

Implementing a Geoinformatics Course for Secondary Schools: First Lessons to be Learned

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This contribution was double-blind reviewed as full paper.

Abstract

The National Curriculum for Upper Secondary Schools in Estonia now places more emphasis on optional subjects, Geoinformatics being one of which. The learning environment of this geoinformatics course was created by the Department of Geography, University of Tartu. Plans and expectations for this course were presented at the AGIT 2011 (ROOSAARE et al. 2011). In the current paper we analyze the results of course piloting and its use for teaching both in-service teachers and school students. The content of the course and learners' feedback are described shortly. Several problems are pointed out. The main conclusion is that such a course is necessary, and that the students enjoy it.

1 Introduction

Optional subjects are accentuated in the Estonian National Curriculum for Upper Secondary Schools in order to enable secondary school students to choose more courses according to their interests and prepare them for university studies. The domain of the Curriculum concerning science and technology includes robotics, applied programming, economics, mathematics, etc. and also a 35-hour optional course in geoinformatics. Advanced e-learning environments have been developed, piloted and implemented by professional teams for all these courses as a part of a governmental programme (financed by the European Social Fund). Materials for geoinformatics were provided by the Department of Geography, University of Tartu. As we prepared the course, we also presented its educational background, conceptual pillars and infrastructure at the AGIT 2011 (ROOSAARE et al. 2011). The aim of the current paper is to analyze the results of course piloting and its usefulness in teaching different target groups.

2 Learning Environment, Content and Implementation of the Course

2.1 Learning environment

As Moodle is the most commonly used learning management system in Estonia, it is the backbone of the teachers' and learners' activity for this course as well. It offers flexibility in time handling, study group formation and setting up the proportions of class-room work and e-learning. The main freeware GIS software for practical exercises is QGIS (<http://www.qgis.org>), but there are several tutorials for ArcGIS Online or ArcGIS Desktop as well. The wide use of existing official spatial data (e.g. provided as WMS service by the Geoportal of Estonian Land Board) is accompanied by the sample data specially prepared for the course (e.g. adapted/simplified vector layers of road and river networks, attribute data on settlements and schools, raster layers on time distances from main cities). Video lectures are given by the university staff. Various presentations and text materials are available in pdf format for the students and in editable formats for the teachers, who also have access to a teacher's book with pedagogic hints. Moodle also includes quiz and feedback tools for students and tutors in order to test their knowledge. The glossary tool helps to explain and understand various terms in read-only mode and is not linked to texts.

Since March 2013, the materials have been free to use according to the Creative Commons License. Registered users can take a look at the course, or set it up for teaching in the Moodle server of the Innovation Centre for Digital Education (<http://www.innovatsioonikeskus.ee/en>), which also provides guidance, if necessary. Another option is to download a backup copy (270 Mb) and install the materials on a local Moodle server, where a teacher with designer's rights is then able to customize the materials according to his/her needs. It is also possible to use the courses provided by the Gifted and Talented Development Centre at the University of Tartu by participating either as a single student or as a tutor with a study group. Furthermore, the authors of the materials track key forums of Moodle courses taking place at both Centres and are ready to render their assistance. There is also a public website of the course (http://taurus.gg.bg.ut.ee/geoinformaatika/?page_id=21), where one can comment, ask questions, or download files.

2.2 Course content

The content of the 'Geoinformatics' course corresponds to the Curriculum (National Curriculum..., 2011). It consists of introduction and 6 themes (Table 1) and is oriented towards forming practical skills of compiling and using geospatial data to solve geographical problems. Although the course is built up around GIS software, it is not just '*teaching about GIS*,' as students are first presented with an overview of various tools whose use is demonstrated ('*GIS is everywhere*'). As it is not a good idea to convince students that solutions to the 'big problems' by governmental agencies are easy, the main aim of the introductory theme is to define geospatial problems connected to the students' everyday life (e.g. analyzing the routes they take to school or their activity space). After that, a discussion follows to help the students discover the best principles and tools for solving their problems. This extensive work usually convinces students that even '*small problems*' are not so easy to solve in practice. Study materials have a sample problem about

school network planning. As it is a multiscale problem (my way to school > allocation of our school > ... > school network reorganization in Estonia), it has the potential to be solved on different levels (depending on the teacher's intention) and to integrate students' extra-curricular knowledge.

Themes typically start with a short introductory section from the textbook to be read before the main lesson. There are often some provocative questions as well, mainly to encourage discussion in the classroom. About ¼ of the time is dedicated to hands-on activities with geospatial data. Some practical exercises (and questions in assessments) are optional, mainly to help teachers to challenge the students who are more advanced in ICT or have deeper interest in geography. As almost all upper secondary school students have an internet connection at home, the place and time of activities does not need to be fixed, but it is important to end each theme with a seminar (unless the course is 100% e-learning) so that the students can discuss what they have learned, what difficulties they had to overcome and how useful the skills were that they gained regarding the solution of the main problem.

