BEST PRACTICE IN E-LEARNING: APPLICATIONS IN PHOTOGRAMMETRY, REMOTE SENSING AND GIS

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ABSTRACT:

This article reports on best practice e-learning applications in Photogrammetry, Remote Sensing and GIS. The rating is based, on results of the Computer Assisted Teaching CONtest (CATCON), a competition organised by ISPRS WG VI/2 that takes place every two years, on observation of recent developments, and on the short-term project "Analysis of e-learning Software and Guidelines for Quality Assurance". In this study, which was supported by the ISPRS foundation, experts from the related disciplines were asked to evaluate 30 e-learning products. Although social interaction and interactive participation are key indicators for success in online learning many tools don't make use of these techniques. As e-learning will play an even more important role in near future, valuable and sustainable tools must be identified, which follow active learning approaches including collaborative exercises and short feedback loops.
This contribution gives practical support for quick reference to first choice e-learning material – not only for university students, but also for primary and high school students. Moreover, consideration of these resources will include a commentary on trends in e-learning and future prospects for further development.

1. INTRODUCTION

As a result of the continuing global economic crisis e-learning will gain more interest and importance. Companies will increasingly make use of online training to avoid additional travelling expenses. Also employees have recognised the needs for professional training in order to keep pace with the rapid development in the fields of photogrammetry, remote sensing and GIS. But beyond the cost factor the quality of life-long learning offers will be essential for the acceptance of e-learning material.

Up to now only few products in photogrammetry, remote sensing and GIS have made an attempt to evaluate the learning materials. This makes a potential user feel uncertain which modules are worth studying.

To overcome this situation, ISPRS supports the Computer Assisted Teaching CONtest (CATCON), which takes place every second year, on the occasion of ISPRS congresses and Commission VI symposia. Certificates and monetary prizes, supported by the ISPRS Foundation - Gold, Silver, and Bronze Award (2008: US$ 1,000; 750, and 500) - are awarded to the three submissions that are judged to be the most innovative.

Moreover, ISPRS funded the short-term project *Analysis of E-Learning Software and Guidelines for Quality Assurance in Photogrammetry, Remote Sensing and GIS* to lay the foundations for evaluating e-learning software. It further gives help to potential users to identify appropriate applications and give recommendations for most suitable material. The project work included the definition of criteria by which e-learning applications should be evaluated and an online questionnaire for reviewing e-learning software.

2. QUALITY EVALUATION

The results of the short-term project, in particular the discussion of 42 criteria for quality evaluation of e-learning material is documented in Katterfeld & König (2008). The criteria emphasized educational aspects, didactics, design, curricular integration and portability. Based on this criteria catalogue a representative selection of 30 English-language e-learning products were reviewed by experts from the related disciplines.

In summary the following issues have been identified:

- Since many criteria in the didactic section only reach average or poor values, the lack of didactical concepts must be mentioned. Hence a more intense occupation with didactics is required. Investments in concepts, elaborated design of instructions and implementation of feedback is crucial.
- Consideration of learning context is generally underestimated. More differentiations within the material would be helpful to suit diverse learning needs. Aspects also important in the didactic section would help to better focus on the learner, such as user-dependent availability of material, exercises and tests, options for individual assessment or individual support.
- Implementation and establishment of metadata information based on international standards is rarely used which prevents an easy data exchange and counteracts interoperability.

The three issues mentioned above are not new. However for the current moment the study identified them as focal points for future development and improvement in e-learning.

The results of the review can be accessed at the webpage of Commission VI / WG 2 (cf. figure 1).

Figure 1: Review results for Remote Sensing education modules
http://www.igg.tu-berlin.de/index.php?id=1624

However the authors are aware of the subjectivity of such personal review. Hence the online questionnaire ((http://www.igg.tu-berlin.de/ISPRS/quality/questionaire.php) is still open for public evaluation.

