A Framework for Personalized Geomatic Engineering E-Learning Experiences

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ΠΕΡΙΛΗΨΗ: Η προσωποποιημένη (προσαρμοσμένη) ηλεκτρονική μάθηση λαμβάνει υπόψη τις ατομικές ανάγκες και απαιτήσεις των εκπαιδευόμενων και αναμένεται να κυριαρχήσει στην εκπαίδευση στελεχών για την κοινωνία της Γεωπληροφορίας. Στον τομέα αυτόν η έλλειψη κανόνων και μεθόδων με GICT (Geospatial Information & Communication Technologies) λειτουργικότητα είναι εμφανής. Στόχος της παρούσας εργασίας είναι η παρουσίαση ενός απλού, ανοιχτού και διαδραστικού πλαισίου (framework) για τη σχεδίαση, ανάπτυξη και οργάνωση επαναχρησιμοποιημένων γνωστικών αντικειμένων (reusable learning objects) με GICT λειτουργικότητα. Το πλαίσιο αυτό -εφόσον στο μέλλον υλοποιηθούν γνωστικά αντικείμενα ανάλογα με το επίπεδο των φοιτητών χρηστών- θα μπορούσε να αποτελέσει μία add-in ενότητα σε ανοιχτού λογισμικού περιβάλλοντα ηλεκτρονικής μάθησης που στηρίζονται στο Internet και σε client-server αρχιτεκτονικές υποστήριξης (π.χ. Moodle).

Λέξεις Κλειδιά: Προσωποποιημένη Ηλεκτρονική Μάθηση, Γεωπληροφορική, Τεχνολογίες Πληροφορικής & Επικοινωνιών, Γεωχωρική Λειτουργικότητα.

ABSTRACT: Adaptive, intelligence or personalized e-learning is recognized as the most interesting research area in distance learning on-line Web-based Education. In particular, for the WBE Geomatics education, so far, there are not well-defined and commonly accepted rules on how the learning material should be designed (metadata-based content development), organized in reusable Learning Objects, selected and sequenced to make "*instructional on-line sense*" in a Web-based Geospatial ICT course. Hence, the goal of this paper is to propose a *framework* for personalized e-learning based on selected user profiles and a domain ontology in order to shorten the gap to between the established traditional e-learning management systems (like Moodle) and the modern adaptive & intelligent WBE tutoring for the benefit of the Geomatic Engineering education. Future enhancements of the proposed *framework*, towards an e-learning *system*, include development and testing of Learning Objects with learners' profiles functionality.

Keywords: Personalized e-Learning, Geomatics, Semantic Web Mining, Geospatial ICT.

I. INTRODUCTION

Adaptive, intelligence or personalized e-learning is supported nowadays by semantic Web mining technologies and it is recognized as, probably, the most interesting research area in distance learning on-line Web-based Education (WBE) [1]. In particular, for the WBE Geomatic Engineering education rich in Geospatial Information & Communication Technologies (GICT) functionalities, so far, there are not well-defined and commonly accepted rules and semantic ontologies on how the learning material should be designed (metadata-based content development), organized in reusable Learning Objects (LO), selected and sequenced to make "*instructional on-line sense*" in a Web-based Geospatial ICT course [2]. In this domain the available e-learning courses and the relative educational material are not dynamic and flexible enough resulting in poor learning experiences [3].

Hence, the goal of this paper is to propose a *framework* for personalized e-learning based on selected user profiles and a domain semantic Web mining ontology in order: (a) to respond effectively to the needs and competencies of the learners; and (b) to shorten the gap to between the established traditional e-learning management systems and the modern adaptive & intelligent WBE tutoring for the benefit of the Geomatic Engineering education [3].

In particular, the proposed WBE Geomatic Engineering *framework* introduces a new metadata schema for reusable LO with GICT functionality, i.e. an enhancement by the integration of adaptive features to LO that allow for the delivery and management of personalized learning experiences. Then incorporates a number of reusable LO, related to topics which are common in the three main Geomatics disciplines (GIS & Digital Cadastre; Photogrammetry & Remote Sensing; and Surveying & Geodesy), e.g. *Digital Design* LO [Fig. 1], with learners' profiles and techniques for personalized content selection. Finally, the proposed *framework* could be used for adaptive course sequencing and personalized WBE GICT course delivery, management and online support.

