WEB-BASED EDUCATIONAL PROGRAMS IN PRECISION AGRICULTURE[1]

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Web-Based Educational Programs in Precision Agriculture

S. Pocknee, C. Kvien, G. Rains, University of Georgia,

T. Fiez, J. Durfey, Washington State University,

and P. Mask, Auburn University

Abstract:

Establishing a set of electronic multimedia educational programs will expedite the understanding and implementation of key precision agriculture technologies. Several universities and private sector partners have joined together to accomplish this task and to make the material relevant to a diverse audience. Sections include base subject information, grower experiences, potential applications, guidance on how to determine the value of application techniques, and links to additional information. The learning modules (provided in a multimedia format) include information on global positioning systems (GPS); variable rate technologies (VRT); remote sensing (RS); sampling and scouting techniques; yield and quality monitoring; and geographic information systems (GIS). The programs of the University of Georgia (UGA) and of Washington State University (WSU) are highlighted. A discussion of the fundamentals of electronic publishing is included. The design of an Internet-era educational program is crucial not only so that the material is conveyed in an efficient and effective way but also so that ongoing maintenance is minimized.

Keywords:

Internet; World Wide Web; Distance Education; Web-Based Learning; Web-Based Education; Web-Based Courses; Precision Agriculture; Electronic Publishing, Cross-Media Publishing.

Introduction:

In agriculture, like in most industries, new tools and information are growing at an ever-increasing rate. To remain competitive, farmers, consultants, and agribusiness must constantly re-train. Some of the most useful new information tools have not been traditionally included in agricultural learning programs. These include GIS; GPS; RS; VRT; and information discovery, processing, and management tools.

Opportunities for individuals trained in these new skills abound; yet agricultural departments in most universities are just beginning to develop related course work. A recent report by the National Center for Education Statistics (Lewis et al., 1999) finds that distance education appears to have become a common feature of many post-secondary educational institutions, and that, by the institutions own accounts, distance education will become more common in the future. Unfortunately, it appears that the field of agriculture has been among the slowest to adopt distance education (Table 1), and hence, would appear poorly prepared to offer Internet learning opportunities. Interestingly, there has been no shortage of precision agriculture-related information sites on the Internet (see http://nespal.cpes.peachnet.edu/home/links/pa and http://ag.arizona.edu/precisionag). This contrast perhaps reflects a technology-based correlation between those interested in precision agriculture and those interested in the Internet that is not present in the wider agricultural community.

In a traditional (pre-Internet) world, printed materials would have served as the backbone for any educational instruction. Printed materials have limitations, however. In their discussion entitled "Print Versus the Web: Advantages and Drawbacks" Marion and Hacking (1998) list four limitations of print media. These are:

1) printed materials require long development periods, and once published they are static and quickly outdated;

2) in attempting to be all things to all teachers and to reach the broadest possible audience, authors and editors may create large, unwieldy texts, from which professors must excerpt what they need;

3) information can only be presented in a two-dimensional format; and

4) print lacks interactivity.

In the context of precision agriculture the first limitation listed above is arguably of the most immediate importance. The quickly changing nature of precision agriculture means that almost all texts relating to it quickly become outdated. The flexibility that Internet-based information allows in terms of modification over time is a potential answer to this problem. Although the Internet overcomes certain print media limitations, it is pertinent to note that print media still has several very attractive features. Marion and Hacking (1998) list the advantages of print media as "user friendly"; inexpensive; convenient and reliable; and easily archived. Obviously, the Internet isn't a panacea for all that ails traditional media. Marion and Hacking (1998) comment on the challenges that the new media presents to educators saying:

> The authors' role will change from writing and revising their texts in a linear process once every three or four years, to continuous involvement when substantive changes are required. Given that authors of college texts usually are full-time professors with research and teaching responsibilities, this more on-going authoring process of a textbook may be onerous to some. Creating content for a web environment that demands more frequent up-dating and creation of new pages and new linkages is a very different experience and process for authors and editors alike.

The Internet is a distinctly different publishing medium from traditional teaching media. The differences result in both opportunities and challenges. An understanding of the limitations as well as the potentials is essential not only for creating and designing a successful web site, but also for updating and maintaining it over time.

Issues

Maintaining Content Focus

Care should be taken to ensure that web based courses do not have the features of the technology as their primary focus. Technology for technology's sake is a trap that should be particularly familiar to precision agriculture practitioners. Landau (1999) wrote, "As guiding principles for using computers in education, it seems important to keep the focus on pedagogy and usability before technology, and to use materials with structural coherence (as provided by a printed text)." Hypermedia such as used on the Internet allows information to be structured in many different topologies: linear, hierarchy, and in a web style (Ginige et al., 1995) and in this sense hypermedia is considered to be very flexible. However, this flexibility does not necessarily result in an enhanced learning environment. Oliver (1996) wrote, "The higher the cognitive demand associated with the interface the less the user is able to attend to the key purposes of the interaction, that is the content of the package." The technology must facilitate, rather than hinder the learning process. Thuring et al. (1991) give some pointers in this regard:

> If a reader wants to navigate effectively, she has to understand the relations between the nodes of the hyperdocument. Therefore, it is not enough to provide structure but it becomes necessary to notify explicitly or even explain the structure to the reader. In order to improve both, navigation and comprehension, an author has to construct hyperdocuments which enhance the perception of local and global coherence relations.

