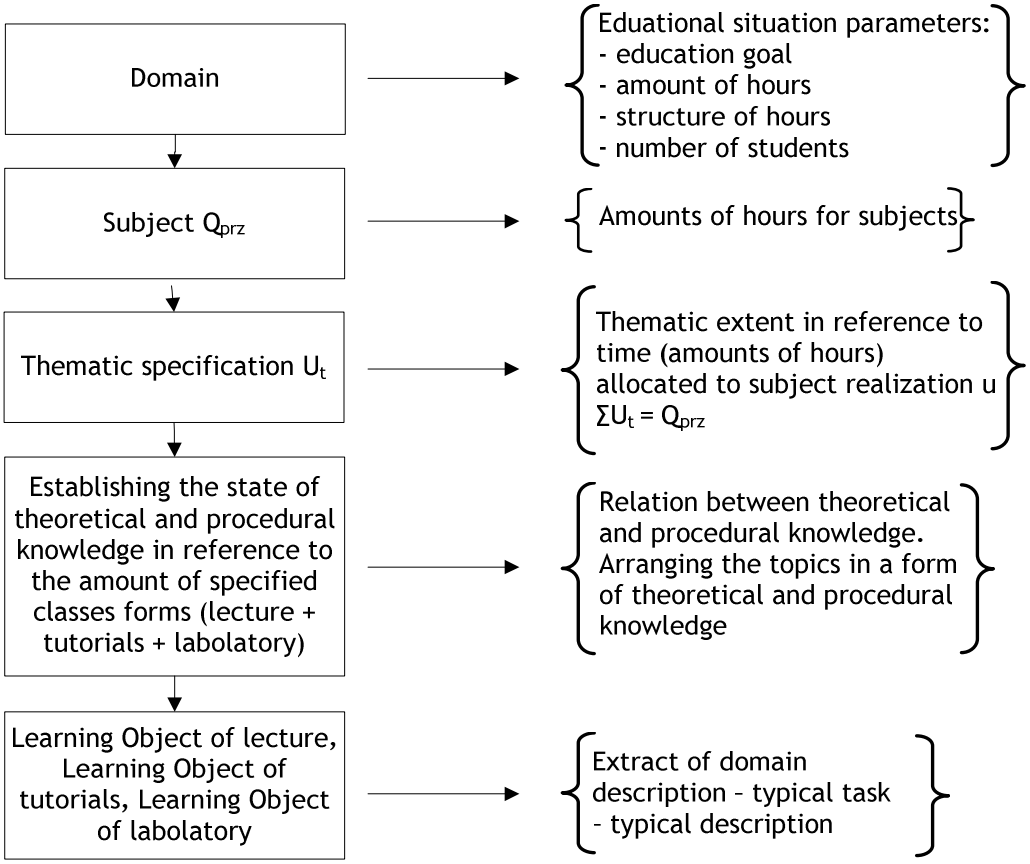

Figure 2. Thematic specification hierarchy

For a certain domain described by parameters of an educational situation, which forecasts the realization of a certain subject in a chosen amount of time, it is necessary to define the state of theoretical and procedural knowledge based on the prepared extent of issues. For different forms of classes the relation between theoretical and procedural knowledge will change, therefore this proportion needs to be explained.

This activity is the basis for developing Learning Objects for specific forms of classes, in which the student is provided with the set of threes "extract of domain description – typical task – typical description" (Kushtina, 2006). This way, the student's ability to structure owned theoretical and procedural knowledge and to link it with the results of personal experience increases. Student's activity also increases. After assimilating theoretical knowledge W_t and receiving an example with the teacher's solution (procedural knowledge W_p), the student is able to use the same task Z_i^{Wp} and formulate a new solution R_{j+1}^{Wp}, formulate his own, analogical task - Z_{i+1}^{Wp} and use the same mechanism for its solution R_j^{Wp} or formulate a new task Z_{i+2}^{Wp} and use a new solution method -

R^{Wp}_{j+2} (table 4). The solved tasks and their solutions can become a base for filling the repository with a new didactic material and can become a new LO.

Table 4. Forms of working with the set: "domain description excerpt – typical task – typical solution"

W_t, W_p ; W_t = lecture, W_p = tutorials, laboratory			
Teacher	W_t	Z^{Wp}_{i}	R^{Wp}_{j}
Student	W_t	Z^{Wp}_{i}	R^{Wp}_{j+1}
Student	W_t	Z^{Wp}_{i+1}	R^{Wp}_{j}
Student	W_t	Z^{Wp}_{i+2}	R^{Wp}_{j+2}

4. CASE STUDY

4.1. Description of the procedure of filling the knowledge repository in the Moodle environment

In the context of the discussions presented in part 3 of the article, portioning knowledge and sharing didactic materials requires applying the dedicated procedure defining when and by who the repository can be filled.

