Intergeo: Interoperable Interactive Geometry for Europe

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ABSTRACT:

Intergeo (http://inter2geo.eu/) is an eContent+ European project dedicated to the sharing of interactive geometry constructions. It will enable teachers and pupils all over Europe to participate from experiences made by pioneers in the field of interactive geometry as a tool for teaching, learning, and research.

Educational contents that were hard to access are made available in a common interoperable format. Tagged with relevant topics and competency based metadata and categorised according to curricula, they will be searchable and easily (re)usable by everyone.

It will impact the value chain in eLearning, by providing building blocks of quality controlled, semantically enriched interactive educational content, on all levels from K12 to university, for classrooms, online courses, or integrated digital education systems.

This project will help a multicultural community, built around interoperable quality controlled eLearning standards, to emerge and sustain itself with a wider audience than the present days niche of dedicated experts, which would not happen by market forces alone.

1 INTRODUCTION

The last decade has seen a bloom in tools that allow teachers to enrich their teaching with interactive data, whether in face to face or distant mode. This wealth has its drawbacks and teachers need support to navigate through this diversity: which software should I use, where can I find resources, will this resource work for my class? Indeed, apart from pioneer work by dedicated teachers, the actual practices in the classroom have not evolved much. The reasons are manifold. Here are the three main ones:

-All the communities that have grown around the different technical solutions and software available have produced resources that they share in one way or another. They have all thought about their practice and produced different approaches.

Currently these cannot be merged, because the data they produce is scattered, both physically and semantically. The resources need to be centrally visible and exchangeable.

-As well as being difficult to find and analyse, the resources are usually diverse in quality and relevance to a specific need. Teachers are unsure in which situation a given resource, even if apparently interesting, could actually be used, and whether it adds pedagogical value to the learning experience. They wait for a bolder colleague to report on her attempt. The resources need to be tested, and published reports need to reflect these tests.

-Mastering a piece of software is time-consuming, and very few teachers grow to become power-users of their tool. The resources need to be easy to use, share and adapt, in spite of software choices.

In order to solve these issues at least for one specific subject, interactive geometry, we propose to centralize educational resources from this field on the Intergeo web platform. All resources will have clear Intellectual Property Rights, promoting open licences. And they will be there in an interoperable file format we are going to create, based on OpenMath [3]. This format will be supported by the most common software programs for interactive geometry, so teachers can keep on using their own.

We proceed as follows. First, we defined an internationalized ontology describing our field of interest. Second, we annotated curricula of various countries with items from this ontology. Third, we let the users annotate their resources and browse through existing resources using the nodes of the ontology. Their use is reported through an online quality questionnaire that helps ranking the resources and identifying improvement axis.

1.1 Outline

The introduction continues with explaining what interactive geometry is and who we are. Section 2 describes the aim of the project. Section 3 presents the metadata based on a multilingual ontology used for both representing the various European curricula, educational levels, and the competencies attached to the resources. Section 4 explains how this metadata allows to search and access the content, how queries are processed, by typing and explicitly selecting competencies and topics or by pointing in a curriculum or a textbook. Then, in section 5 we describe how the evaluation of the quality of the resources will be performed and used. The paper ends with a conclusion Sec. 6.

1.2 What is Interactive Geometry?

The Intergeo project is driven by European leaders in interactive geometry software. We are going to explain what is understood by interactive or dynamic geometry, a way of doing geometry which is required of math and science teachers more and more often. Interactive geometry allows for the manipulation and the visualization of a construction (a figure) on a computer. The construction depends on some free parameters, like the position of one or several control points. The user manipulates the figure through the keyboard, the mouse or a tracking device, by changing one or more of these free parameters. The construction then changes accordingly.

Let us give a simple example. One constructs in a dynamic interactive geometry system a triangle ABC with two perpendicular bisectors of two sides, then the intersecting point O of these two perpendicular bisectors. The third perpendicular bisector is then constructed and seems to pass through the point O. In a dynamic geometry system, it is possible to drag any vertex of triangle ABC and although the shape of triangle ABC is changing, the third perpendicular bisector is always passing through the pointO as depicted in figure 1.

