Integrating Geomatics into the Curriculum

Inquiry-Based-Learning during a Fieldwork Course

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Abstract

In this paper, we address the question of the introduction of geomatics into the secondary curriculum for Inquiry-Based-Learning. This paper relates to an empirical study based on the implementation of a fieldwork course for 140 16-18-year-old students. The study takes place in the intersection of two fields of educational research: the didactic of geology and computerized learning environments. It relates to a socio-constructivist framework and aims at identifying the setting which is necessary for students to be able to carry out a scientific inquiry based on the use of GIS material.

We show that the question of instrumentation is a key question and that the benefit of technology relates to the fact that it mediates the interactions – i.e. assists the students during the inquiry process. Computer based learning environments are, then, considered as instruments which are constructed by the learners through their activity and participate in transforming the learning process.

1 Introduction:

Geomatics is the discipline of gathering, storing, processing and delivering geographical information. This term applies to both the science and the technology which are becoming increasingly used for professional and personal purposes (National Research Council, 2007). Different experimentations relate to the uses of Geographical Information System (GIS) material for educational purposes (see for example Fletcher, France, Moore, & Robinson, 2003; Hall-Wallace & MCAuliffe, 2002; Kerski, 2003; Sanchez & Prieur, 2006). Nevertheless, little attention has been paid to the pedagogical issues of the uses of geomatics and this question must be explored (Bednarz, 2001; Donert, 2007).

The results of a recent study on the uses of Information and Communication Technology for secondary education in France (Fontanieu, Genevois, & Sanchez, 2007) show that geography and geology teachers express a high interest for the uses of GIS material for educational purposes. Beyond the diversity of the tools used by teachers, *virtual globes* - such as Google Earth or the French Geoportail - meet a real success. The uses declared by teachers concern mainly geovisualization. Data gathering or data processing are less common. Nevertheless 7,5% of geography and geoscience secondary teachers in France declare that they use GIS material to carry out field investigations with students. These results address the question of introducing geomatics into the curriculum.

The *instrumental theory* offers a framework to analyse the uses of technology for educational purposes. For Rabardel (1995), an instrument is a two fold entity : *artifactual* (material or symbolic) and *psychological* (knowledge and mental operations). An instrument is elaborated by the learner through his/her activity. This *instrumental genesis* encompasses two processes. The *instrumenlization process* relates to the appropriation of the artifact by the user in order to manage his/her activity. The *instrumentation process* relates to the development of utilisation *schemes*. The *instrumental theory* takes into account the influence of instruments on the cognitve processes, especially in the case of the use of software applications for educational purposes.

This instrumental approach is based on the work of Vygostski (1934). Thus, it relates to a socio-constructivist framework. According to this view, we consider that the learning process results from interactions: interactions between a learner and an object to be known, interactions with a didactic setting elaborated by the teacher and social interactions. *Inquiry-Based-Learning* (IBL), which has been emphasized in a recent report by the European Commission (Rocard et al., 2007), fits such a learner-centred approach. Inquiry-Based-Learning is defined as "… *an approach to learning that involves a process of exploration, that leads to asking questions and making discoveries in the search for new understandings*" (National Science Foundation, 2000). Different authors have addressed the question of the uses of geomatics to implement an inquiry-oriented method of teaching. Baker and White (2003) found "a significant improvement in attitudes toward technology" and "self-efficacy toward science". In more recent work, Baker (2005) emphasized the value of Internet-based GIS for students' inquiries. Kerski (2003) reports the link between the use of GIS and inquiry-oriented, problem-solving skills. This author also identifies that social, educational and political factors are "*found to be more important influences on implementing GIS technology in education than technological factors*".

In France, the development of the uses of geomatics results mostly from the enthusiasm of individual teacher rather than from a national policy plan. There is no supportive national curriculum for the uses of geomatics. Nevertheless, some factors tend to create a helpful context. The geosciences curriculum includes a compulsory geological field trip for the second year of upper secondary school and numerous educational websites describe how to use GPS devices and virtual globes for field studies. A national seminar was held during 2007 in order to increase the educational inspectors' awareness about the use of geomatics for educational purposes. Moreover the Observatory for the Uses of Geomatics[1] (National Institute for Educational Research) develops different initiatives to support the uses of geomatics by geosciences and geography teachers. These initiatives encompass seminars, teacher training sessions and a mailing list. The aim of this Observatory is to facilitate the development a *community of practice* (Wenger, 1998) on the uses of geomatics for educational purposes.

Starting with this view, this paper aims at answering the following questions. (a) How can teachers integrate geomatics into the curriculum and develop an IBL approach? (b) How do the students develop uses of GIS material during a fieldwork course?

