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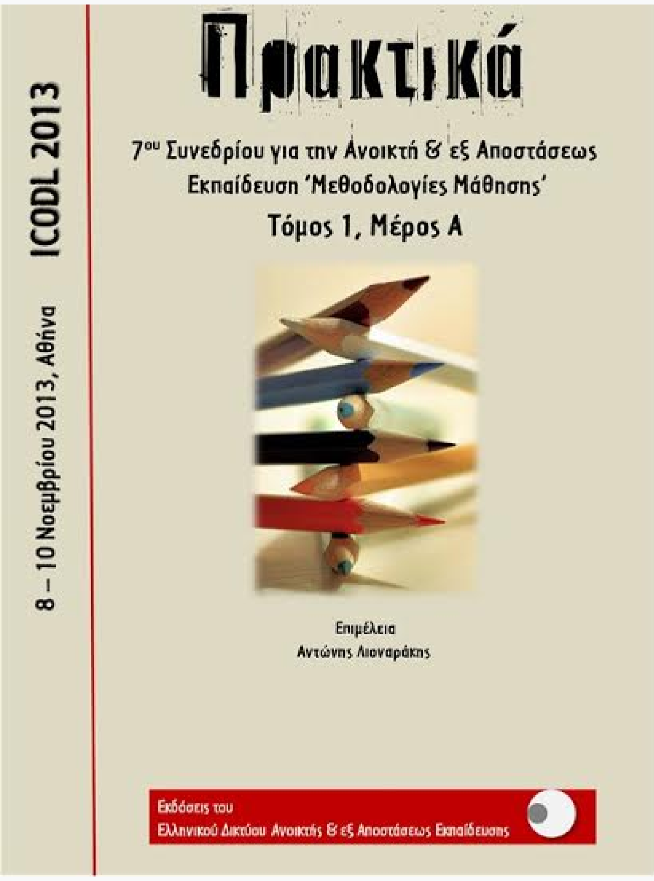

An Instructional Design Methodology for Building Distance Learning Courses

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Abstract

The importance of a distance learning program heavily depends on the type and quality of the provided digital content. The Hellenic Open University (HOU) offers distance learning courses and therefore the volume of the provided digital learning content is significantly large. This fact establishes essential the need for an efficient and effective mechanism for searching, managing and retrieving the educational content. A modern approach for the organization of the digital learning material is the Learning Objects (LOs) paradigm, the use of which is adopted by many e-learning systems and applications nowadays. In this work we try to take advantage of all of the good characteristics of LOs and propose an instructional design methodology that builds courses based on these particular chunks of educational material. The aim of the proposed methodology is exactly to provide guidelines for the design and creation of courses based on LOs. Secondly, it intends to exploit semantic technologies in order to capture and represent the knowledge that is produced during each step. This semantically enriched information, regarding a course, is could be ideally utilized during the creation of LOs.

Keywords: *distance learning, lifelong learning, ontologies, learning objects, instructional design methodology*

1. Introduction

In the era of Internet, the distribution of educational content via e-learning systems is increased continuously. LOs constitute a novel approach in organizing educational content, which is found in the core of a whole new instructional design paradigm developed in the field of distance learning (Baruque, Porto & Melo). Moreover, LOs have been widely used for the creation of web educational content that is exploited by e-learning applications, such as Learning Management Systems (LMS) or Learning Content Management Systems (LCMS). LOs are modules of educational content which are focused on the achievement of specific learning outcomes and can be combined in almost infinite ways in order to create collections and build sections, lessons, or courses. In this way, they provide flexibility in the development of learning content and decrease the required time and cost.

Educational material plays significant role in the process of delivering knowledge, especially in the case of distance learning courses. Contrary to what happens in face-to-face learning, the role of the instructor is supportive – complementary and the educational material constitutes the primary means of learning. The need for qualitative educational content, able to ensure that learners will achieve their stated goals for learning, makes essential the development of ID methodologies, for the creation of educational content using LOs. A methodology or strategy of instructional design is the systematic process of designing, developing, evaluating and managing the entire instructional process to ensure effective and efficient learning (Morrison, Ross, & Kemp, 2001). The development of content which is going to be used from e-learning systems can be benefited from such type of methodologies. Although such methodologies have been used mainly for the development of courses in face to face learning, they are considered equally important also in distance learning. However, it should be adjusted to cope with the technological requirements of e-learning systems and to incorporate the concept of LO for the organization of educational content.