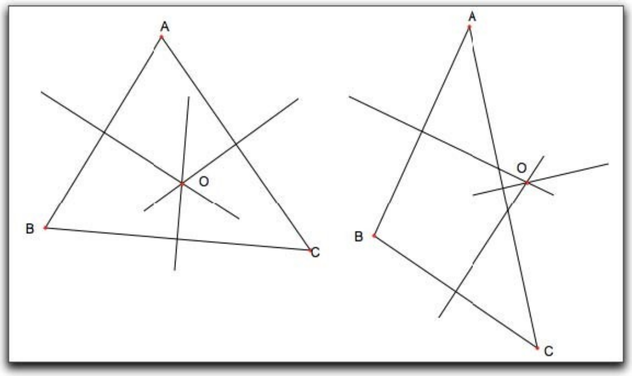

Figure 1: Perpendicular bisectors.

The property of three perpendicular bisectors intersecting in a common point appears as an invariant when varying the triangle ABC. Being able to move screen objects around in space (and so over time) can add significantly to the user's sense of the underlying concept as an object not just in itself but a something invariant amidst change.

Interactive geometry is intended to manipulate scientific data relying on a hierarchical construction. The figure encodes not only the graphical illustration (a curve here, a picture there) but also the relations between the different entities that are drawn. Of course, the main entities and relations in interactive geometry are of geometrical type. You will find triangles, circles, lines and points, barycentres, tangents, secants with given angles and distances [14]. But it is much more general than antique Greek geometry – you can have functions, derivatives, colours, random variables, all sorts of constructs that allow you to visualise and manipulate concepts that arise in all sorts of contexts, inside mathematics as well as outside [1, 5, 7].

1.3 Who we are

Intergeo (http://inter2geo.eu) is a project funded by the European community under the eContent+ programme. It begun in October 2007 and will last for three years.

Our consortium brings together partners from six different European countries. The geometry software that has been developed inside the consortium, however, covers almost all languages of the twenty seven countries of the European Union (and more).

1. University of Education Schwäbisch Gmünd, Germany [Cinderella]
2. Université Montpellier 2, Sésamath association, GNU Edu, France [Geoplan/Geospace/Tracenpoche]
3. German Research Center for Artificial Intelligence (DFKI), Saarbrücken, Germany
4. Cabrilog SAS, France [Cabri II Plus/Cabri Junior/Cabri 3D]
5. University of Bayreuth, Germany [GEONExT]
6. Université du Luxembourg [Geogebra]
7. University of Cantabria, Santander, Spain
8. TU Eindhoven, Netherlands
9. Maths for More, Spain [WIRIS]
10. Jihoceská univerzita, Ceské Budejovice, Czech republic

2 OBJECTIVES

The InterGeo project intends to ease the access to and thus enable the use and reuse of eLearning content based on interactive geometry tools.

Development, generalisation and improvement of geometry content suffers from a scattering of the available software and resources and a lack of quality control.

The answers we propose are:

1. *Interoperability and metadata*: We define and agree on a common description of metadata and basic structure of educational interactive geometry resources, through an ontology definition and an open file format. The resources will be easier to find, identify and use. The common metadata and interoperable OpenMath XML specification for describing figures in interactive geometry will permit a teacher to find, trust, open and adapt the available resources, according to licenses. The specifications will comply with the current standards for learning objects in order to ensure future use and sustainability.

2. *Content*: We will provide a wealth of own content to jump-start the exchange and evaluation of content. Due to the achieved interoperability, user communities from different countries have a chance to actively work together towards a better learning experience, although they have different general conditions, different backgrounds and pedagogical concepts.

3. *Quality Assessment and User Reviews*: We will help to build a common basis of quality standards that enables users to assess the quality of content with respect to teaching situations. To this end, we will build an equality framework able to produce, through an assessment protocol, metadata asserting the quality, the adequacy and the intended pedagogical use of a given resource in a given cultural context.

