Towards developing the Unified Bank of learning objects for Electronic Educational Environment and its Protection

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ABSTRACT

The article deals with the ways of developing the Electronic Educational Environment (EEE) based on a set of learning objects constituting the Unified Bank of Learning Objects. The algorithms of functioning for learning objects and the network formed from them are considered. The concept of the core of knowledge is introduced as a system of established and accepted scientific ("textbook") knowledge used by the “educational community” for developing the theoretical foundations of educational courses.

Taking in account the information explosion happening now which leads to erosion of knowledge, the issue of protecting of the core of fundamental scientific knowledge and the world cultural heritage from destruction and unauthorized change with the use of permitted blockchain algorithm is considered.

CCS CONCEPTS

• **Applied computing** → **Education**; *Redundancy*; • **Computer systems organization** → **Dependable and fault-tolerant systems and networks** → Reliability

KEYWORDS

knowledge transfer, core of knowledge, MOOC, Educational System, blockchain, erosion of knowledge, network of knowledge, epistemology, learning object

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1 Introduction: Education as a strategic resource

The rapid growth of the "digital" component in all spheres of human activity emphasizes the importance of industries related to knowledge [1]. In turn, the development of the Internet, as well as the availability of e-communication, led to the emergence of distance education as independent industry that demonstrates the explosive growth assisting transformation of education, into primary sector of the economy. In monetary terms, for example, the global e-Learning market is forecast to surpass 243 billion U.S. dollars by 2022 [2].

An example of effective approach to e-education policy at the state level is the Advanced Distributed Learning (ADL) [3] initiative. It is supported by USA government and US Department of Defense. This fact demonstrates that the US considers the problems of education and distance learning as an important element of national security. Education (and, above all, technical education) is a strategic resource and an important competitive advantage of the state. The necessity of such an approach is mentioned recently by the number of authors demonstrating that the tendency is global [4], [5], [6], [7]. The attitude towards education as a strategic resource leads to the need not only to assess the quality of electronic information and educational resources but also to set and develop their standards at the state level. At the same time, developing such standards in a global scale is an effective base for international collaboration that implies answering the following questions:

- What is knowledge?
- What knowledge should we transfer?
- How to regulate the transfer of knowledge?
- How to transfer knowledge effectively?
- How to ensure an undistorted transfer of knowledge?
- How to minimize costs when organizing the transfer of knowledge?

2 Knowledge Objects and Knowledge Network

The problem of the definition of the term of knowledge refers to the field of epistemology and until now had no final solution. The original definition was given by Plato and examined by him in Dialogues [8]. However, for our purposes, the concept known as pragmatism [9],[10] is more satisfactory. This conception proclaims that the result that we want to obtain by applying definition of knowledge is essential for constructing the definition body. Thus, we interpret knowledge as the system of information objects, systematic study of which allows us to understand a scientific picture of the world, implement competencies related to technological literacy, correctly interpret the world cultural heritage and restore them in the event of unforeseen damage to these information phenomena. With such an approach, it is essential that transferred knowledge be an integral part of scientific and technological literacy [11].

Generally, knowledge possesses the following features [12]:

- Knowledge has a practical aspect
- Knowledge can be personal or group
- Knowledge has a regulatory structure
- Knowledge has an internal network structure
- Knowledge has an external network structure
- Knowledge is dynamic
- Knowledge is related to public institutions

Using these characteristics, we can define a unit of knowledge (object of knowledge, knowledge object) as a structural information object associated with specific skills and practice of testing and evaluation. The simplest examples of such a unit, is the Pythagorean Theorem, force diagram or calculation of interest, etc. In turn, knowledge units are connected both with each other and with the subject of knowledge - man and the object of knowledge the outside world.

Understanding of knowledge as a system of interconnected knowledge units is now presented in the works of a number of authors, for example [13]. The effect resulting from representation of knowledge in the form of a "knowledge network", as a result of interconnectedness of knowledge units [14] defined as "connectivism". The knowledge network is further immersed in a network of relationships with the outside world. In accordance with this approach, learning is a process of study of this network. The result of changing the subject's relationship with the outside world after mastering knowledge is the effect of a particular value.

3 The Core of General Science Knowledge

Knowledge objects representing the most loaded nodes of the network of knowledge constitute the core of knowledge - the most valuable objects of general scientific knowledge and of the world cultural heritage. Their correct understanding ensures both the communication integrity of the community (society) that has mastered these objects of knowledge, and the effective use of other knowledge objects.

The core of knowledge undoubtedly refers to explicit knowledge, as opposed to an implicit knowledge ("tacit knowledge"), "hidden," for example, in the teacher-student relationship. Additionally knowledge objects can be separated into "universally recognized" and those that are in the stage of development. Only "universally recognized" objects refer to the core. Its dependence on interpretation by the social environment is reduced, as there is a consensus of responsible experts concerning the content and nature of well-established objects of knowledge.