3. CLASSIFICATION OF WEB-BASED LEARNING MATERIAL

In general several types of educational material can be distinguished:

- Textbooks enriched by images and (animated) graphics. This type is represented by the first generation e-learning stuff, such as the Remote Sensing Core Curriculum (RSCC http://www.r-s-c-c.org/), which was originally developed under the frame work of the American Society for Photogrammetry and Remote Sensing (ASPRS). Today, the newly formed International Center for Remote Sensing Education (ICRSEdu), a non-profit corporation, is responsible for managing the RSCC materials. (http://www.icrsed.org/).
- Interactive textbooks, such as the e-learning products of the Canadian Centre of Remote Sensing (CCRS). CCRS provides several interactive training modules mainly focussing on remote sensing. Each tutorial is characterised by rich images, graphics and animations. Quiz tests at the end of most tutorials allow self-guided assessments (http://ccrs.nrcan.gc.ca/resource/index_e.php#tutor).
- Web based Powerpoint scripts, often stored as pdf-document, which can be found in nearly every university. The slides are mainly distributed as additional teaching aids and used by students for reinforcing lectures topics. Depending on the quality, slides include valuable comments for a better understanding. A good example explaining relational databases can be found here (in German language only): http://www.sws.bfh.ch/~schmd/db/SKRIPTE/Relationale-Datenbanken.pdf
- Next generation material was influenced by the appearance of web-based Learning Management Systems (LMS). As a result, organisation of online courses, distribution of learning content and the realisation of instructor-led training were easy to handle. Moreover, tools for application sharing, chats, discussion threads etc. allow new didactical concepts, grouped under the umbrella term *collaborative learning.* LMS are widely used in universities, educational institutions, and also accepted in the industry.
- With the increase of network bandwidth, a new type of online material emerged: lectures could now be recorded, synchronized with Powerpoint slides and distributed as Video on demand courses over the Internet. Nowadays lectures are more and more distributed by podcast. Students have the advantage of taking classes anytime anywhere, learning at their own pace. These techniques are used for global courses (JICA NET, EDUServ).
- Caused by the fact that current educational methods are not engaging students enough, game-based strategies are introduced for content development. Students are now at the centre of the learning experience, which requires active participation and interaction. Reports of how game-based strategies can be used in our fields are found in Balz.& Fritsch (2008).

In the following chapter a selection of best practice web-based learning material is given. This short overview not only focuses on high-education course material, but also includes stuff for kids and teens.

4. BEST PRACTICE EXAMPLES

The following examples of best practice use various forms of digital media and interaction. Each of these examples exhibits one or more exemplary features. They should inform of existing media-supported applications in education and help to develop own ideas for teaching applications. Of course there is much more valuable e-learning material available that could not be mentioned here. Other prominent learning content described in former reports – König, Schiewe (2006) and König et all. (2008) – is not part of this paper.

4.1 Web pages for primary and high school students related to Geodesy, Remote Sensing, and GIS

This example section is related to content valuable for kids. The main objective is to captivate children at an early age in Earth science through multimedia adventures. But the web pages are also of interest for adults, since they represent game based and collaborative techniques.

4.1.1 ESA kids

The European Space Agency (ESA) guides children through the virtual universe. Space related topics are in the focus and kids find lots of information and answers on nearly every question. A variety of remote sensing applications is presented emphasizing the important role the technique plays for environmental monitoring. A nice animation explains the Sun-synchronous orbit of Earth observation satellites. The web page is very varied, including a lab for practical work, pages containing games and quizzes. Given information and news are up-to-date, as seen in figure 2 containing multiple choice question on, ESA's first Earth Explorer GOCE (Gravity field and steady-state Ocean Circulation Explorer), which was launched three month ago.

Figure 2: esa kids web page: GOCE quiz
http://www.esa.int/esaKIDSen/SEM4NWP4KKF_q.html

4.1.2 NASA – IMAGERS

NASA's IMAGERS (Interactive Multimedia Adventures for Grade School Education Using Remote Sensing) Program also addresses children and schools.

Two well-designed multimedia adventures *Adventures of Echo the Bat* and *Adventures of Amelia the Pigeon* try to captivate children at an early age in Earth science through multimedia games. Besides the interactive web sites telling the story, supplemental material is offered for parents and teachers enabling them to impart knowledge on Earth science using remote sensing imagery via identification of land use, exploration of featured habitats, and changes in the environment. Basic technical terms (e.g. electromagnetic spectrum) and fundamental concepts are explained most suitable for kids.

Figure 3: Welcome page of NASA's IMAGERS program
http://science.hq.nasa.gov/kids/imagers/index.html

4.1.3 EARTH EXPLORATION TOOLBOX (EET)

The Earth Exploration Toolbox, funded by the National Science Foundation (NSF) consists of a huge collection of learning instructions based on Earth science datasets. The Technical Educational Research Centers (TERC) working in partnership with several colleges and universities, promotes curricula and materials development. The material offered under a Creative Commons license (Attribution-NonCommercial-ShareAlike 1.0) is free for non-commercial use.

