EXPERIMENTAL TEACHING SOCIAL STUDIES WITH GIS AT JUNIOR HIGH SCHOOL

Dimitrina Mikhova*, Noboru Sadakata*, Keiji Misumi** and Yukio Yoshikawa*

(Received October 1, 2004)

Abstract. *This paper describes a pilot research on using GIS in teaching Social studies at Junior High School. Observations suggest that GIS can be successfully introduced and learned by students in conjunction with meeting the nationally established academic learning requirements. A survey conducted with the students proves their openness to the constructive way of learning with the use of GIS and further work in this field would be justified.*

1. INTRODUCTION

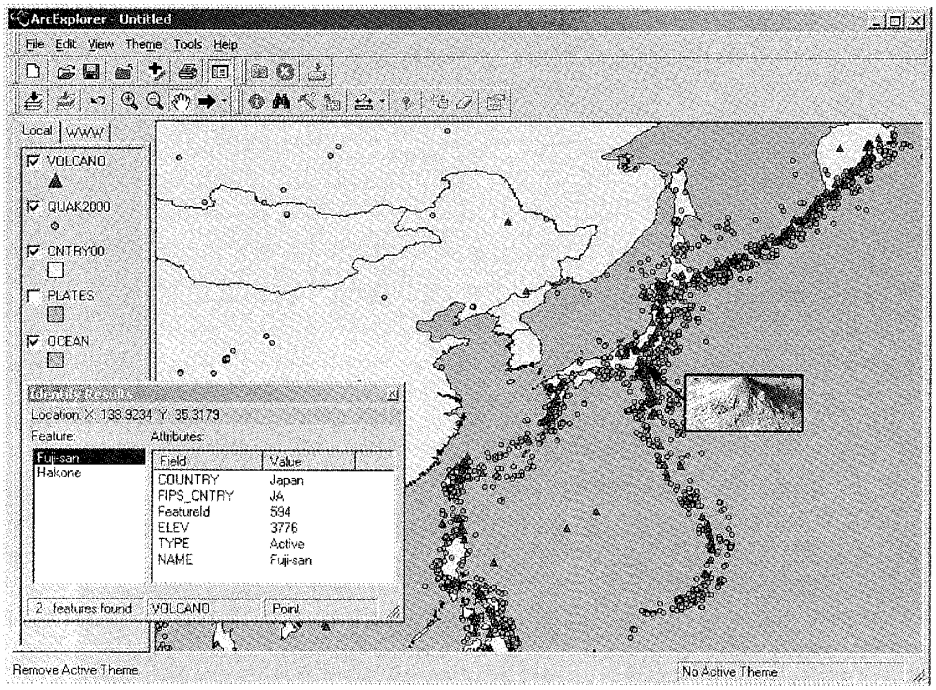
The wide spread of GIS (Geographic Information systems) applications in secondary education in many countries require more detailed research on both the effectiveness of this way of teaching and student's attitude to it. A research team from the Faculty of Education of the Yamaguchi University explored the current state of using GIS in the teaching process in Junior high schools both worldwide and Japan. Based on the positive reports of such applications, the team set up a goal to undertake a research on the feasibility of such an attempt in the current local secondary school environment. An experimental lesson with the use of GIS was designed and held at the Yamaguchi Junior High School. Exploring the Social Studies curriculum and taking into consideration the available GIS software and data, a lesson about Natural disasters (1^{st} grade) was selected for this pilot project.

2. THEORETICAL BACKGROUND

2.1. What is GIS?

GIS (Geographic Information System) is a computer mapping technology that allows the user to create and interact with a variety of maps and data sources. GIS integrates databases with geographically referenced spatial data (maps). GIS allow users to select, query, overlay graphically and analyze physical and social features of our world in an integrated display. It offers capabilities similar to modeling: the power to identify and manipulate elements of complex systems. As such, teaching with GIS provides a specific and rich learning environment. Fig. 1 represents one simple example: Mount Fuji can be

* Faculty of Education, Yamaguchi University
** Yamaguchi Junior High School, Yamaguchi University



found on the map, then identified with its most important characteristics, and even its 3D representation or picture can be brought to the screen.

Fig.1. A screenshot displaying earthquakes, volcanoes in Eastern Asia, using GIS, as well as identifying Mount Fuji with the available information about it in this database and its 3D representation

2.2. The Inquiry method of teaching (Constructivism) and GIS

Today, with the rate at which knowledge advances, the power of telecommunications, computers, etc., we begin to realize, that traditional instruction is becoming more ineffective than ever before. Educators worldwide have been switching gradually to a model of instruction that emphasizes hands-on, research based learning experience in the classroom, typically called Inquiry. As a method of instruction, inquiry is referred to in learning theory as Constructivism. It is interpreted in the field of education as learning methods, where students construct their own knowledge, under the guidance of a teacher. With the inquiry approach to teaching and learning, students themselves formulate research questions, gather background data, choose a methodology for answering the questions, analyze the data, and finally draw conclusions based upon those experiments (Hassard, J., M.Dias, 2003)

This method of teaching is not commonplace; in fact it is very rear, since it is not an easy task to orchestrate it. The teacher should be aware of many aspects of preparation:

- He/she should be comfortable with the subject taught and scientific investigation;
- Should be comfortable with the learning environment, which often consists of diffeent tools such as computers, lab equipment, etc.;
- Should be careful in directing the students in the process of their research, because in this unusual learning setting, when everybody is doing their inquiry by their own pace, the process of learning might drift away from control.

2.3. Why teaching with GIS

GIS is an interdisciplinary technology tool that creates a teaching environment, in which the Inquiry educational approach can be applied naturally. Bednarz (2004), comparing the characteristics of Constructivism and the characteristics of GIS shows vividly, that there is a clear link between them and studying with GIS meets fully the constructivist idea of teaching:

Table 1. Constructivism compared to geographic information systems (Bednarz, 2004).