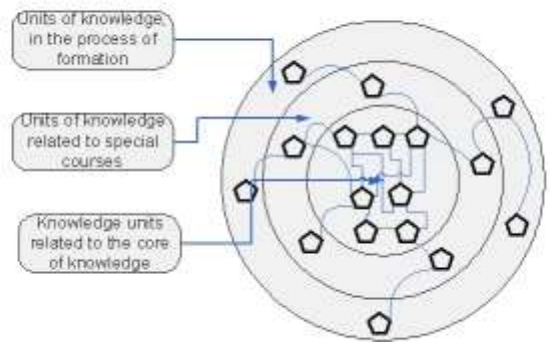

Figure 1: The scheme representing the relative arrangement of knowledge units belonging to the core of knowledge, special courses, and scientific frontiers

There were researchers [14], [15] who tried to determine the standard knowledge core for science, mathematics, and technology that would be optimally useful for every high school graduate, and not just for those who aspire to a scientific or technical career. For this purpose, a team of scientists from the field of chemistry and physics found that few college students understand the nature of the particles and the significance of the periodic table, not to mention the importance of the standard particle model. Thus, despite the apparent need to define the core of knowledge, the difficulties concerning this process are obvious. There is an evaluation of the number of educational objects in the physics course for secondary school [16]. The modeled structure contained 24 thematic blocks, approximately five educational objects in each. Thus, about 100 educational objects per school subject. An alternative evaluation made in [17] explores ~ 600 objects of knowledge (and, accordingly, learning objects) for the course of algebra (however, the authors, in this case, used smaller objects).

4 Micro-Modular Architecture Approach for MOOC Design

Now, the dominant approach in e-education is developing of MOOC (massive open online courses). Examples of publicly accessible portals that allow training in a large number of disciplines using MOOC are “Coursera” [18], and “Open Education” [19], (however, the actual number of such portals is more extensive). There is a large number of approaches in the classification of MOOC and methods of design, described in numerous studies and reviews, for example: [20], [21], [22]. However, the universally recognized MOOC standard has not yet been fully developed, and a significant number of authors and teams use their own standards for designing courses.

Nevertheless, it is possible to divide MOOC into those that are centered around the concept of large-block modules (the Bologna system, up to the conglomeration of training courses), and build on the basis of a micro-modular architecture.

This approach, which advocates organizing MOOC as a system of micromodules of shared access, has a significant historical perspective. His first formulation could be attributed to 1967 [15]. Further development of the concept and its popularization was provided by the head of the committee on the standards of educational technologies IEEE (Institute of Electrical and Electronics Engineers) H. Wayne Hodgins. Following the proposed [20] concept of epistemic atomism, the optimal learning object is an integral educational unit that is self-sufficient for the study of a particular knowledge object and is corresponding to a single issue of a school or university curricular.

A learning object is a means of studying an object of knowledge that constitutes a single concept [20]. It can also be defined as the smallest independent structural element containing three components united by a single goal of learning:

• educational materials (demonstrate and explain the knowledge object)

• training exercises (allow achieving the learning goal)

• evaluation system (allows assessing the degree of achievement of the learning goal)

Thus, the learning object differs from the object of knowledge, in that it not only contains the object of knowledge, but also contains means of explaining and verifying the degree of understanding of the given object of knowledge.

In addition, a learning object is characterized by the following parameters:

•training time is usually from 2 minutes to 15 minutes.

•is self-sufficient - each learning object can be taken independently

•is reusable: one learning object can be used in several contexts for several purposes

•can be aggregated - learning objects can be grouped into larger collections of content, including traditional course structures

•contains metadata - each learning object has descriptive information that makes it easy to find it by searching

The relationship between primary learning materials, learning objects and the training courses built on them is illustrated by a diagram constructed following Autodesc's ideology [23] (Fig. 2). By this scheme, objects can be combined with increasing degree of generalization:

Primary media and text files -> Information objects -> Learning objects -> Sections -> Courses and modules

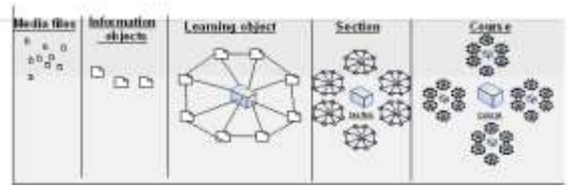

Figure 2: The scheme representing the relative arrangement of knowledge units belonging to the core of knowledge, special courses, and scientific frontiers

5 A General Scheme of Work and Integration of the Learning Object

The sequence of transitions between learning objects determines the sequence of the course.

