

A FRAMEWORK FOR EVALUATION OF WEB BASED LEARNING CONTENT

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Abstract: A framework for adding qualitative and quantitative meta-descriptions of WEB based learning content is discussed in this work. The purpose is to be provided sufficient information about the digital interactive objects included in a WEB based learning resource in order to classify and measure its' suitability for use in online educational process. Taking into account that the interactivity of digital learning content should be regarded in two directives – didactical and technological, a Complex Interactivity Index is introduced. A pilot version of a WEB based tool for validation and evaluation of WEB based learning resources is proposed and some examples are given.

Key words: WEB Based Learning Content, WEB Based Learning Resource, Interactivity, Digital Interactive Object, Complex Interactivity Index.

1. INTRODUCTION

The modern didactic theory and practice pay special attention to the impact of information and communication technologies on the technological aspect of educational process, in order to effectively transpose the established didactic models into their digital representation or to transpose the physical model of learning into its digital equivalent. Moreover, there is a rapid extend of Internet importance of e-learning alongside the varieties of WEB based learning systems [1]. However, this requires taking the necessary measures to counteract possible problems and attacks to destroy information resources [2, 3].

There are newly evolved individuals in the social field. These individuals are placed and operate in completely interactive technological environment, in which they create, perceive, process and provide information only through digital technologies. This characteristic defines them as a new phenomenon, which is addressed by the authors as “*a highly interactive generation*”. Exactly this highly interactive generation is represented by the learners in today's educational system.

The conceptual framework "Education 4.0" [4] defines the structure and basic parameters of the curricula and organization of a digital educational process in a

WEB environment. But there is gap in this definition. The learning process consists of norms, educators, learners and relations between them. As far as norms regulate explicitly educators' attitude, the contemporary learners impose a new attitude and expectations in the classrooms. Perception models of the highly interactive generation regarding the digital content and its' impact on knowledge accumulation, behavioral models, mechanisms for personal communication and information exchange, predetermine the need to be proposed a common framework for classification and evaluation of digital learning content. According to the perception models of this new kind of learners, there is a need for qualitative and quantitative assessment of the efficiency of a learning process, based on WEB technologies. This requires formation of indicators that should be taken into account when educators create WEB based learning content. These indicators should be fundamental in creating a common *framework for evaluation of WEB based learning content* (WBLC Framework).

The purpose of this article is to propose a framework for evaluation of WEB based learning content. The main goal is to present our research in the field of digitalization of the educational process, as well as the design and development of digital learning resources. In this reason, the next section presents the legacy issue and section 3 discusses the important criteria in the field. The results of our research are presented in the sections 4, 5 and 6.

2. THE LEGACY ISSUE AND RELATED WORK

In the existing standards for development of digital content [5-7] and particularly in section 5.4.5 of IEEE Standard [8] (XML schema definition language binding for Learning Object Metadata/ LOM) the interactivity is regarded as a part of the educational element set in table 12, but it is not presented in subsection 5.4.4 as a part of the technical set of elements, as exposed in table 9. There are two core interactivity characteristics, defined in table 12 - Interactivity type and Interactivity level. Such approach steadily supports the prior standard statement that Interactivity has only educational characteristic. However, the conducted studies in the field state that Interactivity has to be regarded as two-layered: *Core Interactivity* and *Educational Interactivity*. Here the Core Interactivity is the first layer, possessing explicit technical characteristic with certain set of technical specifications, which could be used as technical indicators. The upper layer – the Educational Interactivity, has an abstract nature that requires and generates a response, creating a measurable result in a cognitive process occurring in a digital environment. The question is how to achieve qualitative and quantitative assessment of it. The exposed above problem has an impact on other e-learning standard – SCORM, because it is relying on mentioned above LOM standard [9]. One of the possible solutions is to be defined a set of technical indicators in the first layer of interactivity in order to evaluate the Educational Interactivity in a pedagogical con-text.