Ellis (Ellis, 1972) offers the sage advice: "Thinking about the role of computers in education means thinking about education, not computers." The use of multimedia can offer a new perspective on an otherwise static representation of information, but the problems introduced (e.g., additional technical requirements and increased delays in downloading files) can lead to a mixed experience from users (Allen, 1998).

Online Education Limits Participation of Large Segments of the Population

Outside of academia, Internet access still cannot be taken for granted. Figure 1 shows that the majority of agricultural producers lack Internet access in the United States (US). Although a strong trend towards Internet adoption is indicated (US farm Internet use more than doubled between 1997 and 1999 (NASS, 1999)) these statistics do not reflect the reality that the level of service (bandwidth and reliability) in rural areas can often be poor and users may not be able to take advantage of all online tools despite having "access." A similar situation has been recorded in Europe (Waksman and Harkin, 1999):

> A serious difficulty facing farmer access to the Internet is that few farmers (among those equipped) run a powerful enough micro-computer; many equipped farmers are still using PC 286s or low profile 386s. Other obstacles are that IP connectivity remains too expensive for personal usage - even if ISDN is available in a number of European countries - along with substantial access cost to the Internet (investment, subscription, technical limitations). Finally, there is the problem of 'noise' on the Internet because of the poor quality of many services.

The Efficiency of Online Education Is Untested

Quinn et al. (1999) note that the assimilation of text read from a computer screen is significantly less efficient than assimilation of text read from hard copy, although this disparity varies from person to person. The authors argue that multimedia presents one answer to this problem. Ward and Newlands (1998), in a study of the effectiveness of a web-based undergraduate course, observed that most students did not use the Internet interactively, instead opting to print a paper copy of the Web documents at the earliest opportunity. Brusilovsky et al. (1998) note that an Internet learning system should be able to adapt its content to the needs of users with very different backgrounds, subject knowledge level, and learning goals. There are many ways to present information in an electronic environment and it will likely take time to figure out the best conveyance method for individual types of both information and user.

Costs of Development and Implementation

In the current technology boom, the costs of obtaining the services of information technologists are high. Although publishing of simple, static-format Internet documents may be inexpensive (often free), the costs increase rapidly as more advanced functionality (such as database-driven updating and interactivity) is implemented.

Accreditation and Quality Assurance

One of the widely discussed issues of Internet education is quality control. The ability to change and add materials isn't any indication of need to do so. Castleford (1998) writes:

> If the educational potential of the World Wide Web is to be realised, academics need to move beyond the flowery hype from chattering cybersages expatiating on its vast informational potential. As if you had not noticed, the Web is now a bed we share with vast numbers of anorak wearers, get-rich-quick marketers, porn barons, cauliflower-diet promoters and the like. If academics are to be able to educate students on how to use the Web it will need more than pointing them toward a list of "my favorite sites".

In discussing the failure of a number of European agricultural electronic information services in the 1980's Waksman and Harkin (1999) write:

> There was a strong and unresisted temptation for information providers, particularly in non-commercial systems, to open the flood gates of information and treat videotex as an electronic book publishing medium. This creation of an information jungle, coupled with poor navigation processes, was a recipe for disaster. "Too much, too late" - with users being provided with what was available rather than what they needed - epitomised the approach of too many authors:information providers.

Internet based course work should be subject to the same review and refinement processes that other educational documents receive. It would seem sensible that educational documents on the Internet explicitly indicate their "pedigree" by referencing the sources from which the document was formulated and any review process undertaken.

Lack of Interaction with Classmates

Online education may limit the student-to-student interaction that occurs in traditional classrooms. Arguably, this is one of the most important factors of an advanced course. Gibson and Rutherford (1998) point out that live interaction can be replaced by "virtual" interaction though judicious use of discussion forums and listservs.

Case Studies:

The two programs discussed in this paper complement each other. The WSU "Info Tech for Agriculture and Natural Resource Management" Internet site is designed to provide agriculturists and natural resource managers with an understanding of the technologies that are driving precision agriculture and natural-resource management. The site can be found at http://content.ctlt.wsu.edu/agtech. The content caters to both university level students and practicing professionals. The materials are being used in a semester-long class at WSU, although individual subjects could be covered in a single lecture or single evening at home. The UGA program (http://nespal.cpes.peachnet.edu/pa) targets farmers, consultants and extension agents and provides a more applied bent to the information. It is designed to be covered in a two-day period.

Project Goals

The UGA site aimed to provide:

- producer oriented precision agriculture information
- information in a variety of media (print, web, cdrom)
- a collaborative environment for information addition and update (Fig. 2)
- a website structure that could be re-purposed
- tools that allow information update while minimizing ongoing maintenance

The WSU site aimed to provide a technology education for agriculturalists and natural resource managers in a way that maximized content animation without distracting and confusing users.