Input data originates from the science and education program GLOBE (Global Learning and Observations to Benefit the Environment), which started in 1995. GLOBE supports an international collaboration of schools, which collect data for monitoring the dynamics of the Earth's environment. Today, more than 20000 schools around the world are engaged in the international GLOBE network, they have contributed more than 19 million measurements to the GLOBE database.

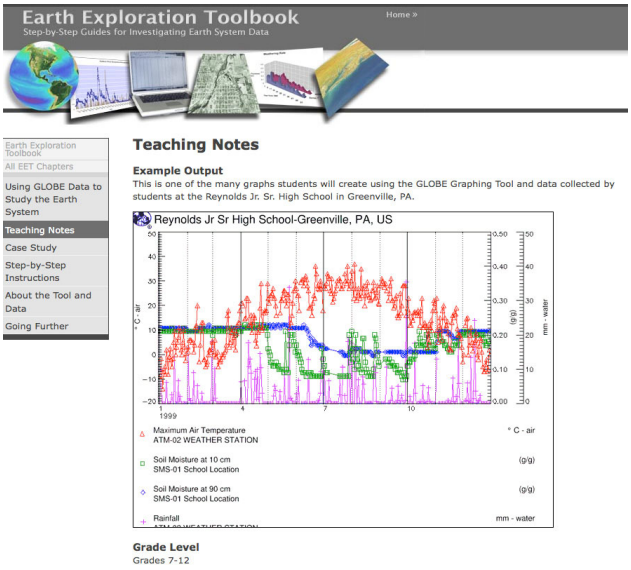

Figure 4: Teaching notes distributed by EET
http://serc.carleton.edu/eet/globe/teaching_notes.html

Worldwide temperature measurements as seen in figure 4 allow comparing the situation in different regions and help to understand how climate changes.

4.2 E-Learning material for university students

4.2.1 CCRS - IMAGE INTERPRETATION QUIZ

The Canadian Centre of Remote Sensing (CCRS) provides a variety of interactive training modules mainly focused on remote sensing (fundamentals, digital analysis techniques, radar etc.). http://ccrs.nrcan.gc.ca/resource/index_e.php#tutor. Each tutorial is characterised by rich images, graphics, and animations. A print version is also available. Quiz tests at the end of the most tutorials allow a good self-control.

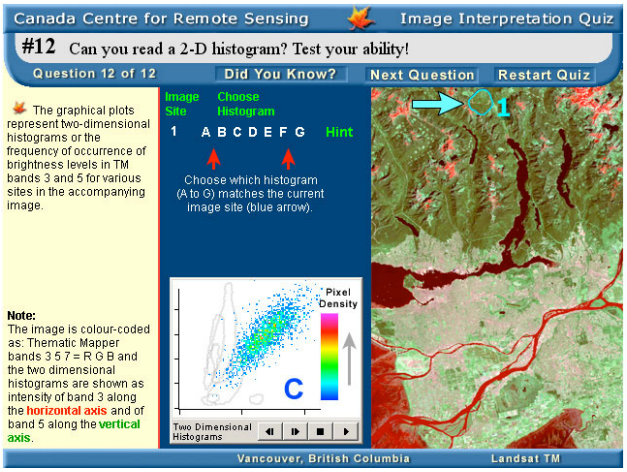

Figure 5: Image Interpretation Quiz (CCRS)
http://ccrs.nrcan.gc.ca/resource/tutor/iquiz/interactive/start_e.php

Of special interest is the interactive Image Interpretation Quiz that is designed for students who would like to explore a variety of interpretation techniques and concepts. The interactive version requires installation of the free Shockwave plug-in. Topics include:

- Feature recognition;
- Band combination colour assignments;
- Image enhancements;
- One and two dimensional histograms; and
- Airphoto / satellite image comparison

In general CCRS tutorials are of high quality and can be recommended without reservations.

4.2.2 3.1 RS-FUN, GT-SIMULATOR

A kind of role game based approach was used for the development of material designed at the Tokai University in Tokyo: RS-Fun and GT-Simulator. Both tutorials help for a better understanding of remote sensing technologies. The course content is especially suited for high school or lower grade students. While RS-Fun focuses on basic concepts of remote sensing (Cho et all. 2007), students can gain knowledge about the basic idea of ground truth spectral measurement by using the Flash based GT-Simulator.

After learning about the spectral reflectance measurement with GT-Simulator, the time required for them to understand the operation of spectrometer at the practical ground truth training was much reduced compared to the students who did not use GT-Simulator in advance.