Introducing such a framework, based on quantitative and qualitative characteristics, will facilitate teachers in preparation of HTML5 based digital learning content intended for use in the learning process in WEB environments [10-12]. The WBLC framework should unambiguously provide definitions, categories and criteria, as well as guidelines for determining qualitative and quantitative values of interactivity and their meta-descriptions in HTML5 documents, declared as a learning content. The focus should be set to the achievement of "*learning content - knowledge - skills*" interconnection in a regulated educational process. The intention of WBLC framework is to propose a uniform way to add qualitative and quantitative values in the Metadata section of any HTML5 app/document, defined as a learning content and this could be accomplished by the well-defined Document Object Model programming API [13, 14]. This way, certain HTML5 content, created with any of the available platforms, could be assessed through the proposed WBLC framework using a Complex Interactivity Index (CII), which formulation is discussed further.

3. DIDACTICAL ASPECTS OF WBLC FRAMEWORK

3.1. Pedagogical criteria

- The students should be regarded as highly interactive individuals surrounded by a WEB based digital environment;
- The students would form a cognitive activity based on digital information flows in a multi-channel interactive environment;
- The students would solve problems using digital devices with highly interactive functionalities, connected to Internet;
- Defined context of use of digital learning content;
- Interconnection of concepts;
- Active and induced impact (relation to active learning);
- Existence of a case (relation to problem solving, research based learning);
- Opportunities for collaborative learning;
- Opportunities for self-study;
- Opportunities for learning through games;
- Opportunities for integrated learning (relation to STEM, STEAM).

3.2. Criteria concerning the didactic model

- Cognition is formed by observation, through abstract thinking and with reflection in active experimentation;
- The cognitive load is distributed according to the results and achievements of the learners;
- The focus of knowledge is set to the construction of independent conceptual constructs through interaction with others;
- Multitasking-oriented learning;
- Complex and composite digital learning tools.

3.3. Criteria referring to learning content included in WEB based learning games

- The topics of the learning content comprise the plot of the learning game;
- The learning content is nested in the development of the plot story (if there is any), and the thematically separated modules or sections are integrated into logically connected game levels;
- There is a developed leveling system and a strategy for rewarding players.
- The learning resources are presented as valuable assets accompanied with unlocking game algorithm. An award is provided when unlock a resource;
- The reward system in the digital learning game is based on a step-climbing model of improvement, comprising two alternating phases – acquisition and mastering of knowledge;
- The reward system includes the following types of rewards: rewards of access (granted for unlocked learning resources); reward keys (unlocking mechanisms); rewards of knowledge; rewards of achievements; rewards of mastery.
- The learning content includes both learning resources for acquisition of knowledge and those for its mastering;

4. TECHNOLOGY ASPECTS OF THE WBLC FRAMEWORK

4.1. Model of digital learning content

In the proposed WBLC framework the digital learning content is considered as a set of digital learning resources, integrating N objects of different media types, classified into four main categories (Fig. 1). Each object of a given media type has its' own defined set of program interactivities, functioning through a set of operations (Op1 - Opn). These operations must ensure adequate interaction of the highly interactive students with the digital learning content provided by the teacher through a WEB based learning resource.

4.2. Complex Interactivity Index

Educational interactivity is any interaction with an object of the digital learning content in the course of a digital educational process, requiring and generating a response and producing a measurable result in the cognitive process. In order to meet the requirements of the highly interactive generation, according to their perception models, there must be implemented certain level of interactivity in the digital learning content. For each digital learning resource it is necessary to be defined a Complex Interactivity Index, which forms its' value by implementation of an iterative algorithm and its' logical structure can be represented as a taxonomy of identifiers (Fig. 2). Based on CII, a classification of digital interactive objects (DIO) and the operations performed over them has been created to support the evaluation of the interactivity of digital learning content (Table 1).