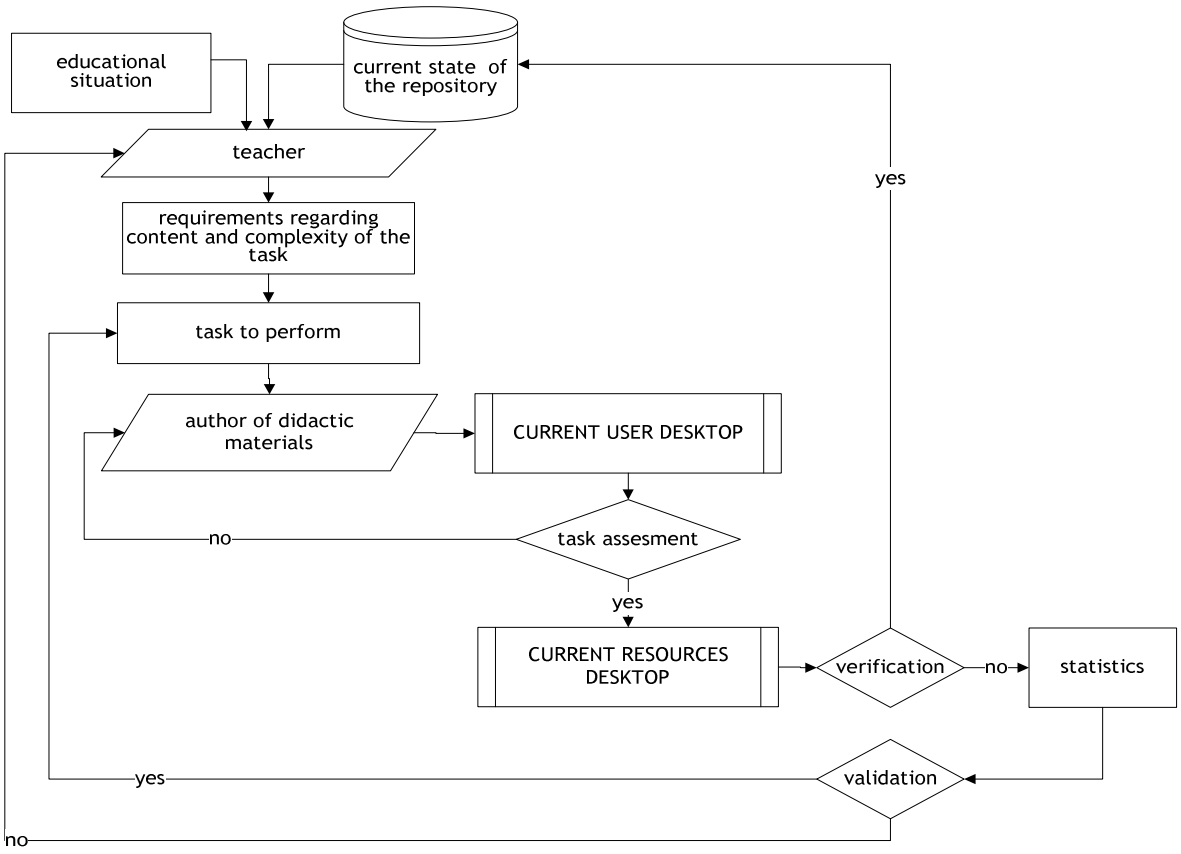

Figure 3. Procedure of filling the repository with didactic materials (Kusztina et al., 2007)

Applying a multilevel system to content management in a network environment requires working with the didactic materials at three basic levels: *current user desktop* – an area for course creators individual work, *current resources desktop* – includes and combines resources of different authors in order to verify their complexity and correctness, *Moodle Platform* – environment of topically integrated and publicly distributed didactic materials, as was reflected by the procedure presented in figure 3. Specific dedication of each of the distinguished environments for working with didactic materials allows for establishing conditions of cooperation between the participants of the education process. Simultaneously it is a form of securing the repository from uncontrolled filling with didactic material that does not reflect the education process needs.

In the presented schema (figure 3) the didactic materials quality control takes place at three stages: *task evaluation* – the level of complexity of the prepared material, choice of methods for solving the presented problem, as well as correctness and logic of the prepared content; *didactic verification* – evaluation of the content from the point of view of content-related criterions; *validation* – allows evaluating whether the education process is well structured and if the teacher developed the requirements well (Kusztina et al., 2007).