Most of the effort made in the field of LOs has been focused on the establishment of technical standards aiming at accessibility, interoperability and reusability of LOs. Such standards define the description mode of LOs with metadata (IEEE LOM[1], Dublin Core[2]), their structure and organization in packages (AICC[3], IMS[4]) as well as their communication mode with the various Learning Management Systems (LMSs). Despite of this fact, more attention should be given to the establishment of educational theories and methods for the creation of LOs which will be pedagogically and educationally effective and rich. A balanced effort in technology and instructional design will bring the maximum possible benefit from the incorporation of the LOs in the teaching practice (Reece, 2009).

2. State of the art

After researching some existent instructional design methodologies, we found out both similarities and differences among them. The CISCO strategy (Cisco Systems Inc, 2003) covers subjects like the definition and the structure of a LO, while it determines clearly the hierarchy of the educational content (Topic, Lesson, Module and Course). Despite of the above facts, an explicit determination of the way the material is subdivided into LOs is absent and there are no instructions concerning the construction of learning path (i.e. sequence of LOs). Besides, CISCO strategy comes with a training character and has not been designed for educational purposes. On the other hand, both the methodology proposed in (Baruque, Porto & Melo) and the M-LODGE approach (Razak & Palanisamy, 2010), don't emphasize to the specification of the attributes of LOs, but they provide some guidelines about the segmentation of the educational content and the construction of the learning path. However, in both methodologies the order in which the LOs are presented to the learner, is defined statically and not dynamically. This static order becomes a flaw in case we want the educational process to be adjusted to the characteristics and the needs of the learner. Finally, despite the fact that there is no common perception, among the designers of

[1] http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf
[2] http://dublincore.org/documents/dces/
[3] http://www.aicc.org
[4] http://www.imsglobal.org/

educational content, for the definition and the attributes of LOs, none of the above methodologies tries to cover in detail the above matters.

Our proposed instructional design methodology, although is based on existing ones, it tries to cover some of their deficiencies by making several additions. Its main characteristics are a) the adoption of the notion of LOs for the design and the creation of educational content and b) the use of ontologies for capturing all knowledge related to a LO, a technique that enables a LO's exploitation by intelligent e-learning systems. Furthermore, by taking into account the specific needs and characteristics of the Hellenic Open University (HOU), which is the main distance learning institution in Greece, the methodology is adjusted accordingly. In the context of the methodology which is described below, we analyze the concept and the features of LOs and then we present its phases and steps.

3. Description of the Methodology

The proposed instructional design methodology, as any well-structured methodology, consists of phases, each of which is further divided into certain number of steps with specific outcomes. This methodology has three phases in total, the *Analysis*, the *Design*, and the *Development* phase.

First comes the *Analysis Phase* in which we determine "what" is going to be taught and to "whom". The second phase is the *Design Phase* in which is determined "how" the educational content will be organized to LOs and "how" the construction of learning path is realized, i.e. the guidance of the learners among the LOs of a specific lesson is performed. The third and final phase of the methodology is the *Development Phase* during which the LOs are developed and characterized with metadata.

3.1 The Analysis phase

This phase aims at analyzing the educational problem in order to specify the knowledge domain, the learning goals of the educational process and the learners' profile (student model). The main outcomes of this particular phase are:

1. An extensive analysis of the knowledge domain in terms of a network of concepts and interrelations
2. The learning goal of the course
3. A set of core concepts, indicating the most important concepts of this particular knowledge domain
4. A summary of the most important characteristics and needs of learners

Step A1: A matter of decisive importance is the analysis of the educational problem, i.e. what is the reason for which the teaching is performed, to which knowledge domain is referred and which needs of learners attempts to cover. The answers of the above questions give us the subject (knowledge domain) of teaching and its main - global learning outcomes.