CHARACTERISTICS OF CONSTRUCTIVISM	CHARACTERISTICS OF GIS
Students construct knowledge.	Students construct knowledge through building databases, maps.
Students discover relationships through experience.	Students explore spatial relationships through mapping.
Students learn in complex, authentic situations.	Students learn from real-world data and places.
Students manage their own learning.	Students guide themselves, identify relationships through exploring data.
The process of learning is as important as the product.	GIS is a tool to explore.

GIS offers opportunities for using in teaching many academic subjects at the same time, or carrying out interdisciplinary projects. There are many aspects of social studies, science, mathematics, environmental studies and other curricula that GIS can help students learn and explore. The important part is to have a location or series of locations to explore and relate them to the curriculum.

With GIS **higher order thinking skills** can be acquired. Students can understand better spatial relationships that are found in their world. Spatial analyses, such as location selection, environmental problems, changes over time, etc., can be successfully carried out with the use of GIS in the classroom.

GIS introduces students to a **new way of seeing, thinking, and interacting with the world** around them. Using GIS, students explore a course contents in a way that enhances logical, mathematical, linguistic, spatial, and interpersonal intelligences. Developing GIS projects improves critical thinking skills such as analyzing, synthesizing, and evaluating. Learning about GIS in a structured setting is beneficial not only in developing **computer literacy** but also provides training in the process of research including gathering, preparing, storing, and analyzing data and presenting the results of analysis using a variety of methods. These are skills valuable in both academic and business settings.

GIS provides a framework for learning other academic disciplines. In addition to interacting with data in a new way, students learn teamwork because GIS projects typically

require a high level of cooperation.

2.4. Getting GIS into the classroom

In order to introduce GIS into the classroom, several steps of preparation are required:

- To provide computer(s). Depending on the specific approach, the number of com puters used may vary.
- To provide appropriate GIS software. This is a problem of many aspects, which we will not tackle in this paper. But we should mention, that it requires a lot of efforts and money. Of additional problem is the fact that most free or low-price software packages are in English, which puts additional stress to Japanese users aiming at using GIS in education. The authors have already encountered a lot of difficulties in this respect, some of which have already been resolved for future applications.
- To provide for teacher's prior education, from two perspectives: how to use the particular program and how to set up a lesson using GIS.

There are different models of using GIS in the classroom. According to Sui (1995), there are two models of teaching GIS:

- **Teaching *about* GIS.** This is instruction, which focuses on GIS as a technology. The emphasis is placed on technical aspects of GIS such as data handling and information management.
- **Teaching *with* GIS**, which emphasizes the process of geographic inquiry and learning to think spatially.

We would like to add, that these models could be applied in many different ways including using them both in the same class. Before applying them, the first practical step might be to use GIS in class as a demonstrational tool for showing both: possibilities for geographic inquiry and the teaching potential of the system.

3. APPLICATION OF GIS IN A PILOT LESSON ENTITLED "PLATE-TECHTONICS, EARTHQUAKES AND VOLCANOES AND THEIR SOCIAL IMPACT".

A lesson using GIS was taught at the Yamaguchi Junior High School, affiliated to the Yamaguchi University. This lesson covered the material relating to the 1st grade textbook in Social studies and concerning natural disasters. Thirty-nine students participated.

3.1. Lesson design

This lesson had the following targets:

- To make students understand the impact of natural disasters, such as volcanoes and earthquakes on people's life.
- A specific point was to draw student' s attention on the fact, that Japan, their own homeland, is among the places in the world most endangered by these natural disasters.

- To make a connection between the occurrences of these natural disasters and the Earth structure (plate tectonics), as well as the association between them.
- To draw students' attention on the possibilities of GIS for demonstration, analysis, making decisions, research and management.

3.2. Software, hardware, preparation

The ESRI ArcView GIS software was provided, as well data relevant to the lesson, such as maps, tabular and picture data about the World and Japan. Some ideas about teaching with GIS were used from the book "Mapping our World" (Malone, L., A. Palmer, 2004) but duly adapted to the particular application. Team members' prior expertise in teaching Introduction to GIS at University levels also proved to be valuable.

3.3. Difficulties and problems

- Since it was the first attempt to introduce GIS in the classroom in this school, an array of problems occurred of different character: educational, technological, linguistic, etc. Students' exposure to computers was not known and this brought to the decision of using GIS in this particular case basically for demonstration, with a brief explanation of other GIS functions.
- There is practically no time within the curriculum to dedicate to studying the GIS program itself.
- Since GIS software is basically expensive, a lot of work and organization is needed to provide it for class use with many license copies. This experimental lesson was the first attempt, envisaged by the authors as a trial to introduce GIS in the local Junior High School. It was decided that according to the results and the effectiveness of this first trial, further steps would be taken towards provision of more license copies, to allow individual work of students.
- Another reason for using GIS only to the level of demonstration was the linguistic problem: the ArcView copy and data to it were all in English. Students from 1st grade of Junior High School were not yet prepared to work with so many terms and names in English. In the future, provision of a Japanese version of ArcView is envisaged, but they were not ready for use for this particular experimental lesson.
- The authors looked at this first experiment as a beginning point, the evaluation and strict analysis of which would offer ideas for further development.

3.4. Lesson implementation

The lesson was carried out in the usual school environment and following basically the standard procedure of a typical lesson in Social Studies. The new element was using GIS as a dynamic means to demonstrate the teacher's key points. In addition to conveying the basic material about earthquakes and volcanoes as natural disasters and the need of knowledge how to cope with them, the teacher had to stress on several key points, for which GIS offered an indispensable help.