Applying the presented acting formula results in that the repository as a computer environment becomes not only a place of didactic materials storage, but by reflecting the education process it allows for obtaining competences. This procedure becomes one of the elements for building quality of the suggested system.

4.2. Procedure of obtaining competences basing on the repository

A supplement to the procedure of filling the repository with didactic materials is the procedure of obtaining competences during an organized training (figure 4), in which the student is provided, through the repository mechanism, with a set of threes: "domain description excerpt – typical task – typical solution" and a corresponding test task (Kushtina, 2006), performed according to the following steps:

1) *Problem analysis* - Establishing whether the issue belongs to the domain stated in the task. This allows for interpretation of the problem and for presenting it in terms of a certain knowledge model with regard to the existing taxonomy – in other words formulating the basic task.
2) *Experience analysis and systematization* – Comparison of the basic task content with tasks placed in the repository. As a result a route that has to be followed to solve the problem is established: we chose the route of developing a proper algorithm or the route of using an algorithm existing in the repository.
3) *Typification of the basic task* – Preparing the basic task passport in the repository language (e.g. in the form of an XML document).
4) *Storing the basic task passport* in the working memory of the current training session.
5) *Developing an individual task solution algorithm* – The algorithm can be described with the help of pseudo-code in a standard language or presented as a simulation task.
6) *Algorithm execution* - The input data has to be chosen directly from the text of the analyzed problem or deducted during its interpretation.
7) *Algorithm effectiveness evaluation* – At this stage, interpretation of output results of the algorithm is made, in the context of the task being solved.
8) *Typification of the developed algorithm* - Preparing the solution algorithm passport in the laboratory language (meta information in the form of an XML document).
9) *Storing the algorithm passport* in the working memory of the current training session.
10) *Preparing a knowledge module in the form of a repository element* - At this stage, one has to fill a repository form including: a set of keywords from the domain knowledge models reflect the content of the stated problem, task passport and algorithm passport.
11) *Supplementing the existing repository* - The required fulfillment level depends on the subject, goal and stage of education and has to be given to each student by the teacher.

The analysis shows that for sharing theoretical knowledge a template is used, connected to the discussed theoretical issue and its application way – usually presented in the form of examples or case studies. The student should link the assimilated theory with the ability to solve a task or to apply a proper procedure or algorithm.