[1] http://eductice.inrp.fr/EducTice/projets/geomatique

2 Method and sample

Our research methodology, called “didactic engineering” by Artigue (Artigue, 1988), is based on the confrontation of a priori analysis of the learning design (LD) – based on our theoretical framework - and the results of implementation of the LD with the students.

The research is based on a fieldwork course in the French Alps. In the years 2005 and 2006, we implemented a geosciences course for the last year of upper secondary school. The students had to answer the following question: Do the French Alps result from a continent-to-continent collision? Students worked in pairs and carried out geological fieldwork. The following table describes the scenario. (table 1).

First step: preparing the geological field trip (in-class session 1h30)

Each group prepares the geological field trip by consulting maps and geological data with Geonote.

The students use…	*The students do…*
A scheme of a continent-to-continent collision model and Geonote	They note the data/clues to collect in order to prove that the continent-to-continent collision model applies to the Alps formation and they suggest an itinerary to collect the useful geological data/clues.

Second step: geological field trip (outdoor-session 2 days)

The students use…	*The students do…*
A GPS device, digital camera, topographic map, geological map	They search for, identify, draw, measure, geo-localize and take pictures of the relevant geological data.

Third step: dealing with data collected during the geological field trip (in-class session 1h30)

The students use…	*The students do…*
Field-notes, data-pictures, other field-documents and Geonote, to edit geo-referenced data.	They select, shape and comment their data. They locate these data in a geological map and produce a dataset as evidence that the continent-to-continent collision model applies to the Alps formation.

Table. 1: Learning design

Geonote is a software designed for secondary education (Lefèvre & Sanchez, 2006). The figure 1 shows the interface of Geonote. The software combines different layers of information such as geology or topography. Geonote allows the students to explore a map by zooming in/out or measuring distances. The students can visualize georeferenced geological data by clicking on hot spots on the map. They can also produce and georeference their own data (a picture and a commentary) by creating new hot spots on the map.

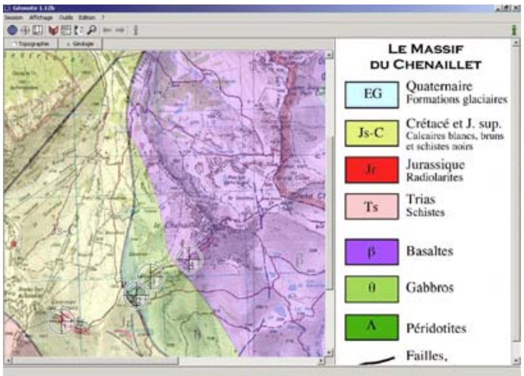

Figure 1. Geonote

Students were encouraged to make predictions and to design their own field procedures to solve the problem. They collected and recorded empirical evidence by themselves and interpreted data. They had to elaborate scientific explanations and to share these explanations with others. The learning design aims at leading students to make meaning out of their work and to be involved in IBL during all the three steps of the scenario.

Data sources of the research include log-files of the use of the software, audio, videotape, and students' written documents from 140 16-18-year-old students.

3 Students can use GIS material to handle geological information

The results of the study show that, during the first in-class session, 69% of the students succeeded in drawing a relevant itinerary. The relevance of the itinerary is assessed by two criteria: (a) the relevance of the empirical evidence that the students plan to collect and (b) the quality of the choice of the trails in terms of distance to walk and relief. Therefore, we state that the use of GIS material can help the students to develop a spatial understanding of a geological context. Software such as Geonote can also be used by secondary school students to analyse georeferenced data in order to make decisions and to plan scientific investigations. We consider that this point is important in order to give meaning to the field study and to help the students to manage their own inquiry process.

Figure 2 represents some pictures taken by students during the field trip. The last in-class session was devoted to producing a georeferenced geological dataset with Geonote. Students wrote a commentary for these pictures and, in some cases (11%), did more than was expected. Some of them (fig. 2a) created a panoramic view and annotated the picture before georeferencing them on the map. Moreover, students were asked to introduce an object into the picture in order to appreciate the scale of the geological data. Some students chose the colour of this object to indicate the nature of the rock represented in the picture. The colour was chosen according to the legend in the geological map, green for gabbro[2] and purple for basalt (fig. 2b).

