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Digital Libraries for Earth System Science: Enabling a Paradigm Shift in Geomatics Engineering Education

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Abstract. GEOTOPOS is e-Repository of Geosciences-based digital content that is being developed at the National Technical University of Athens in order to enhance the traditional learning process and address multiple learning styles and needs, as well as to enable new pedagogical models based on Web-mediated learning environments. GEOTOPOS has been designed in response to users' needs collected through surveys of faculty and students involved in Geomatics Engineering teaching and education. Hence, it is being developed as the mechanism to support the development, use and more importantly re-use of digital resources, which focus on specific topics, disciplines or themes relevant to Geosciences, and they provide information in a variety of forms and from many sources. The purpose of this paper is to present some of the key concepts and critical issues involved, such as the processes of selective combination, query, and discovery of Earth System Science related digital learning resources and information.

1 Introduction – Needs and Requirements for Active Learning

Modern Earth System science views the Earth as a synergistic physical system of interrelated phenomena, governed by complex processes involving the geosphere, atmosphere, hydrosphere and biosphere. Building on the traditional disciplines to study the Earth, the system approach has become widely accepted as a framework from which to pose disciplinary and interdisciplinary questions, especially in relationship to the sustainability of the earth’s resources. Today the challenge for educators to develop and offer courses that provide this deeper understanding is demanding. Hence, in many Universities the typical Geosciences and/or Geomatics Engineering curriculum today teaches many of the basic scientific principles needed to understand how the different components of the Earth working as a synergistic physical system interact and behave in the environment, as well as how they are influenced by anthropogenic-related factors causing important (often negative) disturbances in the environment. It also teaches basic principles and techniques of monitoring the changes of the geographic space that surrounds us, and how to integrate the acquisition, modeling, analysis, and management of spatially referenced data collected by terrestrial, marine, airborne, and satellite-based sensors in order to study remedial technologies in the laboratory and to apply suitable techniques in the field. However, current educational curricula concerning Geosciences-related disciplines often fail to take advantage of more effective instructional methods and therefore do not accomplish all that they could. Mostly due to tradition and because of a lack of both awareness and appropriate educational materials, most instructors usually employ a conventional lecture format, e.g. using a textbook, lab exercises and possible some fieldwork in order to transmit geo-knowledge down to students. As a consequence, students have little opportunity to employ true scientific inquiry, which is fundamental to all the geoscience's disciplines that use spatially related data.

Conventional teaching approaches provide opportunities for developing problem-solving and design skills, but they are inherently limited to simplistic solutions that often fail to take advantage of the rich visual and virtual environments that are available with today's computational tools (e.g. for 3-D visualization of Earth structure and Earth-related phenomena), explore the wealth of real geosciences-related data (e.g. from many satellite sensors for understanding of complex interactions in global, regional or local cycles), use simulations in order to learn to "translate" from one representational domain to another (e.g. from the 3-D world or from a visually-perceived landscape to a map), and use of computer technology to pool the best practices in diverse educational settings. Hence, students lack opportunities to visualize and to form their own ideas, and they rarely get a chance to work in any substantial way at applying the ideas of others to the real world. In this learning environment, students often develop a very limited view of what constitutes meaningful learning as they are only engaged in just developing low level thinking skills (e.g. memorizing facts, procedures, terms, and definitions). This traditional, static lecture format results in a curriculum of disconnected items, subtasks, and subskills, one that fails to convey an understanding of the context in which these separate elements need to be combined to understand complex problems and achieve practical and optimal solutions. And because the opportunities to learn from experience are highly constrained, the student's development of cognitive management skills, including goal-setting, strategic planning, monitoring, evaluating, and revising, capabilities critical for effective learning and functioning, is highly limited.