The recent version of the GT-Simulator can be accessed at the following site:
http://www.yc.ycc.u-tokai.ac.jp/ns/cholab/GT-Simulator.

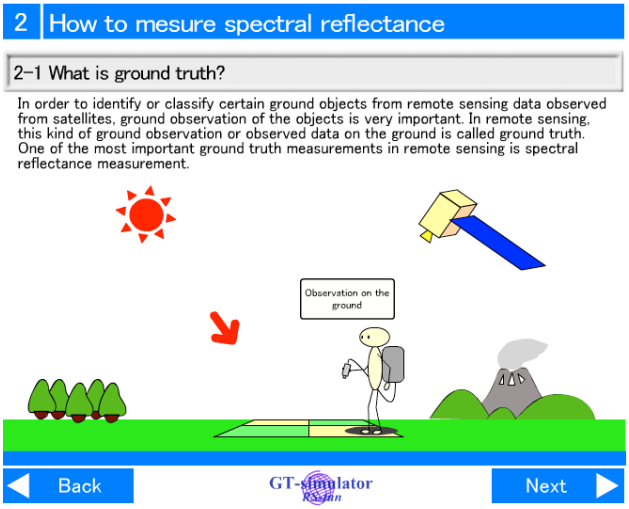

Figure 6: Animated web page illustrating ground truth measurements

4.2.3 INTRODUCTION TO GIS

Introduction to GIS is a self-learning tool developed at the University of Melbourne, Australia. The modules are addressed to students participating in Geographic Information Systems (GIS) courses. It is recommended to work through all parts in a predefined, sequential order.

The modules show a homogeneous structure: after explaining theory and concepts, interactive examples in realistic scenarios help for a better understanding. This is followed by test questions, which require the student to apply knowledge learnt in the related sections.

A glossary and list of references complete the learning material.

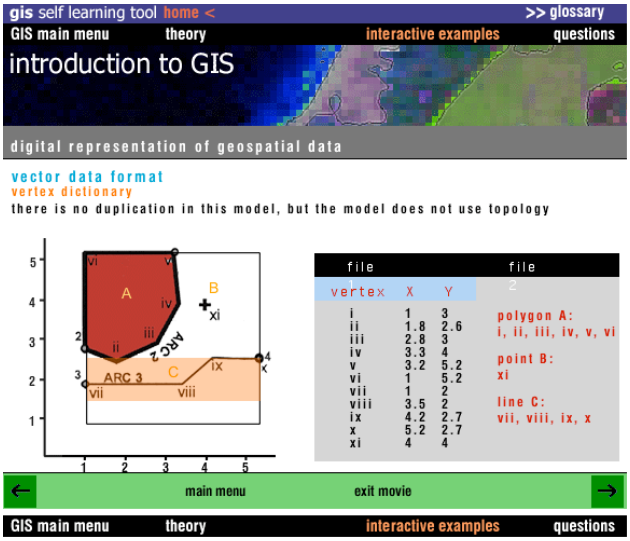

Figure 7: Webpage explaining representation of vector data in a GIS
http://www.sli.unimelb.edu.au/gisweb/GISModule/GISinteractive.htm

4.2.4 FERGI+

During the last two years a variety of e-learning modules have been produced and evaluated by the project partner of the University of Osnabrück and the Universities of Applied Sciences in Oldenburg and Osnabrück (Grendus et al., 2009). The content is offered to students as additional information to lectures but also open to the public during an eight-week free access period. Moreover, certificates are given to participants of small and medium-sized enterprises who take part in a 6-month in-service training available for a fee. Modules are mainly provided in German and partly in English. Content development is based on HTML, CSS, JavaScript, PHP and Flash. For an overview on the courses see http://www.fergi-online.de.