Site Design Criteria

The UGA site design and construction goals included:

- Minimizing ongoing maintenance. The system was allowed the spreading of workload across multiple authors in a collaborative environment. Care was taken to divide of server-side scripts into multiple-use modular components, and minimize the separate web technologies used.
- Ensuring content could be update-able by separate authors without mediation by a central webmaster. Internet based authoring tools were written to allow individual authors edit-access to their own sections in a secure environment (Fig.'s 3 and 4). Authors can edit their sections without knowledge of Hypertext Markup Language (HTML) or installation of any client-side software.
- Keeping navigation simple. Constant navigation elements and Javascript pull down menus help facilitate this.
- Making content portable to other media (i.e., CD-ROM, paper). A separation of document elements (style, structure, and content) was implemented to achieve this. Through careful planning it is possible to have the same content reformatted for different media without intensive manual intervention.
- Client technology neutrality. By minimizing client-side scripts and implementation of browser neutral design elements it was possible to provide a site that functions equally well in a variety of user environments.

- Making a content-neutral site framework. The site framework should be able to be used for other education projects. The achievement of this goal hinges upon the separation of content from both structure and style.

To meet the site design criteria the UGA site used a number of different technologies. The site was designed to run on an Intel based computer running Microsoft Windows NT 4.0 and Microsoft Internet Information Server 4. The server-side scripts for the site were all authored in Microsoft Active Server Pages. Some Javascript was used on the client-side to provide drop-down menu functionality. Programing was done "in-house" by the corresponding author.

The WSU site was designed to provide an engaging presentation format. The site leverages components of a web-based courseware system developed by WSU's Center for Teaching, Learning and Technology. The program was initially developed to deliver economics course work. It has been used by hundreds of students at WSU, and has received very favorable reviews.

This WSU system uses Javascript to present combinations of HTML, Macromedia Shockwave and Flash, and other Java applets in a multi-frame web page. One side of the display is used to display short blocks (~ 150 words) of text as HTML. The other side of the display provides illustrations, animations, or interactive content. Simple navigation buttons lead the user from page to page of content. The textual content and the illustrations for each page are kept in separate files facilitating easy update and maintenance. If desired, the system can be scaled up into a fully online course with student logins and online testing. Other site features include a familiar "book-like" layout (much like chapters in a book) and quick-download capabilities (by virtue of the frames-based layout).

Site Content

Both sites cover core subjects such as GIS, GPS, yield monitoring, and VRT are covered at both sites, however, because of the differing target audiences, they are complimentary. The WSU GPS pages cover in-depth basic information about how the GPS system calculates position. The UGA site compliments this by delivering short descriptions of the many uses of GPS in agriculture along with troubleshooting tips, and links to GPS companies.

The UGA site (Fig. 4) main navigation bar lists six major pages, each with several sub- pages:

- **Management Strategies** (for soils, pests, water, crops, livestock, equipment, people, and data)
- **Management Tools** (GIS, GPS, Yield monitors, RS, asset tracking, and VRT)
- **Providing Services** (developing partnerships, expanding services, people and equipment needs)
- **Forum** (for posting of questions and comments)
- **Resources** (including links, images, software, and video files)
- **Bottom Line** (how to keep costs down, improve efficiencies, increase profits)

The WSU site (Fig. 5) covers the following technology areas:

- **Computer Interfacing** (serial, parallel, SCSI, USB, and IEEE-1394)
- **Geographic Datums and Map Projections** (geoids, ellipsoids, datums, and common projections)
- **Geographic Information Systems** (spatial databases, display of spatial information, analysis of spatial data, and sources of spatial data)

- **Global Positioning System** (what it is, how it works, accuracy, mapping systems, and NMEA)
- **Internet Access to Information** (protocols and search strategies)
- **Remote Sensing** (fundamentals, air- and space-borne systems, image processing, and image analysis)
- **Sampling and Interpolation** (sampling approaches, spatial statistics, and interpolation methods)
- **Variable Rate Technology** (map- and sensor-based approaches and variable rate application of seeds, fertilizer, and pesticides)
- **Weather and Soil Instrumentation** (sensing of temperature, precipitation, radiation, and air and soil moisture)
- **Wireless Data Communication** (electromagnetic radiation and wireless connection methods)
- **Yield Monitoring** (fundamentals of various sensor systems).

Discussion/Lessons Learned:

The sites used as case studies were in their infancy when this paper was written. The reader is reminded that a full evaluation of the Internet programs used as case studies in terms of effectiveness had not been carried out at the time this paper was published. Although the goals and design criteria were based on several years of experience designing and implementing web sites, the authors willingly acknowledge that web-based education is an evolving field. Should the reader be perusing this article as little as a year after publication it is possible (and even probable) that the sites studied will bear little resemblance to their described form. Hopefully, the publication of information about the design and goals of these pioneering Internet sites will aid the development of Internet programs yet to be started.

The development of a web-based education project requires effort in both content generation (what to put on a page) as well as web delivery system design and construction (how to serve the pages up). Clearly, the next few years will provide major challenges in maintaining the sites with current and accurate information. However, the accessibility of the Internet has already greatly reduced the amount of time spent explaining concepts, finding materials, and printing and distributing materials.

The way a course is assembled is very important. No need exists to limit courses to being media dependent. The options of print, voice/video (classroom), CD-ROM, and Internet exist. All have their own advantages and disadvantages (Table 2). Future courses are not likely to be delivered solely in one medium. The challenge will be to choose the correct mix of media for the specific educational needs of students.

