Teaching Virtually: Going Beyond the Static Web Page Text with Virtual Experiences

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ABSTRACT

Computer based teaching has become common place as the demand for specialists continues to increase in view of continuously evolving remote sensing technologies. Moreover, content accessibility via the internet makes anytime, anywhere teaching possible while reaching a larger audience. The majority of computer based courses however, continue to use the static text model and present the student mainly with the same material found in a textbook. Student computer based learning experiences could be much more rewarding if the curriculum included more interaction and practice. It is with these goals in mind that the development of a virtual experiment and game were devised. Herschel's experiment was the first to show the existence of infrared (IR) light. This virtual experiment requires the student to set up the experiment and record data in order to prove the existence of IR light. The 'Field Experiment' game requires the student to plan and execute a field collection campaign with the use of a field spectrometer. These 'beyond the book' experiences hopefully encourage and stimulate students in the subject at hand as well as provide more 'practical' experience that is not available through viewing static text and graphics.

Keywords: distance learning, virtual classroom, optical remote sensing

1. INTRODUCTION

The teaching environment is changing due to advances in technologies and the need for specialists. Technological advances specifically in communication and multimedia are able to provide both teachers and students new options in education. With specialists in short supply, focused education and training are required to bring students up to speed in the shortest time possible. Two of the greatest barriers in education are being taken down: time and place. Time is an obstacle when knowledge and skills are required in the 'now'. For example, an executive does not have time to go to back to school and a soldier far from home does not have access to the traditional classroom. On the other hand, there is a constant need for teachers because specialists are in short supply. Moreover, it is impossible to expect that every teaching institution can accommodate students in every domain and students do not have access to any and all teaching institutes. This is the obstacle of place in education.

Traditional forms of teaching are also continually under scrutiny because of the disparity of the preparedness between students entering the workforce. Consequently, businesses and/or students must invest in additional training. The answer is cheap and accessible knowledge on demand. This is unfortunately not yet available. However, one form of instruction collectively known as distance learning has attempted to accomplish this goal and with today’s available technology has incarnated into many forms providing both teachers and students with alternatives in education.

The textbook is the most basic of teaching tools and in electronic format it can be a web page or digital document. However, with the multimedia power and communication capabilities of today's personal computers, this static medium can be enriched to provide interactivity between the user, teacher and learning materials. As such, the curriculum developer is able, with the available tools, to create an environment which corresponds to interaction between teacher and student.

This paper primarily focuses on development ideas for a course in optical remote sensing information extraction. First, some distance learning program frameworks are introduced as well as the technologies available today that are being introduced into the electronic learning arena. An overview of the goals of the Geoworkforce Development Initiative at

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the University of Mississippi for providing next generation teaching materials are presented. Finally, several ideas on the implementation of remote sensing skills and transfer of knowledge are explained within the framework of the Geoworkforce Development Initiative.

1.1 Current Choices in Distance Learning
Distance learning has been around for quite some time. More recently however, this teaching model has become very attractive in both the business and education sectors. Even in the face of fierce competition, shrinking budgets and scarce resources, businesses must continue to compete. As a consequence, employees must constantly be trained and re-trained in order to be current. Universities and colleges have a similar problem and therefore are looking into non-traditional markets for their services.

Learning at your convenience and away from a teaching center is not a new idea. For years, universities and colleges provided certain courses to students by sending them kits with all the necessary materials. Even audio or video tapes of lectures were sometimes included. One of the greatest drawbacks however was the missing communication between the student and teacher which was either costly when telephone calls needed to be made, or lengthy if done by post. In many instances the student was also required to travel to a specified location for testing and exams.

Today, many of the inconveniences of communication are non-existent largely due to the prevalence of the internet. One of the leaders of online course delivery is the University of Phoenix online (onl.uophx.edu). The University of Phoenix 'was created to answer the unique educational needs of professionals who already possess a wealth of practical knowledge. Our curriculum also emphasize the immediate application of all learning to the workplace, adding real-world value to our education'. This school specifically targets a certain type of student offering a limited number of degrees and the factors of time and place are very attractive to working professionals. With a simple connection to the internet, students can retrieve lectures, questions and assignments. Research libraries and services are also accessible via the internet. The internet is also the primary method of communication between the students themselves and the teacher which can be done in real-time with chat sessions or via a moderated email list.

