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GIS in school education in Estonia – looking for an holistic approach

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Abstract

The strategic role of GIS for geography education is undoubted, but there is a diversity in understandings with regard to what, when and how to teach. Also, the concept of geo-media has growing popularity in the educational context. Its borderline with GIS is quite fuzzy and changing. In this paper we present the case of Estonia on integrating geo-media and GIS into school education. According to the National Curriculum (NC) of Estonia, students must acquire a wide variety of skills in information technology, therefore a list of compulsory ICT based practical works have been added to the geography curriculum. NC now gives more emphasis to optional subjects. Geoinformatics is one of such elective courses at secondary school level. In order to graduate from secondary school every student needs to compile a research paper in one subject in addition to state exams. Advanced students are given more and more emphasis, their special needs being recognized also by the NC. The Gifted and Talented Development Centre at the University of Tartu and Geography Olympiads have been a means to select and involve students. A centrally hosted web-based school information and management system and supporting activities of the Tiger Leap Foundation are assisting teachers, and e-learning platforms (e.g. Moodle) are used by many schools. Advanced students can join social networks of the professional community (e.g. Estonian Geoinformatics Society), have meetings (e.g. in the Annual GIS Day) and present students' research papers.

Keywords: GIS, Geo-media, Geography Education, E-learning, Olympiads, Employability

1. Introduction

Geography is one of the oldest school subjects, but its importance and role have been repeatedly questioned (Cawley, 1998; Goh, 2005). The situation is similar at universities and in the labor market (Mezösi et al., 2001; Rooney et al., 2006; Segawa, 2012) whereby all three are interconnected (Conolly, 2001; Donert, 2007).

We start from the assumptions that educational models for geography in large, medium-sized, small and very small countries should be different from each other (Roosaare et al., 2007).

Arild Holt-Jensen (2005) makes an overview of the changing status of geography, mainly in the Nordic countries, and raises ten hypotheses

about factors influencing the status of geography. He underlines: "The status of the discipline is dependent on the degree to which geography is maintained as a united discipline encompassing both man and nature" (*ibid*, p. 142). Instead of splitting it into physical and human geography – it may contribute to success in science – and dissolving in special disciplines, geography as a field of education should stand out for its strengths. His first statement, important in the context of this paper is: "The status of geography in a country is directly correlated to the position of geography in the school curriculum" (*ibid*, p. 141).

Globalization and the development of positioning technology have brought different ICT applications of geography into wide public use. This process is giving new evidence for geography's utility in everyday life. GIS as an information system with geographic content has been and is central in most of the arguments on importance of geography.

Although there are many papers on GIS education (an overview is made by Baker et al., 2012) and examples on case studies (Milson et al., 2012), the status of GIS in school education is not yet established. A classical question is: to teach geography with GIS or to teach the tools of GIS? The former is traditionally the "right answer", but without the skills of using tools, the geography carried out with the help of GIS is quite poor, limited to semiautomatic thematic cartography. The rising importance of the inquiry methods in education emphasizes the analytical capabilities of GIS and requires more and more mathematical knowledge, i.e. understanding what is behind the buttons of GIS software.

Many obstacles have been pointed out against achieving full potential of GIS in "learning on spatial thinking" (Lee and Bednarz, 2009). An objective reason for such a situation consists in rapid development of ICT, as a result of which concrete GIS tools become obsolete very quickly and the understanding on GIS usage is changing continuously. "We are moving rapidly from a *concert pianist model* of GIS as a tool confined to experts, to a *child of ten model* in which the power of GIS is available to all, the obvious concerns about powerful and complex technology in the hands of naïve users notwithstanding" (Goodchild, 2007, p. 202). Therefore the concept of geo-media has growing popularity also in the educational context (Felsenhauer and Quade, 2012). Geo-media in the broad sense includes media that uses geospatial information (Gryl and Jekel, 2012). The term is wider than GIS, but the borderline between GIS (e.g. ArcGIS Explorer Online) and geo-media (e.g. Google Earth) is quite fuzzy and changing. Increasing capabilities of different geoportals and development of the cloud technology turn the tracking of this division – at least for the educational context – insignificant.

