# EVALUATING A MULTIMEDIA-BASED TOOL FOR SELF-LEARNING GEOGRAPHIC INFORMATION SYSTEMS

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**Abstract**

*The adoption of multimedia (MM) in the development of new learning and teaching materials is experiencing a rapid growth. MM and other computer-aided tools have been tried in Geographic Information Systems (GIS) education since its early days. However, until detailed evaluations are conducted, many MM curriculum transformations may simply be seen as experiments in technological innovation rather than as mechanisms to improve learning. This paper describes the process undertaken and results obtained to evaluate a MM-based tool for self-learning GIS: GISWEB. GISWEB is introduced through a brief summary of its history and content. The paper also briefly summarises the agreement established between The University of Melbourne and other international education institutions where GISWEB is currently adopted. The core of the paper details the initiatives undertaken at The University of Melbourne and at the University of Alcalá de Henares for the evaluation of this new teaching and learning resource. The paper concludes with a discussion and some conclusions drawn from the evaluation results.*

**Keywords**

*Evaluation, Geographic Information Systems (GIS), learning, multimedia, teaching, World Wide Web (WWW)*

## Introduction

The GISWEB project was initiated at The University of Melbourne in 1999 in the context of a University initiative to develop new delivery mechanisms aimed at improving the quality of teaching and learning and at providing opportunities for future distance-based education. All the GIS lecturers in the Department of Geomatics at the time formed the team involved in the project. The team initially received a priming grant for the development of a pilot product where concepts and structure could be tested. This followed by a TaLMET (Teaching and Learning Multimedia and Educational Technology) competitive grant in 2000, which made possible the completion of GISWEB in 2001. Since then, GISWEB has been adopted in GIS education in a number of universities worldwide as a complement to face-to-face approaches and traditional learning materials.

A description of The University of Melbourne's approach to MM and learning can be found in Escobar, Zerger and Bishop (in press). A detailed overview of GISWEB, including its purpose, content, usage, and initial evaluation is in Zerger et al. (2002). The focus of this paper is on evaluation issues and the results obtained from an evaluation initiative jointly undertaken by the University of Alcalá de Henares, Spain, and the Universities of Melbourne and RMIT University, Australia.

## GISWEB: Description and content

The design of GISWEB was driven by the desire to provide full interactivity unlike previous computer aided learning tools, including GISTutor (Raper and Green, 1989), where interactivity was limited to navigation options. GISWEB's multimedia modules are software and hardware independent which provides important delivery flexibility and fills the gap left by vendors' products, like ESRI™ Virtual Campus (http://campus.esri.com), where learning GIS concepts is not separated from learning specific software.

GISWEB focuses on core GIS concepts with a particular emphasis on spatial algorithms and it is structured in eight modules, which broadly come under the following titles:

- Introduction to geographic information systems,
- Spatial data entry,
- Line generalisation algorithms,
- Buffers,
- Vector overlay processes,
- Neighbourhood operations,
- Raster analysis; and
- Terrain analysis.

In addition to these core modules, it contains an extensive GIS glossary, a suite of GIS references, a site map to aid navigation and a user feedback form. All modules follow a similar structure including Theory, Algorithms, Interactive Examples and a Student Test. The theory included in each of the eight modules can also be downloaded as a Microsoft Word file. This allows students to cut and paste the theoretical material to create their own notes as required. The rationale behind the inclusion of the above modules and not others is supported by three main factors. First, the developed modules are those that commonly form the basis of elementary GIS learning. Second, the modules address spatial concepts that students commonly have problems understanding. And third, owing to the financial and time commitment to the project an aim was to maximise the possible longevity of the core content.

A key aim of the GISWEB initiative was to adopt the hyperlink metaphor and to present the modules as a 'tool-box' to be integrated into learning, in no particular or pre-defined order. The final product is a suite of tools that can be selected and pieced together by academics and students alike. In practice, academics use the Algorithm demonstration component of the modules in a formal lecture environment. This provides the lecturer with a dynamic visualisation tool in real-time. Students are then referred to the Theory and Interactive Examples and are encouraged to explore these modules in further detail during computer-based practical classes, and in their own time.