Duplication of effort should be avoided. Content, style, and structure should be separated as style and structural requirements will vary by medium. Ultimately, the content is paramount, but we need to recognize that the presentation of the content will affect its usability; and ease of media transfer will affect its distribution.

The development of interactive content can be achieved. It is however, time consuming and expensive. The need for interactivity should be balanced against the constraints of time and money, as well as the limited cross-media publication possibilities. Even within an Internet-only environment, much uncertainty about the user environment exists. These reasons favor the adoption of a certain amount of technological conservatism.

Education on the web is an evolving process. The difficulties and expense of implementation combined with uncertainty about end-user acceptance suggest a program of small steps followed by evaluation periods. The programs represented here are the first small steps on the road to an important, albeit uncertain, destination.

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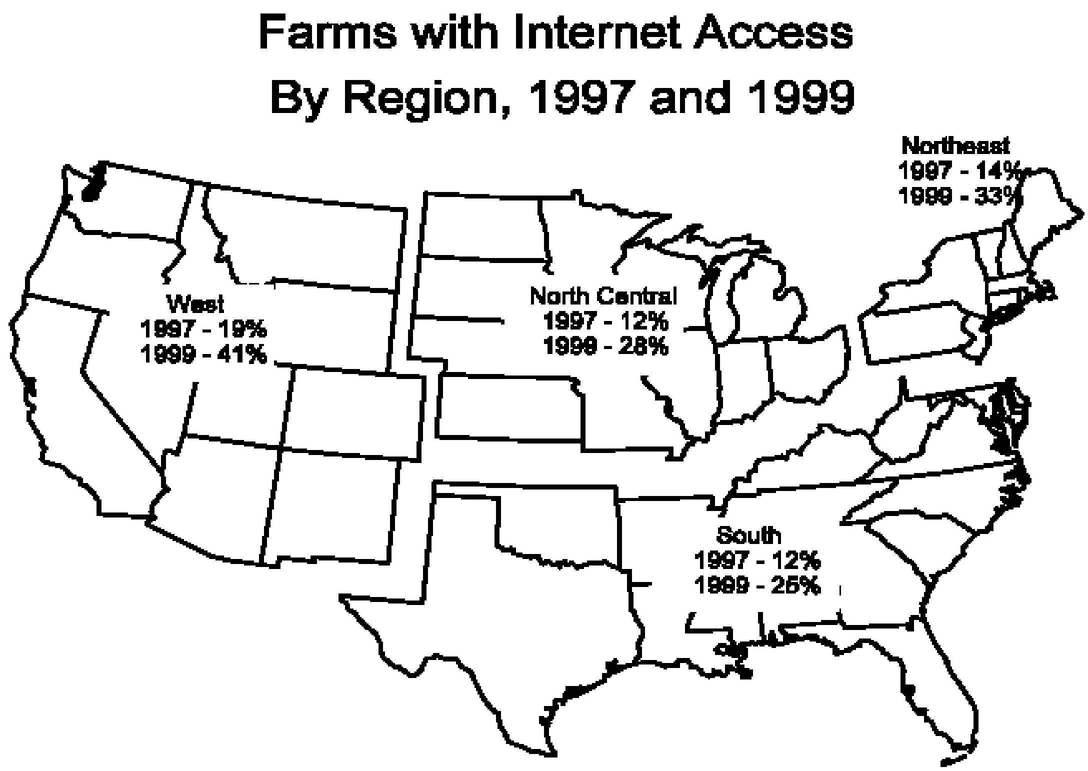

Figure 1. U.S. Farms with Internet Access - National Agricultural Statistics Service (1999).