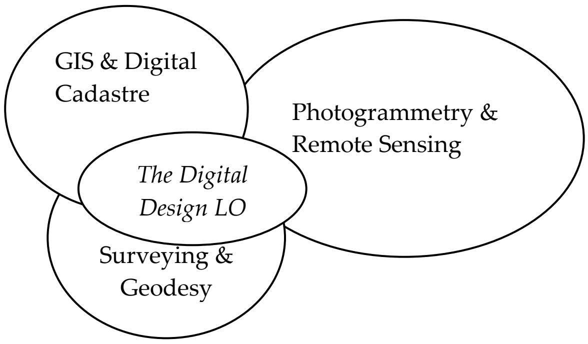

Figure 1 - Positioning of the "*Digital Design*" LO between the three main Geomatic Engineering disciplines

Actually, the proposed methodology benefits from a LO's simple and flexible metadata-based design and an XML markup implementation (as a semantic Web ontology) with embedded GICT functionality, according to the cognitive style of learning needs and preferences in geomatics education. The proposed learning rules are *generic* (i.e. domain-, view-, and user-independent), hosting accordingly lecturing functionality for other relative courses (e.g. WBE for Softcopy Photogrammetry or Digital Architecture courses).

In the proposed *framework* the markup language XML could be combined with a MySQL database. This combination allows for the integration of the *framework* into the *Moodle* Learning Management System (LMS) already used in various Surveying, Photogrammetry and Geomatics courses. The main functions of the proposed *framework* are: the generation of Internet accessed exercises; the metadata presentation; the related ontologies for GICT personalized LO (reusable data) implementation; a collection of answers in HTML form; and finally the automated corrections & hints for the individual users.

The *framework* could enhance the traditional "*one-fits-to-all*" e-learning systems -that deliver the same static learning ICT material to everyone, despite the individual needs, preferences and expertise- to a system to provide efficient, dynamic and open structure, as well as support for students' evaluation and various e-learning management functionalities, like: statistical feedback for the professor on student performance and progress.

Proposed *framework's* tools:

LMS: Moodle;

Database: MySQL, phpMyAdmin;

Markup Language: XML;

Script languages: PHP, Javascript, JQuery.

The objective of the proposed *framework* is to improve the autonomy of students and facilitate the preparation and correction of exercises for teachers and teaching assistants. The ultimate aim of the *framework* is to be a component in the *Moodle* LMS, with the ambition of sharing GICT functionality as a standard *Moodle* module for use by the wider community.

In this paper, the experience of incorporating semantic Web mining technologies (and particularly *ontologies*) in WBE GICT personalized (where the individual requirements and learners' needs are too important) e-learning is discussed.

Paper's structure follows: In 2nd Section (*WBE GICT: The Architecture*), the proposed architecture for an adaptive & intelligent WBE with GICT functionality is presented. In 3rd Section (*WBE GICT: Content Development, Selection & Sequencing*), basic issues from the semantic Web mining area are discussed and the simple metadata-based schema (semantic structure), as well as the proposed reusable LO implementation (ontology) are presented. Also, in this Section, the techniques for personalized content selection and adaptive course sequencing are discussed. Finally, in *Conclusions & Discussion*, after paper's conclusion, a critical paper's review is discussed and possible future extensions are presented.

II. WBE GICT: The Architecture

In the proposed *framework* seven (7) key WBE components (modules) have been identified; namely:

(1) *Data Acquisition*;

(2) *Content Development* (data processing developing reusable LO with metadata tags);
(3) *local or Internet Databases* (reusable LO repositories);

(4) *Personalized Content Selection* (LO retrieval & analysis according to learners' profiles);

(5) *Adaptive on-demand sequencing of the selected LO*;

(6) *The Personalized WBE GICT Course Delivery & Management* (publication in a pre-defined GUI format); and

(0) *The e-Learning Management Control Software* (eg. *Moodle* or other "open" LMS software implemented in XML).

The main interactions between these seven WBE GICT modules are presented in Figure 2.