GISWEB was conceived as a free access tool. For this reason it was implemented as a www-based product. Internet connection and the installation of the free Shockwave plug-in are the only requirements for visiting and using GISWEB www.geom.unimelb.edu.au/gisweb (Figure 1).

In each of the modules, users can visualise, step by step, the processes involved in the different algorithms presented. This is achieved through the incorporation of Shockwave movies. A large number of animations show what the GIS user cannot see while manipulating geographic data with GIS software A varied level of interactivity was also incorporated in all modules in an attempt to provide the user with control over the algorithm and enhance understanding of the procedural options. Self-learning feedback is achieved at the completion of each module via an on-line test. This allows students to evaluate their understanding of each lesson and provides a justification for the answers given.

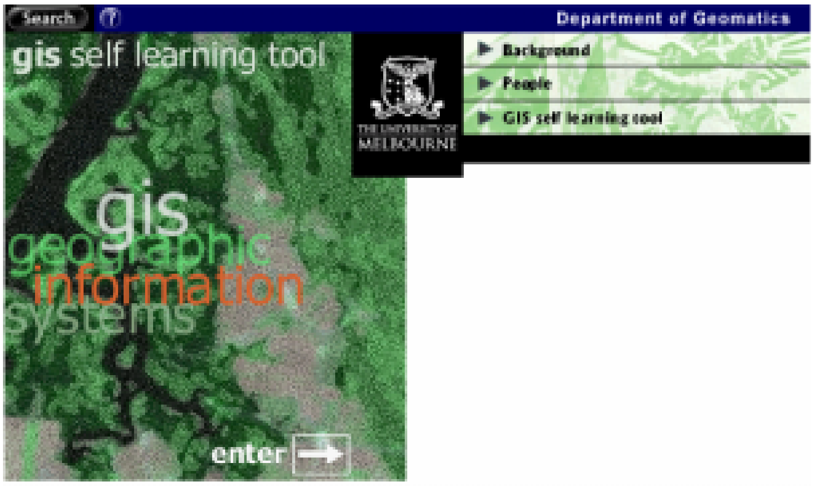


*Figure 1. The GISWEB portal at www.geom.unimelb.edu.au/gisweb*

## The adoption of GISWEB in GIS teaching

Since its completion, GISWEB have been used as a complement to face-to-face and traditional learning materials at The University of Melbourne and at RMIT University in a large range of undergraduate and postgraduate GIS courses.

Other universities like University Louis Pasteur, France, Massey University, New Zealand and Alcalá de Henares, Spain are also making formal use of this tool in different GIS subjects. In most cases, a contract licence was signed by both parties in which conditions and terms of usage were specified. In brief, these conditions can be summarised as follows:

- Unlimited copy and use right for internal purposes
- Right to modify adapt or alter under University of Melbourne guidance and approval
- No license fee

In addition to these institutions, a non-invasive web usage statistics tool attached to GISWEB shows its extensive usage worldwide. Table 1 summarises the main domains accessing GISWEB in one month.

| HITS | BYTES DOWNLOAD | ACCESS DOMAIN |
|---|---|---|
| 16,382 | 206,802,981 | Australia |
| 12,600 | 113,923,888 | Unresolved Domain |
| 3,625 | 44,042,594 | Canada |
| 3,648 | 30,360,802 | Network |
| 2,539 | 26,571,506 | US Commercial |
| 1,474 | 11,299,217 | US Educational |
| 1,105 | 10,669,693 | United Kingdom |
| 675 | 8,702,313 | India |
| 572 | 6,249,126 | Saudi Arabia |
| 494 | 5,515,313 | Argentina |
| 410 | 4,938,527 | Ukraine |

*Table 1. GISWEB usage statistics in July 2002.*

## GISWEB Evaluation: A joint initiative

In the case of the University of Alcalá de Henares, it soon became evident that the language barrier was an impediment for the fully adoption of GISWEB amongst teachers and students. The agreement between GISWEB developers and GIS personnel at the University of Alcalá de Henares included the transfer to Alcalá de Henares of the original GISWEB files for the translation into Spanish of some modules and their consequent adoption in the different GIS programs offered. Due to a shared interest on possible improved learning outcomes, a methodology for its evaluation was then established. The following section summarises the evaluation process and the results obatained.