1.1 Geo-knowledge databases and digital libraries

The wide availability of earth science data and other resources in digital format and the archiving of that information in large web-mediated relational or knowledge databases are some of the more significant changes to have occurred within the

Geosciences community during the last few years. At the university level, in particular, these advances have combined with a number of other factors, so that to encourage, or even force, the adoption of new teaching and learning methods in the education of engineers trained in many Geosciences-related diverse fields such as: Geodesy and Geophysics, Positioning and Navigation, Cartography, Digital Imaging and Mapping using Photogrammetry and Remote Sensing, Geographical and Land Information Systems, Hydrology, Hydrography, Oceanography etc. Not least of these has been the developing awareness that the volume and complexity of the available geo-information in the many disciplines of these complex engineering fields has been increasing rapidly. This demands greater efforts by the universities to instill to their graduates greater capabilities in concept synthesis, problem solving and applications design, as well as the ability to identify and name physical relationships present within available data, and then apply the discovered relationships to the scientific processes and practical applications, so that to increase the rate of scientific progress and the contribution to the management of resources, sustainable development, etc. In turn, this dictates that the new educational goal in the implementation of knowledge management is to increase the amount of tacit geo-knowledge that a learner is formally receiving and is capable of applying to solving real professionally demanding engineering problems. Furthermore, as faculty and other researchers continue to develop research materials, resources for teaching and scholarly publications in increasingly complex digital formats, there is a need to collect, preserve, index and distribute them widely, find related ones, create new content and, collectively, improve both the quantity and quality of digital teaching resources.

In response to these needs, the last few years, digital libraries have been regarded as the ideal environment for structuring, gathering and accessing of information in many forms and formats. Although recognized primarily as architectural frameworks for managing large volumes of shared information resources, digital libraries also have the capacity to function as expert systems by stimulating new thought and understanding through the integration of both spatial and non-spatial data (*Data Fusion*). In broad terms, in order for a digital library to be a seamless extension of a library that provides access to information in any format that has been evaluated, organized, and preserved, it should also encompass a series of activities and tools that bring together collections of resources, services, and users in support of the full life cycle (from creation, dissemination, use, and preservation) of data, information, and knowledge, [7]. In that way, digital libraries have the capability to facilitate all of the aforementioned educational goals. Particularly, of significant relevance is their unique potential to address the special characteristics of Geosciences-related education and to increase the use of best teaching practices, for example, by providing the tools, training, and data needed to build inquiry and discovery into the education process at all levels of teaching and learning activities. Typical examples of such ambitious efforts are the *Digital Library for Earth System Education* (DLESE) [3], the digital repository *DSpace* of the Massachusetts Institute of Technology [4], the Alexandria Digital Library (ADL) [1], SMETE Digital Library [4] and others which are distinct through having a “community” of potential users define and guide their development.

2 The GEOTOPOS Project

At the National Technical University of Athens, prompted by the concept of building a knowledge database combined with portal tools (e.g. a Content Management System, internal and external catalogues and metadata) that integrate and interoperate with digital library elements at different levels, we have recently began developing the GEOTOPOS, an e-repository of Geosciences-related education resources. The GEOTOPOS has been designed with a number of special features in mind that will allow it simultaneously to serve as a system, a tool, and a platform for collecting, managing, indexing, and distributing educational content in digital form in order to enhance the traditional learning process and address multiple learning styles and needs, and hence, to satisfy diverse knowledge management requirements relevant to Geosciences in general and/or Geomatics Engineering education in particular. It also provides a way to manage, in a professionally maintained repository, selected research materials and publications of high quality and educational value, and to give them greater visibility and accessibility over time.

2.1 GEOTOPOS Implementation Scope, Features and Functionality

Upon embarking on GEOTOPOS development, the initial goal was to create a common depository of our faculty's and student's intellectual output in digital formats: research papers, educational instruction documents, datasets, images, audio/visual material, databases, or any other format it was deemed important. However, early on other categories of material, beyond faculty-authored documents and data, was decided to be included for possible support by GEOTOPOS, such as: educational material in the form of course web sites and online teaching and learning resources, old and new, and valuable digital material supporting teaching activities (e.g. virtual labs and fieldtrips, visuals of presentations, etc.). These can take the form of traditional lecture notes and e-books, sample exams, and course calendars, but also include other traditional tools like complex simulations and visualizations, multimedia presentations, or educational videos, as well as maps, aerial photos and satellite images and geographic datasets in various forms. Therefore, it was deemed important to include in the GEOTOPOS design additional such features as:

- Web-based templates and applications enabling rapid development through a distributed effort
- Complex visualizations and simulations
- Interfaces/tools to large geographic and geosciences-related data sets
- Adaptable capabilities for student assessment
- Personal digital educational portfolios
- Content development tools and technologies
- Adaptable materials organized in peer-reviewed collections