Distance learning and teaching varies by institution. At a bare minimum, schools are recording lectures and providing them online for students to review. In other cases, lectures are presented in real time via the internet allowing the students to participate in the lecture by writing questions directly to the lecturer. These types of setups diminish however the freedom of time and place for the student because they need to be enrolled at a local institution or adhere to a course schedule to view the lectures at their specified time.

The examples presented thus far are all synchronous, i.e. they all require that the student either be available at certain times or must complete the course in a specified time. At the other end of the spectrum, course material can be made available to the masses as in the case of MIT's Open Courseware initiative (ocw.mit.edu). Here the material (text) is available online for anybody with an internet connection for free however no degree is awarded.

1.2 Electronic Learning
One of the oldest methods of transferring knowledge and skills is through hands-on tutelage that the apprentice receives from a master. The concept behind this teaching method is that practice makes perfect and all experiences, including failure, is part of the process. Electronic learning or e-learning tries to apply these same principles through simulation.

The most impressive example of simulation is pilot training. Entire cockpits are re-constructed with massive computers recreating real life situations. The pilot is exposed to different situations and must react accordingly in order to land the plane safely. The equipment required to recreate these types of situations is very costly and has been mostly confined to the aeronautics and military sectors. With the advancement of affordable powerful processors and high end graphics card, simulation has come to the desktop.

The greatest advantage of simulation is that the simulation is the instructor. By providing the student with situations in which they need to make choices allows them to practice their skills and apply their knowledge. Furthermore, simulations don't get tired or care if the student is attempting the same thing for the hundredth time. Most importantly they can make the mistakes that in the real world could mean lost revenue or even loss of life. Current examples of e-learning software based on simulations are training for nuclear engineers, telecom technicians, financial forecasters, and
leadership training. The goal as an industry is to try and make the experience as real as possible.

The one drawback is that some knowledge or skills are required before the student can take full advantage of the simulation, i.e. prerequisites. This would entail re-creating the expert.

2. RE-CREATING THE EXPERT

Easy access to and the low cost of technology today allows educators to provide a variety of choices for distance learning. In many ways it is up to the student to find curriculum that suits their needs and learning style. The University of Mississippi's Institute for Advanced Education in Geospatial Science3 is presently developing a distance learning program that would cater directly to the development of the Geospatial workforce.

�This dynamic learning environment will not replace the current concept of university learning in classrooms but complement this process by expanding various learning structures to combine a consortium of experts amplified by virtual classrooms equipped with the most advanced instructions, computations, course evaluation, and management facilities. With the need of an increased professional pool in the field of GeoSpatial Information Technology, our ultimate goal is to develop a highly skilled workforce, well educated and equipped to lead the development of GeoSpatial Information Technology in the next century. Our goal will be accomplished by integrating three substantial environments: expert-lead, self-paced, and collaborative efforts.
3. TEACHING OPTICAL REMOTE SENSING INFORMATION EXTRACTION

One of the courses offered by the IAEGS is entitled 'Information Extraction using Multi-spectral, Hyper-spectral and Ultra-spectral Data'. This particular course deals with the many aspects of optical remote sensing information extraction. The course aims to fulfill many of the goals of re-creating the expert. Currently being developed, the course is based on today's available technologies and this section presents some of the ideas that will be developed to create this particular courseware.

3.1 Automating Examples, Illustrations and Exercises
The textbook is a primary source of information for almost any subject and examples and illustrations are an important component of this teaching tool. The number of illustrations and examples in many cases is unfortunately governed by the publisher's requirements of size. One can imagine the number of illustrations that can be shown just to better explain the notion of spatial resolution or spectral resolution.

E-learning provides the medium and storage capacity to present large amounts of imagery and examples. Digital imagery is rarely printed especially during the information extraction phase and thus can be naturally presented on the computer. A simple interface can allow direct interaction with the sample imagery to zoom in, change channel assignments or view each band separately. This type of interaction also develops familiarity with remote sensing optical data; such as viewing near infrared imagery.