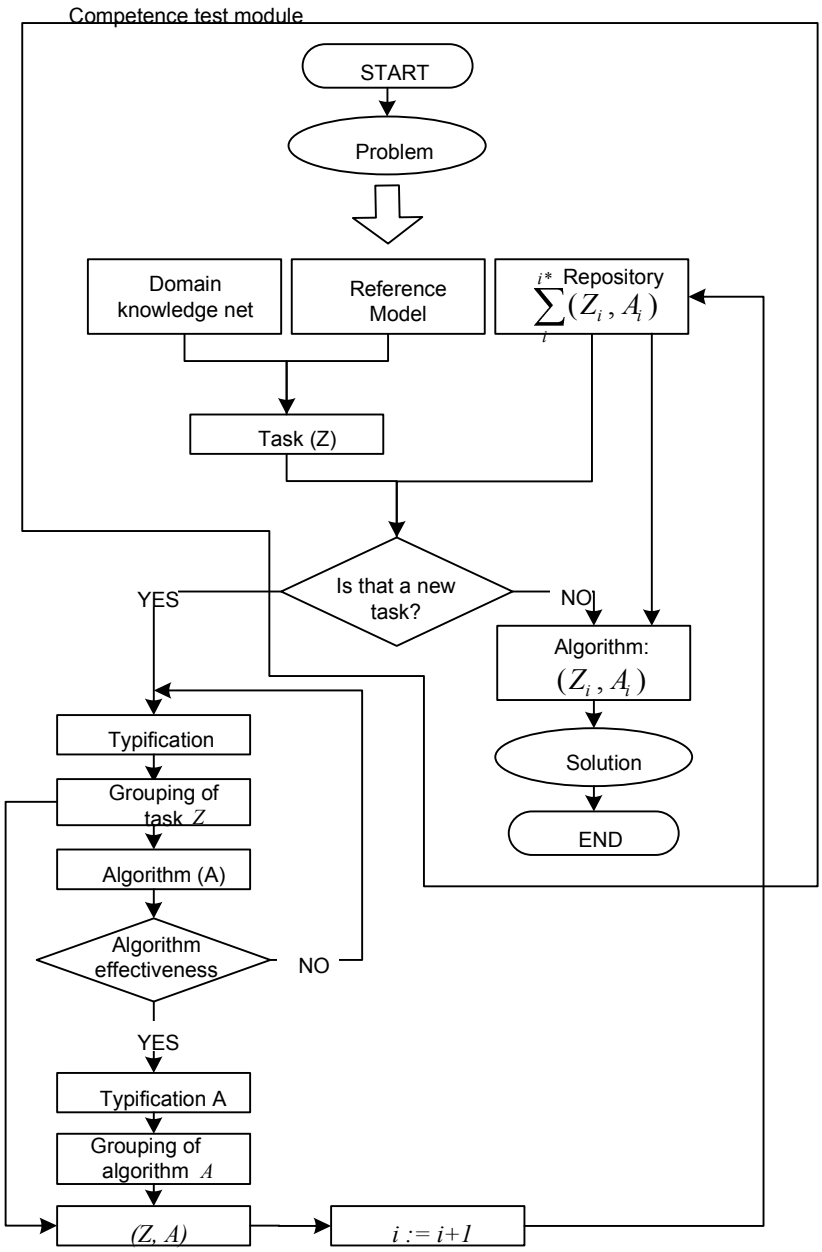

Figure 4. Procedure of obtaining competences during an organized training (Kushtina, 2006)

The student's ability to solve tasks, the ability to link theoretical knowledge with a certain problem's requirements, allows for establishing a method of assessing these abilities, as proposed in (Różewski, Różewski, 2006). Through a set of competence questions, connected with each other in the form of a scenario, the student purposely discovers relations between concepts. The solution implemented for this purpose is based on a client-server architecture (figure 5).

The client application works as a terminal and can be executed on any computer. After a successful login and student authorization, missing data can be obtained from the server if required. The following solutions were used for implementing the project:

- For ensuring system independence of the application Java, J2SE 1.5 was used.
- Global access to repositories was ensured thanks to a server using web-protocols SOAP, HTTP and HTML, JSP, Servlets and XML technology.
- Individual component issues are stored in the form of XML and – thanks to XSLT – transformed into a chosen, optimal presentation form.

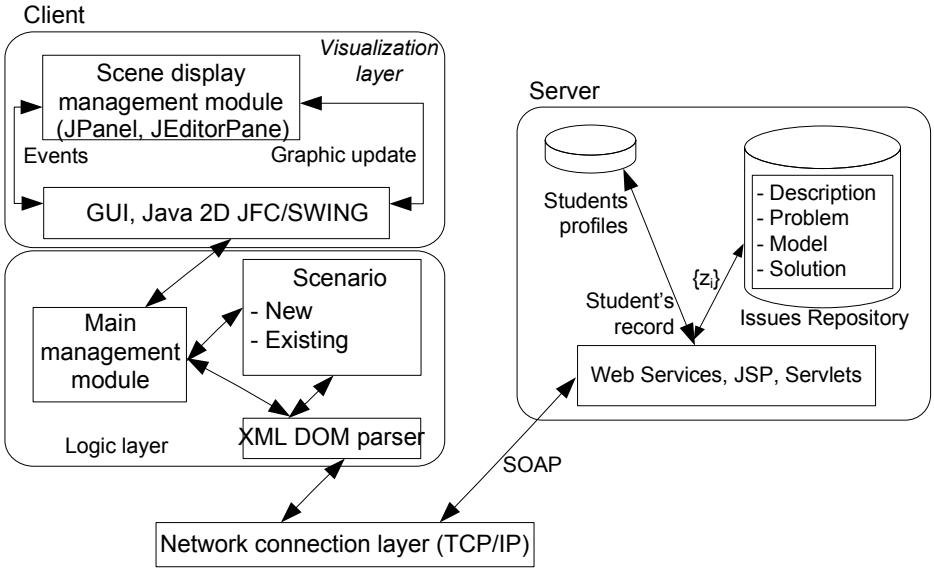

Figure 5. Application modules schema (self-development) (Różewski, Różewski, 2006)

5. CONCLUSIONS

1. The e-Quality project became a basis for quality analysis in ODL conditions, thus showing a new area of issues to be solved.
2. Directions regarding quality of creating the Best Practice Database can be used for developing a knowledge repository – a place for distributing Learning Objects.
3. There exist computer platforms which can be used as an environment for distributing didactic materials, but no approach exists to filling the repository with content
4. Portioning knowledge into the form of LO is insufficient. The process of obtaining competences requires establishing an LO sequence in order to adjust proportions between theoretical and procedural knowledge to the changing educational situation and the personalized student lifecycle.
5. Filling this gap requires developing procedures of cooperation between the participants of the education and competence obtaining process in the knowledge repository.
6. The program developed for the needs of testing competences allows for assessing the correctness of the approach.

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