More precisely, in this step the Instructional Designer (ID) is required to write down:

- The subject of teaching and the Knowledge domain to which is referred
- The Learning Goals of the teaching process
- The Core Concepts of the Knowledge domain

Step A2: In this step we study the profile of learners. Our aim is to collect useful information about the characteristics of the audience (target group) to which the teaching is directed. These characteristics may concern:

- *Demographics*: age, sex, educational background, current competency level, any learning difficulties etc., and
- *Motives*: interests, goals, reasons for training, educational experiences etc.

The collection and recording of these characteristics contributes to the comprehension of the target group's nature and constitution. This enables the adaptation of educational material (i.e. learning outcomes and LOs) that is going to be developed, according to the needs and particular characteristics of learners.

Step A3: In this step an overview of the existing educational material (digital or non-digital) is performed. In particular, the ID is asked to summarize all available educational material used to serve the scope of the course. This same material is going to be used as is or with some modifications in the design and development of LOs that will take place during the next phases of the methodology.

3.2 The Design phase

In the design phase, it is determined how the educational material will be subdivided into LOs, based on the learning outcomes of the course. Actually, during this phase we construct LOs that lead the learner to the achievement of all learning outcomes and specify how these LOs will be organized and combined so as to support the course. The main outcomes of this particular phase are:

1. The representation model of the knowledge domain
2. The Learning Outcomes of the course
3. A set of templates/drafts for LOs, which will form the basis for their development in next phase
4. A sequence of LOs (learning path)

Step B1: An essential requirement, in order to make possible the writing of precise learning outcomes and the development of well-designed LOs, is having a complete view of the knowledge domain. This can be achieved by utilizing an effective knowledge representation technique (like ontologies) which will lead to the creation of the knowledge domain representation model. The resulting model intends to represent the domain concepts and use simple relationships, such as *composition (has)* and *generalization-specialization (is-a)*, as well as more complex ones for the description of the correlations among them. The analysis level of the concepts that appear in the knowledge domain model varies, so there exist concepts which are analyzed to simpler ones and concepts which are not analyzed further (lowest analysis level).

More specifically, in this step the ID is required to analyze each of the basic concepts that has defined in the analysis phase (*step A1*) into sub-concepts and define the necessary correlations among the resulting concepts of the field. What is most important during this step is to produce a complete representation for the knowledge domain in terms of concepts and relations, since the learning outcomes of the course that are going to be defined in the next step, will be based on this work.

Step B2: Based on the Revised Bloom's Taxonomy (RBT) (Anderson & Krathwohl, 2001) the ID defines the learning outcomes of the educational process by taking into account the previously analyzed knowledge domain representation model. The learning objectives and goals that have been set during *step A1* are now analyzed in particular knowledge, abilities or skills (i.e. learning outcomes) that the learner should ideally acquire after the successful completion of the course. The produced learning

outcomes must meet the specifications described in (Kalou, Solomou, Pierrakeas, & Kameas, 2012).
During this step, for each concept to be learned by the learners, the ID defines at least one learning outcome that implies the acquisition of this particular concept at one of the RBT levels. To achieve the above, each learning outcome must include exactly one verb able to express action. The verb actually indicates the level at which the knowledge domain concept, contained in the learning outcome, is acquired. In the effort of defining learning outcomes, ID should also take into account the characteristics of the educational processes' target group, as these have been written down during the analysis phase (*step A2*).
What follows, is the detection of those learning outcomes that are considered significant for the learning process. Having spotted those learning outcomes, the ID should afterwards point out possible correlations of dependence among them (correlation "requires"). As *significant* are characterized those learning outcomes that should at least be achieved from the learner by the completion of the course. Therefore, *significant* learning outcomes place a lower limit concerning the knowledge that should be acquired during the course and hence indicate the minimum information/educational material to which the learner should be exposed. The relationship "requires", which can be defined between two significant learning outcomes, indicates that a significant learning outcome presupposes the achievement of other significant learning outcomes.

Step B3: Potentially, some of the learning outcomes produced by the ID during step B2 may refer to concepts that have not been included to the knowledge domain representation model (*step B1*). The need to create learning outcomes about these concepts indicates that the latter is important in the learning process and thus should be included in the domain model, by revising it appropriately. The ID, apart from updating the model by adding the missing concepts, needs to also correlate them with the already existing concepts.