Despite the huge growth in the use of different geo-media applications in school education in the course of time, this process has taken place according to the general internetization of society and the development of e-learning. The integrating potential of geospatial data is still underutilized.

Universities are trying – and mostly managing – to go along with the technological development, but school education has limited ability to change so quickly. School arrangement is traditionally conservative, constrained by the fixed curriculum and rigid rules to ensure the quality requirements for aids in teaching. One of the main limitations of geo-media usage in the real learning process is the teachers' lack of time (Höhnle et al., 2010). Many success stories of using GIS in school education have been project-based, relying on enthusiastic teachers (Kerski, 2003; Milson and Earle, 2007; Favier, et al., 2009; Demirci et al., 2011). However, the integration of GIS and geospatial applications into the curriculum proceeds, too (Schubert and Uphues, 2009; Rød et al., 2010; Johansson, 2012; Wang and Chen, 2013; Goldstein and Alibrandi, 2013).

In this paper we introduce a possible model of how to integrate geo-media and GIS into general school education, exemplified by the case of Estonia. As a country of "small geography" (one university-level geography department) the emphasis here is on the contingent of advanced pupils, who are supposed to become important players among geography professionals in the future.

2. The role of Geography in the national curriculum

In Estonia, geography has always been a separate subject in the curriculum, although its role has decreased remarkably in the course of time. At present, according to the new National Curriculum (NC) of Estonia (National Curricula for Basic Schools and Upper Secondary Schools, 2011) there are a total of 5 courses (one course having 35 hours) of geography in the basic schools (Form 7-9). However, if we take the time budget as an indicator, the importance of geography in basic schools is the same compared to other non-basic subjects like biology, physics or history. At the secondary school level (Form 10-12), there are 3 courses (105 hours altogether) and the relative importance of geography is rather small (Figure 1).

At the basic school level most attention is paid to natural phenomena, and subject matter is taught through the following topics: map work, climate, water, geology, landscapes, biomes and population. The geography course in the 9th form is a short survey of Europe and Estonia. The latter topic was supported in 2000 by a multi-level electronic textbook, which included also cartographic tools and GIS tutorials[1] (Liiber and Roosaare, 2005). Two thirds of the lessons at the secondary school level pertain to human geography and one third to physical geography. Regional geography is very weakly represented in the Estonian school syllabus.

The NC emphasizes the integration of subjects, usage of ICT including geo-media, research-based learning and career planning. Closely related subjects have been categorised by subject domain, which makes it easier to achieve their common aims through the integration of subject matters. The use of scientific methods is a link between all science subjects and thus forms their common basis. As an integrative subject geography belongs at the same time to the natural sciences and the social studies domain. According to the NC more emphasis is given to ICT competences, therefore a list of compulsory ICT based practical works have been added after every theme in the science domain syllabuses. Even basic school pupils have to collect relevant information from various sources like interactive maps, satellite pictures, databases, climate charts, photos, and from other web-based geo-media sources. Secondary school students need to critically assess, interpret and analyze the spatial data, find correlations, make generalizations and conclusions on maps and collected data.