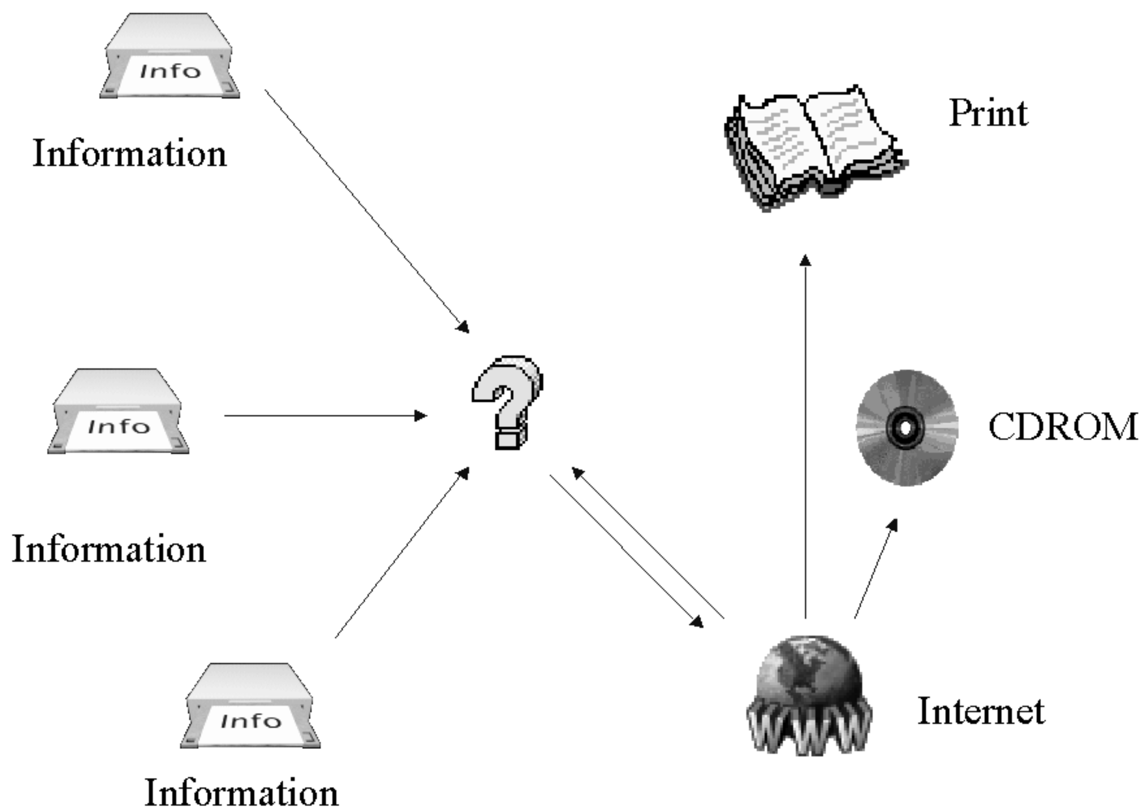

Figure 2. The design model for an electronic course taught collaboratively by multiple authors. The web site is the focal point for collaboration. The question mark represents the mechanism by which authors collaborate in the web environment.

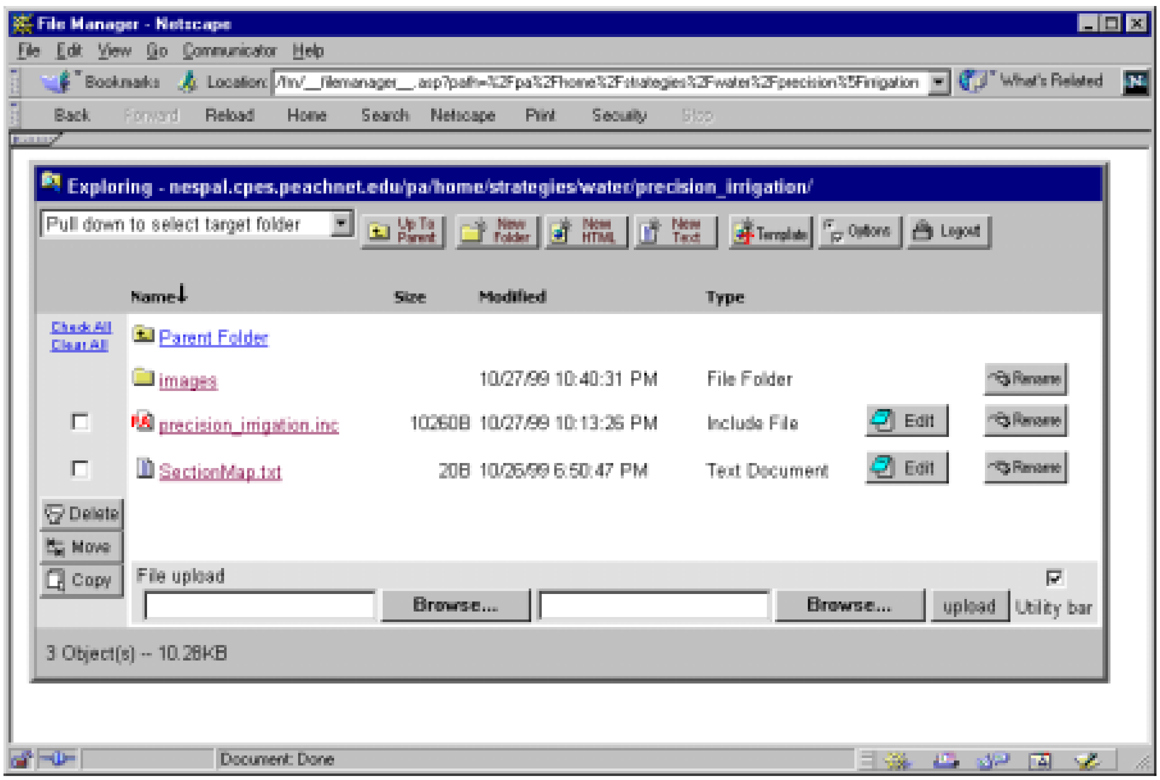

Figure 3. An example of the web based interface used at the UGA site to allow authors full access to their respective areas of responsibility.