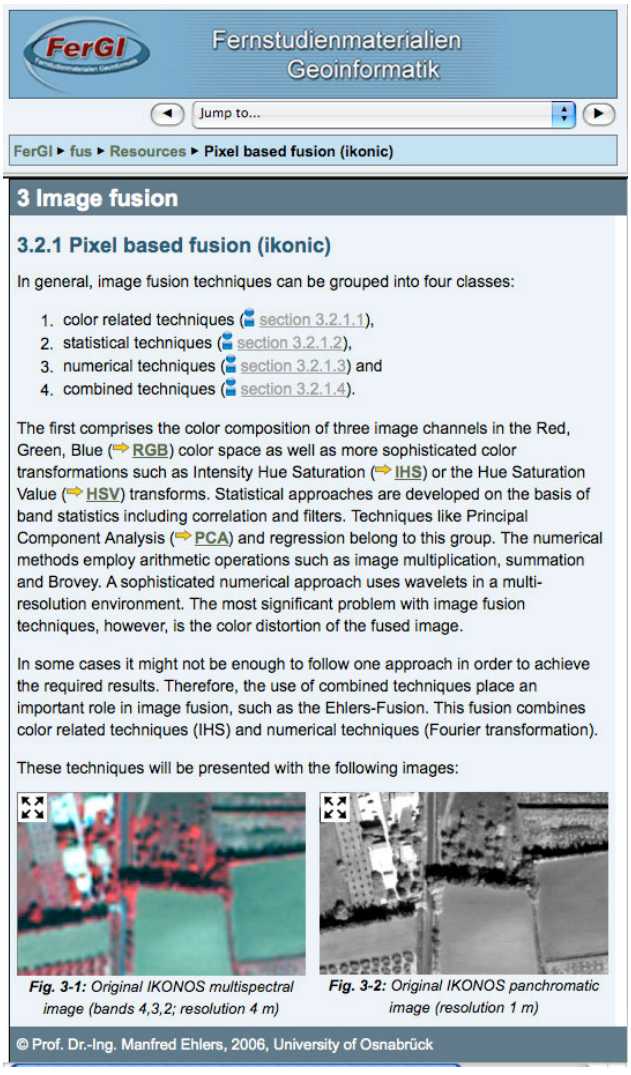

Figure 8: Methods for image fusion illustrated in Fergi+
http://www.fergi.uni-osnabrueck.de/moodle/mod/resource/view.php?id=1201

4.2.5 WEBGEO

The learning portal WEBGEO (Webbing of Geoprocesses) had its origin in a joint research project with the participation of 8 universities in Germany. Topics are structured into four parts: WEBGEO basics (ranging from climatology to geomorphology to remote sensing and more), WEBGEO regional (puts emphasis on regional areas), WEBGEO applied (continuative and detailed topics beyond basic geography) are taught in German language. WEBGEO English offers basic learning modules to international students. All modules, enriched with multimedia elements include test questions, are of high quality.

A further English training course (to be found in WEBGEO applied) was developed to assist the Department of Agricultural Extension (DAE) of the Government of Bangladesh to better understand the concepts and implementation of climate and flood forecast applications. (see fig. 9).

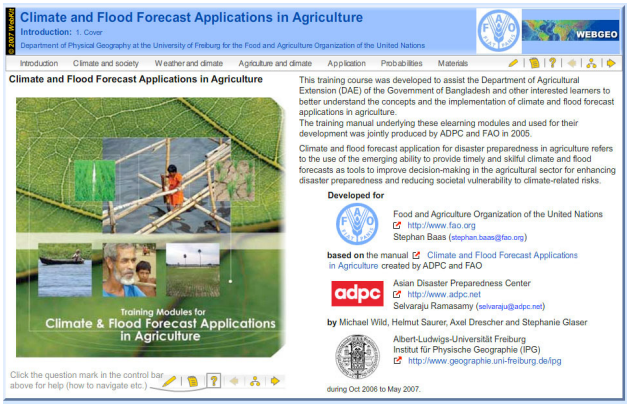

Figure 9: WEBGEO project web page
http://www.webgeo.de/module/applied/FAO/probabilisticforecasts-bgd-fao.html

2005 WEBGEO was nominated to the *Medida-Prix* and has won the *European E-Learning Award* in 2006.

4.2.6 TU BERLIN - CityGML

City Geography Markup Language (CityGML) is an OpenGIS® Encoding Standard for the representation, storage and exchange of virtual 3D city and landscape models. The initiative to setup an e-learning course on CityGML was pushed by the EuroSDR committee who decided to offer online training courses. Now, after the successful run during the sixth and seventh round of annual courses the e-learning modules are available for free use.

In order to offer participants the possibility to consolidate their knowledge, lectures based on MS PowerPoint slides are recorded, stored in Adobe Flash format and open for continuously repetition during the follow-up work. Using an Internet browser with Flash plugin enabled allows participants to view the live video stream of the teacher giving his speech, along with synchronized images of his presentation slides and all the annotations and comments.

