The Geographic Information System (GIS) in secondary education in Serbia

DJURDJICA KOMLENOVIĆ
Institute for Educational Research
EMILIJA MANIĆ
University of Belgrade
DUŠICA MALINIĆ
Institute for Educational Research

This study investigates the application of new educational technologies in geography classes. The research involved 126 students from vocational secondary schools in Serbia taking geography as a compulsory subject. We developed and applied a questionnaire for this research. The results indicate that out of several ICTs available, the majority of students are familiar with the GIS, but only one third can be said to have theoretical knowledge and practical skills for its effective implementation. Students who use the GIS stated that it is a useful tool that contributes greatly to the development of cartographic skills, which is a major advantage given the problem-oriented learning approach, and that it is highly interactive, systematic and precise. These findings suggest that the GIS and other ICTs are still not fully used and that teacher presentation remains the dominant method, which includes less innovative didactic aids. The importance of the application of the GIS in teaching and suggestions for enhancing teacher motivation to apply this technology are discussed in the conclusion.

Keywords: Geographical Information System, Information and Communication Technologies, geography curriculum, vocational secondary schools

The utilisation of contemporary teaching aids facilitates the development of functional geographic knowledge and skills in students which is why more attention is paid to using Information and Communication Technologies (ICT) and particularly the Geographical Information System (GIS) in geography lessons throughout the world (Czerniewicz & Hodgkinson-Williams, 2005; Maree, 2005). Research has shown that students who have the opportunity to use modern teaching aids in the learning process develop geographic knowledge, skills and attitudes more effectively (Backer, 2002; Biebrach, 2005; Komlenović & Malinić, 2008). The GIS, by its nature, enhances inquiry-based skills compared to traditional geographic education (Sui, 1995). The use of the GIS enables students to participate in activities such as monitoring and predicting the causes, development, and consequences of changes in geographic phenomena, but also to answer key questions including what, where and why, as well as those questions asked at a more advanced level of study: Why is some location significant? What needs to be done to promote a certain location (Roberts, 2003)?

The GIS and secondary education

The utilisation of contemporary technologies in teaching contributes to the faster achievement of educational goals, which is why the GIS may be considered as a technique with the potential of facilitating problem-based learning (PBL) and inquiry-based learning (IBL) (Baker, 2002; Bednarz, 2004; Keiper, 1999; Wiegand, 2003). Many studies examine the advantages of the GIS as a teaching aid in the context of interactivity in geography lessons (Johansson, 2006; Johansson & Pellikka, 2005; Kerski, 1999, 2003; Roberts, 2003; Wiegand, 2003). The GIS directs the teaching process towards students; thus allowing them a higher level of acquisition of functional knowledge. It opens up a new approach to geographical

education, i.e. students can use it during empirical and field research, in spatial analysis, as well as the visual representation, interpretation and presentation of research findings.

However, notwithstanding its high didactic merits in geography lessons, the GIS is far from being widespread in teaching geography in schools worldwide. So far, comparing different cases, GIS application in teaching geography has been more as a result of the individual efforts of certain teachers or schools rather than a system-regulated standard in education (Hew & Brush, 2007; Kerski, 2003; Wiegand, 2001). There are numerous obstacles and questions involved in the process of the implementation of the GIS in schools. Some of these issues are more characteristic of developing countries, while others are more prominent in developed ones (Lloyd, 2001; Van der Merwe & Mouton, 2005). They include:

- Lack of or inadequate computer equipment and high cost of hardware and GIS software
- Lack of teacher training and curriculum materials (Demirci, 2008, 2009; Johansson, 2003; Kerski, 1999)
- Systemic issues influencing the use of innovations in teaching (Onwu & Stoffels, 2005)
- Lack of time required for educating teachers about GIS
- Insufficient interest on the part of teachers to educate themselves on applying new technologies (Yuda & Itoh, 2006)
- Insufficient presence of GIS in the secondary school curriculum.

