AC 2007-282: TEACHING EFFECTIVENESS IMPROVEMENT THROUGH GEOBRAIN TECHNOLOGIES IN DISTANCE EDUCATION

Guoqing Zhou, Old Dominion University

Improvement of GIS Distance Teaching Using GeoBrain Technologies

Abstract

GIS course for undergraduate in Old Dominion University (ODU) is delivered via ODU TeleTechNet (TTN) system. The distant students cannot access the large volume of remotely sensed data like campus students when they conduct their homework and lab class. The GeoBrain system is capable of making remote students easily access the large volume of data in data pools through their internet-connected desktop computers without requiring the fast internet connection. With such a unique ready-to-explore geospatial data-rich environment, this paper introduce how we adopt the GeoBrain system as a tool for GIS distance courses to allow students to format, document, and access the geospatial data. The teaching improvements include: (1) add the topics related to GeoBrain technology into the course, and require students to finish the corresponding homework; (2) Add geospatial data standard adopted in GeoBrain system into the course; (3) Develop spatial analysis service modules for distance courses; (4) develop the homework for the courses. Finally, we evaluated the teaching effectiveness after teaching improvement using GeoBrain System by questionnaire survey, and the results demonstrated that the new teaching improvement is capable of adding students' GIS knowledge.

1. INTRODUCTION

The GIS courses for graduate and undergraduate students are offered in Old Dominion University (ODU) via distance education mode. The distance courses are delivered to 15 states, 50 higher education centers, and 4 oversee navy bases (Japan, Koera, Mid-East, and Canada) via both the regular classroom and ODU's TTN (Tele-Tech-Net) system (active satellites, stream video, video tapes, DVD, etc.). One of the problems in the distance courses is that the remote students have difficulty to access the large volume of geospatial data for their homework and distance laboratory via internet.

The GeoBrain system, which is funded by NASA with $5 millions and is in progress, is a prototype geospatial knowledge building system (Di et al., 2005a; 2005b). This system is designated to be capable of mobilizing NASA EOS (earth observation system) data and information through web service and knowledge management technologies for higher-education teaching and research. This system automates a range of geo-computational services at a limited number of geospatial domains and greatly facilitates the construction of complex geo-computation services and modeling, and makes petabytes of NASA EOS data and information, especially those in the ECS data pools, as easily accessible as their local resources, to higher-education users, professors, and students. This system especially allows users to dynamically and collaboratively develop interoperable, web-executable geospatial service modules and models, and run them on-line against any part of the petabytes of archived data to get back customized information products rather than raw data. The architecture of the geoBrain system is depicted in Fig. 1, and the more detailed descriptions can be referenced to Di et al. (2004a, 2004b, 2004c, 2004d, 2003).

This paper presents our efforts in use of the GeoBrain system resource to improve our distance GIS teaching because the GeoBrain system is capable of making remote students easily access the large volume of geospatial data through their Internet-connected desktop computers without requiring the fast Internet connection.