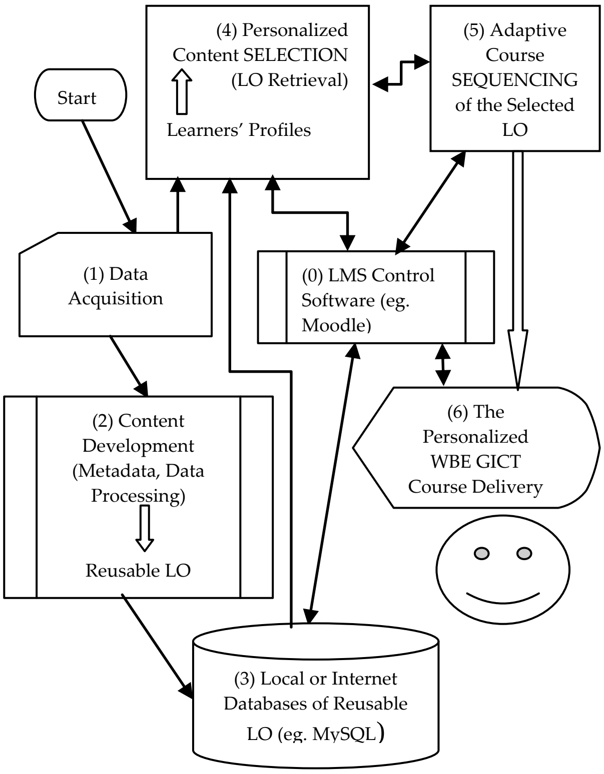

Figure 2 – The seven (7) main Components (Modules) of the proposed WBE GICT *Framework*

III. WBE GICT: Content Development, Selection & Sequencing

Semantic Web Mining

Semantic Web Mining is regarded as an intelligence Web Mining environment (i.e. data mining from Web documents & services) with Web usage mining functionality required in personalization. It is a collaborative initiative led by the W3C and it is based on the RDF (*Resource Description Framework*), which integrates a number of applications by using XML for the syntax and URLs for the naming [4]. The basic idea of using Semantic Web Mining, for delivering and management of personalized WBE GICT experiences, is to enhance the usage mining by exploiting new semantic structures for a quality, smarter and more comprehensive e-learning.

Didactic requirements for e-learning form the size of the reusable learning units. So, the LO must be as small and concise as needed, in order to support content-authors to focused on the didactic features it contains, and then to help them to identify easily the pointers to the specific content descriptions for usability support (metadata-based pedagogical functionality).

The Metadata Schema: A New Semantic Structure

The semantic Web mining allows the reuse of material in different contexts, supports flexible e-learning solutions, scalable handling & personalized, and robust delivery & management. In order to achieve the above functionalities, the involved documents must be annotated with the so-called *meta-information* (i.e. a metadata description of the document for *semantic Web mining compatibility*).

In the proposed *framework* the LO is the basic reusable unit and in order to be adaptive and searchable must have a metadata description. The Dublin Core (the standard metadata schema for documents) and the IEEE Learning Object Metadata – LOM (in the area of education) standard does not support GICT topics, so a novel metadata schema (a new semantic structure) is needed for the Web mining LO structural interface and semantic representation [5] - [7]. Also, for the LO implementation, the XML markup language or the PHP scripting one, seems to be a reliable answer (Internet functionality, object-oriented programming). In particular, the XML or PHP tags make the data meaningful, so the LO items can be searched, extracted, printed in PDF, published and reused in a number of ways on demand (personalization functionality).

The proposed new metadata schema (new semantic structure) is related to the GICT LO tags and it is consisted of five (5) fields with 10 ASCII characters (6 digits & 4 alphanumeric) (Fig. 3):

The first three (3) digits are for the LO's thematic title ID (e.g. could be used: 100 for the *Digital Design* LO; 200 for the *Spatial Analysis* LO, etc.).

Following, the next two (2) digits are for the specific concept's ID (e.g. for the *Digital Design* LO: 00 for a generic topic in Digital Design; 10 for AutoCAD; 20 for MicroStation; 30 for 3ds Max; 40 for Google's SketchUp, etc.).

The next one (1) digit is for the course level (e.g. **0** for an ease e-learning course; **1** for a moderate one; and **3** for a difficult demand course).

Following, for the semantic Web mining, the next two (2) characters are denoted to e-learning course specialization (e.g. 00 for a generic course; GE for a course in Geomatic Engineering; AR for a course in Digital Architecture; LA for a course in Digital Landscape Architecture; EP for a course in Environmental Policy with Virtual Reality, etc.).