Great expertise in eLearning and eQuality assessment has been gathered in recent years, in particular in some European networks such as UNFOLD or MINERVA eQuality projects. Our project builds on the reflection, quality specifications and good practices founded as a result of such projects.

Interactive geometry is a playing ground for multilingual share of educational resources because its very objects are abstract and visual. Of course, pedagogical documents have to be translated and adapted for every specific Community of Practice, but this is not the major obstacle for a user once the genuine interactive geometry content (as provided by the consortium) is identified.

Learning Object Repositories (LORs) are a traditional platform type to propose sharing of learning objects. This generality implies shallow annotation standards such as LOM, that failed at providing efficient retrieval mechanisms. Our ontology based mechanism is much more specific.

3 INTEROPERABILITY AND METADATA

The Intergeo project was facing the issue of cross-curriculum search which would be fine grained because the focus on mathematics asks for more specific identification. We give an example, review the issues and projects that addressed them and describe our solution.

3.1 A Simple Example of Cross-Curriculum Search

Consider the competency (or skill) of constructing the division of a segment in *n* equal parts. This should be matched by queries using strings such as “divide in equal parts”, “diviser en parties de même longueur”, etc. Curriculum standards, however, do not all speak about this topic in the same way. The English curriculum only mentions the operation of enlargement, whereas the French national program of study mentions “connaître et utiliser dans une situation donnée les deux théorèmes suivants” and provides the formulation of the “Théorème de Thalès” and its converse [11]. All these should match in some way.

Mismatching across some of the curriculum boundaries is easy: In French (théorème de Thalès) and Spanish (teorema de Tales) indicates the intercepting lines theorem. However, Thales’ Theorem in English or in German (Satz des Thales) refers to another theorem.

3.2 Similar Projects and Approaches

Topical information in learning objects repositories is usually very broad like the WebALT repository [8], close to a curriculum standard. Another approach is free tagging but it needs unsustainable multi-cultural support. GNU Edu [12] provides topical information directly within the curriculum: learning objects are tagged by skills described in a curriculum, split into years and chapters. Skills have translated keywords to achieve cross-curriculum search. TELOS from the LORNET research network [13] aims at complete courses and not individual resources. England’s Curriculum Online [2], Microsoft Lesson Connection [10] and the ExploreLearning [4] enterprise, have annotated the curricula of England and the USA. The CALIBRATE project [18] provides annotated but too few curricula.

3.3 The GeoSkills Ontology

The basis of our approach is to enrich usual LOM like metadata [16] with a list of mathematical competencies [9] (prerequisite or trained), topics, educational levels and programmes which have names in many languages and which can be tagged on each resource. These lists are arranged as an ontology so as to provide a knowledge management tool and standards-based interoperability with guaranteed computational results.

Example of topics: Isosceles Triangle; of competencies: Calculate trigonometric ratio; of pathways: elementary-school; of levels: Gymnasium Saarland 7te.

We are working on a competency editor web-based tool: it will complement the curriki-based platform to allow: graphically browsing the competencies, topics, levels, and their relationships (e.g. from a resource annotated with a given topic), translating, adding or editing various names, curriculum-encoding, creating and editing competencies and topics present in a given curriculum.

4 CONTENT SHARING

4.1 Resource model

The model for a resource stems from the work of the SFoDEM project [6] at the genesis of the Intergeo project.

A full fledged resource in the SFoDEM form is as a collection of sheets: a learner sheet, a teacher sheet, a technical sheet and some others. Only the learner sheet is visible to an unidentified visitor so that learners can be directed to the resource page for an online use of the resource.

Each sheet consists of a wiki page where the insertion of interactive geometry constructions is done in an easy to use wiki syntax in the same way as static images. All sheets are exported, together with the construction files, in a downloadable bundle that can be used offline.