During the 1980s only a few secondary schools in very few countries (the USA, some Western European countries) recognised the GIS as a new teaching aid in the geography classroom (Johansson & Pellikka, 2005; Wiegand, 2001). Ten years later many developed countries had already introduced the GIS into the secondary school curricula, albeit without any significant impact on education itself (Briebarch, 2007; Kerski 2003; Scheepers, 2009). Although developing countries started to introduce the GIS in schools, they lagged some 10-15 years behind the developed ones. Aware of the situation, the European Union started a project (GISAS) in order to strengthen the launch of the GIS in secondary schools (Johansson, 2003).

Table 1: The GIS in the school curriculum and the current state of its use

Country	Year of introducing GIS in schools	School level	Actual use of GIS in the classroom
South Africa	2006	Secondary school level (Grade 10, later in Grade 11 and 12)	Not widely spread
USA	1996	US National Scientific Education Standards	Wide use of digital maps, but small number of schools adopted GIS
Turkey	2005	National curriculum for secondary schools (9^{th}-12^{th} grade)	At the beginning of GIS adoption in schools
England and Wales*	1991; 2000	National Curriculum Programme of Study (KS3, KS4 an A level)	GIS has been compulsory in geography teaching since 2007
Norway	2006	Secondary school level (upper level, 16-19 years old)	Advanced use of digital maps and GIS
Finland	2003	National Frame Curriculum for the upper secondary schools, GE4	Not widely spread in schools, except at GE4 level
France	2000-2002	Secondary school level (only in the tutorials for history/ geography teachers)	No general use of GIS in schools, except in individual cases

Country	Year of introducing GIS in schools	School level	Actual use of GIS in the classroom
Germany	1998-2001	Secondary school level (GIS is included in several different curricula)	Remarkable progress in using GIS in schools in the last five years
Belgium**		Secondary school level (only the Flemish community in 3rd grade)	GIS is only mentioned in the Flemish curriculum

Source: Klonari *et al*. (2009)

* Obligation to use it from 2007

** The situation is different for two ethnic communities, Flemish and French; no data about the time of introduction of GIS in schools

Although the GIS was introduced at secondary school level (usually in the upper grades) in almost all countries, there were some differences in the way it was used in the teaching process. In those countries where the GIS was introduced into the secondary school curriculum, geography teachers were expected to use not only digital maps, images and internet sources, but also certain forms of creative work and advanced options within this tool (Andersland, 2006; Klonari *et al*., 2009; Lambert, Gardner & Swift, 2007; Rod, Larsen & Nilsen, 2010; Schaffer, 2003). There were also differences among these countries in the level of GIS usage in the classroom (the biggest breakthrough was made in British and German secondary schools). On the other side, those countries that have no explicit mention of the GIS or have introduced it indirectly into the curricula accelerate the use of ICT, not only the GIS (e.g. Austria, France, Denmark). These include those countries where the GIS is not mentioned at all, except on rare occasions in tutorials for teachers (France). Developing countries are at the beginning of this process (Demirci, 2008, 2009; Komlenović & Manić, 2009). Serbia is a case in point.

The GIS in geography in secondary education in Serbia

At the end of the 20th century considerable changes were introduced into the education systems of European states, with special emphasis on the development and continuous improvement of vocational education and training the young for involvement in the labour sphere and lifelong learning. Keeping up with these trends, significant changes were introduced into the Serbian education system at the beginning of this century, with the focus on the reform of vocational secondary education (Despotović, Maksimović, Dimov, Šećibović & Žugić, 2002). The modernisation of vocational education takes place gradually, through the introduction of experimental projects dealing with the diversification of school programmes and curricula harmonised with the needs of the labour market and European standards (Komlenović, 2004, 2009).

Upon completion of eight years of primary education, students aged 14 and 15 enrol in secondary level education. Students can choose between grammar schools (gymnasium) and vocational schools (three-year and four-year schools). After gymnasium, students are expected to continue their education at universities while, after the vocational level of education, young people are able to enter the world of work or proceed with further education. The curriculum of vocational schools is realised through compulsory, elective and facultative subjects.

