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Introduction

Geographic Information Systems (GIS) are defined as: "An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes." (Wade & Sommer, 2006) Originally, GIS users were comprised primarily of scientists and engineers. In time, hardware and software advancements provided the catalyst for expanded use by the global community. In addition, the continued integration and access to information systems via the Internet and mobile devices has contributed to the success of GIS in society. Aside from commercial training, institutions of higher learning have played a major role in the technical training of GIS professionals. As with other technically orientated topics of study, pedagogical considerations exist that include: problem solving skills, information retention, and approaches towards learning. A pedagogical approach utilizing student generated and existing Internet GIS resources may provide an effective method of addressing GIS education.

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GIS Described

GIS shares many qualities of other information systems. Data storage, data retrieval, and data display are characteristics shared by almost all. However, GIS is unique in that geographic location provides its foundation. All data that is functional in a GIS has geographic reference. There are many coordinate systems to choose from, ranging from the classical geographic latitude and longitude, to Cartesian systems such as Universal Transveral Mercator (UTM).

The second principle of GIS is the layering of geographic data. This entails categorizing similar features on the landscape into a slice of information that represents those features for a designated area. A good comparison would be a standard road map for a state: Even though there are many things the map could represent, the roads are the features of importance. Also, the state would be the designated area. In the GIS, a method called layering provides a logical and orderly method of storing relevant geographic data for display in a map-like manner and analysis.

Thirdly, GIS feature data is connected to attribute information describing it. The relationship between a feature and its attribute information provides an environment providing the graphical component of GIS to be enhanced with descriptive information. An example of this would be a layer depicting parcel information for a community. The layer would look like a typical parcel map. By selecting an individual parcel, the system would display attribute information such as: ownership, area, zone and tax information.

Although a GIS provides the means of creating quality cartographic maps, along with map elements such as titles, legends, north arrows, etc., the real power behind the information system is the ability to perform attribute and

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spatial queries. The combination of geographical reference, layering, and attribute data provides the environment needed to identify specific landscape features and spatially compare them with other objects in space. Relationships between features include: distance, direction, and physical descriptions. Spatial analysis ranges from simple queries, to complex modeling.

Environmental Systems Research Institute Software

The primary provider of GIS software in the world is Environmental Systems Research Institute (ESRI). Since the 1960's, ESRI has created GIS software to accommodate a variety of client needs. Operational environments range from command line driven to windows based applications. In addition, ESRI is a leader in providing Internet GIS software solutions globally.

Released in the year 1999, ArcGIS was developed to provide an environment that was user-friendly but capable of providing robust GIS operations. The base version of this software is designated as: ArcGIS ArcView, and the higher level version: ArcGIS ArcInfo. Extension applications may also be added to enhance GIS capabilities.

The interface environment is very similar to many windows based software applications, such as menus buttons, and display windows. Aside from containing GIS operations, the most noticeable difference is how it manages and represents layers of information in a map-like manner.

Basic GIS Skills

There are several foundation GIS skills: data entry, data creation, data editing, attribute analysis, spatial analysis, and output display. Although the levels of complexity vary, almost all GIS operations fall under one of the mentioned categories. Data types primarily comprise vector (point based models), raster (grid based models), or attribute (tabular) information (Davis, 2001). Data creation often entails digitizing paper maps or related spatial graphics into GIS format (Longley, Goodchild, Maguire & Rhind, 2007), but conversion of existing GIS data into another format and the encoding of attribute tabular data also apply. Data editing comes in many forms. These include: correcting digitization errors, updating attribute information, and adjusting coordinate information. For quality control, the Spatial Data Transfer Standard (SDTS) provides structure regarding descriptive information for the accuracy and quality of GIS data (Obermeyer & Pinto, 2008). Attributer queries access the attribute tables of GIS data to identify feature data that meet specific criteria (Ormsby, Napoleon, Burke, Groessl & Bowden, 2009). This method uses alphanumeric statements that range from finding an object by name, to identifying areas that meet complex environmental conditions. Spatial queries are those that spatially analyze the relationships between objects in space (Longley, Goodchild, Maguire & Rhind, 2007). As with attribute analysis, the level of complexity varies. An example of the simplest of spatial analysis technique is overlay analysis: determining what objects occupy the same space. An example of more complex analysis includes epidemiological modeling (Longely & Batty, 1996). Output display for GIS is typically a map that is either for reference or thematic. GIS software is capable of including cartographic elements, such as a title, legend, scale bar, as well as other operations that allow for the creation of a professional product. In addition, GIS data output can be represented in graph or tabular format (Ormsby, Napoleon, Burke, Groessl & Bowden, 2009).

