GIS in Teacher Education – Facilitating GIS Applications in Secondary School Geography

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Geographical Information Systems (GIS) have not yet been widely introduced to secondary school geography education in Finland. However, in the outline of the new national curriculum for upper secondary schools, GIS is incorporated into the elective, advanced geography course. The Finnish universities will therefore face new challenges in reconstructing their degree requirements for geography teachers in the future. GIS applications may help teachers to facilitate the implementation of constructivist and inquiry-based learning environments at secondary schools. Despite its potentials, many secondary schools in Finland still lack the resources and know-how required to use GIS in education. This paper shows the findings of a questionnaire survey focusing on in-service geography teachers at upper secondary schools in Finland.

1. Introduction

The educational use of Geographical Information Systems outside the universities and institutes of higher learning has been limited until now. One of the many reasons for this has been the absence of GIS from the National Curricula. Its novelty and unclear legal requirements have not encouraged secondary schools to adopt GIS in the classrooms. In the National Curriculum for England and Wales, for example, GIS was mentioned for the first time in 1991 but without any major effects on educational practice it disappeared from the Statutory Orders by 2000 [1]. The educational use of GIS in secondary schools has been widely promoted in the United States of America but according to Joseph Kerski [2], less than 1 % of the high schools are now using GIS technology in teaching there.

GIS in education is currently a topical issue in Finland, too. The National Board of Education is reforming the National Curriculum for upper secondary schools and produced an outline in 2002. In that outline, GIS is incorporated into geography course number four which is an elective, advanced course on regional studies. During this course the students conduct a regional study focusing on a selected area. Among other methods, GIS is used as a tool to collect regional data and produce thematic maps. The students are expected to learn the basics of GIS and cartography, understand the potentials of different GIS applications, and to be able to process,
interpret and visualize geographical data with Geographical Information Systems [3]. These reforms will have an effect on the teaching and degree requirements of the Finnish universities and teacher colleges educating pre-service geography teachers. There will also be a growing demand for in-service training of geography teachers nationwide. The legally binding status of GIS in the new Curriculum for upper secondary schools obliges the Finnish schools to provide an advanced geography course for any student willing to participate in it. This places considerable pressure on schools to acquire sufficient know-how and equipment for the implementation of these new requirements during the autumn term 2005.

GIS in secondary school education is a new topic in Finland and there are few schools and teachers who have used GIS in the classrooms earlier. In order to face these challenges, the Department of Geography at the University of Helsinki in Finland established a pilot project called ‘Geographical Information Systems in Teacher Education’ in 2001. The aim of this project is to facilitate the use of GIS in secondary school geography by providing training to both pre-service and in-service geography teachers. The project cooperates with an upper secondary school in the municipality of Hausjärvi in Finland where GIS data is collected, processed and tested in real geography lessons with local teachers. In addition, the project studies the implementation process of GIS education in the collaborating school and reports its findings and results on the Internet so that other universities and teacher colleges in Finland can use these findings, too. The pilot project has carried out a questionnaire study of the readiness of the Finnish upper secondary school geography and biology teachers to use GIS in their lessons. This paper is based on the findings and preliminary results of this questionnaire study.

2. The Pedagogical Potentials of GIS in Secondary School Geography Education

The recent emphasis on pedagogy focuses on a shift from a behaviorist to a constructivist approach in learning. Problem-Based Learning (PBL) and Inquiry-Based learning are instructional methods, which are based on constructivism and are challenging the customary methods used in secondary schools. Students’ roles are changing from passive recipients of geographical information to active members of an interacting group, which processes and interprets geographical information on real-world issues and collectively builds up knowledge through inquiry and reflection. Similarly, teachers’ roles are changing too. They will not be the sole source of information anymore as the students are encouraged to use the Internet and construct their knowledge on the basis of sources which provide information outside the narrow framework of textbooks and paper maps. Rather, the teachers will become instructors who will guide their students to the right sources and provide them support and motivation in the process of self-directed learning.

GIS has the potential to facilitate PBL and Inquiry-Based learning if the techniques are incorporated into secondary school curricula. Many previous studies and papers support this view, e.g. Baker [4], Keiper [5] and Wiegand [1]. GIS may foster a resource rich environment, enhance spatial reasoning and support problem solving in
the classroom. In addition, the proper implementation of GIS instruction may promote geographic competence and interdisciplinary learning in the classroom [4]. Parallel to the use of other Information and Communication Technology (ICT) in education, also GIS provides the students with experience and technical know-how, which may be beneficial for their future job opportunities. Goodchild and Kemp (1990) argued that the use of GIS in the secondary schools would motivate the students to choose careers in science and engineering [5].