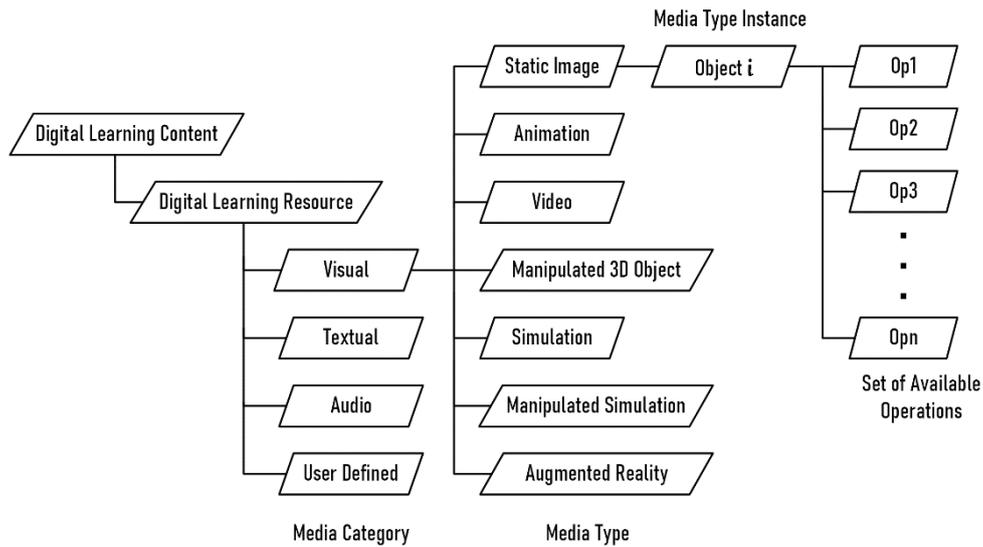


Fig. 1. Model of digital learning content

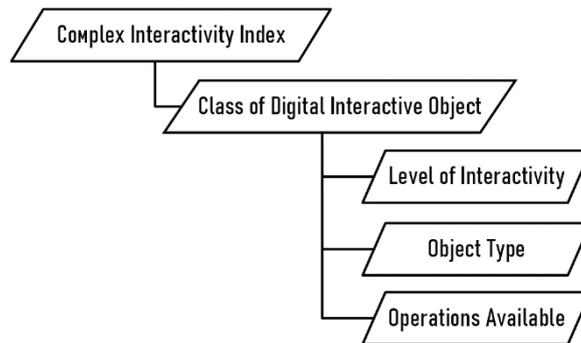


Fig. 2. Complex Interactivity Index

4.3. Environment for access to the WEB based learning content

The environments for access to WEB based learning content are client agents – browsers, ensuring HTML5 documents to be displayed correctly and thus satisfying the requirement of prerequisite 1. The access is established thru HTTP via Document Object Model API interface.

4.4. Visual design

When developing the visual design, the norm of ISO 9241-210:2019, clause 3.15 is applicable, dealing with the perceptions and reactions of the consumer as a result of the use of a product (in this case digital learning content), as well as the

basic Gestalt psychology principles [15] for visual perception – similarity, continuation, closure, proximity, figure/ground, and symmetry and order.

Table 1. Classification of DIO

<i>Class of DIO</i>	<i>B: Basic</i>	<i>C: Complex</i>	<i>S: Sophisticated</i>
<i>Level of interactivity</i>	<i>Basic level: Static functional interactivity</i>	<i>Complex level: Polymorphism and inheritance of interactivity</i>	<i>Sophisticated level: Contextually generated interactivity</i>
<i>Object type</i>	<i>Simple objects</i>	<i>Complex objects</i>	<i>Sophisticated objects</i>
<i>Operations available</i>	<i>Elementary operations:</i>	<i>Complex operations:</i>	<i>Sophisticated operations:</i>
	<i>Hyperlinks Hints Input/Output events Scroll No transformations Direct manipulation over a container Pseudo manipulation over content parts</i>	<i>2D/3D transformations Digital filters Deformations Direct manipulation over parent objects Direct manipulation over child objects Linear and affine transformations Morphing Streaming</i>	<i>Manipulations over: Objects in virtual reality; Objects with augmented reality; Holographic objects. Intelligent agents Linear, affine and non-Euclid transformations Dialogue mode with objects</i>