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Online Resources and Instruction

There is an extensive body of research regarding the potential benefits of incorporating Internet based resources towards improving education. Although research directly related to GIS education and the Internet is limited, it is logical to assume the body of Internet based resource literature can be extended to GIS education.

There are a variety of opinions regarding the effectiveness of introduction of web-based resources into, or in some cases replacing, traditional classroom approaches. The scope of Internet integration ranges from complete utilization of the Internet, to the use of web-based resources to enhance delivery. Some research suggests there is no significant difference in teaching a course online or in the classroom (Donavant, 2009). However, the proper integration of web-based resources may enhance a previously traditional class to the point that its virtual version is relatively the same in quality (Schoech, 2000). Aside from distance learning courses, a significant amount of research supports the integration of web-based resources to enhance a student's educational experience.

There are a variety of successful instances of utilizing models or frameworks. A major concept in web-based pedagogy is Just-in-Time (JIT) education. This deals with providing web-based education that can be accessed by students at any given time or place. A study by Cho, Schmelzer, and McMahon (2002) compared JIT and traditional methods. A model based on JIT, collaborative learning, critical thinking, and user acceptance of technology was generated, and results indicated potential improvements in course effectiveness. Chappell and Schermerhorn (1999) researched the impact of student electronic portfolios from the stakeholders perspective. Findings of the study indicate that aside from the standard benefits of using electronic portfolios, university administration, faculty, students, employers, and parents/alumni demonstrated a notable level of enthusiasm and support.

A potential benefit provided by the Internet is greater communication and interaction. Persell (2004) incorporated web-based discussions in a manner that effectively enhanced student engagement in a sociology course. Kuechler (1999) explored the Internet's easily accessible data environment and noted great potential benefits. Stocks and Freddolino (2000) identified that students who provided greater access to web-based resources (discussion questions, instant feedback, self-tests) tended to rate their classroom experience higher than others. Aside from the more traditional objectives of integrating web-based resources in a classroom setting, researchers even managed to increase student knowledge and positive attitudes toward organ donation (Vinokur, Merion, Couper, Jones & Dong, 2006).

Simply using web-based resources does not guarantee success, and certain factors need to be considered. Donavant (2009) observed a relationship between online learning success and formal education level. At the public school level, Wallace (2004) noted that many teachers are not sufficiently prepared to integrate the Internet in the classroom. Even at the university program level, the advancement of distance learning is challenged by obstacles (Godschalk, 2001). In addition, student preparedness is a factor that needs to be considered (Kuechler, 1999; Jensen-Lee & Falahey, 2002). Another factor is student willingness to contribute online (Jensen-Lee & Falahey, 2002). Although search engines provide a great deal of functionality, a creative mindset is needed that can expand upon an established structure (Kendrick, 1999). In regards to the incorporation of materials on the Internet, it is beneficial to be aware of copyright limitations (Jensen-Lee & Falahey, 2002; Ludlow, 2003).

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Proposed Model

Fort Hays State University provides several GIS courses: Introduction, Intermediate, Advanced GIS, and GIS Programming. Considering the documented positive results of utilizing web-based resources and innovative practices towards improving education, researching their potential to improve GIS education has merit. Therefore, exploring the creation of a web-based pedagogical model to enhance GIS education is the research objective.

The model would have three primary objectives: First, to create a web-based resource containing technical and theoretical GIS information that could be easily accessed and enhanced. Moreover, this resource would be available after graduation and if accessed regularly, potentially improve retention of GIS theoretical knowledge and technical skills. Second, to provide an electronic environment that allows students to interact and solve problems in a collective and efficient manner. Third, to enhance technical spatial problem solving skills, and providing an archive of successful approaches. The model would be divided into three components: resource development, assessment, and engagement/problem solving.

