The GEOTHNK platform: connecting spatial thinking to secondary education

Marinos Kavouras  
School of Rural and Surveying Engineering  
National Technical University of Athens  
H. Polytechniou Str. 9, 15780 Zografos Campus, Greece  
mkav@mail.ntua.gr

Margarita Kokla  
School of Rural and Surveying Engineering  
National Technical University of Athens  
H. Polytechniou Str. 9, 15780 Zografos Campus, Greece  
mkokla@survey.ntua.gr

Eleni Tomai  
School of Rural and Surveying Engineering  
National Technical University of Athens  
H. Polytechniou Str. 9, 15780 Zografos Campus, Greece  
etomai@mail.ntua.gr

Nancy Darra  
School of Rural and Surveying Engineering  
National Technical University of Athens  
H. Polytechniou Str. 9, 15780 Zografos Campus, Greece  
nancyd@survey.ntua.gr

Alkyoni Baglatzi  
School of Rural and Surveying Engineering  
National Technical University of Athens  
H. Polytechniou Str. 9, 15780 Zografos Campus, Greece  
baglatzi@mail.ntua.gr

Sofoklis Sotiriou  
Ellinogermaniki Agogi  
D. Panagea Str, 15351 Pallini, Greece  
sotiriou@ea.gr

Angelos Lazoudis  
Ellinogermaniki Agogi  
D. Panagea Str, 15351 Pallini, Greece  
angelos@ea.gr

Abstract—The GEOTHNK project focuses on spatial thinking, a newly acknowledged ability with profound and rewarding effects on numerous aspects of everyday life and science - from giving and following directions and interpreting maps and diagrams, to achieving innovation in STEM disciplines. Spatial thinking constitutes a key competence for life and work in the 21st century and therefore an essential component of European educational and training activities. GEOTHNK aims at enhancing geospatial thinking skills and engaging users in meaningful, inquiry-based learning experiences.

Keywords—spatial thinking, semantic network, informal learning, learning pathways

I. INTRODUCTION

Spatial thinking was supplanted in education for a long period of time by other forms of thinking (verbal, metaphorical, hypothetical, and mathematical). Yet, it has been acknowledged that spatial literacy is of high importance both in different scientific domains and everyday life.

The geospatial domain presents an excellent opportunity towards achieving a meaningful connection between theoretical, higher-level concepts (e.g., geographical phenomena and processes), tools of representation (e.g., maps and terrain) and their application in everyday life such as locating one’s, home or following directions to an unknown place using their mobile phones or web-based applications.

The project is based on the synthesis of the three components of spatial thinking namely (a) concepts of space, (b) tools of representation, and (c) processes of reasoning.

By introducing a holistic view, the project aims at providing a powerful ICT platform for guiding and assisting teachers of secondary education to prepare transdisciplinary educational scenarios. Moreover, actions such as browsing and sharing educational scenario will be supported by the platform.

The added value for teachers will be the ease of retrieving information, connecting it and visualizing it in order to design educational scenarios as well as sharing them in an intelligent and user friendly way.

II. WHY LEARN TO THINK SPATIALLY?

What is common in tasks such as reading a map, finding your way in a shopping mall, interpreting a diagram, and understanding the spatial distribution of a phenomenon or the association of places and events? They are all tasks that rely on a mental skill called spatial or geospatial thinking. Spatial thinking has lately been acknowledged as an important ability both for sciences and everyday life. A report from the US National Research Council [2] entitled “Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum” underlined that “without explicit attention to [spatial literacy], we cannot meet our responsibility for...
Spatial thinking is considered as a key ability for the STEM disciplines (Science, Technology, Engineering, and Mathematics). Research results stress the rewarding effects of developing geospatial skills in increasing the participation in STEM disciplines, lacking of which acts as a barrier for students leading them to drop out [4]. Even more, spatial thinking is a vital talent for achieving STEM innovation, however due to being neglected by educational systems it has been missed [1]: “Individuals with such talents constitute a lost resource for creating future STEM innovation, since 90% of STEM doctorate holders scored in the top quartile of spatial ability during adolescence” [5].