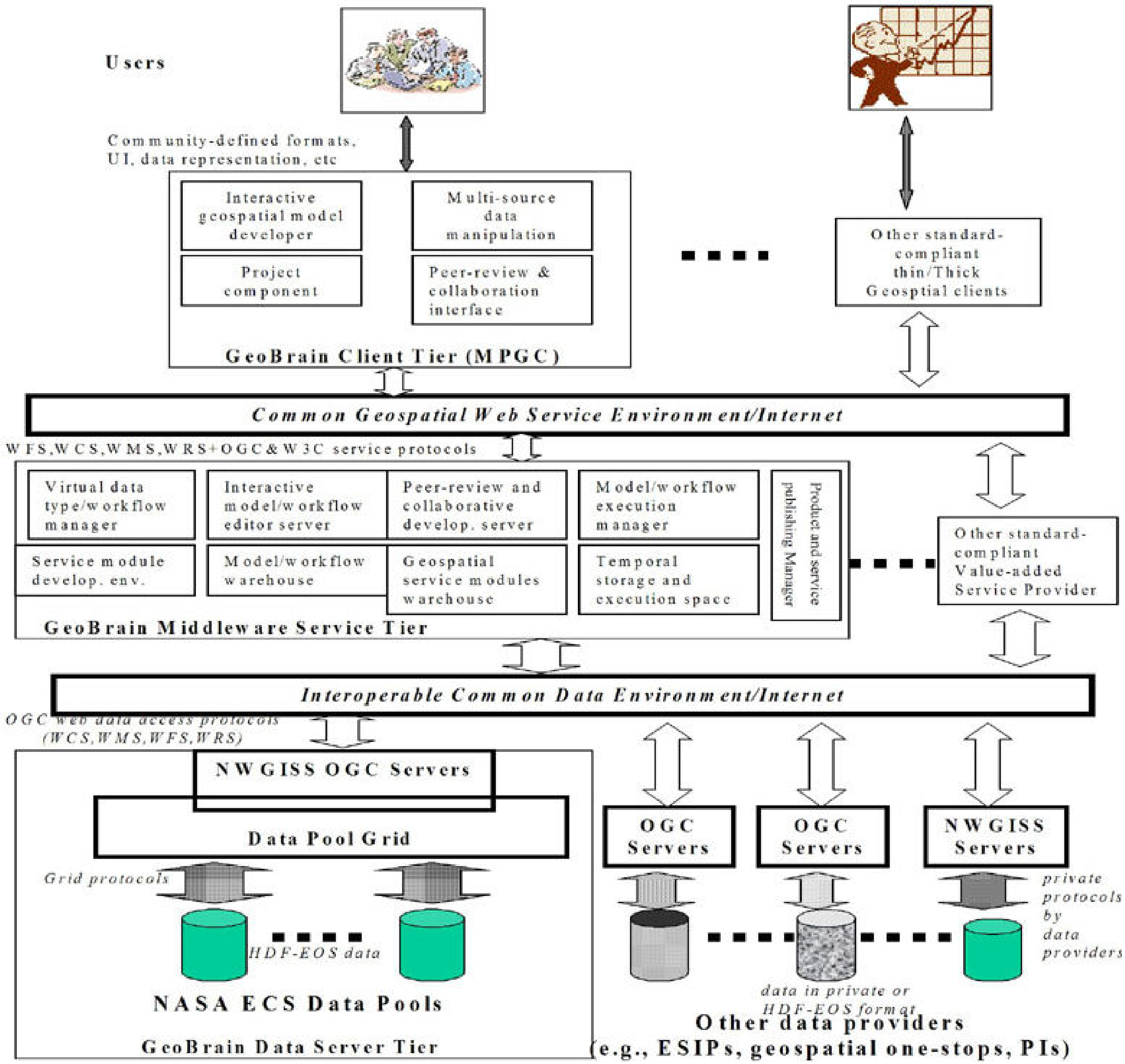

Fig. 1 The configuration of Geobrain system (Di, 2003)

2. GIS DISTANCE TEACHING

2.1 ODU's TTN

ODU's TeleTechNet (TTN) is a system for interactive distance learning via satellite. The system enables the instructor to deliver a "live" lesson from a central campus in Norfolk, Virginia, concurrently to any number of classrooms within the footprint of the satellite. Using this interactive satellite distance education system, students not only see and hear their professors; they take an interaction with their instructor in the class also. At present, ODU's TTN supplies academic courses and teacher training courses, as well as some corporate training. Students throughout the continental United States and on US naval vessels (currently the live classes go to an aircraft carrier and prepackaged CD-ROMs are used on submarines) are able to earn their bachelor's and master's degrees from a fully-accredited university without leaving their areas of residence. The main components of the TTN system include (Fig. 2):

- **Master Control Center:** it is a hub of all incoming and outgoing video and audio signals. The "live" lesson including language and pictures can simultaneously be broadcast to any remote classrooms via satellite uplink. Telecommunications linkages are ITFS (Instructional Television Fixed Service): one-way video and two-way audio via return phone lines.
- **Central Classroom:** Each central classroom has three digital "chip" cameras (one high-zoom overhead camera for use by the professor to transmit hand written notes, print materials, slides, or other illustrations; the other two are placed on the front wall to view professor and students, respectively). All are remotely controlled by operator using pan, tilt and zoom, four monitors for students to view the class from any seat, a microphone mounted at each seat for student, a VCR, an echo canceller, a video switcher unit (to shift between the laptop, multi-media units).
- **Distributed Classrooms:** The ODU's TTN transmits the live lessons from the central classroom to over 50 remote classrooms concurrently. These remote classrooms are equipped with cameras, a computerized monitoring system and individual student desk top microphones linked to land-line telephones. The system enables remote students to speak to the instructor, and simultaneously look at web-based class material stored on the ODU servers.