Examples and illustrations are one of the strongest manners of portraying subject matter to students. With the increased capacity to hold more examples it is also possible to make them more diverse. However, the sampling of examples should be purposeful. A typical sample should always be included because it reflects what students should expect to be the usual. This is important earlier in the student's development again for familiarity. Unique examples should also be included illustrating a rare or atypical situation. This can be done using the same location or different locations illustrating the possibilities of optical remote sensing. Finally, examples showing maximum variability deliberately seeking out the widest possible range of the characteristics of interest for the study. Basically, some thought must be put into the choice of examples because even though storage is not a limiting factor, student patience is.

Since this is also a collaborative effort, examples can come from various sources as well. Experts are generally confined to certain areas of study and providing examples from different branches of remote sensing enables students to learn the material using examples in which they are more interested in.

Updates are also very important not only to show students the evolution of some of the sensors (for example providing both old and new NOAA AVHRR imagery) but also to keep up with student demands. Students are an important factor in improving courseware and therefore suggestions to topical examples and illustrations should be noted and addressed accordingly. Furthermore, advances in sensor technology and information extraction methodologies are frequent and therefore an updating system should be in place as part of the courseware.

Exercises can also be automated and interactive. First off, in a classroom setting not every student needs to get the same question because the program can decide from a range of questions on the same subject. This encourages discussion among students rather than simple copying. When the courseware is being used as a distance learning tool, the student has a larger assortment of exercises to choose from resulting in better skills development.

Many times remote sensing exercises also require the student to have access to image manipulation software. Remote sensing software comes in many varieties and most importantly is costly. The exercises available in the courseware will already have the answers available. This provides instant results and more importantly minimizes the chances of technical difficulty with installing proprietary software. This last point is especially important for distance learning students who do not have access to a computer lab with the necessary software. Although there are internet accessible alternatives where students can use remote sensing software remotely, this option does not necessarily allow for anytime access and the courseware is not about endorsing any particular product. Furthermore, understanding the underlying methods and algorithms is much more important.

Preparing the answers to exercises in advance also has the benefit of being able to track the student. Figure 1 provides a
simple schematic of this idea. A question is presented to the student and a number of choices are made available (or when computations need to be made, a text area to write the answer). Once the choice (or answer) is selected, three outcomes can be expected. The first is that the student has chosen correctly. This can let the algorithm know to either ask a similar but more difficult question or to go on to the next exercise. Making an educated guess can provide the student with a short explanation of why it's not entirely correct and to try the exercise again. Finally, the wrong answer will link the student to the section within the courseware explaining the concepts again for review.

![Diagram](image)

**Figure 1 – Schematic of automating simple exercises.**

Exercises can be much more in depth than the schematic presented in figure 1. Remotely sensed information is rarely extracted based on a single decision or answer, for example classification. One of the more difficult aspects of this type of automated questioning is deciding on an algorithm or format to which most questions will adhere to. Furthermore, the format should provide for easy updates.

Scores from these types of automated exercises can be used to suggest further review of certain sections. Alternatively, if the student would rather continue with the exercises, a different set of questions can be presented that are similar to those where the student requires the most review.

Providing such an exercise engine requires much more preparation by the teacher. It is not enough to randomly choose questions and answers from a given exercise database. The first exercises should be carefully selected in order to best underscore the material at hand. Once the 'mandatory' exercises have been worked through the student can then continue with a range of examples allowing them to further explore the subject.

### 3.2 Virtual Experimentation

Hands-on experimentation is generally a part of any science curriculum and many experiments can be simulated in a virtual environment. Some of the advantages of virtual experiments are that they can be performed anytime with no need for specialized equipment. The equipment itself can be manipulated within the virtual environment and physical principles are also simulated. This provides life-like responses that are observed and recorded by the student. At the end of an experiment, the student must use their observations to answer laboratory questions just like in the traditional manner (but have nothing to clean up).