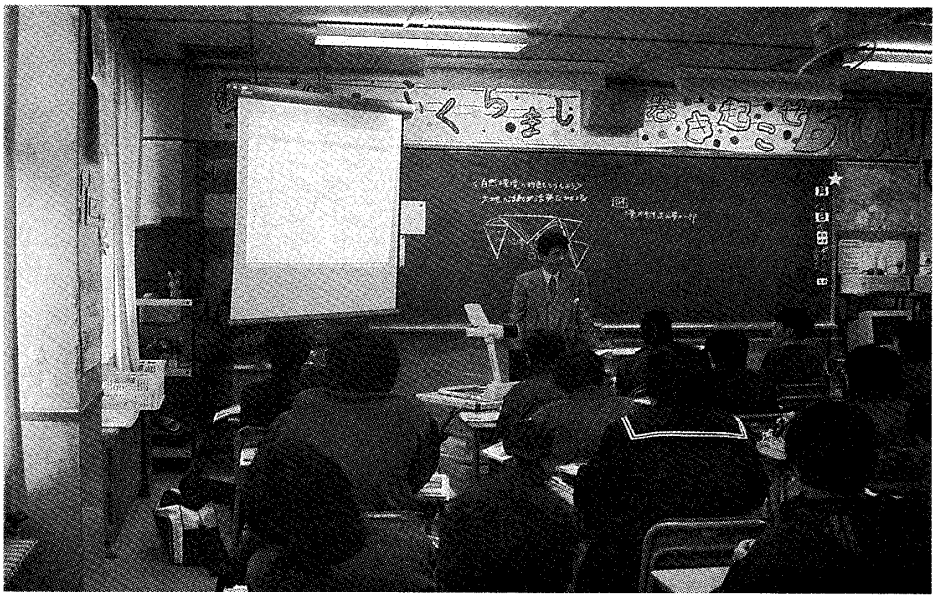


Fig. 2. The Social Science class using GIS

a. What is the relationship between earthquakes, volcanoes and tectonic plates?

Showing sequentially the maps of earthquakes and volcanoes one by one, and them together helped the students understand their close spatial connection. Then explaining plate tectonics and superimposing the map of tectonic plates brought to the immediate understanding of their relationship. Adding a space image supplemented the picture to a real sensation of the earth setting (fig.3)

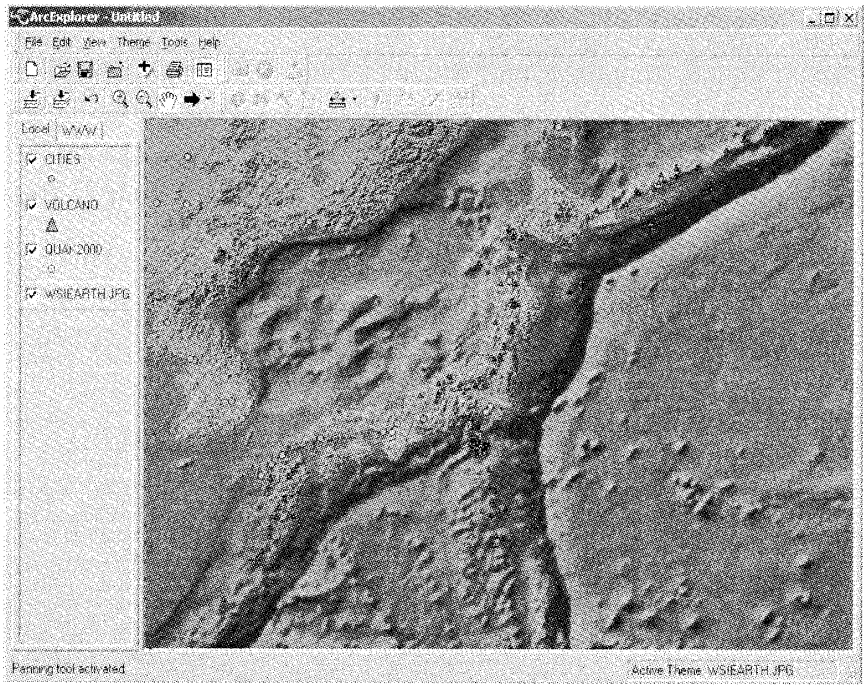


Fig. 3. Screenshot of earthquakes, volcanoes, tectonic plates and major cities covering the region of Japan. The same elements can be shown for any part of the world.

Meanwhile while explaining this relationship and using GIS the teacher tried to explain the basics of GIS and its capabilities. Compared to other examples of using GIS in class throughout the world, this time was extremely limited. In order to make students understand well the basic features of GIS and how they can use it (not only in the class environment), at least one special lesson should be dedicated. If this time is found, later on it will pay off, since the students would be able to do their own research on different problems.

b. What is the relationship between the lines of earthquakes, volcanoes, population densities and big world cities?

Brining the world map of population densities, the map of major cities, the map of earthquakes and the map of volcanoes created a vivid picture of the situation where and what number of population in the world could be endangered by these natural disasters (fig4).