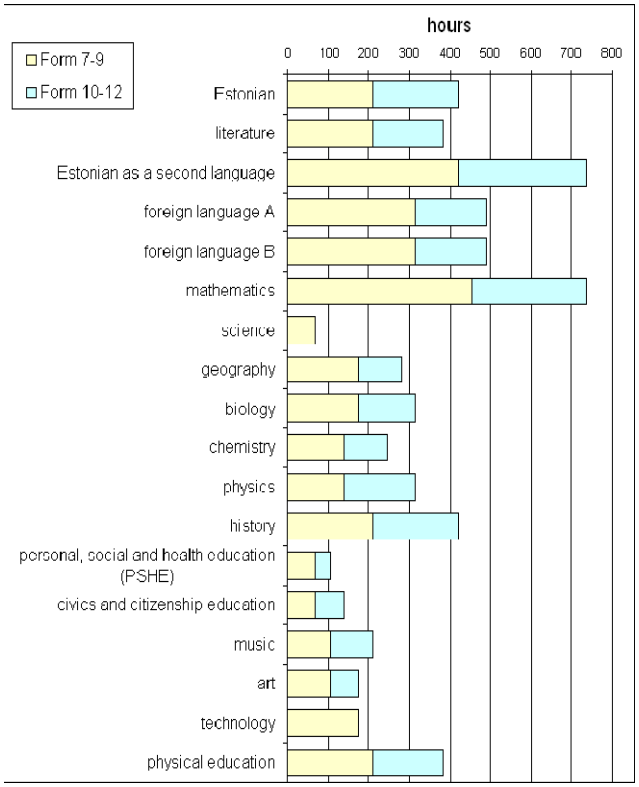

Figure 1. Position of geography in the time budget of school subjects (Forms 7-12).
Source: National Curricula for Basic Schools and Upper Secondary Schools, 2011.

The updated NC is more flexible than the old one: the number of compulsory courses for all pupils was reduced from 72 to 63. So secondary school students can choose more optional courses according to their interests and skills to prepare themselves for ongoing studies in the high schools. Elective courses in the domain of science and technology include (besides robotics, applied programming, elements of economic mathematics etc.) an optional course of geoinformatics as well (35 hours). All the above-mentioned courses have high-level e-learning environments developed, piloted and

[1] http://www.geo.ut.ee/kooligeo/EGCD/opik/juts/ juts.html.

implemented by professional teams during a "TeaMe" programme[2]. The Department of Geography at the University of Tartu is in charge of the course of geoinformatics (Roosaare et al., 2011) that is analyzed in the fifth section of this paper.

The NC requires that in order to graduate from secondary school, every student needs to compile a research paper in one subject in addition to the three state-level and one school-level exams. Probably the requirement of a research paper in the NC will foster the usage of GIS by secondary school students, because GIS is more and more acknowledged to be a good tool in research work in other subjects as well. Processing, analysing and visualizing the spatial data is useful not only for traditional subjects (e.g. history or biology), but also for the cross-curricular topics – e.g. for "environment and sustainable development", "civic initiative and entrepreneurship", and "career planning". Since geo-media skills are highly valued in many professions, students who have acquired GIS competence during their secondary school studies have multiple advantages in career planning, either in the high-school studies or in the labour market (Rooney et al., 2006; Roosaare et al., 2007; Arrowsmith et al., 2011).

Thus the requirements of the new national curriculum promote in every way the implementation of geo-media and GIS both in basic schools and in gymnasium.

3. Teachers' role in the usage of geo-media

Although the national curriculum has a notable influence on teaching at schools, the real teaching-learning process in the classrooms depends on teachers' professionalism. As always, there are teachers who are very enthusiastic to implement new technologies and teaching methods and the others, who prefer to stay loyal to the traditional methods – teaching with "chalk and board" (i.e. "PowerPoint show" now).

Nowadays, nearly all teachers can use a computer classroom with internet access, but the computers are sometimes a little out-dated. Most schools are using a centrally hosted web-based school information and management system *eKool* (e-School). In many schools more and more geography lessons take place in the computer labs.[3] The questionnaire survey made in 2011 amongst geography teachers (N=76) showed that most of respondents use computers for preparing the lessons, but only one third of respondents answered that they often carry out geography lessons in the computer labs and really work with geo-media.

Many studies are showing that the lack of teacher preparation in GIS, insufficient curriculum time for GIS, lack of suitable instructional packages, high general workload of teachers and extra preparation time are the main impediments in the integration of GIS into school geography (Liu and Zhu, 2008; Yap et al., 2008; Wheeler et al., 2010). The same limiting factors are mentioned in our investigation among Estonian geography teachers.

There are lots of possibilities for teachers to improve their didactical and technological competences. In 1997 the Tiger Leap Foundation (TLF)[4] was created to foster the usage of modern technology in schools and to improve the ICT-related competencies of teachers and students. During the last 16 years various ICT equipment, teacher training courses, e-learning materials, projects' support, and competitions for teachers and pupils have been offered to schools by the TLP. To facilitate the implementation of the new national curriculum, the TLF is now offering integral state-of-the-art solutions of ICT infrastructure, education technology and teacher training.