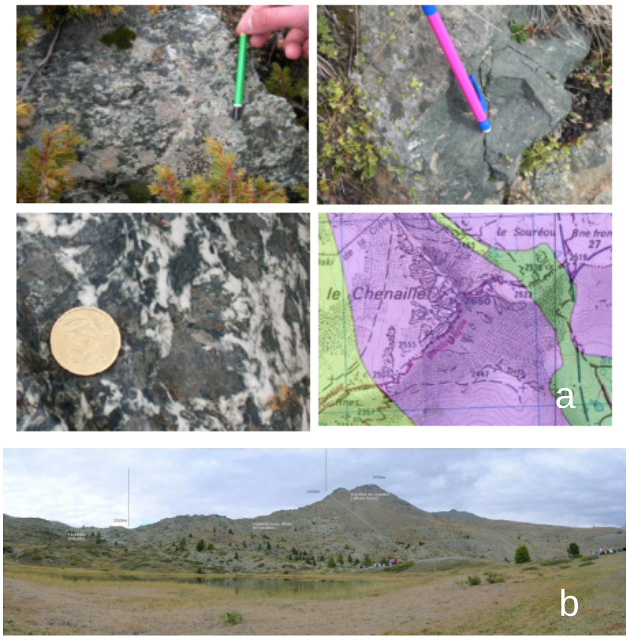

Figure 2. Some pictures taken and modified by students

More evidence of the appropriation of the software by the students was found during the in-class sessions. All the students produced a set of relevant geological data and 72% of them succeeded in georefencing the data on the geological map. For a majority of them (64%) the commentaries of the data fitted the geological problem.

These results demonstrate the capacity of students to adopt the software and to use it to handle geographical and geological data and to carry out scientific investigation. Students used Geonote to design the procedures of the inquiry process. The collecting and recording of relevant data in the field were was conducted with the aim of creating a set of data to be integrated into the software. As a result, students imagined innovative ways to deal with the data. Furthermore, students used Geonote to write explanations and to communicate their ideas to others. Therefore, we can state that the software plays a key role during all the inquiry process.

These findings demonstrate that a software is a *proposition* (Pargman, 2005) which is elaborated - in a given context - through the activity of the users. A software is an artefact and become an *instrument* through the learner elaboration of the *schemes* for the uses of

[2] Gabbro is an igneous rock

this artefact. This point of view emphasize that the design of a software is distributed by designer and users and illustrate the concept of *conception in use* (Rabardel, 1995).

In the next part we examine the impact of the software on the learning process.

4 GIS material can mediate the interactions during the learning process

The impact of the uses of GIS material on student activity can be illustrated by the following example (fig. 3). The dialogue was recorded during the field trip. Two students were looking for metamorphic minerals as evidence for a subduction phenomenon and were taking pictures of these minerals.

1	*Student1*	*Come on, I have found a ring …*
2	*Student2*	*In the middle it's pyroxene, it's a ring of what?*
3	*Student1*	*Pyroxene and here it's actinolite… and chlorite. OK we will take the all of it … Look at that… the green, the black and here, it's hornblende. You have to take the thr… two.*
4	*Student2*	*The two sides… I have to take?*
5	*Student1*	*Yeah*
6	*Student2*	*OK, it's cool, I will […]…*
7	*Student1*	*Of course not… You take this one, and then this one…*
8	*Student2*	*[…]*
9	*Student1*	*Take this one, the objective is to take this one…*
10	*Student2*	*[…]*
11	*Student1*	*Zoom in here. Don't you want to zoom in? Because it's important… No, zoom in here…I can hold the coin if you want.*
12	*Student2*	*What we wants to see is this…*

Figure 3: dialogue between two students who are taking a picture of metamorphic minerals

In the first part of the dialogue (1-5) the students focus on the determination of the rocks' minerals. It has to be noticed that they spend time in order to make a precise observation of these minerals in order to be sure that they have found a relevant clue. In the second part of the dialogue (6-12), the students discuss how to take the picture. As a result, we can state that the main features of the situation are (a) the involvement of the students in the observation and the determination of the minerals and (b) the richness of the dialogue between students.

We state that the involvement of students in the inquiry process – which has been observed for a large majority of students - results from two key points of the learning situation. One of them is the fact that the students know what they are looking for. They use the scientific model of a continent-to-continent collision as “conceptual lenses” to interpret the field data. The second key point is the use of GIS material. The students have to follow an objective. This objective consists in taking a picture of a metamorphic mineral and to georeference this picture on a map. As a result, they are able to assess the outcomes of their work *i.e.* finding or not the metamorphic mineral and taking a relevant picture. The possibility for the students to assess their strategy allows them to be autonomous.

The influence of the software on student’s activity is also demonstrated by the students’ exchanges during the writing of the commentaries of the pictures and the georeferencing of this pictures in the map during the second in-class session. Two types of record were found:

- Students express their feeling or opinion about the data:

[The picture shows metagabbros]

1	*Student4*	*This one is number 76. We drew it… Here, we see it well. This is the environment, the outcrop.*
2	*Student5*	*Yes.*
3	*Student4*	*Oh yes, cool! This one allows us to see the big blocks*

- Students construct an explanation about the forming of the data:

[The picture shows metagabbros and pillow lavas]

1	*Student6*	*Pillow lavas under the gabbro and later… metamorphism. Do you see that? It means that it’s a crustal accretion. Look at that, it has been expanded!*

The use of the software to achieve the task – selecting a picture, writing a commentary and georeferencing the picture on a map with the software – leads the students to describe the pictures and to construct an explanation. So, the student activity depends on the software characteristics. Furthermore, the students do not use Geonote in the field, nevertheless, the influence of the software on the learning process continues during fieldwork. The impact of the software on the student’s activity illustrates the *instrumentation process*.