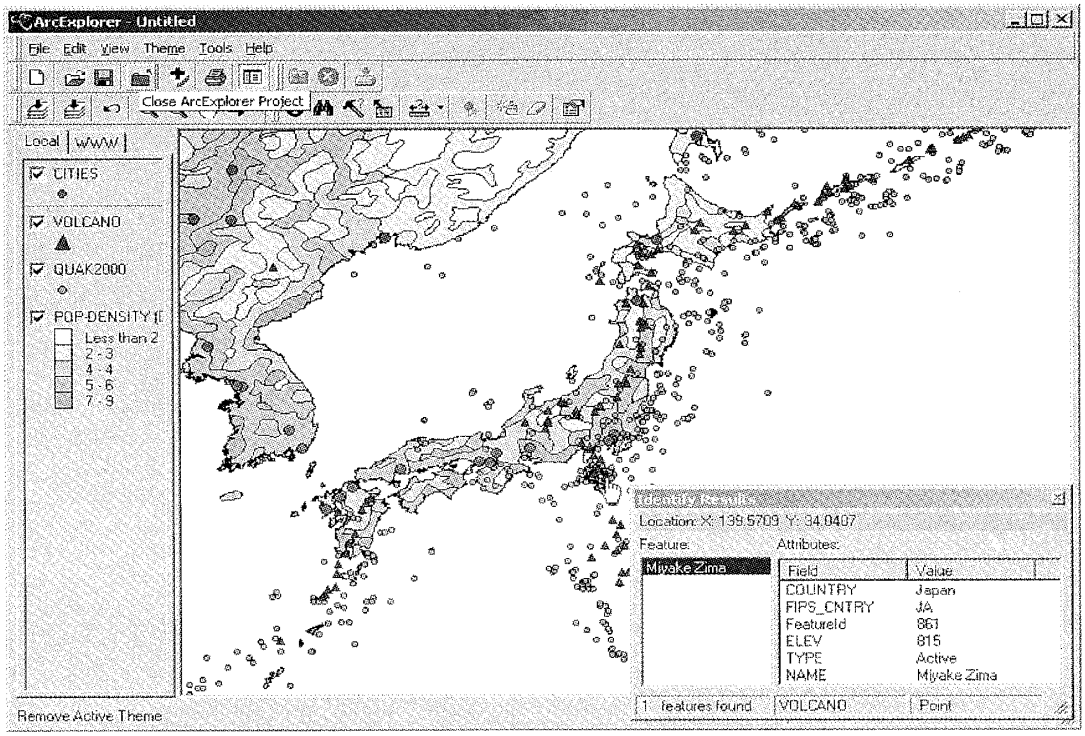


Fig. 4. Screenshot of the combined map of population density, major cities, earthquakes and volcanoes.

c. A major point that had to be tackled was the place of Japan compared to other regions in the world, as far as danger from earthquakes and volcanoes was concerned. Using the GIS database that was an easy task to achieve (fig.5).

These examples and many others, relating to the lesson show, that using GIS as a demonstrational tool has its high merits. But in order to reach a point when the real constructive method of teaching is implemented, a long way further should be gone, requiring a lot of efforts and organization.

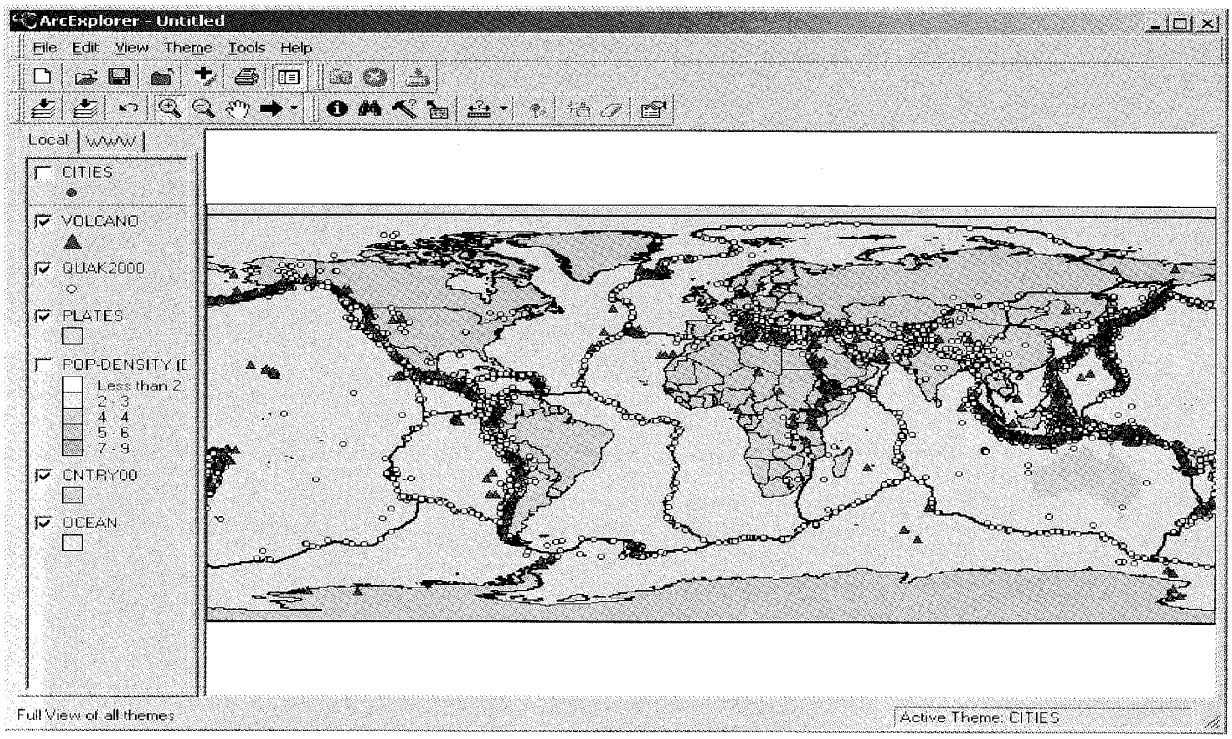


Fig.5. The plate tectonic boundaries and occurrences of earthquakes and volcanoes.

3. After the lesson, a survey was carried out with the students, to get information in several aspects:

• Student's exposure to computers and their willingness to use new technological tools in the process of learning. How and where do students get help in learning new technologies.

• To what extent GIS helps in this particular case in mastering the study material.

• What is the general attitude of students to using GIS in class?

This information was necessary to draw some constructive conclusions about future work in introducing GIS in class. 39 students were surveyed: 19 boys and 20 girls. The survey was carried out right after the class.