Lately, spatial thinking has also been acknowledged as highly relevant to social sciences and humanities [3], as well as critical for several tasks required in daily life, such as giving and following directions, navigating in known and unknown spaces, and interpreting images, graphs, and diagrams. Furthermore, understanding central visual-spatial notions such as scale and generalization finds also its cognitive analog to the way people learn, communicate, or deal with (not necessarily spatial) everyday life issues. It actually constitutes a very important and new approach to learning (learn-to-learn), differing from the more established auditory-sequential type of learning.

There has already been some work done in this field for instance, TeachSpatial 1 is an environment developed by the US National Science Digital Library (NSDL) for browsing several hundreds of teaching and learning resources annotated with spatial concept terms. SPACIT 2 is an EU LLP project which aims at providing teacher training courses to promote students geo-communication skills targeted in the secondary education curriculum. Digital-earth.eu 3 is a Comenius Multilateral Network which focuses on the provision of broad access to resources and the implementation of geo-media as a digital learning environment. It is complementary to two previous Comenius Multilateral Projects (GISAS and iGuess 4) that used specific GIS software for the production of teaching materials for schools. ScOT (Schools Online Thesaurus) 5 provides a controlled vocabulary of terms used in Australian and New Zealand schools including relevant resources for all subject areas of the curriculum and relates terms in a browsable structure. GeoLearner 6 is an educational software program designed to improve knowledge of World Regional Geography. The software includes a series of interactive maps and quizzes to enable users spatial knowledge of cities, countries, and physical features.

The above projects, repositories and standards highlight the importance of enhancing spatial thinking and provide useful resources of course materials. However, they do not deal with the three necessary components of geospatial thinking in an equivalent and integrated manner.

III. GOAL OF THE GEOTHNK PROJECT

GEOTHNK aims at underlining the importance of learning to teach and think spatially in secondary school as well as introducing a novel platform for implementing means and methods of spatial thinking.

The main goals are (Fig. 1):

1. to enhance spatial thinking through an innovative ICT-based approach and an open, collaborative educational environment. Spatial thinking will be enhanced by fostering its three fundamental components: (a) geospatial concepts, (b) representation tools, and (c) reasoning processes.
2. to offer a methodological approach which allows the interdisciplinary organization and semantic linkage of knowledge.
3. to offer an interdisciplinary approach: semantic linkage of components from different disciplines (courses).

IV. THE GEOTHNK PLATFORM

To address its goals, GEOTHNK will not develop just another repository of geospatial knowledge, it aims at developing an innovative socially empowered learning platform to engage learners in extended episodes of playful learning, where scientific (and in our case geographical) concepts and ideas are not taught in isolation but in a way that emphasizes their correlation and relevance. In this framework, the project will add to the state of the art in the area of interest by:

1) enhancing geospatial literacy at different levels of education and training through an innovative ICT-based approach and an open, collaborative educational environment.
2) offering a methodological approach which allows the interdisciplinary organization and semantic linkage of knowledge.

In more details, the GEOTHNK platform will enable access to various thematic resources and to learning pathways through an effective search mechanism. Semantic technologies will be applied for intelligent retrieval of information resources. The platform will enable the creation of new learning pathways through an easy to use authoring environment that will support both the creation and the organization of learning components. The learning components
will be semantically linked and relative information for the enrichment of learning pathways will be provided. A rich semantic network will be utilized for linking the high level concepts and will provide a dynamic structure facilitating knowledge visualization and exploration.

The GEOTHNK Front End (Fig 2) will be a collection of web-based tools enabling the user to capture geospatial and related knowledge in the form of digital learning resources as well as organize them by establishing links among them. Moreover, the tools will empower users to exploit existing learning resources to design educational scenarios. The users will be able to visualize the conceptual structure built.

The GEOTHNK semantic network will function as the back end of the GEOTHNK Platform. It manages the dynamic conceptual structure storing links between concepts and enabling navigation through these concepts. It encompasses mechanisms to compare synonymous learning components, ground their meaning, and resolve semantic interoperability problems. The semantic network will consist mainly of high level concepts from the secondary school curricula.