In Fig. 3 shows the scheme of the functioning of the learning object with the minimum necessary configuration, containing the following components:

- preliminary testing unit
- resulting testing unit
- reference to the previous course object
- reference to the subsequent course object
- reference to the objects necessary to understand this learning object
- educational material

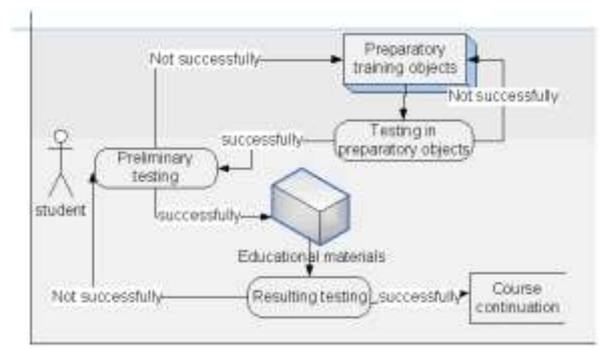

Figure 3: General scheme of the organization of a learning object

The Pythagorean Theorem, for example, can be integrated into the course of teaching school geometry, locksmith, joiner, and tin works, into the initial course of physics, astronomy and geography (Fig. 4).

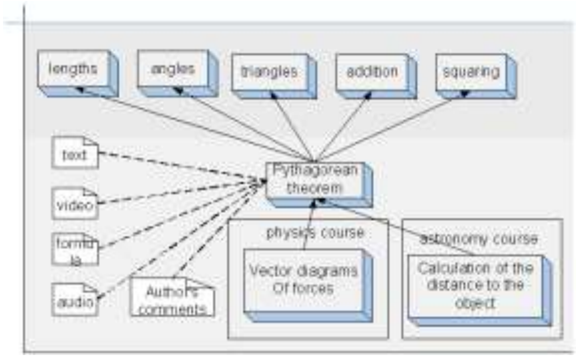

Figure 4: An example of integration for the training module - "The Pythagorean theorem" (illustrative)

The presence of learning objects of several levels of complexity and the possibility of additional "settings" and adaptation: the possibility to connect additional content and comments - can meet the specific requirements of specific courses using a set of approved training facilities.

6 Unified Bank of Learning Objects and Educational Environment

These learning objects may compose a bank of learning objects and assignments with open (free) access for being used as bricks in the construction of the MOOC. In order to develop learning objects in a quick manner, the texts of existing textbooks, supplemented with audio, video, and testing elements may be used. Further, they can be edited with regularity every two years, by the appropriate commissions.

Efforts concentrated on educational objects evaluating and designing will allow developing of the core around which the Unified Electronic Educational Environment may be centered.

Public modules exclude charging. At the same time, they should be protected from plagiarism by automatic content checking. Educational objects of third-party authors after certifying can be paid elements in different MOOC. In this case, it is reasonable to organize - a distributed system of micropayments based on Smart Contracts using permitted blockchain [24],[25], [26] in which part of the payment is sent to the rights holder of the learning object in the case when during the completion of the MOOC the user addressed the special paid module.

Mechanisms mentioned above provide the base foe developing Unified Electronic Educational Environment. It may solve the following tasks:

- organize an accessible Unified Bank (repository) of learning objects
- ensure the safety of educational objects related to the core of knowledge
- ensure the possibility of developing MOOC with the use of certified learning objects
- ensure the possibility of testing with the use of learning objects

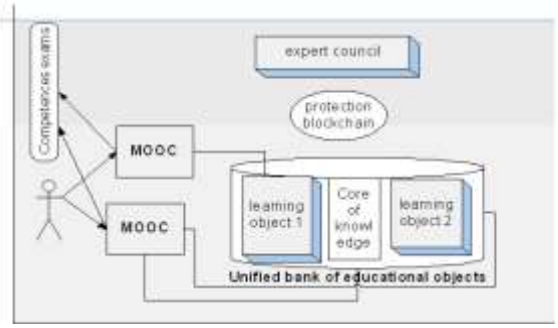

Figure 5: The general structure of the unified educational environment

7 The Problem of Knowledge Erosion

When developing electronic educational resources, authors and developers pursue very diverse goals. Along with solving urgent problems of transferring knowledge to students and establishing a basis for further research in developing areas of knowledge, there are negative trends in the growth of the number of information resources. Sometimes the content and style of presentation do not meet the criteria for education quality. Multiple interpretations of the basic part of knowledge inevitably lead to its distortion, involuntary or deliberate mistakes, and inaccuracies. At the same time, there is a process of erosion of knowledge associated with a general information explosion and the emergence of an excessive number of interpretations of the established theories and concepts [13], as well as their active replicating in the media and information networks . This leads to the effect denoted by the term "erosion of knowledge" [45].