4.5. Specification of digital objects

It is appropriate to be given a technical description of the different types of objects which build up a digital learning resource as shown on fig.1. The classification below lies on the presumption that knowledge is interpreted via small objects of the learning content. Three classes of objects are differentiated in WBLC framework – *basic*, *complex* and *sophisticated* (Table 1). Any object of these classes should permit assignment of certain level of interactivity.

Basic objects are those whose decomposed parts do not provide any meaningful information. For example, a static image could be decomposed to certain number of pixels. But none of them could be used to carry meaningful information. Simple objects consists of text and static image media type.

Complex objects are those allowing decomposition of the main container object which is carrying information into certain small simple logic parts also carrying some meaningful information. For example the dynamic image sequence knowing as video could be decomposed to a number of static images. As far as the video is the primary carrier of the information, the decomposed static n-th image is containing information as well. Complex objects consist of video, animation, and audio media types.

Sophisticated Objects are those comprising all media types because interactivity with such objects relies explicitly on bundle of human senses. Sophisticated objects

should provide functionality for manipulations in virtual and augmented reality, with holographic objects and intelligent agents. They should allow linear, affine and non-Euclid transformations and dialogue mode of operation.

5. ASSESSMENT AND EVALUATION

This part of the framework provides guidelines for preparation of digital learning content and evaluation criteria for measuring the progress and achievement of learners in a WEB based learning process, as well as a categorization of WEB based learning content to facilitate its classification and description.

5.1. Criteria

In general, the digital learning content, as any learning content, should consider the extent to which the new knowledge is linked to already assimilated knowledge and concepts, thus building new concepts in the subject area. Following this concept, the WEB based learning content should:

- be delivered in a form adequate to the established mental model of technology-based perception of the learners;
- be designed following the logical connection between existing and new knowledge;
- provide opportunities for the formation and consolidation of skills;
- allow integration with different online methods for assessing learners (tests, assignments, simulations, etc.).

The assessment methods should:

- be based on the results, directly obtained by activities and actions of the learners with the developed learning content;
- be aimed at measuring the quality of learning with WEB based learning content by taking into account the levels of understanding of phenomena, norms and facts, conceptualization, information processing, critical thinking, and problem-solving skills;

5.2. Categories

The categories presented below, together with the CII, will serve to classify and describe WEB based learning resources using metadata, and thereafter – to evaluate them. Evaluation and assessment of the WEB based learning content are focused to the content itself regardless the technologies used for its' creation.

Category 1

This category covers the digital learning resources containing objects of single media type. For the objects of this category it is not required to have any interactivity.

Category 2

For the digital learning resources of this category it is required to be combined objects of at least two different media types. And at least one of the objects presenting these media types is required to have certain interactivity.

Category 3

This category requires at least three media types to be combined in a digital learning resource. The category covers learning applications (including learning games) and for all the objects of the digital learning content an assigned interactivity is required.

5.3. Defining the Complex Interactivity Index

The WBLC framework imposes that every DOM element in HTML5 document, declared as learning content, which is intended to represent an object of a learning resource, has to be classified according to Table 1.

A specific activity in defining CII is the development of a module for parsing and generating CII's value. It is required a specific name attribute to be assigned to each interactive object in the learning resource. For example, below is given the HTML code of an object, representing the program counter in an interactive WEB based simulation of a processor:

```
<div id=PC onclick="showslidingWindow(0,true,'popupPC')" class="popup" name="C">
```

and according to the name attribute, the object is identified as a complex DIO.