The strategy of the Ministry of Education and

[2] "TeaMe" with main objective to enforce interest of young people in career in science and technology is financed by the European Social Fund. Budget of the TeaMe programme for years 2009–2013 is 3.4M€. http://www2.archimedes.ee/teadpop/index.php?leht=389.

[3] According to the official statistics (http://www.riso.ee/en/content/statistical-overview-2011%E2%80%932012) 75% of households in Estonia have Internet connections and practically all school kids are using Internet.

[4] http://www.tiigrihype.ee/en.

Research envisages that by 2020 the whole curriculum will be covered by digital study materials (The e-Schoolbag initiative). This involves developing an advanced teaching/learning infrastructure. To achieve this several projects will start in the future. Concerning geography we plan to continue our multi-level approach: basic study material on the use of geo-media will be provided for an ordinary pupil according to the compulsory syllabus; advanced level tutorials will be offered for potential participants of Olympiads, who are supposed to use their GIS skills in group work, tackling spatial allocation problems for example.

About a quarter of Estonian teachers are registered users of the TLF education portal *Koolielu* (School Life). Via this portal, they can share thousands of study materials structured on the basis of the NC. Every teacher can find good instructions for geo-media based lessons from *Koolielu*[5]. A special competition was organized in the scope of GIS-day in 2012 to get contemporary study-materials to use geo-media tools at schools. All those works are ready for use and available for teachers.

Thus, the lack of suitable instructional packages for geo-media based lessons cannot be a barrier for GIS usage in schools.

In the last five years, short courses on new technologies in geography education (how to use GPS, GIS or data loggers and sensors of Vernier) were held by Tartu University lecturers for the participating students during the final competition of the Geography Olympiads. Prolonged courses with the same content were organised for the teachers accompanying students. Again and again, we have to recognize that students acquire technology-based skills more quickly than teachers.

Also, the web-based GIS courses (for ArcGIS 2009 and QGIS 2012) organised for both the geography teachers and interested students are showing that teachers spend nearly two or even three times more time on practical exercises with GIS than students.

The figures on Estonian teachers' age-gender structure (Figure 2) is showing that the teachers are aging – older teachers are dominating over younger ones (middle-aged women, 45-54, are the dominant group). According to estimations, the picture among geography teachers is the same.

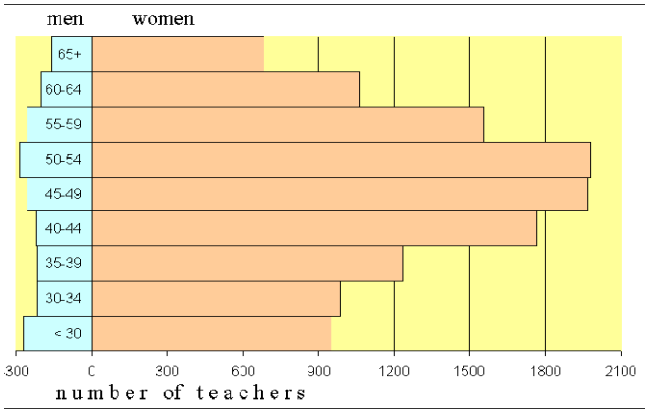

Figure 2. Age-gender structure of teachers in Estonia. Source: Estonian Ministry of Education and Research[6].

Despite the fact that all teachers have common ICT competences, most of the geography teachers did not acquire GIS knowledge and skills during their university studies more than twenty or thirty years ago. Therefore, many elderly teachers prefer to use computers as little as possible. At present, every university student majoring in teaching has to carry out some lessons in the computer lab during their pedagogical practice.

To sum up: the existing funds should be spent not for producing new study materials, but for in-service education and the geo-media training of those teachers who are not active geo-media users yet. However, it is not easy to reach them.

4. Geography Olympiads as stimuli for using geo-media

The Geography Olympiads are the famous phenomenon that also promote geo-media usage by students and develop GIS based competences.

[5] http://koolielu.ee/waramu/view/1-b35ab841-f36d-4105-91f8-33c9521d16e5.

[6] Statistical data about teachers of general education: http://www.hm.ee/index.php?048055.