4. SURVEY RESULTS

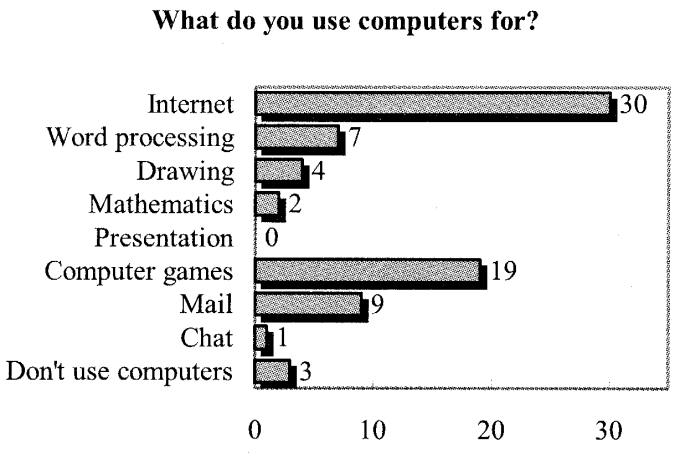


Fig. 6. Tasks for which students use computers

4.1. Since working with GIS requires previous exposure to computers, the first group of questions aimed at finding out students' readiness, attitude and willingness to work with computers in class in the process of learning. 75% of the whole class use computers for navigating Internet (fig. 6). 45% use them for playing computer games. Remarkably small number use computers for writing (35%).

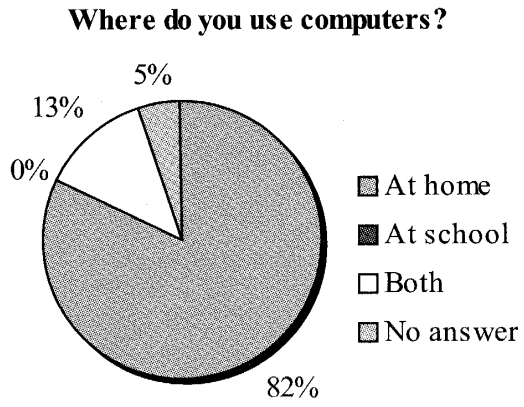


Fig. 7 Place of using computers

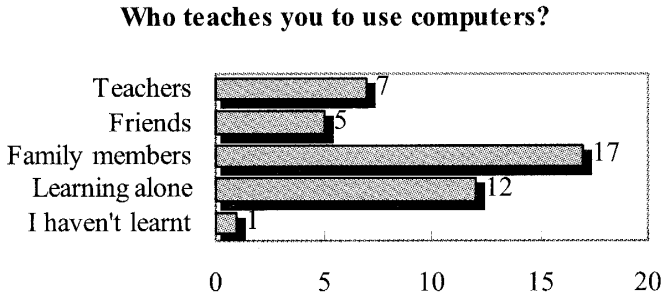


Fig.8 Where students get help in learning computers

The fact that 25% of the students do not use Internet shows, that the school curriculum does not suggest options of using it for individual research on wide bases. Nowadays in order to include more constructivist elements in teaching, skills of Internet navigation are a must. Obviously more thought should be given to teaching how to use computers and Internet at school.

This idea is supported by the information about where computers are used (fig 7). Most of the students in the experimental class use computers primarily at home. The total percentage of children using computers at school is not very big-around 15%. It is basically boys that use computers at school or both school and home.

In relation to the fact that students use computers mostly at home, it is natural to expect, that they get help basically from family members (fig 8). This shows, that there are not many school tasks, which requite use of computers and Internet. The role of teachers is rather low at present. If GIS is introduced in the classroom, acquiring computer and Internet literacy will come together with learning the required academic material. But we should not underestimate the difficulties relating to the extreme workload of teachers.

Their time for self-education and experimentation is very limited. Especially in order to achieve introduction of GIS in class, teachers need more help, which can be offered by the University. This help may be in different forms. Discussions among this research members outline two tasks in future work in this field:

- University teachers may organize seminars for teachers and demonstrate the GIS potential for more effective teaching, as well as discuss the practical problems from educational, financial and management points of view.
- University teachers may work together with schoolteachers for developing specific lessons with GIS, which can be shared.

The data about frequency of using computers adds up to the general picture of moderate exposure to the modern information technologies and sources. Boys using computers every day outnumber girls, but as a whole the percentage of both girls and boys using computers daily is not very high: 39% (fig 9).

It is striking to see that a high number of students(30%)have no opinion about"Should everybody learn to use computers?"; there is one answer "no". The interpretation of

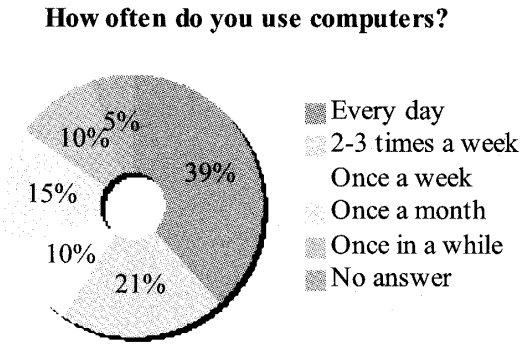


Fig. 9 Frequency of using computers

this may be biased. It can be judged from both emotional and practical point of view. Emotionally ("let everyone decide for themselves") could be understood. But taking into account that a lot of today' s work along the Constructive method of education requires computer knowledge, this fact brings some concern.

4.2. It is of special interest to understand the **opinions of the students about using computers in class (the second group of questions)**. Information was sought from both academic and emotional perspectives.

The majority is convinced that using computers in class can help the teacher to explain the lesson better (fig.10). The second the highest ranks the reason "to give students chance to learn through research", which is the main goal using GIS in class. This fact suggests, that further actions in using GIS as a teaching instrument in class might be relevant and highly successful. (The total number of answers is more than 39, because students could choose more than one consideration).