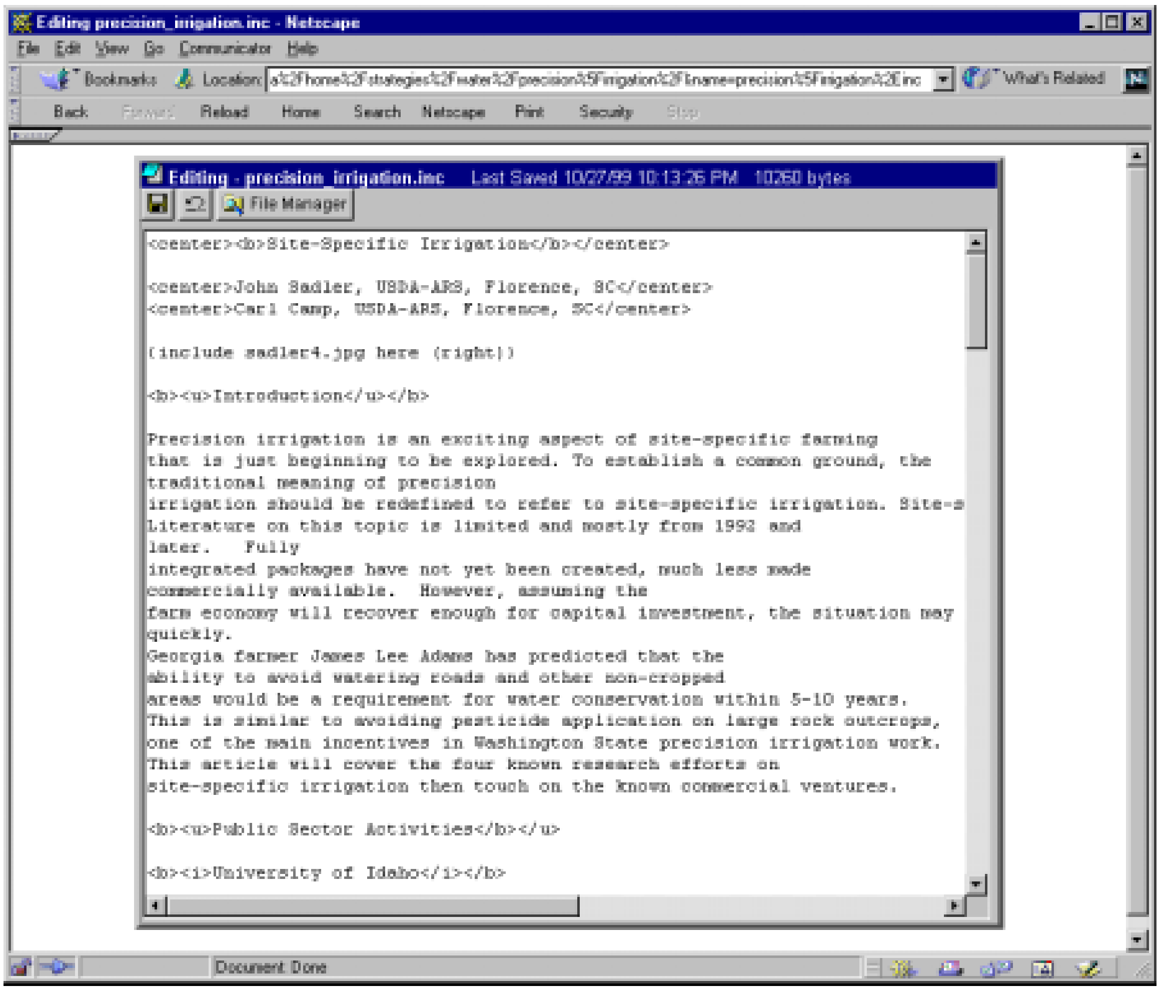

Figure 4. An example of a file within the in-browser editing environment. Note the limited HTML codes required.