One experiment that will be simulated is the discovery of infrared light. In 1800, Sir Frederick Herschel discovered a form of radiation other than visible light. In his experiment, he used a prism to disperse sunlight and measured the amount of heat in each colour with blackened thermometers. One of the thermometers he had placed just beyond the red region of the spectrum and found that the temperature was even higher. A real example of this experiment is shown in figure 2 (lower right) where a box with a prism attached is used to disperse the sunlight onto a white paper. Thermometers with blackened bulbs are set at various positions within the spectrum and their final readings are recorded.
This same experiment is shown in figure 2 virtually. As with the real experiment, thermometers are provided and the student places them within the spectrum. The simulation itself will not have varying light intensity nor the need to adjust the prism in order to get a sufficiently wide spectrum. To make the experience as 'life-like' as possible, the thermometers will gradually rise to their final resting positions (3 – 5 minutes). All the while the students must record data from all of the thermometers every 30 seconds to 1 minute. Placement of the thermometers is the key to this experiment and improperly positioned thermometers will show spurious results. Results will also not all be exactly the same because the students themselves place the thermometers and light intensity can be changed from experiment to experiment.

![Diagram of virtual experiment and real example](image)

**Figure 2 – The virtual Herschel experiment. Upper left shows a diagram of the virtual experiment. Lower right image is a real example.**

3.3 Virtual Field Work
Every remote sensing student should have some kind of field experience and students taking distance courses are no exception. However, organizing such a feat would be very difficult and expensive. The solution is found in the video games industry where game engines can generate 3-dimensional virtual worlds. These same game engines can be used to generate scenes of field experiment locations. Armed with a hand-held spectrometer, the students can take the necessary measurements to accomplish their mission. One such mission could be a field calibration campaign.

The first thing students can expect playing such a game is to learn how to use the hand-held spectrometer. Then the students must place targets in the correct areas and measure the ground reflectance. The resulting data would then be used to do a calibration exercise using real remotely sensed imagery. To make the game more interesting and teach some practical aspects of field work is to have the student take with them water and food supplies and/or extra equipment. If by the time they reach their virtual field site they are not prepared, then they either faint (from not having enough supplies) or have to return home to get the proper equipment. Although this is a virtual experience, it does provide a type of practical experience that is more familiar to students in this computer age.

Another useful technology is the ability to have 360° views. These views can be related to imagery that the student was using for classification allowing them to compare the site from above and from the ground.

4. DISCUSSION

The ideal situation would be to have teachers available to all students who require their expertise. In reality, this ideal is becoming less and less possible because of the lack of funding in many colleges and universities. Moreover, tuition for students is also escalating and forcing many to choose different learning alternatives.

Another alternative is to create a curriculum that is self contained and requires no teacher. The examples described here only begin to develop such a curriculum. Most importantly, all the classic teaching tools and techniques must be included in such a curriculum and as with any new curriculum, the courseware will need to be tested and assessed.
The greatest hurdle to developing such a curriculum is funding. Projects such as these are not attainable by just any degree granting institution. The cost of putting together such a curriculum can be far greater than hiring a teacher. However, the expected impact on the geospatial workforce is incredible. Anywhere anytime learning would be within anybody's grasp. The technology itself is maturing quickly and the industry is ripe for such advancement.

The question remains however whether this is enough to replace the expert. Students learn by developing cognitive pathways similar to those of the expert. To what extent can this be done by replacing the expert with a multimedia experience? The examples provided in this paper focus on optical remote sensing information extraction. This does not presume that all domains can be simulated in the same manner. On the other hand, questions that are unanswered by the courseware should provide students the direction in which to find answers and hopefully teach them how to teach themselves. This is by far the most important lesson that any teacher can convey.

5. CONCLUSIONS

Advanced technologies in communications, computing and graphics are available today to enrich student's learning environments. Development costs of e-learning however are still preventative for many domains of study. However, even small steps in this direction provide more options for the student.

Development costs are still a limiting factor and there is not enough information to conclude whether such a curriculum can replace those given at traditional institutions. As distance learning systems become more prevalent, their applicability in preparing students to the workforce will become apparent.

REFERENCES


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