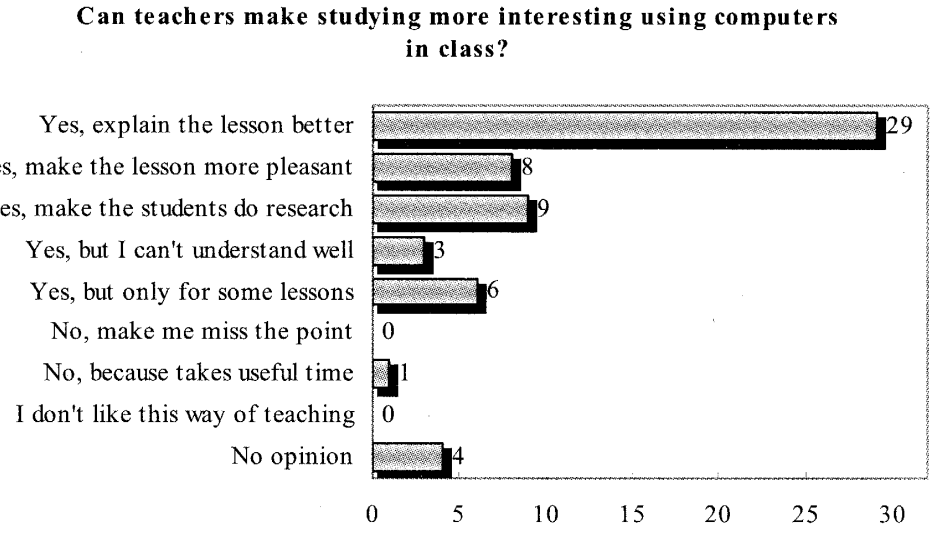


Fig 10. Views about the effectiveness of using computers in class

The emotional attitude to using GIS in class was tackled through the question: "How did you feel in this class?". The fact that almost 50% of the students were excited about studying using GIS (fig. 11) suggests that more such experiments should be undertaken in the future. They stay open and are ready for using the constructive model more widely.

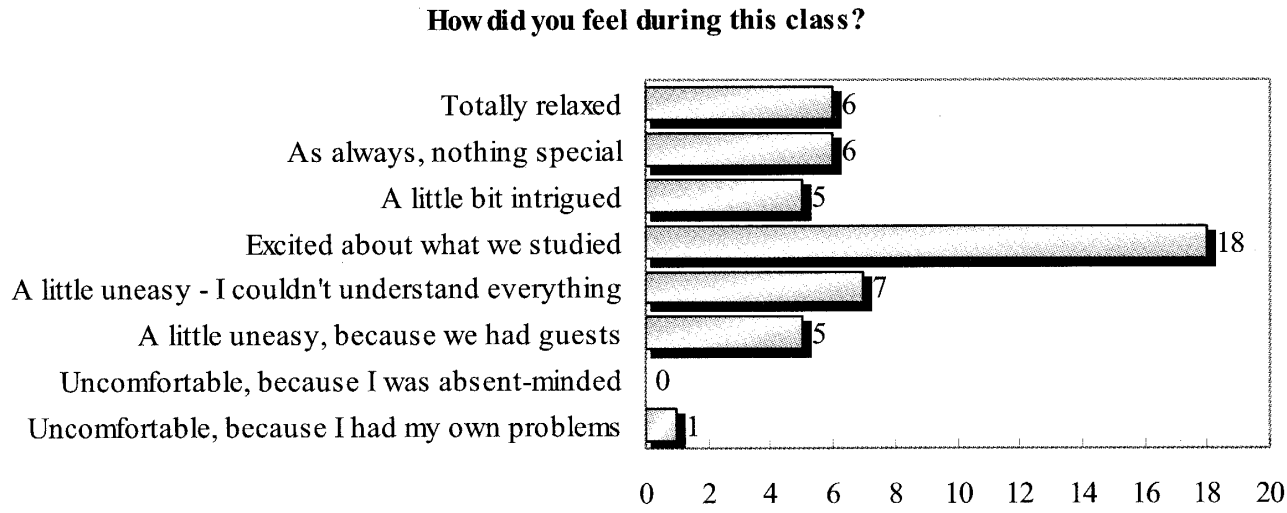


Fig. 11. The emotional attitude of students

4.3. The third group of questions tried to find out **how effective was this single use of GIS in class.**

Most of the students reported understanding the taught material. The answers "Yes" and "Yes, but need more studying" can be considered in one group, generally maintaining that using GIS helps understand better and this can be interpreted as a successful outcome of the experiment. Disappointing is though the fact, that rather high number of students say they "understood a little". This can be attributed to the fact, that some of the students were exposed to such information for the first time. Obviously, one standard class time only is not enough to achieve very well both tasks: learning the academic material and learning the technology of GIS.

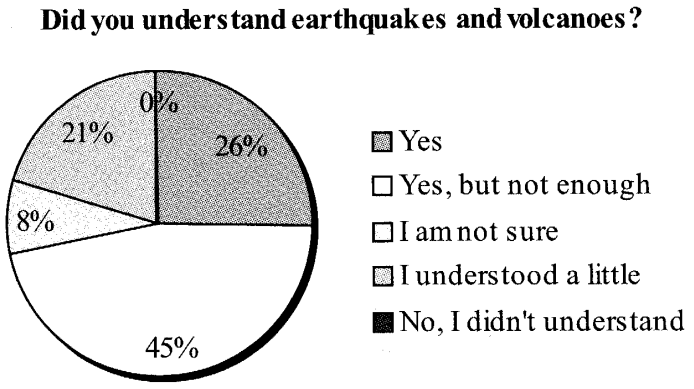


Fig. 12. The effectiveness of a class, in which GIS was used as a method of demonstration