Step B4: In this step we want to determine "what" should be presented to the learner, in order to be able to satisfy the learning outcomes defined in *step B2*, and consequently to successfully complete the learning process. Therefore, the aim of this step is to design LOs able to lead to the previously set learning outcomes' achievement. Especially for the significant learning outcomes, at least one such LO should be predicted. Therefore, a course is supposed completed, only after the learner successfully completes the LOs of type "assessment" that are associated with the significant learning outcomes. Such LOs can be an open question, a problem, a project etc.
It is important to emphasize that here it is expected the definition of ideal LOs, as regards their structure and content. Essentially, we seek to create a draft/template on which IDs will base the development of LOs during the next phase (*step C3*). The LOs designed in this step, fulfill the requirements described in (Nikolopoulos, Solomou, Pierrakeas, & Kameas, 2012) regarding their structure, their content and attributes. Additionally, a LO depending on its role (i.e. supportive or fundamental) in the learning process can be characterized as either *core* or *supportive*. *Supportive* LOs are objects that encompass and support the knowledge conveyed by the *core* ones. They actually convey complementary or prerequisite knowledge, which helps learners to successfully complete the course. In essence, supportive LOs aim to recall concepts, which in the particular course are considered already known, by the

learners. On the other hand, core LOs contribute directly to the satisfaction of one or more learning outcomes, which have been produced for a specific course and consequently knowledge domain.
For each LO defined in the current step, the ID has to identify their characteristics, namely to provide some of its basic metadata elements. In (Nikolopoulos, Kalou, Pierrakeas, & Kameas, 2012) an educational metadata profiles based on IEEE LOM is proposed, that takes into account both educational and technical aspects of a LO. This set of elements constitute in substance, the draft of a LO and provide all the required information that is necessary for its development.

Step B5: After the completion of *step B4*, what should be determined now is the order in which the LOs will be presented to the learner, in the context of a course. The question that arises is how the learning path, on which the learner is going to be navigated in order to complete the educational process, is manufactured. The way of construction could be either static, where the sequence of LOs is predetermined and is the same for all the learners, or dynamic, where the sequence of LOs is adapted according to the criteria that are placed and differs among various learners.
Within the context of this methodology it is proposed the dynamic construction of learning path, through which is emerged the flexibility provided by the development of courses with LOs. The dynamic adaptation of the route (learning path) followed by the learner during the educational process is performed based on two criteria:

1. The *learner's profile*, through which learner's needs and characteristics like learning style, interaction preferences (language, environment aesthetic), competency level etc. are specified, and
2. The *requirements of the instructional strategy* (way of teaching) that is adopted in each case. Examples of instructional strategies are '*Problem Based Learning*', '*Game Based Learning*', '*Collaborative Learning*', '*Example Based Learning*', '*Exploratory Learning*' etc.

Moreover, the adjustment of the path of LOs that the learner should follow, may be affected by either the interrelations among the domain concepts - as these have been declared at the representation model of the knowledge domain - and/or by the relationships among the significant learning outcomes (*step B1* and *B2* accordingly).
The aforementioned dynamic adaptation can be achieved by a system (educational software) with the use of intelligent agents. Such a system could take as an input the aforementioned information and will guide each learner accordingly during the educational process. However, in order for that to be feasible, the design and development of the instructional designs' core elements (i.e. Knowledge domain Representation Model, Learning Outcomes, LOs) should follow the standards and meet the requirements that have been placed in (Kalou, Solomou, Pierrakeas, & Kameas, 2012) (Nikolopoulos, Solomou, Pierrakeas, & Kameas, 2012).
At this point, it should be emphasized that the adaptability of the system should be controlled. The control of the system's adaptability ensures that the learner will be exposed in the whole information that is necessary for the successful completion of the educational process and is mainly achieved through the significant learning outcomes the presence of which is judged essential.

3.3 Development phase

This phase aims at the development of the previously designed LOs and renders them suitable for storing and management by digital repositories or exploitation by Learning Management Systems (LMSs). An essential prerequisite in having advanced

management, search and retrieval services for LOs, is their proper characterization with educational metadata. The main outcomes of this particular phase are:
1. The digital files for the previously designed LOs
2. The metadata records of the developed LOs

Step C1: During this step and particularly for those LOs that was found that the existing educational content is inadequate or even absent, we seek for additional material in libraries, collections, digital repositories etc. This material should be characterized by the term “Open Educational Resources” (OER[5]), meaning that is freely offered in the educational community and that under concrete legal regime[6] can be enriched, improved and redistributed for use in teaching, learning and research. For example, it can be e-books, video lectures, academic journals, presentations, educational software and more. In case such educational material is located, the ID must return to *step B4* and re-design LOs using this additional educational content.