The changes in vocational education were initiated in the 2002/2003 school year in order to respond to the needs of profession and real-market demands. After the long-standing realisation of the Experimental Programme and a detailed internal and external evaluation of all its segments, the curricula 'entered the system'.

The GIS was incorporated into the secondary school geography curriculum in four fields of work: *Economy, law and administration; Chemistry, non-metals and graphic art; Transportation; Geodesy and construction.* The interest among students in these fields is quite high, and they are attended by students

with fairly good academic achievement. After the completion of these secondary school profiles, it is possible to find a job within three or four months (Komlenović, 2009).

Geography is a compulsory subject for these fields of work, accomplished in one school year with two classes per week. The structure of the curriculum comprises several modules which are based on learning outcomes, forming a set of functionally related knowledge, skills and abilities considered necessary to perform a certain job (Komlenović, 2004, 2009). The referential framework for modularisation is the concept of professions presented as clusters, which contain a set of functionally and organisationally connected learning packages/units, i.e. modules. The same modules can form part of different profession clusters, which contributes to horizontal and vertical mobility within the education system. For example, those modules dealing with Cartography and GIS are present in geography curricula in all of the education profiles of the afore-mentioned fields of work, but the depth and scope of teaching contents vary since they are adjusted to the needs of the profession in question (Komlenović & Manić, 2008). The module entitled GIS with all its components figures as an important novelty and has been introduced due to the need for both the development and modernisation of the above-mentioned professions. The objective of this module is to obtain knowledge of the GIS and its use. This can be achieved by realising the defined outcomes and suggested contents: (1) The concept and characteristics of geographical information; (2) Geographical information technologies: the global positioning system (GPS), remote detection, GIS; (3) GIS – concept, structure and application; (4) Using information from the Internet; (5) Examples from practice (Official Gazette Republic of Serbia – Educational Gazette, No. 5/2011).

Research methodology

- *Research goal*. This research investigates the application of new educational technologies in vocational secondary schools in Serbia. We set out to determine whether students acquire knowledge about new educational technologies in geography classes and whether they apply them in teaching processes as defined by the geography curriculum for this level of education. It should be mentioned that certain fields of work in vocational education comprise modules referring to ICT including GIS, digital map, Auto CAD Map and Geomedia Professional 3.0, GPS.

- *Sample.* The participants were 126 first- and second-grade students from vocational secondary schools in four Serbian towns. Schools where geography is a compulsory subject were included. The student sample was random (40 boys and 86 girls) and encompassed the following fields of work: Economy, law, administration; Chemistry, non-metals, graphic art; Transportation; and Geodesy and construction.

- *Instruments.* The analytical-descriptive method was used in the research. We developed and applied a questionnaire for this research with two sets of questions. The first set of questions (open-ended and multiple choice) referred to student opinions on the use of ICTs in geography instruction, while the second (multiple choice) focused on student perceptions of the practical application and usefulness of knowledge about educational technologies in everyday life.

- *Data processing.* The data were processed in the SPSS 11.5 statistical package and appropriate statistical procedures were applied. In the descriptive part, in addition to frequencies and percentages, the mean (M) and standard deviation (SD), depending on the nature of the variables, the *t*-test was used to determine the significance of the differences among groups. The answers to the open-ended questions were coded according to the categories defined in advance.

Results

The research results indicate that over half the students (57.1%) had been given the opportunity to acquire knowledge about new educational technologies in geography lessons and, in this respect, there is no difference among them as regards their academic achievement (M_1=4.56, SD_1=.603, M_2=4.71, SD_2=.498,

t=-1.527, p<.129). Table 2 lists the technologies that students learned about and applied in their geography lessons.