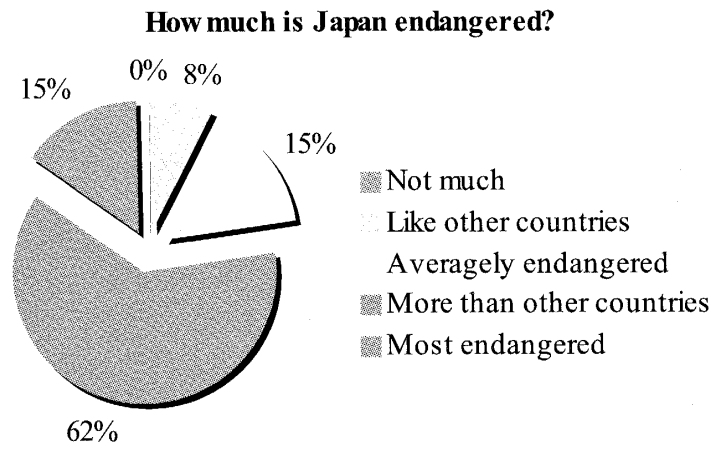


Fig. 13. Finding out the effectiveness of using GIS

The core of the lesson was about the social aspects of managing earthquakes and volcanoes. Using GIS the specific situation of Japan had to be underlined and students had to understand well its vulnerability to natural disasters. The graph shows that the basic contents had been correctly conveyed with small

deviation from the correct answer.

From the graphs (Fig.10-13) and from the free comments in the survey it is obvious, that with the help of GIS and its high level visualization potential students could understand the geography of earthquakes and volcanoes very well, as well as the extremely vulnerable situation along the Pacific Rim and Japan in particular. But even though the students understood the basic points about plate tectonics, most of them could not remember the exact boundaries of the plates and how they meet in Japan. This failure can be attributed to some coordination gaps during the lesson planning. A tip might have been offered to the students that they might be asked to draw these borders on paper maps, so they could try to remember them. The students appeared unprepared for such a task. We would argue, that if students had the opportunity to operate the GIS program by themselves, they would have had more time and chance to explore the plate boundaries better and remember them later. At this particular lesson the teacher had the chance to show them only once and for a very short time.

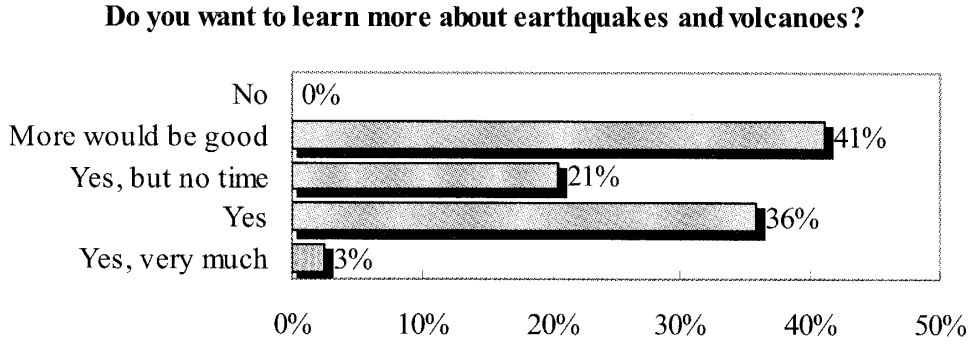


Fig. 14. Did students get further interest in the topic of studying?

The aim of the lesson to kindle the attention and the curiosity of students to the studied topic has been achieved. Fig. 14, as well as some free comments in the survey show, that most of them show interest and willingness to learn more on these problems.

As expected, with the very little explanation of GIS at this lesson, students did not show a very high understanding its philosophy. Still, it is encouraging, that even though the time of explaining GIS was extremely short (only 2 minutes for the GIS philosophy), the outcome of the answers is rather positive: most of the choices fall into the groups of"a little "yes, but I need more explanation" ; number of those answering entirely negative is rather small.

Of special importance was to check how close the students' understanding of GIS is to the real jobs that can be done with the system. The question "What is GIS" was asked and some answers offered, as in fact all the answers had been true in one or other aspect. But some come more close to the GIS nature, others concern only some of its aspects. The students were asked to choose three of the possible answers. The fact, that the answer "f" prevails (a computer program for dealing with geographic data) prevails is extremely encouraging. The students could grasp the very general idea of GIS just in one only short explanation and a practical demonstration. Of course, on the other hand

the rather big number of answers "c" and "d" is somewhat disappointing, though these answers are still correct, but they omit the active part of using GIS: operations and analysis with data. Obviously, this point should be underlined more aggressively in the future implementations.