Tab. 1: Learning content of the Geoinformatics course (35 hours)

Theme	Study Activities	Hours
Introduction	Examples on everyday use of spatial data. A sample problem about school network planning	1-2
1. Practical use of geomedial	Investigating different map servers and their comparative analysis. Practical work with <i>Geoportal of Estonian Land Board</i> and <i>Google Earth</i> .	4-5
2. Spatial data and databases	Investigating vector and raster data, starting to use desktop GIS software.	5-6
3. Projections and georeferencing	Investigating maps with different projections; determining rectangular and geographical coordinates; making measurements on maps	5-6
4. Queries from GIS	Main types of GIS analysis. Making attribute and spatial queries; proximity and network analysis, map algebra	6-7
5. Thematic mapping	Compiling thematic maps using data about Estonia.	6-7
6. Geospatial problems	Functionality analysis of QGIS tools in comparison with internet geoportals; group work in solving an allocation problem	4-5

The first theme is about the practical use of geomedial. Google Earth and other internet tools are used to solve the logistics of a tourist trip (incl. plane tickets and hotel reservation). A set of maps for a selected place is compiled via recourses of the Geoportal of the Estonian Land Board (<http://geoportaal.maaamet.ee/eng>) as the "My home place atlas". The main

topic of the theme's final seminar is a comparative analysis of different map servers from the point of view of performed tasks.

During the second theme, students will understand the main properties of raster and vector data. They will create new layers in QGIS, use WMS services, digitize from orthophoto objects with different geometry and add necessary attributes. They may (optionally) do some fieldwork with GPS. Finally, students assemble all created materials, and, as a result, will have a QGIS project named "My school and its surroundings".

Theme 3 focuses on map projections and their properties. Assessments on georeferencing cover the basics on projections in QGIS and additional exercises by MicroCAM. Students should perceive the importance of projections in geoinformatics, especially how directions and distances measured in maps depend on chosen projection parameters.

Different queries from GIS are covered in theme 4, starting from attributive and spatial search. By asking more complex questions (e.g. 'where is the best place for...'), the students are moving towards geospatial analysis in a step by step manner, which gives them a good ground for critical discussions that help to involve knowledge on history and human geography.

Theme 5 is entitled "Thematic mapping" and requires the students to put their skills on cartographic requirements of visualization into practice. They compile maps on the location of schools in Estonia, use a choropleth method to describe the number of students by counties, and add diagrams on the schools' structure by counties. During seminars, students work in groups, preparing their symbol systems and presenting them to others. A critical analysis of students' maps from their peers will follow.

Theme 6 is the last and the most important theme, which returns the focus to the geospatial problems raised in the introduction. The theory section explains the typical steps in problem solving and the illustrative part exemplifies it with spatial modelling and geosimulation. In the first assessment, students analyze the functionality of QGIS, then form workgroups and start to solve their problems. The course ends with a final discussion of the solutions presented by groups. Depending on the problems and consequences, the results may even find their way to students' research papers or conference presentations (ROOSAARE et al. 2013).

2.3 Implementation

The preliminary version of the course first passed a test by a specialist on user interfaces (GLÄSER 2012), and was thereafter piloted during the study year 2011/2012 in three intentionally different secondary schools (incl. one elite school in Tallinn and one country school on Saaremaa island). For the fourth pilot place we targeted a school in Narva (a Russian-speaking border town), but due to organizational problems the plan failed. Teachers of the pilot schools conducted the course (materials were set up in the university's Moodle server) with one of their classes. Teachers had tutor's rights in Moodle and all students were in one and the same group. Course developers tracked the respective forums and assignments, teachers gave feedback in team meetings and students answered feedback questionnaires at the end of each theme. Thereby, the following two main lessons were learned: the proposed exercises require much more time than we planned; lack of basic

knowledge and skills in general file management is a big “bottleneck” for most of the teachers and some students as well.

During 2012 the course materials passed different review and evaluation procedures prescribed by the Ministry of Education and funding organizations. We have taken the proposed advice into account and the next piloting step began in the academic year 2012/2013. We conducted the course in 100% e-learning mode. Different groups were formed in Moodle. Besides school-based groups (teachers as tutors and students as learners; some groups completed only a part of the course), there were also some mixed ones in which the teachers took part via the Open University and students individually via the Gifted and Talented Development Centre (both categories had learners’ rights only). About one hundred participants went through at least some themes of the course altogether.

In the academic year 2013/2014, several teachers who participated in pilot courses use the materials at their schools on their own. According to our preliminary estimation, the course of geoinformatics is presently conducted in 15 secondary schools (there are 230 secondary schools in Estonia). We also started a new round with the course to further help teachers and to widen the circle of users of our materials. It is funded by the *Eduko* Development Programme for Education Sciences and Teacher Training, it currently has 40 participants and it combines e-learning activities with periodical class-room meetings. The majority of these teachers are also teaching geography at their school; smaller (but partly overlapping) is the group of teachers involved in teaching informatics-related subjects. Hopefully, most of them also plan to introduce geoinformatics at their schools, like 5 of the teachers have already done.