Student Websites

Considering the ease with which individuals can access the Internet, it is logical for a web-based model to incorporate individual websites. With increased access to the Internet via computers and mobile devices, students who develop and maintain their GIS Technical Information website would have access to Just-In-Time knowledge that is essential in the professional community. For preliminary studies, Google was chosen as the provider of personal websites for a variety of reasons. Aside from being a free service, Google provides a variety of functions that can be integrated into personal websites that make them ideal for use in this manner. These include: the ability to set access, services like Google Maps for geographic inquiry, and an Internet based email system (Google, 2010).

Resource Development

ArcGIS software has many operations available, and often, users become proficient using a certain set of them to accomplish specific tasks. Both necessity and curiosity are catalysts towards exploring the functionality available. Student web-pages would contain several primary folders: data entry, data creation, data editing, attribute analysis, spatial analysis, and output display. For each, students would be tasked with describing how to complete various operations. The range of task complexity would range from introductory in level to advanced. The option to include graphics, animations, and sound files would be available. Entering technical descriptions for GIS tasks would be treated as course assignments and awarded points for completion. A rubric for scoring would be established using performance standards common in the GIS community. Ultimately, the quality of web-based documentation would be based on the pragmatic approach of whether or not students could complete documented GIS technical tasks whenever asked. If the documentation entered was not sufficient in content, students would have the opportunity to augment it in the future.

Beyond online assignments, quizzes and exams would assess student knowledge and proficiency in GIS theory and technical operations documented in their personal GIS websites. This approach provides the means for assessments to engage more technical operations and content versus the more

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traditional approach. Student access to personal GIS websites makes it reasonable to expect a higher level of performance in the classroom.

Engagement and Problem Solving

To help improve problem solving skills, the course websites would address a variety of real-world scenarios to be solved using GIS. Some of these could include: natural disaster management, economic analysis, and resource management. Using a chat room, each student would contribute several points of consideration towards solving the problem. Participation points would be awarded based on their level of interaction and constructive ideas shared via a rubric. Aside from in-class discussion, establishing a chat room would allow for discussion and problem solving to continue beyond scheduled class time. The best approaches towards problem solving scenarios would be archived on personal GIS websites for further reference. The creation of flow charts to illustrate problem solving steps could also provide a useful method of visually mapping the required steps.

Preliminary Study

During the Fall of 2009, a preliminary study was conducted at Fort Hays State University in the Intermediate GIS course. Students were asked to develop personal GIS websites for use in the classroom. No statistical analysis was attempted at this preliminary stage; however, a variety of useful observations were made:

Although many traditional students are adept in the use of computers and the Internet, not all students are comfortable with web-site development. Initially students were directed to create a personal GIS website~~s~~ and set up the appropriate folder structure. Unfortunately, some who struggled with creating their web-sites were reluctant to ask for help. By the time this was noticed, several students had already fallen behind. The solution was to develop all websites as a class and proceed only after each student demonstrated the ability to add and edit entries.

The level of note taking and documenting technical operations was on occasion, inadequate. With increased access information on the Internet, the practice of note taking seems to be challenged. As with creating websites, instruction on how to logically document technical operations is beneficial.

Due to the nature of GIS, an operation that falls under the category of analysis could also be labeled as data editing. This situation can make it difficult to determine where entries belong on personal web-sites. A simple solution is requiring students to create a reference that identifies the location of each technical description like a book's table of contents.

The unforeseen obstacles towards student creation of personal GIS websites made using them during exams problematic. In order for this approach to be fair for the entire class, the development of these resources must have an adequate amount of structure established prior to implementing this approach. However, several students from this course were enrolled in the Advanced GIS course in the Spring of 2010. It was observed that they referenced their personal GIS websites at various times in class to work through technical tasks addressed in Intermediate GIS.

Summary

Research literature suggests that the utilization of web-based resources can enhance the classroom learning experience for students. There are a variety of approaches that can be taken, but research also indicates that adhering to a

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predetermined course of action or model is a significant component towards meeting pedagogical objectives. The development of a Web-based model for GIS education has the potential to improve learning through: student generated documentation, ease of access to technical and problem solving strategies, student collaboration, online assessments, and timely feedback. The preliminary study of student development of personal GIS websites suggests that establishing a structure that addresses the various student levels of familiarity regarding website development is required. Moreover, providing an adequate framework towards managing technical and theoretical documentation entries is beneficial. Implementing and testing the proposed model using a quasi-experimental approach is the next step in this research.

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