Finally, for the ontology-driven knowledge management functionality, the last two (2) characters are denoted to personalization based on aggregate usage profiles and the e-learning domain ontology (i.e. individual needs and requirements of the learner) with GICT functionality. Actually, these 2 characters are the ontology tag for ensuring effective personalization and they are going to describe the content and the relations between the various GICT topics. Through this tag the proposed *framework* will express hierarchical links between entities to find recommendation set according to the ontology domain. For instance, CS for content-based personalization (i.e. content similarity to the topic as it defined from various users log files) and individual needs and requirements of the learner as a GICT student; UP for user-based personalization (i.e. content similarity to the personal user profile as it defined in personal log files) and individual needs and requirements of the learner as a GICT professional, etc.

LO title's ID (e.g. 100)	Specific Concept's ID (e.g. 20)	Course Level (e.g. 1)	Course Specialization (e.g. GE)	The Ontology tag (e.g. UP)

Figure 3 – The proposed Metadata Schema (new semantic structure) for the Semantic Web Mining with Reusable Learning Object

GICT Ontologies: The Reusable Learning Object

Ontology, in semantic Web mining, formulates a representation of the learning domain by specifying all of its concepts, relations, functions, conditions and regulations of the host domain [8].

The design and the development of the ontology are related to the formal definition of the data set (with reusable functionality) and their structure. Hence, a well-defined ontology can be considered as a quality knowledge unit that could be used further for knowledge mining and personalized e-learning systems support.

Ontologies allow for the representation of knowledge that enables inference to be performed obtaining thus new insights; and hence offer the way to deal with complex and heterogeneous representations of various Web resources. So, ontologies are regarded as the backbone of the adaptive e-learning technology.
Following, the structure of a reusable LO as the proposed ontology for the *framework* is presented:

- Title: The LO title (e.g. *Digital Design*, *Spatial Analysis*, *Environmental Policy*).
- Generic Core Content: The definition of the core educational concept (content) for which the LO is designed accompanied by some generic examples and applications.

  Also, a number of *pointers* -embedded intelligently into the text- should point to the specific content descriptions according to the introduced metadata schema.
- A number of Specific Content Descriptions: To support reusability - The detailed descriptions of specific educational concepts into the Title domain (e.g. in case of a *Digital Design* course: Theory of design, AutoCAD tutoring, MicroStation tutoring, Real Time Landscaping Architect tutoring), accompanied by some examples and applications for each description.

  The tags of these specific descriptions will follow the introduced metadata schema.
- Test: The *test* element used for e-learning evaluation. It includes several (e.g. 10) *test* items relevant to learning difficulty level and to the concept of the LO. Also, for a fair judge examination policy, the actual *test* item is assigned to the learner randomly by the

  i = random (1..10) function.

  So, the following assessments function is needed:

  TEST (i, text-script);

  where:

  i = 1..10

  text-script = {
  AutoCAD 2D;
  Digital Design for GICT generic applications;
  Moderate CAD knowledge;
  etc. }

Table 1 presents the XML implementation of the WBE GICT ontology supporting the *Digital Design* LO. It includes one title and one generic core content item (moderate level for GICT e-learning with user-based personalization, three specific description items to support LO reusability on demand with 2 options (2D AutoCAD, 3ds Max), and two test elements, one with a resource reference to an external XML examination-file and the second one representing the way to form an examination from the available LO's test items.

In this case the examination *test* includes the *test* items from *test03* to *test06*, which is the combination of all available LO's *test* items related to GE user-based personalization functionality (i.e. the UP parameter).

Table 1 – The XML implementation of the WBE GICT ontology supporting the *Digital Design* reusable learning object

```
<LearningObject Digital_Design_="http://www...."
<Title id="100">Digital Design </title>

<Generic_Core_Content id="100001GE00">
        <paragraph> The Digital Design in
        general...
        AutoCAD 2D modeling …
[ptr→Tag:100101GESA] …
        Visualization 3ds Max
[ptr→Tag:100301LASA] …
        ……… </generic_core_content>

<Specific_Description id="100101GEUP">
        <paragraph> AutoCAD…2D modeling….
        ……… </specific_description>

…………………………………………….

<Specific_Description id="100301GEUP">
        <paragraph> 3d Studio Max visualization
        ……… </specific_description>

………………………………………………..

<TestItem identifier="testUP"
identifierref="http://www.xxx.xx/exam-UP.xml"/>

………………………………………………..

<TestItem identifier="testUP">
        <beginItem>test03</beginItem>
<endItem>test06</endItem>
</testItem>
```

Similar LO descriptions could be defined for *Topography*, *Digital Cadastre*, *Spatial Analysis*, *Environmental Policy*, etc. covering the GICT curriculum.