The versatility of the parsing and generating module is based on the structural isomorphism of the DOM, i.e. when applying the taxonomy exposed in 3.2, for all identical objects in the constructed document, an identical logical structure is formed, which ensures the detection of those interactive objects united by a common indicator (name and attribute value) and classified as shown in Table 1.

5.4. WEB Based Tool for Evaluation of WEB Based Learning Content

On fig. 3 is presented the process of evaluation of WEB based learning content in accordance to WBLC framework. The process comprises three phases – coding, validation and evaluation, and while the first phase runs within the implementation of the learning resource, the next two phases require development of a standalone application to analyze and evaluate the completed HTML document. The first task of the developed tool is to check the “application-type” attribute in the meta-section of the document: `<meta name="application-type" content="LearningContent"/>`.

The latter has two possible values – “*LearningContent*” and “*LearningGame*”. If none of them is set, or the attribute is missing, an error message is displayed. The next task is to be found the meta-tag, containing the CII. If such a tag is not present, this means that the document is not validated and the validation process is to be started. It involves parsing of the HTML code and calculating the CII. At the end of validation, the CII meta-description is added to the meta-section of the document:

```
<meta name="complex-interactivity-index" content="CAT3.B11.C3.S1.G1.RW4"/>
```

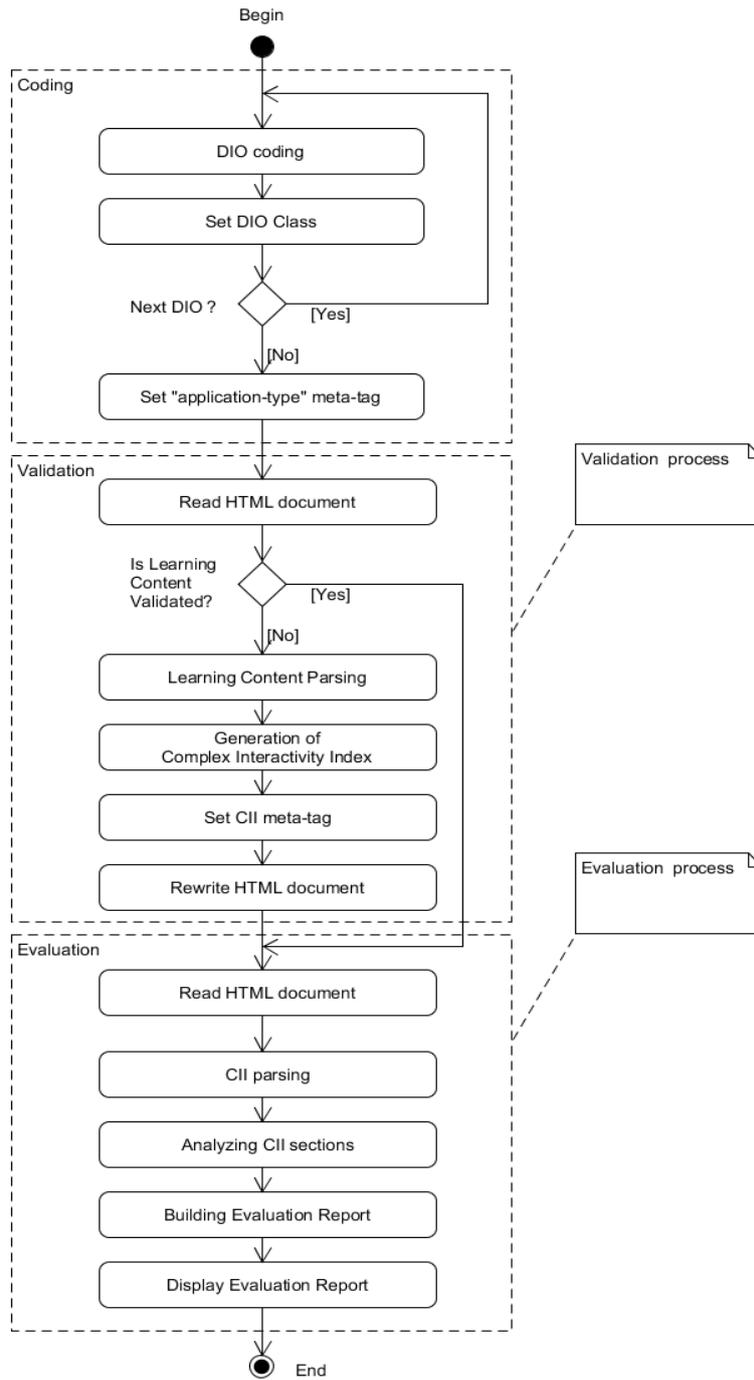


Fig. 3. The process of evaluation of WEB based learning content