The overall goal of the GEOTOPOS project is to enhance student-learning opportunities by enabling them to partake in global, web-based knowledge discovery activities, in which they can directly experience different contexts and access a variety of digital Geosciences-related information sources via a range of appropriate tools. To achieve this goal the project set out to deliver on the following objectives:

- Teach engineering information retrieval, manipulation, and archiving skills to students of Geomatics Engineering disciplines.
- Measure the use of those skills through suitably designed activities and assessment tools.
- Improve cataloging and gathering of resources that broaden the use of Earth science data.
- Enhance the learning performance by the provision of access to information that would have been otherwise difficult to access.
- Develop and provide tools for digital content generation.
- Use the prototyping results to redesign course content and the GEOTOPOS technology and functionality as needed.

2.2 Digital Objects Models and Collections

The primary purpose of repository development within teaching and learning has been to ensure the availability of content, to improve the quality of the learning experience, and to cater to different learning styles. Towards that end, the GEOTOPOS educational materials are organized collections of digital information in their simplest form, the so-called ***"digital objects"***. These are essentially typical digital resources from many sources, and in many formats, including texts in various formats (e.g. text, pdf, html), videos, images and animations, scientific visualizations generated from data or model outputs, simulations, remotely-sensed imagery, maps, etc. that all have an educational context. Since these resources are digital, and available online, they can be used as originally intended or they can be altered or combined to meet the needs of other educators or to serve in different educational and learning contexts, thus becoming ***re-useable*** or ***re-purposing*** digital objects. On the other hand, closely related to the structuring of content for the learning of individual concepts is the structuring of content for courses, course clusters, and discipline-related streams. For this purpose, the digital objects contained in GEOTOPOS can be used and re-used to create new, customized resources, following the instructional concepts known commonly as the ***"Learning Objects"*** and ***"Knowledge Objects"*** [2], [5]. This allows the GEOTOPOS' users to build collaborations and sharing which are well-established traditions in higher education.

Learning Objects generally are small instructional components of digital content that can be re-used a number of times in different learning contexts, and for the purpose of maximizing the number of learning situations in which the resource can be utilized. Typical examples of Learning Objects include combinations of digital objects encompassing multimedia content, instructional content and learning objectives, instructional software and software tools, and data referenced during technology-supported learning. On the other hand, knowledge objects consist of a complete, discrete package of information/content (i.e. a small number of learning objects) that has a stand-alone meaning and/or representing a highly structured interrelated set of data, information, and knowledge. Therefore, knowledge objects can be thought of as the components of instruction that enable the learner to be more productive by providing the dynamic opportunity for repetition and review.

The use of digital resources in the form of Learning and Knowledge Objects empowers the user and promotes the process of informal learning, which in itself is perhaps the most important change created by systems like GEOTOPOS, since it allows customization of the educational materials for the learning needs of particular users, level of educational setting, or enable "just-for-me learning" or "just-in-time learning" modes of education.

From a conceptual point of view, Learning and Knowledge Objects have associated with them some distinct typical characteristics such as: pedagogical goals, learning target, methodology, categories/subjects, syllabus, length, teaching load, mentoring/teaching, evaluation, educational standards, etc. In that way, all available Learning or Knowledge Objects provide a vehicle for continued re-use of content material beyond the lifespan of any particular educational element, module or course. Thus the modularity supported within GEOTOPOS is seen as a major enabling technology for fostering educational material adaptation and re-use. Furthermore, the strategy of handling educational resources as learning and knowledge objects allows to create, store, search, re-use, and re-purpose information content in a way that is based upon the widely accepted essential information types that are founded on state-of-the-art cognitive and task-based learning theories: concept, fact, procedure, process, and principle. This leads to adopting the strategy of ***Reusable Learning Objects*** (RLOs) and ***Reusable Knowledge Objects*** (RKOs), whereby the terms "reusable" and "repurposing" are used to emphasize the advantages to authoring and using small pieces of learning and information as a useful "base" for content that can be modified to fit specific educational needs. Typically, RLOs are composed of a small number (5 to 10) of digital objects representing content items, practice items, and assessment items or activities that are used to illustrate a single objective, a concept, a procedure or a principle. Thus a learner can use different RLOs as a stand-alone performance support tools or aids to his/her learning process. Respectively, combining a small number of RLOs together with an Overview (e.g. of learning objectives), a Summary (e.g. of conceptualizations, tasks, problem-solving techniques, instructions and reasoning) and an Assessment (e.g. of learning achievements) creates various RKOs that

- Can be directly tied to specific educational and learning objectives, cognitive levels, learning practices and delivery mechanisms.
- Allow integrating knowledge management, web-based training, and performance support, reference and curriculum information into a single, Web-based resource.