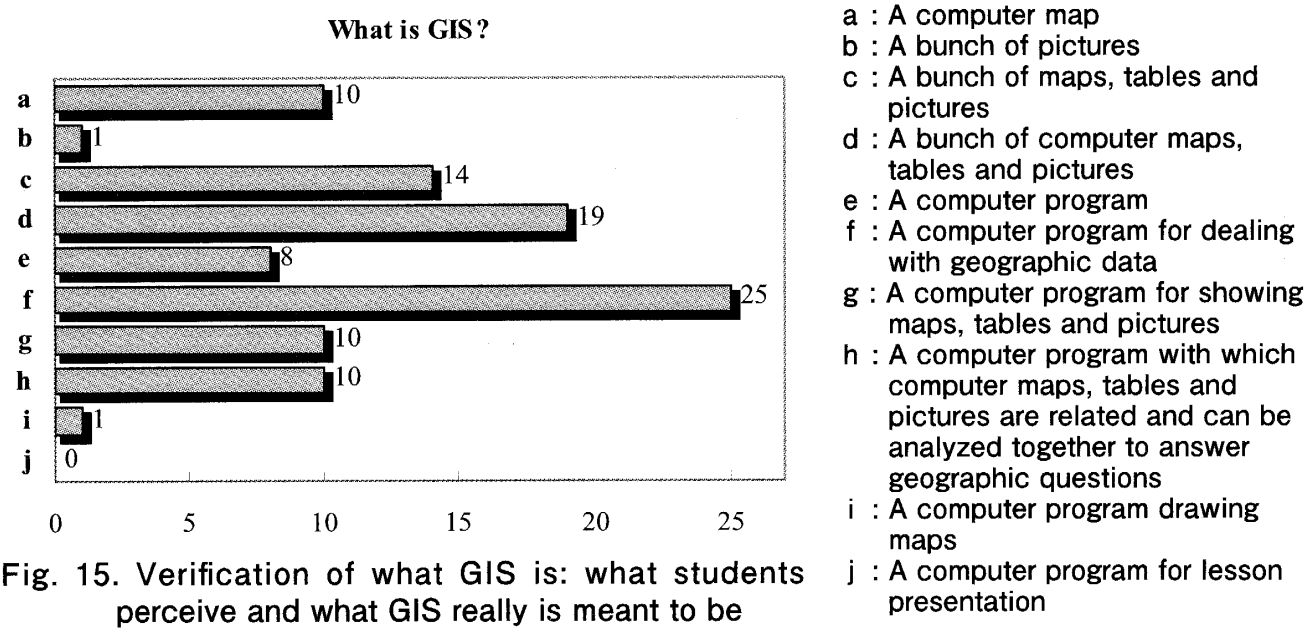


Fig. 15. Verification of what GIS is: what students perceive and what GIS really is meant to be

An attempt was made to get information about students' potential interest in the technology and its implementation in further studies. Most of the answers fall into the group of "Yes, but it is very difficult". This brings us to the conclusion, that further lessons should put special emphasis on a simple, easy and natural way of learning the system, to avoid stress and hesitation.

4.4 Finally, the students were asked to express their free opinion about this experimental class, in which GIS was used. Formalization of answers is rather biased, because students were free to point out different ideas. Still a picture can be outlined based on the repetition of answers. In 20 (51%) of the answers GIS has been appreciated for better understanding the teaching material. 33% of the students underline their appreciation of learning with computers and GIS, 1 stressing specifically on the better visualization with GIS. Three students express their excitement about studying earthquakes and volcanoes; they would like to learn more about these phenomena. Five students stress on their appreciation the GIS dynamic character, making learning exciting and avoiding boredom and sleepiness. One student demonstrates a striking appreciation of GIS, suggesting the possibility of teamwork and learning, project development, etc. Seven students (17%) stress on their wish to have more lessons with GIS in the future, while 2 would like to learn more about GIS itself. Two students complained, that because GIS was demonstrated on a single computer and their seats were at the back, they could not see very well, but they suggest that if they had had the opportunity to

operate the computer by themselves, this problem would have been solved. Four students complained of personal reasons for not being able to concentrate in class very well and one complained, that could not understand GIS.

Based on the students' impressions as we find them in their answer sheets, a conclusion can be drawn that there is a stimulating interest to GIS and studying with GIS. This lesson was rather demonstrational and did not reveal the broad GIS potential for exploration. Even so, interest is evident and efforts for further work in this direction would be justified.

CONCLUSIONS

Our pilot lesson providing data for research on using GIS at Junior High School shows, that there is a suitable ground for more aggressive implementation of the constructive method of education using the GIS environment and reaching beyond the demonstrational abilities of GIS. No matter of the rather hesitating position of students while expressing opinions of how much they understand this educational tool, most of the them show a firm positive and appreciating attitude.

- Using GIS in education is inevitable in the future, since research in general, including this particular work show, that this is a way of better understanding through active learning. Junior High school students are rather open to accept such a learning environment, but still a kind of fear exists, which will require a lot of efforts from teachers to overcome it.
- There are many difficulties providing all the necessary things to teach with GIS. Provision of GIS software, license for use on many computers at a time, hardware problems, and provision of relevant data, installation and preparation of lessons: all these require a lot of time, knowledge and dedication. It is very difficult for the teachers to secure all these requirements. To overcome these difficulties successfully, more involvement of university teachers is necessary.
- Taking into consideration the results, the weak and strong points from this first experiment, this team is planning to continue its work with a network of lessons in different schools, using GIS. For this purpose action has been taken with the help of the Faculty of Education of the Yamaguchi University, to provide GIS-software licensees. At present Master course students are being taught how to use GIS in class, with the perspective of further applications. Work is in progress in preparation of GIS lessons, in conjunction with the Junior High School curriculum in Social studies. One form of this work is developing of graduation thesises on problems of GIS lesson development.

AKNOWLEDGEMENTS:

This paper has been supported by the Dean's Fund of Educational Research at the Faculty of Education, Yamaguchi University.

REFERENCES

1. Bednarz, S. Reaching new standards: GIS and K-12 Geography. *GIS/LIS '95 Proceedings.* Bethesda: ACSM/ASPRS, AAG, URISA, AM/FM, 2004.
2. John Schmitz, Carolyn White: GIS and its application in Education. SC2003 *Education Program http://web.aces.uiuc.edu/aim/sc2003online.htm*
3. Hassard, J., M. Dias: Students' Experience in a Constructivist Community of Practice: An Inquiry into TEEMS- A Science Teacher Education Program. 2003. *http://scied.gsu.edu/Hassard/Teems/narst2000abs.html*
4. Malone, L., A.Palmer: Mapping our world. *ESRI Press*, 2004.
5. Rider, M. *http://carbon.cudenver.edu/~mryder/itc_data/constructivism.html*
6. Sui, D.Z. (1995) A Pedagogic Framework to Link GIS to the Intellectual Core of Geography, Journal of Geography, 94(6).
7. Thomas R. Baker: The History and Application of GIS in Education *http://www.gisdevelopment.net/education/papers/edpa0003.htm*