In the above example CAT3 denotes that the resource is classified as a representative of the third category; B11, C3 and S1 show that there are 11 basic, 3 complex and 1 sophisticated DIO found in the resource; G1 means that the resource is a part of a learning game, and RW4 denotes that the resource is associated to a reward of achievement. The CAT parameter has three possible indexes – from 1 to 3, representing the categories of digital learning content.

The G parameter takes index 1 or 0 depending on whether the resource is a part of a learning game or not. The RW parameter has 6 possible indexes – from 0 to 5 denoting as follows: 0 – no reward for this resource, 1 - reward of access, 2 – reward key, 3 – reward of knowledge, 4 – reward of achievement, 5 – reward of mastery.

The evaluation process involves parsing of the CII, analyzing the sections of the index, building and displaying the evaluation report (fig. 4).

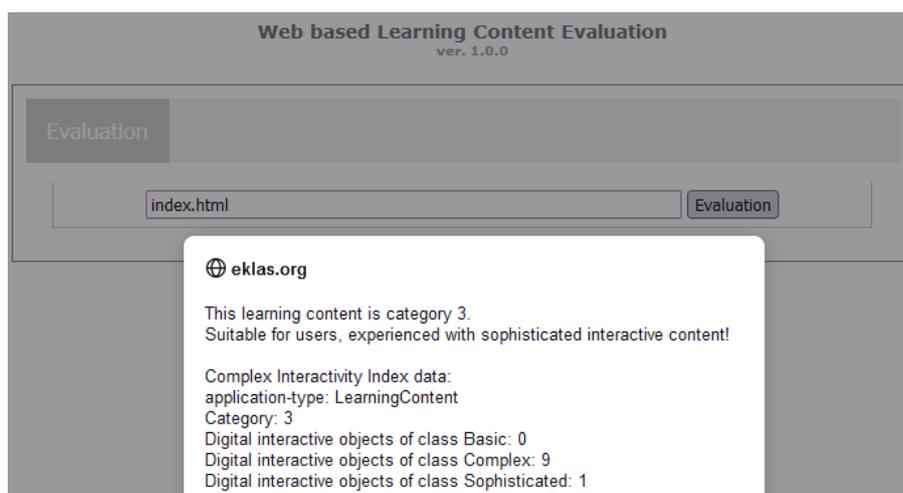


Fig. 4. Evaluation report

6. CONCLUSION

The quantitative and qualitative characteristics, systematized in the presented framework, will facilitate educators to make their decision when and how to use certain learning content in a digital educational process in WEB-based environments to ensure adequate pedagogical interaction with the learners of the highly interactive generation according to their perception models.

The set of criteria, reflecting the pedagogical, didactical and learning games' aspects serve as indicators to be used not only as a reference guide throughout the process of development of the digital learning content, but also as evaluation markers for its assessment.

The concepts of categorization of the digital learning content, together with the Complex Interactivity Index, allow more precise automated meta-description and as

a result – more precise automated classification and evaluation of the content in WEB based learning environments.

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