For the end users, the use of RLOs and RKOs change the face of information flow in two major ways. First, it provides sources of information that serve the same functions as books and libraries but are more flexible, easier to update, and easier to query. Second, it enables the construction of packaged knowledge services (e.g. continuing education, distance learning and training), allowing users to invoke the services they seek or desire. The latter is achieved by providing suitable tools that allow the end users to also offer their own work for inclusion in the knowledge-based systems like GEOTOPOS, thus promoting the sharing and reuse of accumulated knowledge.

Special digital object groupings within GEOTOPOS are treated as collections of logically related material. ***Collections*** are digital resources grouped together because they are organized around a theme, a resource type or some other criteria. The determining characteristics of a collection *may* include resources that have a common format; topic coverage; geographic coverage; temporal coverage; pertinence to a particular study or project objective; source of origin; or physical location. In that way, the GEOTOPOS digital resources could support the information needs of specific communities of interest (e.g. faculty staff, students, engineering professionals), thus, creating global communities of learners. The items in these virtual collections do not have to reside on one server, but they share a common interface to assist the user in accessing each collection. Therefore, the emphasis in GEOTOPOS is on organization and access to the digital resources, not on physical collections, and its design and content determines and can influence the type of learning that it supports. This constitutes the realization of a paradigm shift that takes place from conventional libraries as collectors of items to an e-repository that serves as facilitator of access to all types of Geosciences-related information, provided by its community of users and being accessible at any time.

This information model of GEOTOPOS is implemented around a technical infrastructure composed of an ***Access Layer***, a ***Content Workflow Layer,*** and a ***Storage Layer,*** each underpinning a set of corresponding enabling services, i.e. the ***User Services***, the ***Presentation Services*** and the ***Metadata Services*** which provide the required functionality within an entirely web-based environment, cf. [2]. For the development of the web-based environment of GEOTOPOS, we used the PHP (***P****re* ***H****ypertext* ***P****rocessor*) scripting language, which is an object-oriented server-based language that is made available as *open source*. PHP is similar to JavaScript, since both give the possibility of incorporating small programs (*scripts*) within the HTML (*Hypertext Markup Language*) code of a web page, while also helping the design process by supporting object-oriented programming. Furthermore, as a database we use the MySQL Server, which is compatible with all the commonly used operating systems and satisfies completely the foreseen needs of GEOTOPOS. This part of the system consists of a central relational database that manages the individual sub-systems, their content and the user's privileges, as well as from a small number of individual sub-databases that manage the digital content of GEOTOPOS.

2.3 Need for and Use of Metadata

The GEOTOPOS uses a robust structured query language (SQL) relational database to store and index the individual resources records. This is largely achieved by rich metadata descriptions that subsequently are effective in helping instructors or students locate suitable data in immediately usable forms and most types of learning resources and integrating them effectively into their teaching or learning activities. In turn, services within GEOTOPOS interact with each other through metadata, keywords and meta-tags, which describe the relationship of the digital objects to one another in order to support discovery, use, and storage of those objects.

Metadata are the descriptive optional fields that that can describe information objects in the GEOTOPOS repository. They can be different in nature, such as fields containing mostly terminology (e.g. titles, key words), various attributes (e.g., creator name), or more structured information (e.g., numeric values, dates, format or protocol specifications) about a digital object. A digital object's associated key-metadata may be regarded as "handles" or "signatures" that uniquely identify the object or may also contain other information or properties, such as regarding access methods, licensing agreements relating to the underlying content, usage terms and restrictions, permissible operations, the sources and contributors of the underlying information components, the rights of each source and notices of ownership, the kinds of permissions that must be updated, and how to obtain these rights, etc.