Subject Olympiads have long traditions (in geography since 1965) and they are very popular in Estonia. From year to year, the competition is becoming more serious and intensive because the results are highly recognized. The winners of the National Olympiad and all of the participants in the International Olympiads are entitled to enter Tartu University without further competition for student positions which is a serious stimulus for secondary school students.

In 2005, computer-based exercises were first included in the Olympiad's written tasks for the secondary school level. Students had to find, interpret and analyze some geographical information from internet portals (Liiber and Roosaare, 2007). During recent years students participating in the final round of the competition have to use thematic maps and spatial information from the map server of the Estonian Land Board to solve real life problems. Last year, for instance, secondary school students had to use this server in order to analyze the situation related to the opening of a sand quarry in a parish of South-Estonia: identify different restrictions, suggest a route for sand transportation and make impact assessment.[7] Exercises during the fieldwork included the finding of control points by means of GPS and the solving of different tasks there.

Many tasks, especially the geo-media based ones from the Olympiad, are later introduced into ordinary classroom work to diversify the teaching-learning process.

There is a rising tendency that the more gifted secondary school students predominating in the final rounds of the Olympiads tend to be concentrated in a limited number of elite schools located in the capital city and some larger towns. Nevertheless, students' interest in geography stems mainly from their school experience, that depends on good teachers (Liiber and Roosaare, 2007).

Therefore the Geography Olympiads serve as a development engine not only for students but for school geography in general, including geo-media implementation.

All of the information about the Geography Olympiads, including suggestions to prepare for forthcoming ones and the tasks of prior competitions, can be found on the Estonian School Geography Website.[8]

Subject Olympiads grip the contingent of advanced students who are of interest for universities as future professionals. Fortunately, the need for special attention to gifted pupils is stressed by the NC as well. All the work with the gifted students in Estonia is managed and coordinated by the Gifted and Talented Development Centre (henceforth GTDC) at the University of Tartu.[9] The main aim of the GTDC is to give opportunities and possibilities for the development of gifted pupils. For that purpose GDTC organizes special sessions for those students who are preparing for the international contests and at the same time offers multiple elective courses for those school students who have a deeper interest in specific fields of science. The courses are predominantly web-based and carried out in the e-learning environment (Moodle at present), that enables students to participate in the course irrespective of where they live and to learn under the tutorship of high-level teachers.

Therefore the modern education technology and readiness of pupils to use it are giving new opportunities to all students to get the best possible education in spite of the situation in their home school.

5. Elective course of geoinformatics as a bridge between school and university

An opportunity to create the whole learning environment (including tutorial exercises, slides, videos, interactive tests and feedback, as well as proper support materials for teachers with lesson plans) enabled us to make use of our experience with the Olympiads. Taking into account curriculum requirements, the real situation in schools, good educational practice and our understanding of spatial literacy, certain conceptual pillars served as a basis of the course

[7] http://kooligeograafia.ut.ee/materjalid/olympiaadid/2012_Otepaa/Internetivoor_Otepaa_2012.png.

[8] http://kooligeograafia.ut.ee/.

[9] http://www.teaduskool.ut.ee/english.

(Roosaare et al., 2011). Some of them are as follows:

- Practical orientation. Despite the fact that the course is oriented towards forming working skills (with QGIS or ArcGIS), the aim is to use what one has learnt for the solution of geographical problems (e.g., a backbone question is the school network[10] and students' routes to the school. Access to the necessary detailed geospatial data is via WMS from the Geoportal of Estonian Land Board (e.g. orthophotos of 0.5m resolution) and adapted for learning thematic layers (e.g. schools, settlements, roads) and can be downloaded from the learning environment.
- Stratification of material. Since the course will be used differently (selected by students with different interests and basic knowledge, conducted in computer class-room or individually, by the QGIS or ArcGIS), the tutor can customize the learning environment and individualize tasks for students.
- Flexibility of timetable and in study groups. The latter uses the scheme of the GTDC. We foresee it as a possibility to form more specialized study groups with advanced interests in a more narrow topic (e.g. students learning programming or taking a course in robotics) and supervised by a specialist (e.g. an MSc student). As a result, GIS may be used by students for their research papers in other subjects.
- Perspectives for professional career. Connectedness to the professional choices and questions of employability are emphasized as important aspects of elective courses by the NC. In addition to presentations in the study materials, it is possible for advanced students to join email lists and social networks of the professional community (e.g. participate in some events of the Estonian Geoinformatics Society[11]). It will also be possible for advanced students to complete the course at that level, which makes it count (by the Accreditation of Prior and Experiential Learning Project) for university level credits.