4.2 Resource browsing

The Intergeo platform’s main goal is to allow sharing of interactive geometric constructions and related materials. Overall, sharing a resource is the execution of the following roles: the author provides content to the Intergeo platform; the annotator provides authoring, licensing, topical, and pedagogical information on it; the searcher navigates and searches through the platform’s database to find relevant resources to use in teaching; the curriculum encoder inputs and maintains the set of topics, competencies, and educational contexts; the competency translator maintains their formal as well as everyday names; the quality evaluator reports on her usage of the resource in the classroom through an online questionnaire [17].

Topics, competencies, and contexts are addressable through URLs identifiers, thanks to OWLdoc. A browser version can be seen from http://i2geo.net/ontologies/dev/.

We designed two means to let the users easily designate tokens (topics, competencies, or educational contexts): by typing text or by pointing in a book.

We extend the familiar autocompletion: both for search and annotation, users can type a few words in a text field and the autocompletion popup presents a list of matching tokens (see Figure 2). More information and tests at

http://www.activemath.org/projects/SkillsTextBox/.

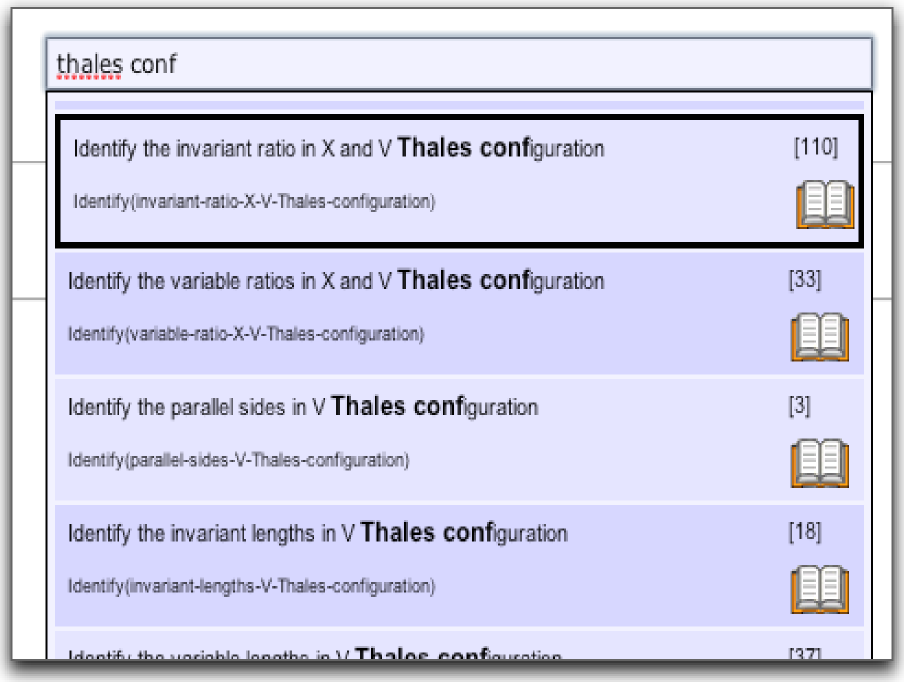

Figure 2: Competencies triggered by "Thales conf".

We will allow graphical browsing of curriculum standards or textbooks that users know well. The idea is that a user can then browse through a table of content, through pages he is graphically familiar with, and click on sections of interest. This click will trigger the selection of the competencies and topics associated with these sections, the search field. Although we shall mostly not be able to offer whole textbooks to browse through, we expect it to be unproblematic to display their tables of contents.

5 QUALITY ASSESSMENT

Quality assessment of eLearning has slowly evolved into a clear necessity. In the Intergeo project, the quality assessment is based on user's evaluation reports in the form of a questionnaire to be taken by teachers to evaluate different aspects of the quality of their planned or passed teaching experience, in order to give a ranking score to resources and to identify directions of possible improvements.

Our methodology stems from previous projects namely the JEM (Joining Educational Mathematics) network, the eQuality project and the IREM project SFoDEM.