2.2 GIS Distance Teaching

Good distance teaching practices fundamentally parallel good traditional teaching practices (Wilkes and Burnham, 1991) if the teaching mode can be modified according to the characteristics of distance education and technologies available. For our GIS TTN courses, our teaching mode includes:

1. Course Design: Since the ODU's TTN distance delivery including stream video, video tape, video DVD, and satellite are not self-paced except the live satellite; we had to establish a well-designed syllabus and presentation outlines on the course website. The presentation with visuals and graphics aims at contributing to students' understanding to the course. Because the students are highly–motivated and usually have full-time jobs, they sometimes schedule their class attendance according to their needs. It is not uncommon for students to watch a videotape, rather than attend class, due to work requirements. Therefore, we must follow a set schedule by which the students complete the assigned homework. Taking into account the change of environments and technologies necessitated by the distance mode, the GIS course design usually follows the rules below:

(a) Determine early the student characteristics, such as age, motivation, background, and knowledge. This information becomes critical because the students in our GIS course range from recent high school graduates to licensed land surveyors;
(b) Specify desired learning outcomes;
(c) Identify relevant subject content and assessment activity;
(d) Determine appropriate teaching/learning strategies;
(e) Revise and re-validate the course design throughout by periodic monitoring the outcomes from examinations and assignments.

2. Lecture: Although the TTN system enables the remotely students to immediately interact with instructors, the major shortcoming from the instructor's perspective is the lack of visible body language and eye contact from students. This means that instructors used to traditional in-class teaching cannot use these immediate non-verbal cues to make adjustments while teaching. Thus, the student evaluations often reflect the position that conventional instruction is perceived to be better organized and more clearly presented than the distance education. Thus we always maintain eye contact with the camera, are willing to repeat questions, and possess a sense of humor.

3. Web-based Lab: The students conducted their laboratory via Citrix software in the GIS laboratory class before 2004. Citrix web server software technology enables remote students to access our server from their own devices and platforms over the web. We put ArcView, ArcInfo software and experimental data in a DELL 680 server (four 650 Mhz CPUs). Each student was set up with an account to enable them to run and operate ArcView and Arc/Info software remotely.

4. Faculty & Student Communication System (FSCS): A network communication system, called the *faculty student communication system* (FSCS) is established for communication between instructor and students. Using the FSCS system, the students can turn in their homework, email to the instructor; the instructor can deliver the slides and lecture notes, make an announcement, return the graded work, view the submissions by site name, by date, or by all, or privately compose a message to a student. In addition, the FSCS system can be used as forum window for the student's discussion to some difficult concepts.

2.3 GIS Teaching Evaluation before 2004

Like many other educators, we are concerned that the distant students learn as much as those students receiving traditional face-to-face instruction. We periodically therefore examined the effectiveness of courses by questionnaire during the course of a class. The questions include such as

(1) Is the distance delivery of the GIS course as effective as the traditional face-to-face teaching?
(2) What are the most important factors affecting the effectiveness of the distance GIS course?
(3) What are the characteristics of effective distant students and teachers?
(4) How important is teacher-student and student-student interaction in the distance education process, and in what form(s) can this interaction most effectively take place?
(5) How do we develop a GIS distance learning environment, e.g., web-GIS, to enhance the effectiveness?
(6) How do we develop an empirical distance education module for different target groups and different purposes?

The most frequent complaints from the students are web-based laboratory when the students used a modem-based home computer due to the too slow Internet transportation speed for large images. After 2004, we distributed the ArcGIS 8.3 education version and laboratory data to remote students. The laboratory teaching effectiveness is obviously improved, but the students can not still access the huge volume of the other geospatial data.

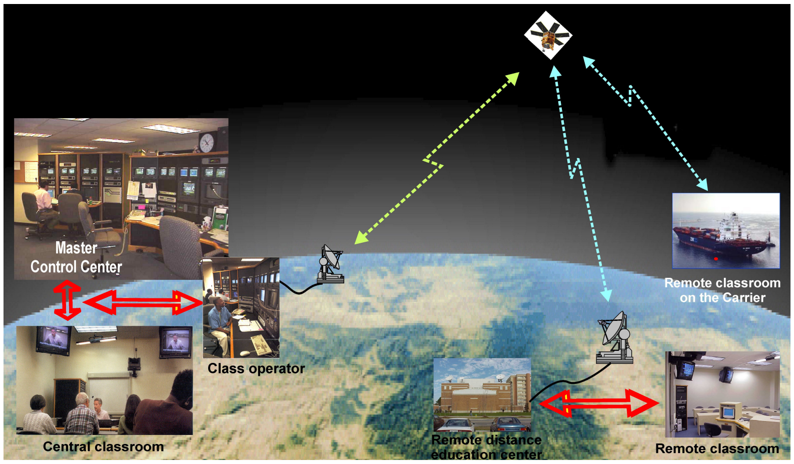

Fig. 2 The configuration of ODU's TELETECHNET (TTN)