On the mathematical level objects of knowledge being information packages undergo distortion in accordance with C. Shannon theory [27], on the sociological level this phenomenon was mentioned by Umberto Eco [28] , M. Fucko [29] and other authors. The easiness of digital form of knowledge replication leads to the fact that numerous distorted forms of original conceptions infest accessible e-resources and increase risk their incorrect understanding. In case the distorted conceptions belong to the core of knowledge, the practical consequences may be strikingly destructive.

In IBM presentation, it is estimated that every 18 months “structured data are growing at 32%, unstructured data are growing at 63% and replicated data are growing at 49%” [30], that means that proportion of unstructured data in the total amount of data is constantly increasing.

The core of knowledge becomes hidden with irrelevant and imperfect information that in turn leads to the disintegration of the integrity of the scientific picture of the world, its fragmentation. Fragmentation of the scientific picture of the world, leads to the impossibility for a subject to derive clear causal relationships and understand scientific (and cultural) landmarks.

Within the framework of the described approach, the following urgent tasks have to be solved:

- protecting the core of general scientific knowledge from the deformation of meaning;
- avoiding unnecessary duplication when using online courses of concepts related to the core of general scientific knowledge.
- ensuring the formulation of the main cultural, historical and ideological concepts in accordance with the requirements and position of the scientific and educational community
- saving the world's cultural heritage in undistorted form.
- providing a possibility of flexible design for educational courses, which will combine, protection of meanings and concepts related to the general scientific core of knowledge as well as the cultural heritage, and the possibility of personalized presentation of these concepts.

8 The SCORM Standard in Developing Learning Objects

Educational objects developing has to take advantage of already existing concepts such as metadata and SCORM. Metadata are described in accordance with the standard specified by IEEE [31]. They obey the standards developed for SCROM [32] (Sharable Content Object Reference Model).

SCORM is the set of specifications and standards developed in organizations such as IMS, AICC, ARIADNE and IEEE LTSC and then merged into a single SCORM system and finally presented by the ADL collaboration.

Such objects have the properties of the Sharable Content Object (SCO) [5]). That is, they have communication capabilities within the framework of the LMS (Learning Management System) in accordance with the SCROM RTE standards and correspond to a structurally small object of knowledge (corresponding to the concept of Knowledge Node - knowledge units [33], [34].) Compliance with this standard, developed by the international consortium ADL (Advanced Distributed Learning) [3 allows to include modules and knowledge objects developed by third parties in the MOOC. It is important, since the ADL, which unites dozens of laboratories in the field of electronic communications, artificial intelligence, and cognitive psychology, employing thousands of specialists, carries out work that can not be done by specialists of any separately considered country.

Currently, open edX [35] and Lectora[36] are successful examples of available online services for creating objects under SCORM standards and organizing them in MOOC.

9 Permitted Blockchain as a Way to Protect and Certify the Core of General Scientific Knowledge

Given current well-seen processes of information explosion and avalanche-like replication of "garbage information," the core of general scientific knowledge have to be protected from spontaneous distortion and requires a complete, guaranteed undistorted transferring to the trainees as representatives of the following generations. Effective protection of the core of knowledge from unqualified audits should be combined with a regulatory mechanism that provides the possibility of its editing only in case of a steady consensus of experts.

Thus, the Electronic Educational Environment due to its importance should be implemented in the form of a distributed database, allowing recovery in case of damage, and edited by consensus experts.

The educational environment presented above, should have the following properties:

1. be distributed
2. consist of a sufficient number of synchronized copies
3. be resistant to unauthorized changes and partial destruction of media

Blockchain as a means of record keeping, ensuring the preservation of records and preventing unauthorized changes to them, was introduced into the modern appeal by Satoshi Nakamoto [37]. The concept of Blockchain is now primarily associated with crypto-currencies [38], [25] but on the other hand this algorithm allows strong protecting of a valuable base. Stratification of Knowledge areas and access to their change will ensure that only the experts admitted to this field will be able to edit a certain area of the records, and a wide range of people, including from other areas of knowledge, can use them in building the MOOC.

10 Conclusions

Summarizing the previously identified priorities in the development of the Unified Electronic Educational Environment, we can formulate the following conclusions:

Developing UEEE based on learning objects and following internationally developed and approved standards may save recourses and ensure mutual understanding of scientific core knowledge.

Compatibility of learning objects with the international standard SCORM enable a possibility to include into courses various modules developed by international developers, as well as the possibility local modules to be connected to international courses. The Open Education platform currently being developed in the Russian Federation [19] uses the Open edX standard [35], that supports converters [11], which allow loading modules created in accordance with a standard for SCORM modules. Thus, compliance with the SCORM standard will automatically lead to the ability to use the module in the Open edX system.

UEEE should have the capabilities of being a national educating center and an open depository for designing training courses. In this case, this structure will become a center around which e-education will develop.

Significance of such a base implies necessity to protect it from distortion and damage. For this purpose permitted blockchain algorithm can provide balanced solution for accessibility and strong protection.

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