A. Data Acquisition
For data acquisition a number of Web resources (documents and services) and Web Usage Mining - WUM (personalized e-learning applications are using WUM for extracting all personal data related to user's behavior and required for learners' profiles implementation) could be used, like: books, Internet sources, lecturing notes, server's logs files, etc. [9]. Also, for this purpose some simple task-defined user-friendly GUIs with GICT functionality are needed for the data-entry procedure [10].

B. Content Development
For reusable content development a number of GUI open-source environments are available, like: the SCORM project (Cernegie Mellon University / Learning Systems Architecture Lab) [11], the IEEE Learning Object Metadata (LOM) standard [5], the Metavist 2005 software which creates FGDC-compliant metadata (Federal Geographic Data Committee; http://www.fgdc.gov), the OMEKA project (http://www.omeka.org), the AICC project (http://www.aicc.org), the ADL network (http://www.adlnet.org), etc.

The above content development tools are generic with limited functionality for e-learning GICT content development. So, for a particular WBE GICT framework, there are two options: manual data-entry or the development of some new GUI data-entry forms implemented in XML, PHP or MS-Access [10].

C. Reusable LO Repositories
After the content development procedure, the reusable LO should be added to local or Internet databases or learning object repositories for collection, sharing and reusing of distributed LOs [12]. The proposed metadata schema, because of its simple ASCII format, could easily be adopted by these databases for an effective LO access and management.

D. The Personalized Content Selection Procedure
The Learners' Profiles (LP) include education, background, cognitive style, learning preferences, needs, teaching & evaluation rules, and details on progress & performance in related LOs. These LPs are mapped to specific WBE selection criteria (pedagogical module), which are used as an input to e-learning management control software for forming the appropriate metadata pointers to the specific content descriptions. Then, the on-demand LOs are composed and, finally, a content menu for the requested WBE GICT course is dynamically synthesized [12].

Pedagogical Module

In most WBE systems that incorporate course sequencing techniques, a pedagogical module is responsible for setting the principles and rules of content selection and instructional planning. In the proposed framework this pedagogical module is a part of the management control s/w, and the selection of content (i.e. the GICT learning objects) is based on a set of selection criteria according to LPs. Most of these selection criteria are *generic rules* [12], and there are no well defined and commonly accepted criteria on how the GICT learning objects should be selected and how they should be sequenced to make "*instructional value*" with GICT functionality. So, in order to design highly adaptive WBE GICT systems a set of selection criteria rules is required, since the involved dependencies between the educational characteristics of the GICT learning objects and the potential learners' profiles are very complex [9].

In the proposed *framework*, the metadata schema has the potential to a semantically more accurate retrieval of content data, and hence the LO selection problem could be addressed by proposing a selection criteria module as a challenge for design pedagogy (theory & knowledge), that instead of "forcing" an educational material designer to define the set of the selection rules in a traditional way; supports an on-demand metadata-based decision that actually simulates the decision process of the educator.

E. Adaptive Course Sequencing
The next step is the on-demand sequencing according to the learning GICT communities. So, WBE GICT adaptive course sequencing is defined as the process that selects GICT learning objects from a local database, an Intranet or a global Internet-based digital repository (i.e. huge knowledge databases with design and GICT functionality) and sequence them on-demand (i.e. in such a way which is appropriate) for the targeted GICT learning community or individuals interested in WBE GICT. Personalized learning trends to present the GICT learning objects associated with a WBE on-line course in an optimized order for sequencing [9], [12].

F. GUI intelligent WBE GICT course Delivery & Management (GUI formatted publication component)
This delivery module (the 6th *framework* component) includes XSL files, for transforming the XML files into a number of publication documents, like: PDF documents, RTF documents, HTML files, Wiki forms, etc. So, in the WBE GICT client/server environment, every time when a request from a client for a specific content to be presented to the learner is received, this publication component invokes the right XSL file for the appropriate transformation. Hence, the on-demand content will appear on client's browser in a user-friendly GUI format.