## Evaluation of GISWEB

Previous studies have evaluated the GISWEB product itself and determined whether basic objectives were achieved. This included an evaluation of interactivity, ease of navigation, effectiveness of the design, consistency and broader issues of human-computer interactions. This component of the project has been discussed in Zerger et al. (2001) and broadly summarised as:

- Students valued the provision of theory material in Word format as it allows them to make additions, and further build-up a tailored learning resource,
- There was a general need for more flexible navigation so that particular sections could be by-passed by more experienced users. The hyperlink metaphor creates design challenges as, from an educational perspective, it may be desirable to direct students through a module rather than by providing 'outs',
- A common observation was that the time required to download shockwave animations was excessive and a major limitation in the work. Owing to this, we have permitted some educational institutions to mirror the GISWEB site locally and some students have been provided with CD-ROM versions; and
- For a number of pages, not all the information could be seen on the screen at the same time requiring the user to continually scroll and lose track of their starting points. This is likely to be a common limitation of many multimedia-based projects that require a computer terminal as the display interface.

A second form of evaluation examined the perception of users (students) towards the use of multimedia technology to compliment learning. And finally, personal evaluation undertaken by the researchers involved in the project and in the teaching of GIS subjects was critical. In Escobar, Zerger and Bishop (2002) the later two forms of evaluation and results from 2001 academic year were discussed. Student use and perception was evaluated using what it has been described as both 'invasive' and 'non-invasive' techniques.

Amongst the techniques described by Christel and Olligschlaeger (1999) for evaluating the impacts of multimedia-based learning, this study focuses on (a) Transaction logs, described as a non-invasive evaluation technique that tracks user interaction through a site, and (b) Formal empirical studies, which are characterised by the use of formal questionnaires with relatively large user cohorts and formal statistical evaluations. A discussion on results obtained in the analysis of transaction logs can be found in Escobar, Zerger and Bishop (2002).
This section presents the results obtained at the university of Alcalá de Henares by a formal empirical study aimed at evaluating learning outcomes amongst students that learnt GIS through GISWEB.

## GISWEB at the University of Alcalá de Henares. Evaluation of learning outcomes

The University of Alcalá de Henares offers GIS courses at undergraduate and postgraduate levels in Geography, Environmental Sciences and Geodetic Engineering programs (http://www.geogra.uah.es/). GIS is taught in the second year of Environmental Sciences, in the first year of the coursework PhD program in Geography and in fourth and fifth years of Geodetic Engineering. Among the modules covered by GISWEB, Vector overlay processes, Neighbourhood operations and Raster analysis were selected for the trial. This choice was conditioned by the necessary adaptation to course contents in each of the three programs.

## The evaluation

The issues related to evaluation of new teaching materials are numerous and of diverse nature. Assessment of learning outcomes when methods and students are different presents significant difficulties as documented in Benigno and Trentin (2000). Acknowledging its weaknesses, the method adopted to evaluate learning outcomes from GISWEB is detailed below.

Each of the GIS classes of the University of Alcalá de Henares was divided in two separated groups containing approximately the same number of students. Table 2 summarises the characteristics of the groups that used GISWEB. In each of the courses, the content appropriate to the selected modules was taught with GISWEB to one half of the class and with traditional materials and lectures to the second half.

| Program | Year | Students | Average age | % women | Previous GIS knowledge |
|---|---|---|---|---|---|
| Environmental Sciences | Second | 38 | 19 | 65.79 | Nil (100%) |
| PhD Geography | First | 10 | 30 | 64.29 | Some (57.14%) |
| Geodetic Engineering | Fourth and fifth | 14 | 26 | 56.25 | Some (87.5%) |

*Table 2. Characteristics of students using GISWEB in the trial*

It is important to note that age differences and previous knowledge in GIS are variables that may have an impact in the evaluation. The groups were determined by random allocation which, given the reasonably large class sizes, should have produced similar characteristics for each comparable group

To evaluate learning outcomes, the tests originally included in each of the modules were adopted. These were deleted from the on-line resources provided to the students. The test questions were therefore previously unseen by all students.