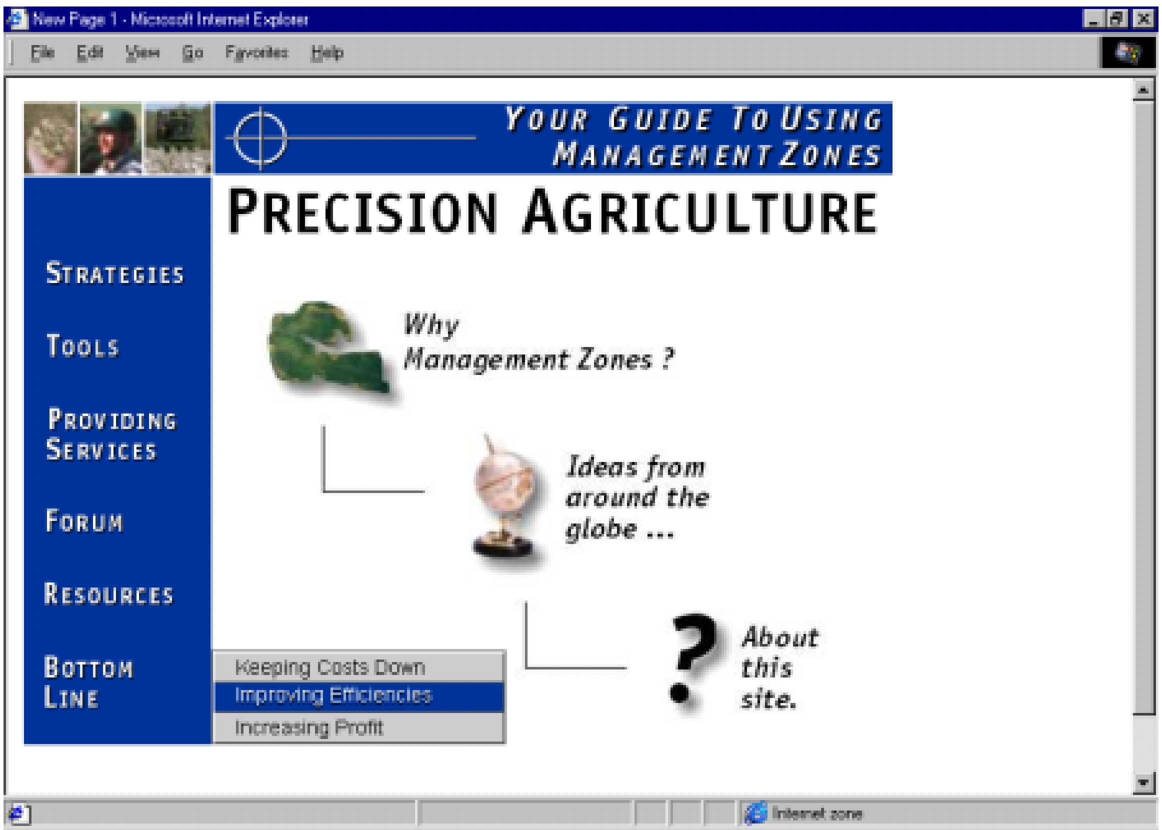

Figure 5. University of Georgia site at http://nespal.cpes.peachnet.edu/pa

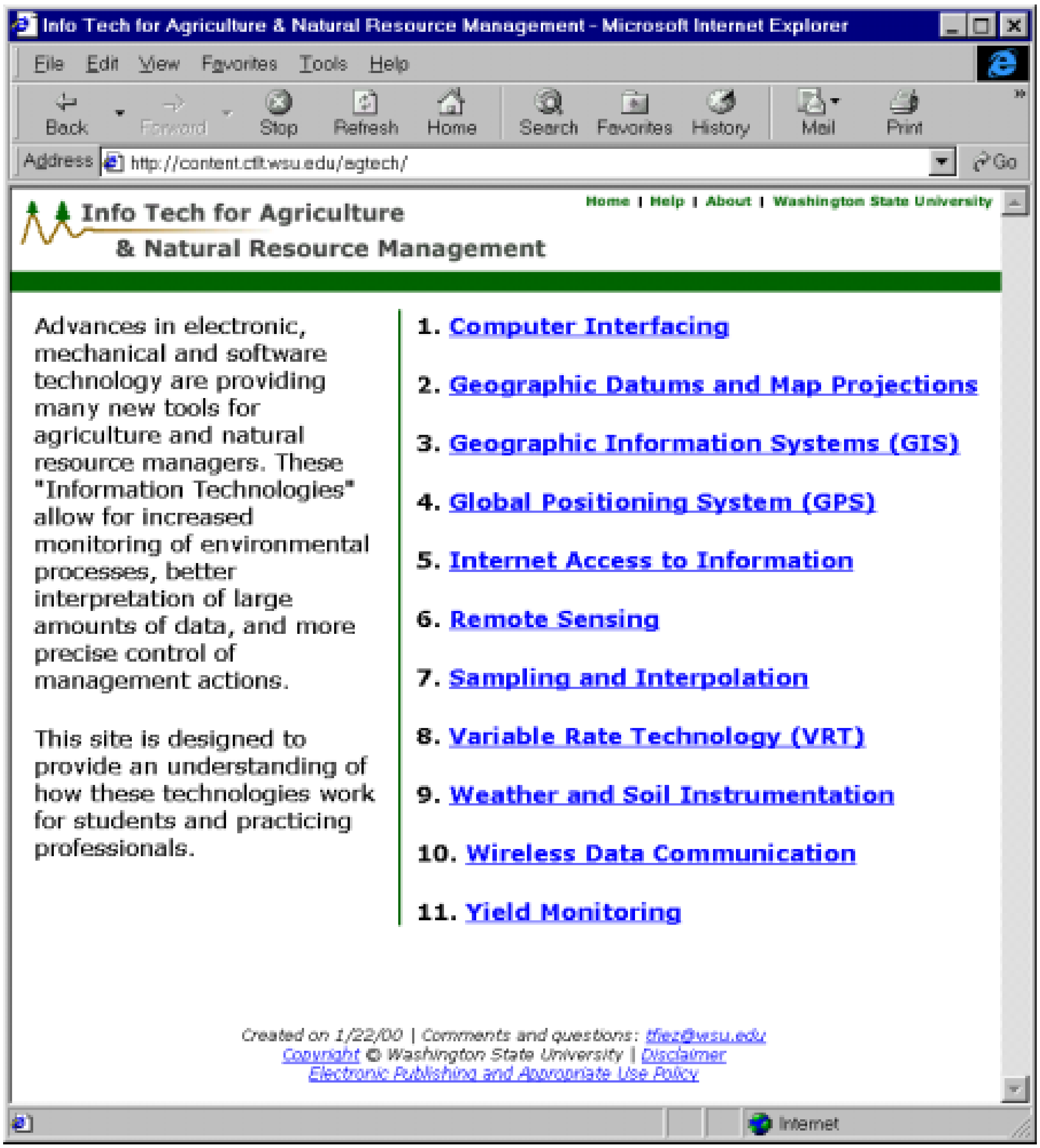

Figure 6. Washington State University "Info Tech for Agriculture and Natural Resource Management" site at http://content.ctlt.wsu.edu/agtech