Table 2: Distribution of student answers on the application of new technologies in geography classes

Educational technologies		N	M	SD	Significance of differences
GIS	yes	59	4.56	.623	t=-1.262, p<.209
	no	64	4.69	.500	
Digital map	yes	14	4.07	.616	t=-4.078, p<.01
	no	109	4.69	.522	
Auto CAD Map and Geomedia Professional 3.0	yes	4	5.00	.000	t=1.373, p<.172
	no	118	4.62	.553	

Table 2 shows that out of all the mentioned educational technologies, the GIS figures as one of the most often used in geography lessons. There was no significant difference in knowledge about the GIS among students with different levels of academic achievement. Although almost half of the research participants are familiar with the GIS, only 37.3% of the respondents were able to define this concept and place GIS in the service of cartography. Out of 37.3% of those students who were able to define GIS, 34.9% could also list its basic elements. Bearing this in mind it can be said that around one third of the students in this research are aware of the GIS as a new educational technology, which contributes to the development of students' functional geographic knowledge and skills during the teaching process.

It is quite obvious from the afore-presented table that GIS software packages such as Auto CAD Map and Geomedia Professional 3.0 are not used in geography lessons in the Serbian schools that participated in the research. These findings are similar to those from other countries in our region, such as Bulgaria or Hungary (Klonari et al., 2009). The situation is slightly better when it comes to using digital maps as a teaching aid. Those students who used digital maps were given the task of locating a county, place, town or street. A statistically significant difference was found in using digital maps with respect to academic achievement (t=-4.078, p<.01).

Somewhat less than half of the students (47.7%) say that, in addition to the already mentioned techniques, they also had had the opportunity to learn more about GPS in geography lessons as a technique for collecting data in the field. Satellite remote sensing, used to acquire information about the Earth's surface without making contact with the explored objects, was studied in geography lessons in the case of 38.3% of students.

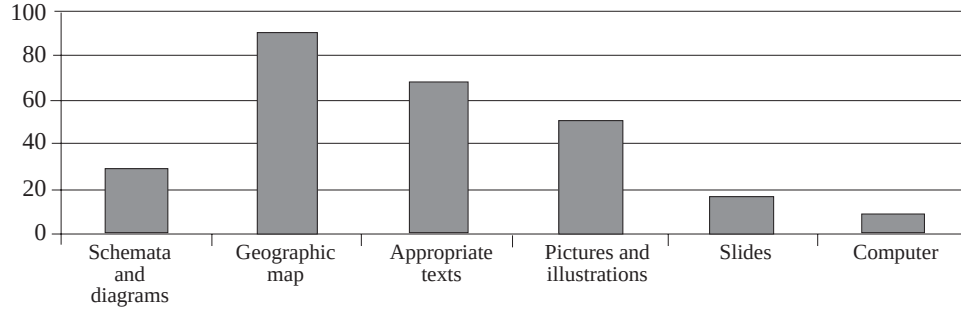
Although computers are considered to be widespread and an irreplaceable means of communication in the computer era, their use in schools is still not frequent enough for the purposes of education. Similar problems occur in other developing countries (Demirci, 2008; Scheepers, 2009) and even in some developed ones (Klonari *et al*., 2009). For example, in our research, more than two-thirds of students stated that they used computers as a teaching aid in geography lessons extremely rarely or not at all. This is a fairly large obstacle to incorporating the GIS into the teaching process, which is practically non-existent in developed countries (Klonari *et al*., 2009). A computer is a constantly available teaching aid with a clear didactic purpose for less than 10% of the students in our research sample, as presented in Table 3.

Table 3: Distribution of student answers on computer use in geography classes

Computer use in geography classes	Frequency	%
We do not use computers	72	57.1
We use computers very rarely	18	14.2
We use computers often	25	19.8
We use computers all the time	11	8.7
Total	126	100

Since computers are a necessary precondition for applying and learning to apply new educational technologies, it becomes clearer why the latter are scarcely present in Serbian secondary schools, although some studies show that modern school equipment does not necessary imply great GIS breakthrough (Kerski, 2003). Despite the rare use of computers as didactic aids in geography instruction, most students (86.7%) say that they expand their geographic knowledge via the Internet at home, friends' homes or Internet clubs.

The respondents estimate that learning new teaching content in vocational secondary schools mostly takes place through teacher lecturing (48.1%). Along with this dominant teacher lecturing and frontal teaching, new material in geography is also acquired using analogue maps (91.3%), appropriate texts (69.1%), pictures and illustrations (51.5%) as well as schemata and diagrams (30.1%), and occasionally by means of slides (17.4%) and computers (8.7%), which is shown in Histogram 1.