In 2012-2013 the course was piloted both in the school classroom version (3 schools) and in the mode for individual use (16 teachers and 20 students from different schools, some in-service students). Altogether about one hundred learners went through this course and gave us useful feedback to be taken into account during course improvement. Beginning from the 2013/2014 academic year the learning environment will be managed under the auspices of the Ministry of Education and Research (MER), but UT is continuing to support the course.

6. Discussion – towards a more flexible organization of education

The importance of teachers for success in education is clear, but the reality is that pupils are better users of ICT tools. They acquire skills in e-activity more quickly than aged female teachers and for them, traditional textbooks are not the gateways to the world, but boring school stuff. There are exceptions, but exceptions are rather a confirmation of the rule. Why are young innovative graduates not interested in working in schools? It is a complex and wide social problem in Estonia (for our good neighbour Finland the situation is quite different) and its step-by-step solution is being attempted by the MER during the ongoing education reform.

However, in the case of a small country, where "everybody knows everybody" it is possible to dismantle barriers in education more easily. One good opportunity arising from the ICT technology is a possibility to individualize the learning process. This is also a commitment in order to develop pupils' skills in the best way. For society, it is especially important that the more talented pupils, our leaders in the future, have the best possible education irrespective of

[10] Situation (described in Sepp and Roosaare, 2013) is explained to students during an opening seminar of the course.

[11] One good example resulted from the testing of the course in three secondary schools during spring 2012. Some students already used GIS in preparing their research paper. One of these, about coastline changes of Island Aegna was presented in the GIS–day conference and is accessible: http://www.gispaev.ee/gis-paev-2012/kava-ja-ettekanded/.

their home school and the teachers they have there.

The situation in school geography is not bad due to the wide distribution of geo-media equipment (GPS and LBS in cars and smartphones; virtual travel by the Google Streetview to complement real trips of kids and their parents). In order to give a meaning to all the information showering students today they need good tutors and supervisors. The education technology enables us to create inter-school study groups and use a different assortment from the huge amount of existing study material. Formal and juridical restrictions could be solved step-by-step. A key problem is the question of tutors for the courses and supervisors for the research papers. In addition to the active teachers we are involving via the Olympiads, the potential of the Master students at university should be used more and more. This would have a bilateral benefit and maybe contribute to a national "Youth to School" initiative[12].

Another prospective challenge for school geography is to get ready for forthcoming changes by switching to the e-examination. It is an opportunity to apply more geo-media tools, emphasize ICT skills and students' geospatial thinking skills (instead of going towards the easier way of factual tests). For that purpose a completely new instruction for examinations is needed, but this is already a topic of another paper.

7. Conclusions

The use of maps, geo-media and GIS has been traditionally a part of school geography education, but contemporary ICT enables and favours its wider use, especially in the cross-curricular topics.

Increasing emphasis on elective courses by the National Curriculum and the adoption of education technology solutions by schools opens the door for more flexible and individualized teaching/learning solutions. The latter is more important for gifted and talented students.

The first step forward has been made and a module of technology-based elective courses, starting from 2013/2014 academic year, also includes geoinformatics.

Since the implementation of an elective course for very few students of specific interest may be difficult at the level of schools, then a possible solution might be to establish Estonia-wide study groups tutored by specialists.

Co-operation between schools and universities is widening. Increasing numbers of activities enable secondary school students to participate in lectures, seminars, meetings, fieldwork etc. organized by universities.

There is enough learning material on the web, even in Estonian. The need is rather for adequate courses on the effective use of existing materials. Such courses might be oriented first of all to teachers in order to help them reach a certain level of geo-media usage in their work.

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[12] http://www.nooredkooli.ee/?lang=2.

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