The advantages of GIS seem to be enormous to geography education if harnessed correctly. Unfortunately theory and practice are hard to reconcile in real life. The teachers must continuously cope with limited resources and availability of time when planning and implementing their lessons. Meyer et al. [6] pointed out some key issues which were considered obstacles to using GIS in the schools. Among these issues were limited access to and availability of hardware and software, time constraints and inadequate skills in technology and geospatial ideas and data. Bednarz et al. mentioned three obstacles to the widespread integration of GIS into geography education. They likewise mentioned the lack of software and data as the first constraint. The second was the lack of teacher training and curriculum materials, and the third were the systematic barriers to encouraging innovation in education [7].

3. Research on the Readiness to Use GIS in the Classroom

In September 2002, I carried out a questionnaire survey to find out the readiness of Finnish upper secondary school geography teachers to use GIS in their curricula. I sent an e-mail invitation to participate in the survey to 219 teachers in 163 upper secondary schools whose e-mail address was found from the list of homepages of Finnish upper secondary schools maintained by the National Board of Education. They were asked to fill out a questionnaire on the Internet. In the case of 117 upper secondary schools, the invitation was sent to one teacher only but for the rest of the schools the number of teachers receiving the invitation varied between two and four. Apart from two schools, there was only one filled out questionnaire per school. 21 teachers did not receive this invitation because their e-mail addresses were out of service or they no longer worked in the school. One teacher refused to fill out the questionnaire because there was no fee for that. The sample therefore consisted of 198 upper secondary school geography and biology teachers in 149 schools across the country.

A total of 69 teachers filled out the questionnaire in time, a reply rate of 34.85 per cent. These teachers represented 65 upper secondary schools in Finland (figure 1). I got replies from eight upper secondary schools from Helsinki, four from Tampere and two each from Vaasa, Rovaniemi, Joensuu, Jyväskylä and Turku. The other places on the map were each represented by one upper secondary school. The results were encouraging as eight teachers in eight upper secondary schools from my sample (11.59 per cent) mentioned that they had already used GIS in the classroom. The concept of GIS covers here a wide array of different software and Internet-based services. Three teachers were using desktop GIS while the rest were using a cd-rom
Fig. 1. Location of survey respondents by number of upper secondary schools returning the questionnaire.

database or Internet browsers to visualize maps and attribute data in the classrooms. The location of these schools is shown in figure 2. The upper secondary school in Hausjärvi currently co-operates with the "GIS in Teacher Education" pilot project and uses the computers and software provided by the University of Helsinki. In spite of its novelty, 14 respondents (20.29 per cent) said they have used GIS software earlier during in-service training courses or at their work. Those teachers who are currently using GIS in their teaching mentioned that GIS is mostly used for map visualization and making thematic maps for the students. They have used GIS in the advanced geography course. Three schools are currently using MapInfo program but the other schools do not have any GIS software installed. They used different web based services to view maps and GIS data. These free programs installed from the Internet do not provide any analysis tools for geographical data and one teacher said that they have plans to visit the university nearby to be able to use the full versions of GIS software with the students. Most of the respondents (about 57 per cent), however,
mentioned they have never even heard of GIS before (figure 3.) Although most of the teachers were not familiar with GIS technology, they were given some information on it in the introductory letter and were asked to mention the biggest obstacles in using GIS at their school. About 26 percent of the teachers did not answer the question, but the teachers who answered mentioned one or more obstacles that often overlapped in their questionnaires. The reasons for not using GIS mentioned by the Finnish teachers were quite similar to the ones mentioned by the American teachers in the national assessment of GIS in American High Schools carried out by Joseph Kerski (2001)[2].

In Finland, lack of in-service training was mentioned as the biggest obstacle by one fifth of the respondents (figure 4.). This was followed by lack of funds for schools and lack of computers and classrooms suitable for GIS use. Lack of time was only mentioned by 12 per cent of the teachers. The poor availability of software and ready-to-use teaching materials also came up in their answers. The teachers often mentioned that the reasons for not using GIS are interlinked, especially in the case of school resources. Most upper secondary schools do not have enough funds to obtain updated GIS software or build new GIS labs or classrooms for computer-assisted geography education. The existing classrooms equipped with computers are often fully used in computer education.
Fig. 3. Teachers’ knowledge of GIS according to the questionnaire survey in 2002.

Generally, the teachers had a positive image of using GIS in geography or biology education. 33 teachers (47.8 per cent) shared a positive image towards the incorporation of GIS into the curriculum. Eight teachers (11.6 per cent) shared a neutral image on the issue and 11 teachers (15.9 per cent) did not answer to the question at all. Almost one fourth of the teachers (24.6 per cent) shared a negative image of using GIS at schools. These 17 teachers provided several reasons for their choice. Most of these reasons were the same as depicted in figure 4. Some teachers questioned the cost-effectiveness of using GIS at schools. Also the high price of the software provoked opposition among the teachers with negative images. Some

Fig. 4. The issues considered as an obstacle to using GIS at schools.
teachers were worried about the computerization of geographical education and said that paper maps are often more useful than desktop mapping. The teachers were also doubtful of the additional value of GIS in upper secondary school geography education.