3 Feedback from Teachers and Students

All implementation procedures set up by funding organizations, as well as our intention to improve the course, required permanent feedback. For example, pilot teachers and reviewers fulfilled detailed evaluation questionnaires and wrote reports. Taking their comments into account was mandatory. Feedback tools in Moodle and discussions at seminars also helped us. However, we did not conduct any didactic experiment, and due to changing conditions in the learning environment and in the content of assessments (different learners solved the tasks with different thoroughness), the quantitative numbers in the feedback are not trustworthy for statistical analysis.

Summarizing various feedbacks, we can see that the course corresponds to the learners’ expectations, and successful finishers were satisfied with learning outcomes. Students pointed out that they are now able to make maps and input the required information themselves. The course was considered to have been ‘normal’ by one half of respondents; for teachers it was a little bit more towards ‘difficult’. Comparing the level of difficulty of the course by themes, the results were as follows: the easiest one (1st) was difficult for 10%, and the 4th, estimated as most demanding, was difficult for 40% of the learners. During the piloting stage the most difficult part for the teachers was to sustain their role in the introduction and in theme 6 – finding an interesting geospatial problem and designing its solution. Therefore, we are paying more attention to this topic in our classroom meetings during the course 2013/2014. Several of these difficulties will be eliminated when teachers conduct the course for the second time.

We also enquired as to how much time was required for each assessment in each theme, but the answers were very diverse (1 to 360 minutes) and contradictory in some respects – probably the ‘time required’ was interpreted differently. On average, the ‘easiest’ exercise required 35 minutes and the ‘most difficult’ one 78 minutes. Interestingly, teachers required much more time compared to students. One reason could be that teachers are more thorough in their approach and they also think about the didactic side while students just want to find a quick answer. However, according to the questionnaire filled in at the beginning of the course, many participating teachers find even the common ICT tools like Google Earth or different Geoportals too complicated and time-demanding. When working with QGIS or ArcGIS, these teachers are prone to get tangled in a multitude of small details which are intuitively understandable for the majority of students.

Evaluations on the boring–interesting scale show that solving practical problems was more interesting for students than reading texts, answering questions and solving tasks, which involved repetitive operations. Some students found everything very interesting.

Furthermore, we noticed a clear correlation between themes and understandability of the respective exercises – the tasks in the more advanced themes were harder for the participants to follow. For example, 92% of the respondents found the first theme exercises understandable, but for the last, 6th theme, it was only 80%. Materials and data were sufficiently easy to find in the Moodle learning environment for 90% of the participants.

The feedback from participants in the academic year 2012/2013 showed that conducting the course in the web suited most of the people very well, especially when they could work at their own pace. The guides for practical tasks were sufficient enough for the majority, although some noted that meeting up occasionally to discuss more complex problems would have helped. Three people found that working together with a tutor would have been more effective, but for the most, the tasks took up too much time to complete them in the classroom.

The feedback given to us by teachers during the classroom meetings of the academic year 2013/2014 course show that more and more participants are using a newer version(s) of the software, different operating systems and user interfaces in different languages and they would like to have detailed tutorials for all these cases. Also, the teacher’s book has to be updated accordingly. However, when we take the small number of course supporting team members into account, and regarding the fact that the geoinformation society in Estonia is of miniature size, such approach seems unrealistic.

Another teachers’ concern is about security restrictions in the school computer class-room which are too strict in their opinion. As a result, additional errors occur in QGIS and help from the school’s IT-specialist is often required. But the more time is spent on external questions, the less is left for substantial ones.

4 Discussion

The course is necessary to help to bring school geography into the XXI century, to make it more up-to-date and enjoyable for students. Teachers, especially those of older generations, need extra training as their curriculums were missing GIS related subjects. When comparing teachers and students as learners, we can point out that teachers are more

thorough in their approach, which can also explain why they usually take more time to solve the problems. Advanced students can be (and in some schools they are) used as teachers' assistants.

Teaching the GIS course runs smoothly in the schools where it is taught as a compulsory subject in the field of science. For example, in the Tallinn Secondary Science School the geoinformatics course is taught in double quantity – 70 hours. A common problem for all optional courses, including ours, is that several schools have too few interested students to even operate the course – presently, the necessary minimum is 12. One solution is to organize joint courses for multiple schools – all the ICT requirements therefore are met. At the moment, the main problem has been the shortage of teachers to tutor the students, as our educational system lacks the means to pay a motivating salary for supervising students studying in different schools. Such groups would also enable teaching geoinformatics jointly with robotics or programming, which would be a challenge to the authors of the instructive materials.

Our curriculums include an independent research project as a mandatory subject. A lot of teachers see the GIS course as a perfect tool to help the students acquire the necessary skills to successfully complete their projects. Some good examples already exist (e.g. VARBLA 2012).

To sum up, we can say that the course is essential and all who have completed it “with us” (both teachers and students) have been more or less satisfied with it. It is great to see that the teachers who have acquired the necessary skills and knowledge also want to conduct the course in their schools. Aged geography teachers are happy to succeed in their ‘struggle’ with GIS. Younger teachers with good geomedia-related skills obtained from the university could also help to ensure the sustainability of the geoinformatics in secondary schools.

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