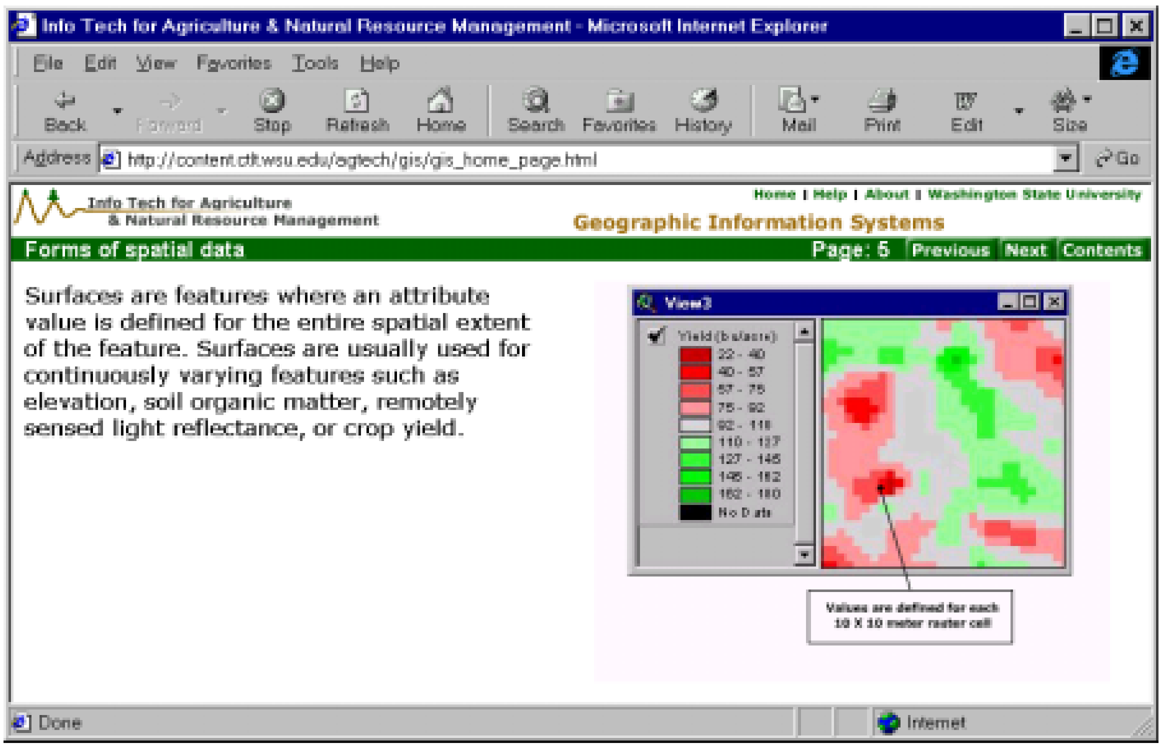

Figure 7. A sample page from the Geographic Information Systems section of the Info Tech for Agriculture and Natural Resource Management site.

Table 1. Percent of 2-year and 4-year post-secondary education institutions offering any distance education courses in 1997 - 98 that offered college-level, credit-granting distance education courses in various fields of study in 1997 - 98, by course level and field

Field	Courses at either level [1]	Undergraduate courses [2]	Graduate/first-professional courses [3]
English, humanities, social and behavioral sciences	70	71	22
Business and management	55	51	30
Health professions	36	31	24
Physical and biological/life sciences	33	32	8
Mathematics	32	32	7
Education	29	19	40
Computer science	26	25	10
Vocational/technical fields	17	17	3
Engineering	12	9	16
Agriculture and natural resources	7	7	3
Library and information sciences	6	4	7
Other fields	16	13	13

[1] Based on the estimated 1,680 institutions that offered any distance education courses in 1997 - 98.
[2] Based on the estimated 1,620 institutions that had undergraduate programs and that offered any distance education courses in 1997 - 98.
[3] Based on the estimated 750 institutions that had graduate or first-professional programs and that offered any distance education courses in 1997 - 98.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Postsecondary Education Quick Information System, Survey on Distance Education at Postsecondary Education Institutions, 1998 - 99.

Table 2. Advantages and disadvantages of various modes of communication - adapted from Chu and Chan (1998).

Print	Voice/Presence	CD-ROM	WWW
Advantages Defacto standard High resolution Can convey words, pictures, motion Multiple formats and portable Hierarchical organization/navigation Archival Kinesthetic experience (collect and save books/clippings)	Advantages "Tradition" High resolution Re-enforce context (gestures) Interactive	Advantages Searchable High resolution Can convey words, pictures, motion, sound	Advantages No physical or temporal barriers Can process/analyze data Searchable Accessible across networks Can convey words, pictures, motion, sound
Disadvantages Physical and temporal barriers Not interactive	Disadvantages Limited format (requires physical presence, not portable) Not archival Physical and temporal barriers	Disadvantages Limited format (requires computer) Physical and temporal barriers	Disadvantages Limited format (requires computer, not portable) Low resolution