3. GIS TEACHING IMPROVEMENT USING GEOBRAIN SYSTEM

Teaching improvement of the GIS course using the GeoBrain system is conducted by: (1) the concepts, technology, and theory adopted in the GeoBrain system was first introduced, and the homework was designed; (2) some questions in the homework only can be answered through the GeoBrain system operation.

3.1 Improvement of Undergraduate GIS Teaching

Since there are many independent data and service providers and subsystems in a federation of distributed data and information systems, GIS users used a lot of volume of geospatial data. Thus, *Geospatial Data Standard,* was added into the existing course, and the GeoBrain system was employed as an example to address the importance of geospatial standard. The class especially explained

(1) How and why the GeoBrain system uses the Open GIS Consortium (OGC) standards for the data finding and access, the OGC and W3C standards for the web services, and
(2) How the GeoBrain leverages the new and ongoing development in the knowledge representation and management, especially the workflow management.

After this chapter is lectured, a quiz exam is designed for the students. The questions contain such as:

(1) What standard is adopted in the GeoBrain system to access NASA and non-NASA geospatial data?
(2) How does the GeoBrain system design a common data environment providing standard interfaces to the data provider's archives?
(3) How does the GeoBrain system implement W3C and OASIS web services standards?
(4) How does the GeoBrain system allow other foreign systems to interoperate with it through standard interfaces?
(5) How can any other system using the same standard interface as GeoBrain be interoperable and federal-able with GeoBrain?

3.2 Improvement of Graduate GIS Teaching

GI*S* Topics (OTS523) is a graduate course. Web-based GIS is one of the most important topics. The following topics are added, and the graduate students were required to finish the corresponding homework (described in Section 3.3):

(1) Concept, theory, and technology of Geo-object and geo-tree as well as their applications in the GIS,
(2) Concept, theory, and technology of grid, web-based geospatial interoperability, web-based service,
(3) Standard-based web service system and its application in the dynamic and interactive construction and running of interoperable geospatial service modules and models over the web as well as web-GIS,
(4) Characteristics of Open GIS Consortium (OGC), Web Coverage Service (WCS), Web Feature Service (WFS), Web Registries Service (WRS), and Web-GIS,
(5) Geospatial data processing, information extraction, and knowledge management in GIS, and
(6) Workflow warehouse and workflow language (BPEL4WS).

After these concepts are introduced in class, the GeoBrain system was taken as an example to explain the Web-based GIS. All of the students were required to understand the above topics in depth via running the GeoBrain system and finish the homework designed below.

3.3 Homework Design based on the GeoBrain System

The homework for the above two courses (CET413 and OTS523) has been designed and developed. The homework includes the concepts, technology, and theory related to the geospatial data standard and web-based GIS, which were adopted in the GeoBrain system. Thus, the questions in the homework only can be answered via the deep understanding to the GeoBrain concepts, technologies, and operations. For example, the questions contain such as

(1) What are the problems of geospatial data dissemination? How does the GeoBrain system solve the problems? How does the GeoBrain system meet the needs of GIS users?
(2) What is geo-tree? What is geo-object? What is grid? How does the GeoBrain system apply these techniques?
(3) How do we use the GeoBrain system to set subset, convert and display various formats data in geospatial data? The tasks probably contain, e.g., converting HDF files to plain binary, geoTiff, ascii ARC/INFO grid, and shape files; creating XML-based capabilities document automatically for NWGISS.
(4) How do we use the GeoBrain system format, document, and distribute geospatial data?
(5) How did the GeoBrain technology solve problems related to geospatial interoperability and knowledge discovery?