WBE-Testing & Self-Assessment

For e-learning course testing including self-assessment quizzes the following PHP scripting software routines are proposed:

Name	Type	Description
test.php	Application	Script to display a form for the quiz questions
score.php	Application	Script to assess learner's answers
rtf.php	Application	Script to generate an RTF certificate from the template
pdf.php	Application	Script to generate an PDF certificate from the template

Alternatively (markup implementation):

test.html	HTML page	HTML form that contains the quiz questions
etc.		

H. The e-Learning Management Control Software

The following application example is used for the e-learning management control software (the 7th *Framework* component) demonstration and presentation. So, supposed that:

- Learner's profile (good knowledge of ICT; moderate knowledge of CAD).
- Learner's needs (Digital Design for Landscape Architecture, AutoCAD I, SketchUp, GIS / Spatial Analysis applications functionality).
- Examination rules: University/tutor/course regulations or learner's willing for self reexamination (moderate, e.g. N=5).

Hence, after applying a simple mapping procedure, the information about the data (i.e. the LO metadata contents) are found; and they are the values of the pointers (pointing to specific descriptions): 100101GEUP, 100401GEUP.

In Table 2, the control software for the adaptive course sequencing structure in XML batch coding is displayed. Also, in the case of a PHP scripting implementation (Linux, Apache, MySQL5, PHP5), the course sequencing structure will be modular (routine-based) instead of the batch/goto programming logic.

Table 2 – Control Software: Adaptive Course Sequencing (XML Batch Programming)

Step	XML Implementation
1:	<Title id="**100**">Digital Design </title>; counter=0; N=5;
2:	TEST (random(1..10), moderate CAD knowledge); if (FAILED) goto Step-13
3:	<Generic_Core_Content id="100**001**GE00">
4:	TEST (random(1..10), digital design for GE generic applications); if (FAILED AND counter++<N) goto Step-3 else if (counter=N) goto Step-13
5: ……	[ptr→Tag:100**101**GEUP] … (AutoCAD 2D) goto Step-7
6: …..	[ptr→Tag:100**401**GEUP] … (SketchUp) goto Step-10
7:	<Specific_Description id="100**101**GEUP">
8:	TEST (random(1..10), AutoCAD 2D); if (FAILED AND counter++<N) goto Step-7 else if (counter=N) goto Step-13
9:	goto Step-6
10:	<Specific_Description id="100**401**GEUP">
11:	TEST (random(1..10), SketchUp); if (FAILED AND counter++<N) goto Step-10 else if (counter=N) goto Step-13
12:	END (pass); Stop
13:	END (failed); Stop

IV. Conclusions & Discussion

The presented work, which is just a *framework* and not an e-learning ready-to-use *system*, is an attempt to address the content development and the LO selection and sequencing problem in intelligent personalized learning systems with Geospatial ICT functionality. For the content development a simple metadata schema was introduced and incorporated in LO structure as a challenging ontology for design pedagogy; so reusability is supported and the GICT LO are designed in a simple de-contextualized manner. The proposed methodology provides the *framework* for designing intelligent e-learning systems in geomatic engineering, in digital architecture, etc. and tries to integrate the semantic Web mining vision by using ontologies with WUM (Web Usage Mining) techniques for a better adaptation of learner's needs and requirements. A limitation of the *framework* relates to that: The created *ontology* depicts the way that the e-learning domain should be taught to the learners and based on the view of the designer. Hence, if the semantic Web *ontology* is not implemented correctly, then the initial set of recommendations will be far away from the actual user's learning attitude and in this case the proposed *framework* will not be able to add new recommendations into the initial fault set.

In future extensions, learning characteristics like content difficulty or semantic functionality, which affects both selection and sequencing of reusable LO must be defined. Also, future research would related to LO intelligent selection and decomposition from existing WBE courses in similar disciplines, allowing reuse of these disaggregated LO in different disciplines (while preserving e-learning functionality and the educational characteristics they were initially designed for). Future enhancements of the proposed *framework*, towards an e-learning *system*, include development and testing of Learning Objects with learners' profiles functionality.

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ΣΤΟΙΧΕΙΑ ΣΥΓΓΡΑΦΕΩΝ

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