Step C2: All LOs defined during the *Design Phase* are now developed. A LO:
a) can be extracted from the existing educational material of the course or the material that resulted from the search realized in *step C1*
b) can be developed from scratch, something which presupposes the development of new educational material, or
c) can be formed by a combination of existing educational material and new one

The development of LOs can performed using a variety of authoring tools, provided for this reason. The choice of the most suitable authoring tool varies by case and depends on the technical type that has been determined for each LO to be developed.

Step C3: In this step, each LO is characterized with metadata according to a suitable educational metadata schema. The above process produces a metadata instance for each LO, describing various aspects of a LO. The structure of such an instance is defined by the conceptual data schema specified by the selected standard or application profile.

Specifically, the ID is required to characterize each of the developed LOs, based on the conceptual data schema that she has chosen. Usually the description of LOs with metadata is performed through the completion of a metadata form (digital or non-digital) by the ID. This form can be part of the digital repository that hosts the LO, something that makes the characterization process more effective and efficient.

4. Learning Objects for the Course Module of “Software Engineering”

The methodology described in previous section, was applied to a selected piece of material in order to reorganize it, using well-designed and well-structured LOs. More specifically, the methodology was applied in order to support the 2nd week of study for the knowledge domain of the Java Programming Language. This course is included in the course module of “Software Engineering” (PLH24) of the HOU’s “Computer Science” study program. Our goal was to produce LOs by utilizing mainly the printed and the alternative educational material (digital) which is offered to learners for this particular week of study.

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[5] http://wiki.creativecommons.org/OER

[6] The legal and technical framework for the OER is provided by Creative Commons (http://creativecommons.org/)

After implementing the first steps of the methodology described above and writing down all necessary information regarding the analysis phase, we proceeded with the design phase (*step B1*) and built the representation model of the knowledge domain of Java. The produced model was afterwards transformed in a formal representation, namely an ontology, as described in (Kouneli, Solomou, Pierrakeas, & Kameas, 2012). Part of the implemented ontology is depicted in the following figure 1.

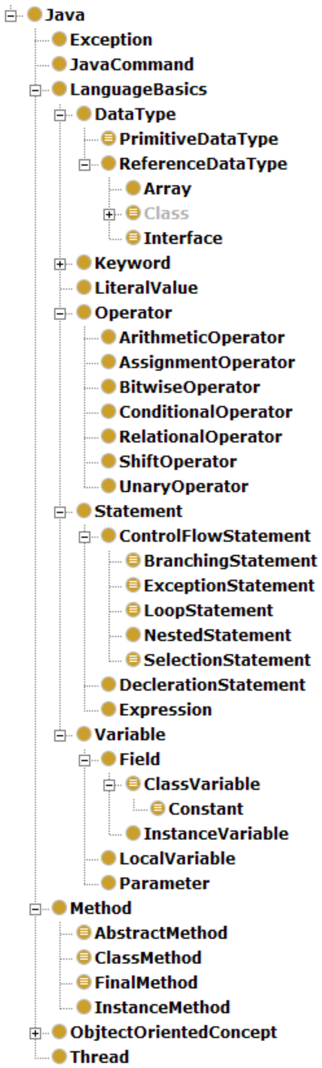

Figure 1. Part of the ontology for the Java Programming Language. This ontology is the result of the formal transformation of the representation model for Java, produced during step B1.

The definition of learning outcomes for the 2nd week of study of the Java course was accomplished during the next step B2, and has been based on the knowledge domain analysis of step B1. To perform that task, we took into account the existing course's learning outcomes, most of which were replaced by new and well-structured ones. All thirty-one learning outcomes that were finally produced were correlated with at least one concept from the knowledge domain. The verb used for the creation of each learning outcome, denotes the "performance" of the outcome. "Performance" corresponds to one of the RBT levels in the cognitive domain. Moreover, each learning outcome may also entail a condition and a criterion.