Currently, in GEOTOPOS, as a minimum there are three types of metadata associated with its digital objects:

- ***Administrative Metadata*** represent the management information for a particular digital object, including the date it was created, its content type (e.g. image) and format (JPEG, GIF, etc.), rights information, and other typical properties (e.g. scanning resolution the image).
- ***Descriptive Metadata*** is used in the discovery and identification of an object. Examples include Dublin Core records. Additionally, descriptive metadata for digital objects applies to information on the full collection of files associated with the digital object and their relationships to one another.
- ***Structural Metadata*** is used to display and navigate a particular object for a user and includes the information on the internal organization of that object (e.g., a virtual lab may have an introduction, objectives, actions and a set of evaluation resources associated with it, in a similar way that a book has an introduction, chapters, pages and an index).

As a first step at establishing an adequate metadata classification framework, we started by defining a minimal set of required (e.g. title, language, and submission date) and optional fields that can describe an information object within GEOTOPOS, and by using XML as a common syntax for expressing structure in the data contained in the GEOTOPOS knowledge database. In some cases, the *Resource Description Framework* (RDF), a layer on top of XML, also is being considered as a means to provide a common basis for expressing semantics. In any case, the metadata associated with each item's record in GEOTOPOS is indexed for browsing and searching the system in many different locations (i.e. within a collection or across collections).

In this initial phase of the GEOTOPOS development, the implemented Search Service part of the system enables educators and learners to search and browse for educational resources by grade level, keywords and associated Earth System science and Geomatics Engineering-related controlled vocabularies, and educational resource type, while we are currently implementing the capability to search across multiple collections (e.g. *Core-*, *Broad-* and *Informal-Collections* having gone through various levels of peer reviews, [2]). At a later stage, it is planned to extend this search capability to enable spatial and temporal search of resources such as data, maps and images in support of user-centered, georeferenced discovery, together with integrated tools and services for data exploration, and the creation of personalized collections.

3 Using GEOTOPOS as an enabler of thematic driven teaching and learning

In order to illustrate the education shift paradigm from "teaching" to "learning" that is made possible with systems like GEOTOPOS, we outline the way we foresee that the GEOTOPOS digital resources and tools can be used to realize a new e-Learning paradigm loosely termed *Thematic Driven Learning* which supports constructivist mode of instruction (i.e. that the learner rather than the educator develops or constructs knowledge) and considers the knowledge, skills, and abilities of learners and how the differences among learners affect instructional planning and design.

Consider, for instance, a course instructor who wishes his or her students to have access to a variety of topics or issues organized under *Themes* aligned to a specific course content or a textbook's chapters on geoscience-related topics, for example: how Kepler's and Newton's laws are used to describe satellite dynamics; how the choice of satellite orbits affect the measurement performance of satellite sensors; how orbit computations are used to georeference satellite data; etc. Educational materials or content, for each of these themes can be provided from GEOTOPOS (i.e. in the form of stand alone *Digital Objects*, e.g. pdf articles, or previously created Learning/Knowledge Objects) as a starting point for students to draw background information from. Or pointers to selected high quality web sites (e.g. NASA's education portals) on specialist topics or resources aligned with the *Themes* can provide a source of additional material for student use.

In order to promote learning, students can then be required to select one *Theme* under which they would write specific assignments giving a topic *Outline or Investigative Cases with Examples*, through learning activities (i.e. the re-usable *Learning* or *Knowledge Objects*) engaging them on a multiple phase process based on problem posing (e.g. analyzing the case), problem solving (e.g. investigating key questions), and peer persuasion or decision making (e.g. producing materials supporting reasoning and conclusions). Alternatively, in other assignments, students can be required to write a *Synthesis* on issues arising within a further selection of *Themes*, while being guided to experiment with available real-time or archived data and tools in order, for example, to perform sensitivity studies to assess how changes in key system variables alter the system's behavior or the measurement results. Such sensitivity studies can help students identify the components or parameters of a system to either help one affect a desire change with a minimum effort or to help estimate the risks or benefits associated with proposed or accidental changes in a system of interest. In that way, the knowledge gained while using models pertinent to one system and the understanding of model development and implementation are transferable to other geosciences-related disciplines or similar problem situations. Submitted student assignments are then added to the material or content of GEOTOPOS, which could be used and explored by other students in subsequent work. Furthermore, since the *Synthesis* assignments are an opportunity for students to argue their own ideas, an idea interchange could follow. Furthermore, assignments submitted according to *Themes* can be assessed on-line using the GEOTOPOS-supplied *evaluation* or *self-assessment* tools (e.g. quizzes, ConcepTests) providing feedback, which can be generated with the help of a selection of pre-prepared suitable comments aligned to the assessment criteria for each particular assignment or activity together with a score for each criterion, that is made available to students on-line. This, as it enhances communication between the students and teacher over the traditional classroom course instruction, is a significant improvement, compared to the standard browsing-type e-Learning approach that only provides basic capabilities for accessing course content or other resources.