Histogram 1: Most frequently used teaching aids in students' estimate

The majority of students who have used new educational technologies in geography lessons say that, first and foremost, these meet their own interests (25.2%), and then that they make a considerable contribution to a more successful acquisition of geography knowledge (21%), while they also think that knowledge about new educational technologies and the skills for their application would be beneficial in everyday life and for further professional development (10.9%). Today, most geographic maps for various purposes are manufactured in digital, and not analogue (paper) format, which implies that mastery of using digital maps, i.e. the basics of the GIS, is something necessary for everyday life, and can be especially important for one's future profession as well. The following were recognised by students as the advantages of applying new education technologies in the function of everyday life and further professional development: faster information accessibility (44.4%), minimising data quantity (21.2%), better offer of information and services (18.3%), as well as the contribution in predicting and decision making (deciding) (16.1%). The students' opinions on the advantages of using the GIS in geography instruction are presented in Table 4.

Table 4: Student opinions on the advantages of using the GIS as a teaching aid

Advantages of using GIS in geography classes		N	%	Total	
Interactivity	yes	59	95.2	62	100%
	no	3	4.8		
Development of cartographic skills	yes	60	96.8	62	100%
	no	2	3.2		
Problem-oriented learning approach	yes	54	87.1	62	100%
	no	10	12.9		
Systematic and precise	yes	46	74.2	62	100%
	no	16	25.8		

The table shows that the use of the GIS in geography classes means most to students because of the possibility of developing cartographic skills – which is in accordance with the basic function of this information system – since cartographic skills are among the key geographic skills that students should develop. The interactive learning approach is another important component of the GIS singled out by students, which may be an expression of the need for the modernisation of teaching, as well as an indication of the students' wish for a more active role in the teaching process. Problem-based learning also makes the GIS an attractive technology which does not provide ready-made and processed facts but, instead, activates students' higher mental functions for the purpose of solving a given task. The systematicity and precision offered by the GIS, which facilitates the understanding of regularities in thematic maps, are recognised by most students as an important characteristic and advantage of its use.

Conclusion

This paper was aimed at determining whether ICT is applied in the geography teaching process in vocational secondary schools in Serbia. The research findings show that the GIS was singled out from the other offered ICTs as one of the new and most mentioned education technologies. However, although the majority of students stated that they knew what the GIS represented, only one third of them have the knowledge and skills to use this technology in practice. The largest portion of the geography teaching process is based on oral presentations and frontal teaching with the usage of less innovative didactic aids (analogue maps, texts, etc.). If we bear in mind that Serbian society is passing through a very turbulent transition process, which has great repercussions on all spheres of life, it can be concluded that, according to the research results, the involvement of the GIS in secondary schools is satisfactory. This statement can be supported by the fact that computers are rarely used as a didactic aid in geography lessons and there is very little hardware support for the implementation of the GIS in the classroom. However, since most students stated that they have access to the Internet and computers outside school, it can be argued that, with adequate teachers' instructions, the GIS could play a more active role in the teaching process in the future. The teacher's role should be to direct students towards genuine sources of information and data and to help them in the process of self-directed learning.

Hence, if all circumstances are taken into account, our final conclusion would be that the use of the GIS in geography teaching in Serbian secondary schools is still in the initial stages of implementation. This conclusion implies the necessity of a systematic approach to the introduction of ICT into Serbian schools. In this sense, it is necessary to train teachers about the possibilities and obstacles involved in using the GIS in schools. This can be achieved through initial teacher training at university level or later, through professional teacher training. In addition, international experience with the use of the GIS in schools, students' interest in it, as well as some examples of good practice could also be useful. Our research has shown that students perceive the GIS not only as a great potential for cartographic skills development, but also as a teaching aid in the interactive problem-oriented learning process. From the standpoint of knowledge recipients, the GIS places students in the position of active creators in the knowledge process and increases their personal geography competences.

Endnote

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