3.4 Improvement of Distance Laboratory Class

In the previous GIS courses, the distant undergraduate and graduate students cannot access the large volume of geospatial data like the campus students for their laboratory class. With the GeoBrain system, laboratory materials for the two courses (CET413 and OTS523) have been developed. The laboratory materials required student to operate the GeoBrain system and then answer the questions. The laboratory materials related to the GeoBrain operations for graduate and undergraduate students include such as:

(1) Operate the GeoBrain software to access multi-source data served by OGC compliant web coverage servers, web map servers, web feature server and web register server,
(2) Work with all three types of HDF-EOS data, namely swath, grid, and point,
(3) Apply the GeoBrain interactive modeling environment to construct and test the models (be constructed graphically) through the GeoBrain client; apply the editor server to instantiate, run, modify, debug, save the model and submit it to peer-review server for review,
(4) Apply the GeoBrain system to develop and test the models graphically;
(5) Use the icons to categorically display all available service modules, click and drag a module to the model,
(6) Graphically display all GeoBrain virtual and real data types. For example, for a type of virtual data, the students are required to copy an entire or part of a geo-tree and then paste it to the model.

For the graduate student laboratory class, the additional exercises are designed as follows.
(7) Construct geospatial models and run them over the web for "knowledge" generation,
(8) Develop additional service module using the GeoBrain service module development environment, and
(9) Encourage the graduate students submit their geospatial models to the GeoBrain for test and evaluation.

4. TEACHING EFFECTIVENESS ASSESSMENT

We assessed the teaching effectiveness through the two methods: statistical assessment in accordance with the final exam, and the questionnaire survey.

4.1 Assessment through the Final Exam

The GIS course (CET413) has been offered for 6 years using the ODU TTN distance teaching system. The teaching evaluation had not been as ideal as expected from 2000 through 2003, although a series of measures of improving the teaching effectiveness with a consideration of characteristics of the distance teaching were taken. In Spring 2004, the ESRI Inc. provided the remote students with the free license for ArcGIS 8.1 software so that the remote students can run the software at their home computer. Meanwhile, the instructor prepared each homework and laboratory material. The students were required to complete their homework, distance laboratory, and exams using software at home. As a result, the teaching evaluation is over the mean of the department and the college. However, a further analysis from the compiled data of 2004 final exam indicated that the class has a weakness (81% percentile) in "become profession in the integration and analysis of spatially-referenced data using GIS for problem-solving" (Fig. 3). This maps to the course objectives a, b, c, d, e, f, g, i, and j (from ABET program outcomes (a-k)), as shown in the CET 413 syllabus (Table 1). We made many attempts to improve this, but the results were not significant. In Spring 2006 GIS courses, we took the GeoBrain system and technology as an example to explain the importance of the geospatial data standard and the web-based GIS system, and how the GeoBrain system abided by the standard and what technologies the GeoBrain system is being adopted to realize web-based geospatial data display, query, manipulation, analysis, and interpretation, as well as decision-making. With such a teaching improvement, the teaching effectiveness from 39 out of the 46 registered students achieved 5.41 points, which is much higher than the mean of department (4.45) and the mean of college (4.64).

Moreover, the statistic analysis from final exam in Spring 2006 indicated that this shortcoming has been overcome, and 90% percentile has been achieved (Fig. 4).

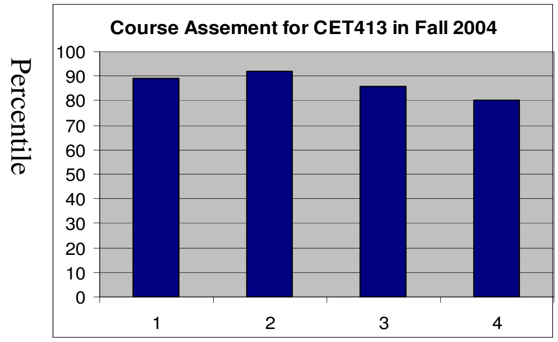

Fig. 3 Accreditation mapping for GIS course assessment in Fall 2004

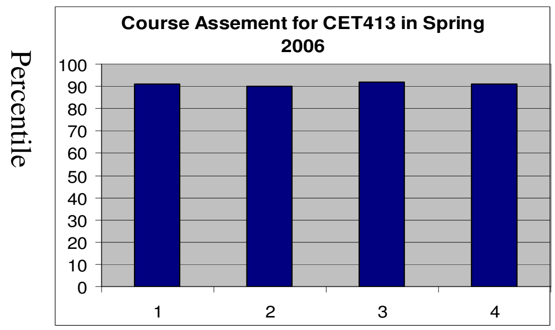

Fig. 4 Accreditation mapping for GIS course assessment in Spring 2006

Table 1 Outcomes assessment of GIS course according to the ABET

CET 413, GIS	**OUTCOMES**										
Objectives	a	b	c	d	e	f	g	h	i	j	k
Provide an introduction to geographic information systems (GIS) including the concepts, hardware, software, and operations of software	x	x	x	x	x	x	x		x	x	
Understand GIS data capture, types, storage, analysis, display, and standard	x	x	x	x	x	x				x	x
Have skills at solving the spatial analysis problems using GIS software	x	x	x		x	x	x			x	
Become profession in the integration and analysis of spatially-referenced data using GIS for problem-solving	x	x	x	x	x	x	x		x	x	