### Environmental Sciences

Seventy-five students were enrolled in the GIS course included in the second year of Environmental Sciences. Thirty-seven of these students received a traditional lecture on Raster Analysis while the other thirty-eight learnt the same content with GISWEB.
The average mark obtained in the test given was 5.5 out of 10 for the GISWEB group and 3.5 out of 10 for the other group. Only 31.25% of the students that attended the traditional lecture were able to pass the test while this figure reached 70.37% for the group that learnt Raster Analysis with the help of GISWEB.

### PhD in Geography

There are a total of 22 students enrolled in this program. Ten of them made use of GISWEB for learning Neighbourhood Operations and obtained an average of 7.33 points out of ten while the remaining twelve received a traditional lecture and scored an average of 6.3 in the same test.

### Geodetic Engineering

There were 25 students enrolled in the GIS course of this program. 14 of them learnt Vector Overlay Processes assisted by GISWEB while the other 10 only received traditional lectures on the subject. The differences in the test results are minimal in this case. The average score for the first group was 10.33 out of 13 while for the second was 9.33. This may be because of a higher degree of prior GIS knowledge among the students.

In addition to test results, the evaluation also payed attention to time spent by students in studying the facilitated GISWEB modules. Interestingly, a degree of correlation between time invested and test result was found. The two students who invested least time obtained the lowest scores while students who obtained the highest scores invested more time than the average (53 minutes for each module). However, there is not a statistically significant correlation between time invested and score obtained. This reinforces the assumption that different students require different learning pace.

The evaluation project undertaken at the University of Alcalá de Henares also analysed responses given to the feedback questionnaire included in GISWEB. Responses given by Australian students can be found elsewhere (Zerger et al, 2002; Escobar, Zerger and Bishop, 2002). From the responses obtained in Spain, it stands out that all the students use computers in their studies. Over 80% use the Internet frequently and 34% posses a medium to high level of computer literacy. All of them have a computer at home and over 70% also have Internet access. 66 students (97%) consider it an advantage for their studies to work with MM and web-based tools and 65 of them state that MM delivery of education courses gives a deeper understanding of the material. All of them believe that new technologies offer important advantages to GIS learning and 92% would like to study other GIS aspects with the support of this kind of tool. Half of the students state that they would access and use this kind of materials on a weekly basis if the whole GIS curriculum would be developed with MM.

In the analysis of the open questions included in the questionnaire, it stands out that 60.29% of the students include guided self-learning as the main quality of GISWEB, followed by 48% who include interactivity and visual aid as further positive qualities of GISWEB. Although 55.88% consider that contact hours could be reduced, the majority also prefer the lecturer’s presence when learning GIS concepts (see also Francés, 2002).

## Discussion and conclusions

Previous studies have clearly demonstrated that GISWEB facilitates the lecturer’s task in formal lectures. It helps to demonstrate dynamic concepts and algorithms and provides a more visually attractive complement to the theoretical explanations. The evaluation study undertaken in Spain reinforced these findings. There is also evidence that students, both locally and internationally, appreciate this initiative as an innovative and useful learning tool. Lecturers in Australia have also noticed that many students do not voluntarily access this kind of learning material and encouraging greater use may require integration of the modules into formal assessments. This was tested in Alcalá de Henares with excellent results. However, our ideal model is one of voluntary adoption of the technology, which will hopefully vindicate our efforts with multimedia.

From results obtained in the tests completed by the Spanish students, the following conclusions can be drawn:

- MM functionality, animations and interactive tools in particular, helped students to learn dynamic GIS concepts,
- The adoption of tools like GISWEB appeared to be more advantageous in students with none or little background in GIS,
- Individualised teaching and learning can be assisted by tools like GISWEB where students learn at their own pace; and
- Users of GISWEB learn better and faster.

These encouraging results, when considered in the context of increasing levels of computer literacy and access to the Internet by students, demonstrate that multimedia is not only a valid delivery mechanism for improving learning outcomes but also that conditions for the adoption of this kind of tools in education exist.

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