By using the GEOTHNK platform, teachers will be provided with a huge amount of resources, high level concepts and reasoning tools in order to form the most appropriate learning pathways for their class. In an intuitive manner, the platform will support easily drag and drop actions and easily comprehensible visualizations.

The GEOTHNK platform with the integrated tools and resources will be based on an open education platform, and will remain publicly accessible after the project’s completion. It has also been foreseen the incorporation of the developed platform to ODS\(^7\) (Open Discovery Space) a socially-powered and multilingual open learning infrastructure to boost the adoption of eLearning resources, an ongoing project partially EU funded in the framework of CIP-ICT-PSP.

For demonstration purposes, an exemplary educational scenario is described below. The educational goal of this scenario for secondary school students is to “design their own town”. In this scenario the main objectives for teachers are to teach students the world in spatial terms, how human systems work, the uses of geography, how space and environment are related, which are the interactions in urban spaces are and how maps work.

Indicatively the spatial concepts which are related to this scenario are: location, distance, areas, proximity, connectivity, adjacency, elevation, aspect/slope, scale/detail, time, spatial structures, spatial properties, space-time context, po-

\(^7\)http://www.opendiscoveryspace.eu/
sition, spatial dynamics, spatial relations, spatial interaction, spatial transformations, representation, spatial principles

With the aid of the GEOTHNK platform, the teacher will be guided in order to build the learning pathway for this specific scenario by using concepts from the semantic network (Fig. 3). In this sense, the teacher needs to (a) develop the necessary background knowledge about semantic pathways in education, (b) be introduced to the ICT tools available in the GEOTHNK platform, (c) pick an interesting geographic location possibly but not necessarily with some self-containment (e.g., an island, a cove, a plane terrain), and (d) decide about the size/population of a town and possibly its primary role/character (a rural/fishing town, a touristic resort, a university town, a regional center/capital, etc).

The teacher shall provoke curiosity by presenting to the students examples of different town types, good, unexpected, paradoxical, or bad design/evolution. Also he/she can ask the students some provocative questions about their realizations, criticism of familiar urban sites neighbourhoods. Tools would be historical or recent imagery, available on the web, google earth, maps.

In an inquiry based way, the teacher directs students to think and express more systematically and scientifically the concepts involved (city, town, infrastructures, environment, designated areas/zones, etc.) and their spatial relations. Special attention will be paid in the main representation tool (map), the spatial qualitative/quantitative characteristics of the available landscape (understand topography, scale, location and distance, boundaries, slope zones, aspect, proximity, buffer zones, etc.). The teacher should be guided to identify possible misconceptions in students’ thinking. The teacher may form groups and ask them to follow different approaches in explaining urban space cases. The teacher is supposed to combine the feedback from students answers into the design of the hypothesis.

In the core stepwise approach for designing the town, the teacher will search in the platform or the web for other similar/related educational pathways of town planning. He/she will determine the extent of the knowledge domain (supporting spatial/aspatial concepts needed) depending on the group characteristics (age, background, interest). The teacher will define the proposed new pathway with the use of the platform tools: the connection of high level concepts involved, the associated spatial concepts, the resources available including other existing pathways. The teacher will define same or different criteria for the groups to follow and assist them throughout the exercise providing methodological and technical support guidance. The platform will suggest appropriate representation tools such as light and open GIS tools, interactive maps, etc., statistical and reasoning tools.

V. CONCLUSION

GEOTHNK highlights the importance and need of spatial thinking in secondary education. With the aid of an ICT platform it will guide teachers in creating and sharing educational scenarios. Major part of these scenarios are the learning pathways consisting of high level concepts and their relations. The pathways will be visualized focusing on the teaching goals of each scenario and showing the relations between the concepts. The whole process will be enriched by external resources and reasoning tools.

GEOTHNK envisions being a reference point for teachers in accessing geospatial information resources, representations, demonstrations etc. and a user friendly working environment for retrieving and preparing educational material in the form of educational scenarios.

VI. ACKNOWLEDGMENTS

Research within the GEOTHNK project is undertaken with the support of the Lifelong Learning Programme of the European Union, under grant agreement No 2013-3954/001-001, Project Number - 543451-LLP-1-2013-1-GR-KA3-KA3MP.

REFERENCES