The first objective of quality assessment is searchability: we want the "good" resources to be ranked first by a search engine. The second one is reusability by improvement of resources and their metadata through quality cycles based on users' feedback.

In this second year 2008-2009 we will bootstrap these quality improvement cycles by organising tests of resources in the classroom and analysing quality reports from users' evaluations.

5.1 Processes

We adapted the educational model proposed in the eQuality project [15] to our situation: Open Distance Learning provides a student with learning material from an ODL university course. Our objective is to provide a teacher teaching content using resources found on our web-site. The roles are somewhat shifted, as summarised in Table 1, but the need for emulation and support, feedback and analysis are strikingly akin.

e-Quality in ODL	*Student*	*Teacher*	*Institution*	*Course*	*Learning event*
Intergeo	*Teacher*	*Author*	*Project*	*Resource*	*Teaching event*

Table 1: The correspondence between eQuality and Intergeo models.

5.2 Author with hats

The teacher using a resource goes around the cyclic process described in Fig. 3 and the resource itself follows a similar cyclic process. The author of a resource has several hats on her head to manage this cycle.

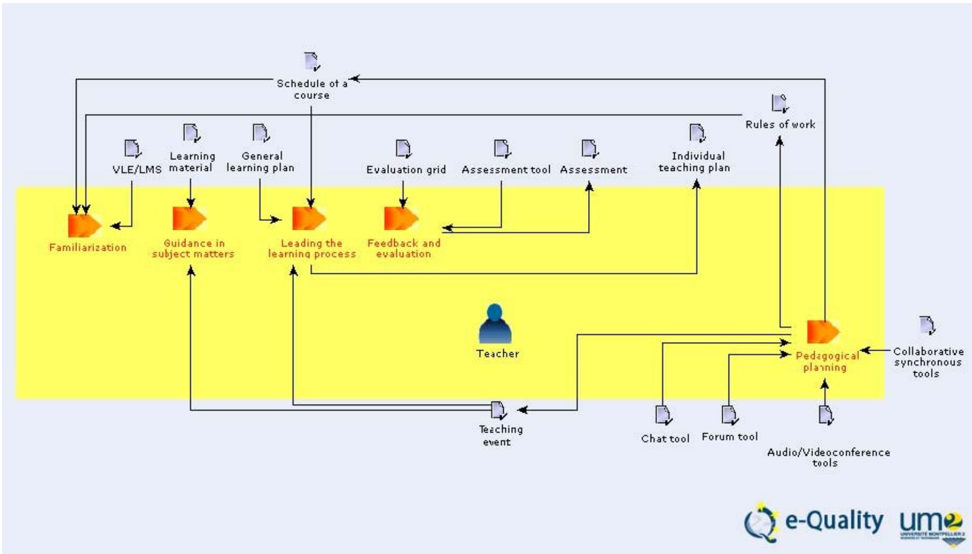

Figure 3: Teacher's workflow.

5.3 Licenses

Unclear licenses are a real impediment to the use of resources found on the Internet. The Intergeo project aims at rising the awareness of the share holders in the value chain to this issue. The author chooses a license contract for the content that she intends to share. The Intergeo project is promoting the use of open licenses that allow adaptation and reusability such as the Creative Commons Share Alike license. According to the licence, a teacher is encouraged to take on his own hand to improve a given resource and issue a new version of it, taking into account the users' feedback given by the questionnaire and the forums.

6 CONCLUSION

The Intergeo project is reaching usability. We welcome participation from interested users, mainly secondary math teachers to try and report on the contents on our web site http://inter2geo.eu/. We are seeking participation of Textbooks Editors and Publishers, as well as officials from Education Ministries in order to get competencies and up to date curricula. The community in eLearning is welcome to enrich and use our curricula and ontology of competencies, as well as the tools that we developed. Our ontology GeoSkills can be tested at http://i2geo.net/ontologies/dev. The SkillsTextBox GWT project can be enjoyed at
http://ls.activemath.org/ projects/SkillsTextBox.

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