A similar paradigm shift concerns the concept of *Virtual Field Trips and Virtual Labs* for real-life training. Gaining experience of methods, techniques and practical applications can play a major role in the learning process. For the Geosciences-related disciplines this can be acquired either through lab exercises and hands-on training with suitable instrumentation or through field trips that provide insight into realistic engineering applications and reinforce the understanding gained in lectures. Analyzing these experiences eventually leads to improved understanding of all aspects of a subject, be it a fundamental principle or an advanced application. However, to provide significant amounts of such experience in intensive teaching blocks is often not practical or feasible, e.g. due to the lack of adequate (and often expensive) equipment. In that connection, virtual field trips or microcomputer-based laboratories can enable students to undertake similar tasks outside the normal teaching blocks of a conventional course. In that context, the GEOTOPOS rich digital resources in real- and archived-data sets, as well as the availability of various interactive tools such as Java applets, videos, computer programming toolboxes, etc. can be used by an instructor to construct virtual field trips or to emulate laboratory measurements together with appropriate assignments and other activities that guide students to conduct an online experiment by following a series of steps, reading extensive information, testing a measurement tool, or reviewing a set of critical thinking answers.

Virtual lab assignments are intended to provide relevant, hands-on experience with the research process and allow students to learn by testing and evaluating scientific hypotheses. For example, an *Orbit Modeler* activity can use videos and extracted images from GEOTOPOS to accurately portray satellite motion (based on orbital mechanics), the inter-relationships between satellites and the relationships between satellites and locations on the Earth. In addition, using e.g. appropriate Matlab modules and web-based orbital element sets to simultaneously portray satellite constellations in orbit and place an observer on the Earth, in orbit by a selected satellite, or freely moving through space can test various satellite models and real-life measurement schemes.

Similarly, virtual field trips can have three main focuses. The virtual fieldtrip may be created prior to an actual trip, thus preparing the students for the tasks they will have to do in the field. This allows the instructor to focus on particular points of interest that the students should pay attention on. A virtual fieldtrip could also be created after an actual trip by utilizing the data, images, and measurements etc. that were collected in the field and creating new knowledge objects that can be included in GEOTOPOS for use by other students or for other learning activities. This type of usage would reinforce the concepts taught and also be a type of "scrapbook" for the actual field trip. The last type of virtual fieldtrip would be just that, virtual. The students would not actually be going on a trip but “visiting” a destination via selected web links included in GEOTOPOS or via pre-constructed web pages on which videos, graphics, sounds, panoramic photos, maps etc. could be used to help create the effect of visiting the location.

4 Conclusions

This paper attempted to articulate a vision of the necessary knowledge representation system technology and an organizational scheme and approach to achieving it. It also argued that progress in this area would dramatically change for the better the way that systems like GEOTOPOS can serve simultaneously as a system, a tool and a platform for collecting, managing and distributing educational content in digital form, in order to enhance the traditional learning process for a multitude of learning styles, needs and situations. Central to this concept is the notion of establishing an information infrastructure for promoting the sharing and reuse of educational resources. Therefore the overall goal of GEOTOPOS is to support re-use of educational resources by reflecting the teacher's and learner’s experiences with materials acquired from GEOTOPOS back into the way the GEOTOPOS’ digital resources are indexed and categorized.

Even from its present prototyping development phase, it has been evident that the GEOTOPOS has the ability to transform the relationship between learners and resources, facilitating both formal and informal learning by providing a framework for integrating digital information and knowledge across many Geosciences-related discipline boundaries. However, with respect to educational content, we consider necessary to investigate further the development of a knowledge taxonomy, specially designed to classify digital resources with respect to curriculum requirements, that would greatly enhance the processes of search and retrieval, and support the constructive approach to learning in ways that present approaches cannot. That, combined with specially designed search, retrieval and composition schemes, would offer truly new opportunities for teaching, learning, and authoring using available knowledge and information in the complex Geosciences- and Geomatics Engineering-related disciplines.

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