Conclusion

A computer based learning environment can be considered as an instrument. This instrument is constructed by the teacher who elaborates the learning situations and by the learner through his/her activity. The benefit of a computer based learning environment does not result from the fact that it facilitates the work of the learner but from its capacity to mediate the interactions.

Therefore, GIS material can mediate the interactions between the students and a dataset of geological data and help them to develop a spatial understanding of a geological context. GIS material can be used by the students to carry out scientific investigation.

The use of GIS material for educational purposes can transform the learning process. We state that this transformation results from 3 points:

- The software allows the teacher to implement school activities which consist of interactions between the students and geological data. These activities help the students to build knowledge about the studied field;

- The software allows the teacher to implement school activities which consist in building a geological interpretation of the studied field by linking the data with a geological model;

- The software mediates the interaction between students who are led to formulate assumptions and to argue their point of view.

As a result GIS material transform the learning process by offering the teacher the opportunity to imagine innovative learning activities in order to implement an IBL approach. According to this view, GIS material can help students to be involved in autonomous learning activities and can assist them during all the inquiry process.

References

Artigue, M. (1988). Ingénierie didactique. *Recherches en didactique des mathématiques, 9* (3), 281-308.

Baker, T. M. (2005). Internet-Based GIS Mapping in support of K-12 education. *The Professional Geographer, 51* (1), 44-50.

Baker, T. R., & White, S. H. (2003). The effects of G.I.S. on students' attitudes, self-efficacy, and achievement in middle school science classrooms. *Journal of Geography, 102* (6), 243-254.

Bednarz, S. W. (2001). *Thinking spatially: incorporating geographic information science in pre and post secondary education*. Geographical Association. Avalaible on: http://www.geography.org.uk [2008.

Donert, K. (2007). Geoinformation in European education: a revolution waiting to happen. In K. Donert & P. Charzynski & Z. Podgorski (Eds.), *Teaching geography in and about Europe* (pp. 117-126). Torun: HERODOT network for geography in higher education.

Fletcher, S., France, D., Moore, K., & Robinson, G. (2003). Technology before Pedagogy? A GEES C&IT perspective. *Planet* (Special Edition 5), 52-55.

Fontanieu, V., Genevois, S., & Sanchez, E. (2007, 11-12 octobre 2007). Les pratiques géomatiques en collège-lycée. D'après les résultats d'une enquête nationale sur les usages des outils géomatiques dans l'enseignement de l'Histoire-Géographie et des sciences de la vie et de la Terre. *Géomatique Expert,* 49-55.

Hall-Wallace, M. K., & MCAuliffe, C. M. (2002). Design, implementation, and evaluation of GIS-based learning material in an introductory geoscience course. *Journal of Geoscience Education, 1* (50), 5-14.

Kerski, J. J. (2003). The Implementation and Effectiveness of Geographic Information Systems Technology and Methods in Secondary Education. *Journal of Geography, 102* (3), 128-137.

Lefèvre, O., & Sanchez, E. (2006). *Géonote : un environnement informatique d'aide au travail sur le terrain pour l'enseignement des sciences de la Terre.* Papier présenté à la conférence 8ème Biennale de l'éducation, Lyon.

National Research Council. (2007). *Learning to Think Spatially*. Washington DC: National Academic Press.

National Science Foundation. (2000). *Inquiry: Thoughts, Views, and Strategies for the K-5 Classroom* (nsf99148): National Science Foundation.

Pargman, T. C. (2005). Cas de l'écriture de groupes avec collecticiel. In P. Rabardel & P. Pastré (Eds.), *Modèles du sujet pour la conception. Dialectique activités développement*. Toulouse: Octarès.

Rabardel, P. (1995). *Les hommes et les technologies. Approche cognitive des instruments contemporains*. Paris: A. Colin.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H., & Hemmo, V. (2007). *Science Education Now : A Renewed Pedagogy for the Future of Europe*: European Commission.

Sanchez, E., & Prieur, M. (2006). *Démarche d'investigation dans l'enseignement des sciences de la Terre : activités-élèves et scénarios.* Papier présenté à la conférence Scénariser l’enseignement et l’apprentissage : une nouvelle compétence pour le praticien ?, Lyon, pp. 71-77.

Vygotski, L. (1934). *Pensée et langage* (1998 ed.). Paris: La Dispute.

Wenger, E. (1998). *Communities of practice. Learning, meaning and identity*. Cambridge, UK: Cambridge University Press.