I studied the readiness of teachers to incorporate GIS into their curriculum and their insights of its use in future with 15 statements. They were asked to fill out a Likert-style questionnaire and choose from four options that would best correspond to their own opinion on each statement. The results presented in table 1. indicate that teachers are not yet familiar with GIS. The “I do not know” option was often chosen when GIS was mentioned in the statement. However, half of the teachers agreed or strongly agreed that GIS enhances student problem solving. Even more teachers (56 per cent) agreed or strongly agreed that GIS enhances student spatial thinking. According to the study, teachers are willing to use new educational methods and support inquiry-based learning. Most schools have modern computers available and are eager to invest in

Table 1.

The readiness of teachers to use GIS was studied with these detailed statements. Table shows the percent of responses.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>I do not know</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am proficient with the most common software (Word, Excel, graphics and browser).</td>
<td>25</td>
<td>30</td>
<td>0</td>
<td>42</td>
<td>3</td>
</tr>
<tr>
<td>Our school has modern computers.</td>
<td>61</td>
<td>23</td>
<td>0</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Our school invests in new educational technology.</td>
<td>33</td>
<td>36</td>
<td>1</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>I know the sources of digital GIS data suitable for my curriculum in the Internet.</td>
<td>3</td>
<td>4</td>
<td>10</td>
<td>31</td>
<td>52</td>
</tr>
<tr>
<td>GIS is easily incorporated into my curriculum.</td>
<td>10</td>
<td>12</td>
<td>46</td>
<td>19</td>
<td>13</td>
</tr>
<tr>
<td>I do not have enough time to learn new educational technology.</td>
<td>17</td>
<td>35</td>
<td>1</td>
<td>41</td>
<td>6</td>
</tr>
<tr>
<td>I encourage my students to adopt the ways of inquiry-based learning.</td>
<td>37</td>
<td>54</td>
<td>3</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Excessive teacher-centrality should be avoided in the classroom.</td>
<td>39</td>
<td>45</td>
<td>0</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Apart from textbooks, I often use additional curriculum materials.</td>
<td>44</td>
<td>46</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Field trips are an essential part of my lessons.</td>
<td>13</td>
<td>12</td>
<td>0</td>
<td>49</td>
<td>26</td>
</tr>
<tr>
<td>I want to introduce more sophisticated educational methods.</td>
<td>63</td>
<td>32</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>GIS enhances student problem-solving.</td>
<td>21</td>
<td>29</td>
<td>49</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>GIS enhances student spatial thinking.</td>
<td>31</td>
<td>25</td>
<td>39</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GIS will be an integral part of geography education in the near future.</td>
<td>16</td>
<td>25</td>
<td>30</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>I often use cross-curricula themes and examples in my lessons.</td>
<td>49</td>
<td>39</td>
<td>1</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>
new technology. The fact that 45 per cent of the teachers said that they are not proficient with the most common software may partly explain why one fourth of them had negative image of using GIS at school. It would mean the need to learn some other computer software and for those teachers who are not experienced with computers such a learning process would bring an extra workload. This must be kept in mind when in-service training on GIS is organized for teachers. One important finding was that even though over 97 per cent of the teachers used the Internet in their lessons to search for additional data (statistics and reports), most of them were not aware of applicable GIS sources on the net. The availability of time to learn new educational tools seems to be a problem for 52 per cent of the teachers.

4. Implications and Conclusions

The questionnaire study revealed that the Finnish upper secondary school geography teachers’ knowledge of GIS and its usability in the classroom is not very good. Most of the teachers in the survey were not familiar with GIS technology and had not received any in-service training on its use in education. There will be a huge demand for GIS training for in-service geography teachers once the New National Curriculum is accepted. The universities and teachers colleges will have to provide the teachers an in-service training which clearly underlines the potentials of GIS in the classroom and avoids the use of unfamiliar exercises and data. Teachers do not feel that GIS is easily incorporated into their curricula and in-service training therefore must focus on the pedagogical rather than technical part of GIS. This brings us back to the core of GIS education. Daniel Sui argued in 1995 that GIS education involves two aspects, namely how to teach about GIS and how to teach with GIS [8]. Both aspects must be present in in-service teacher training. Thus before they become motivated and ready to invest time and money in learning this new educational technique they should be convinced that GIS is not just a top-down implemented experiment, but rather a tool which really brings added value on geography education. Thus the trainers should focus on the issue ‘How to teach geography with GIS?’

A central issue in the facilitation of GIS applications in secondary schools is the availability of GIS software and data. Most upper secondary schools in Finland have modern computers that can be used to acquire GIS data and view thematic maps via the Internet. The teachers are experienced in using the Internet in their lessons so it would be a natural way to introduce basic GIS applications to them. Currently, only a few teachers know where to obtain GIS data on the Internet. There are many sources on the Internet providing free GIS data and shared software for the schools. The first steps in using GIS in the classroom could be taken with the help of these materials and the need to obtain licences for desktop GIS programs for the schools may be estimated later when the proficiency of teachers with GIS improves.
References