4.2 Assessment through the Questionary Survey

After the CET413 and OTS523 courses are finished, the undergraduate and graduate students were required to fill out a survey form to assess how much they benefited from the activities. The evaluation of survey form is classed ranging from 0 through 100. The number of the "0" indicates poor, and the number of "100" indicates excellent. The survey forms included 10 questions. They are

(1) Whether do you benefit from the GeoBrain learning?
(2) Whether does the GeoBrain increase your knowledge about geospatial data processing?

(3) Whether does the GeoBrain better improve your distance learning, such as homework, distance laboratory, and examination?
(4) Whether does the GeoBrain help you understand the geospatial data concept, definition, and manipulation?
(5) Whether does the GeoBrain improve your understanding to the geospatial data format, type, conversion, and dissemination?
(6) Whether does the GeoBrain enhance your understanding to geospatial standard?
(7) Whether does the GeoBrain enhance your understanding to web-based GIS?
(8) Whether does the GeoBrain increase your understanding for spatial data analysis, query, and interpretation in web-based GIS?
(9) Whether does the GeoBrain better support your research (only graduate students)?
(10) Whether are you happy to recommend the GeoBrain to others?

The survey results demonstrated that 95% students thought that the GeoBrain system can significantly improve the learning effectiveness (Fig. 5), and 93% students thought that the GeoBrain system enhances their knowledge in geospatial field. On the other hand, the survey shows that 62% students felt that the GeoBrain can help them for the research. The reason for this low rate is probably because the research areas of those graduate students have a relative low overlap with the GeoBrain research group. In particular, over 80% students would like to recommend the GeoBrain system to other users. Thus, the significant improvement after using the GeoBrain system for the distance GIS course can be drawn up.

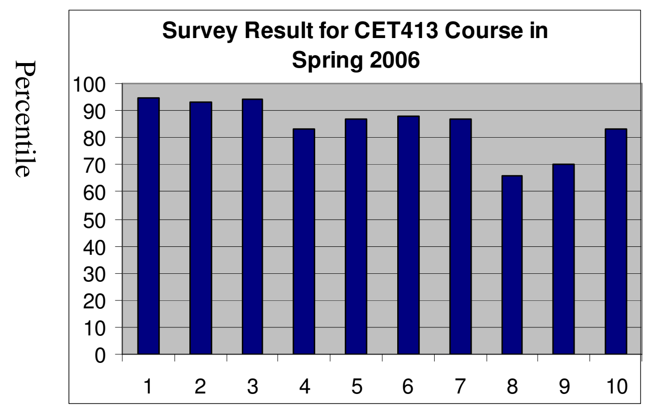

Fig. 5 The survey result for the GIS course improvement in Spring 2006

5. CONCLUSIONS AND REMARKS

We have taken different measures to improve the distance GIS courses. Despite our efforts, the teaching effectiveness from the students' evaluation is not satisfying before 2004. After applying the GeoBrain system, the teaching evaluation demonstrated the GIS teaching effectiveness has obtained a significant improvement. This is mainly because the GeoBrain system used a friendly computer-interface to "visualize" the many concepts, and definitions related in geospatial data, analysis, manipulation, and visualization. Thus the students learned these concepts in a comfortable and easy-to-learn learning environment.

From our experience, many factors in fact influence the distance teaching effectiveness, such as (1) students (e.g., high-motivation), (2) Faculty (e.g., the instructor's responsibility), (3) Facilitators (acting as the instructor's remote site "eyes and ears."), and (4) support staff (e.g., equipment setup, the collection of assignments, proctored tests, etc.). This paper only presents how we applied the GeoBrain system for the GIS teaching improvement. In summary, there is no mystery to effective distance education, except hard work, dedicated efforts from many individuals, and the integrated efforts from students, faculty, facilitators, support staff, and administrators.

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