In Table 1 we present some example learning outcomes that were created in the context of the pilot program performed for the course module PLH24. They are categorized according to the concept to which they relate and the Bloom level.

Table 1. Example Learning Outcomes for the 2nd week of study of PLH24 course module

Concept of the Knowledge Domain	Bloom Level	Learning Outcome
Data Types	Knowledge	*"Provide the 2 different kinds of data types that are supported by Java"*
Data Types	Knowledge	*"Describe what is an alphanumeric"*
Data Types	Application	*"Construct statements by using primary data types and reference data types"*
Arrays	Knowledge	*"Define what is an array type"*
Arrays	Comprehension	*"Explain the difference between the multidimensional and the one-dimensional array"*
Control Flow Statements	Knowledge	*"Name 5 control flow statements that are used by Java program"*
Control Flow Statements	Analysis	*"Analyze a 'for' statement to its individual components"*
Control Flow Statements	Evaluation	*"Reason which is the more appropriate control flow statement for the construction of an iteration loop"*

During this pilot application of the proposed methodology, no update of the knowledge domain representation model was necessary, so we proceeded with step B4, which provides for the design of LOs. The creation of LOs has been based on the set of learning outcomes that were specified during *step B2*. As a result, twenty-four LOs were developed in total, so as to satisfy the learning outcomes of the 2nd week of study of the Java course. The educational material used for the development of LOs, came from the following sources:

1. Book of the "PLH24 – Software Design" module, subject "Programming Languages II"
2. Alternative Educational Material, "PLH24 – Software Design" module, subject "Programming Languages II"
3. Book of the "PLH10 – Introduction to Informatics" module, subject "Programming Languages".
4. Selected exercises/lectures, "PLH24 – Software Design" module, subject "Programming Languages II"

The content of the aforementioned material was proved insufficient to produce LOs able to satisfy all set learning outcome. Consequently, a number of deficiencies in the existing material were revealed. What is more, among the above resources, which have been used for the development of LOs for the PLH24 module, it was also used a book covering the knowledge domain of Programming Language and belongs to another HOU's course module ("PLH10 – Introduction to Informatics"). The need to exploit this particular material, in order to develop LOs regarding the course of Java, has arisen from the fact that many knowledge domain concepts are common in both the knowledge domain of Java and C. The above fact makes clear that the same LOs can be used in different educational contexts (i.e. meets the reusability requirement of a LO, as defined in (Nikolopoulos, Solomou, Pierrakeas, & Kameas, 2012)) and depicts one of the main advantages of using LOs instead of traditional educational content. During the development phase, twenty four LOs were finally created, and for each LO a metadata record was produced, using the educational metadata schema proposed in (Nikolopoulos, Kalou, Pierrakeas, & Kameas, 2012).

5. Conclusions and future work

Through this work we propose an instructional design methodology that aims at organizing distance learning courses, using LOs. It consists of a number of phases and steps, each producing well-defined outcomes, and its novelty lies in the fact that takes advantage of ontologies for representing all aspects of a course.

To evaluate the proposed methodology, we apply it for the re-organization of the printed and alternative educational material (digital) of the 2nd week of study of the HOU's Java course. As a result, twenty four LOs have been produced for the fulfillment of the learning outcomes that were set. However, some learning outcomes were not able to be satisfied by the LOs that were developed using the existing educational material. This fact revealed the need to develop LOs, by utilizing additional educational material. It is important to notice that these deficiencies in the HOU's existing educational material became evident due to the use of ontologies. The network of relations among the knowledge domain concepts with which the ontology provided us, helped in discovering "non-obvious" correlations among the structural components of a distance learning course (knowledge domain concepts, learning outcomes and material). What is more, the knowledge domain ontology for the Java programming language revealed the correlations among concepts in the Java and C programming language and led us to the conclusion that LOs designed for a particular course can be used within different contexts as well.

In future, we seek to a more systematic evaluation of this methodology, something that will be ascertained by its application for the re-organization of the material of more distance learning courses. Critical evaluation parameters are the quality of the produced LOs and the feedback received from tutors and IDs who apply it in order to create courses that are based on LOs. Equally important is to control the methodology's effectiveness and its application to other knowledge domains.

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