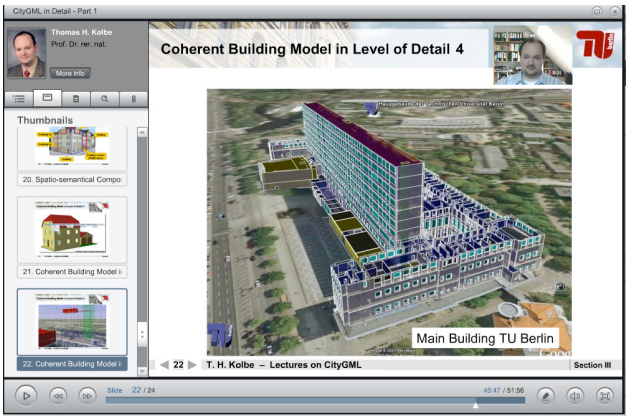

Figure 10: 3D building representation based on the CityGML standard
http://www.igg.tu-berlin.de/courses

The course content is structured in several lectures and exercises. Every chapter is enriched with a lecture-on-demand module. Required test data and relevant publications are offered for (free) download. Links provide access to further information and software that is needed for the exercises. In order to connect the participants, discussion board threading, wiki and real time textual chat, are open for use.

4.2.7 INTERMAP

Intermap Technologies™ is a digital mapping company creating digital elevation models, orthorectified radar images, and numerous value-added products based on its proprietary airborne Interferometric Synthetic Aperture Radar (IFSAR) technology.

To learn more about the fundamentals on IFSAR systems, Intermap has put a free course on Digital Elevation Models from IFSAR on the Internet. Audio supported slides enriched with Flash multimedia elements allow for a deeper understanding. Questions and a final quiz allow checking that what has been taught has actually been taken in by the student.

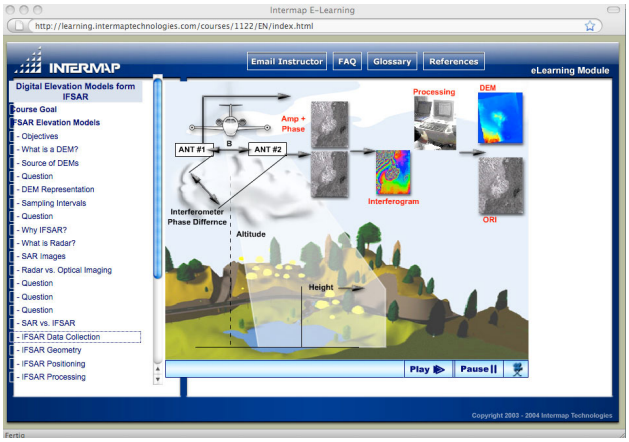

Figure 11: IFSAR data collection principle
http://learning.intermaptechnologies.com/courses/1122/EN/index.html

Moreover, Intermaps Resource Center offers a wide range of additional material. Beside advertising information, sample data, white papers etc. the user can download archived webinar recordings (http://www.intermap.com/right.php/pid/1/sid/476).

4.3 E-Learning material for software training

4.3.1 ESRI

Figure 12: Welcome page to ESRI's training program
http://training.esri.com/gateway/index.cfm

ESRI has been one of the first companies that recognized the significance of online training at an early stage. Since 1998, ESRI Virtual Campus offers self-paced training over the Internet. All universities or institutions participating in the ESRI Site License Program get unlimited-seat access for using these modules. Depending on the license agreement with ESRI, users are entitled to have free access. The web courses cover a wide range of topics related to ESRI software, the application of GIS, and the theory behind GIS technology. Courses take between 3-20 hours to complete. Registered users have up to one year to complete them.

5. RECENT AND FUTURE TRENDS

There are several clear trends in the development of e-learning material that are evident from progress made during the last two decades.

Internet delivery is increasing as bandwidth limitations diminish. This allows the usage of reliable techniques for transmitting streaming media to distribute content to many simultaneous listeners and viewers. To publish complete lectures via the Internet only non-interactive linear communication is necessary (*webcasting*). The ability to webcast content with a cheap and easy accessible technology is applied successfully especially in India in oder to enhance the quality of engineering education in the country by developing curriculum based video. Within the framework of the *National Programme on Technology – Enhanced Learning* (NPTEL), a joint venture by seven Indian Institutes of Technology and the Institute of Science Bangalore, supplementary content for 129 web courses in engineering/science and humanities have been developed in the first phase of the project. In addition, 110 courses have been developed in video format, with each course comprising of approximately 40 or more one-hour lectures. The lectures are distributed via YouTube as video sharing website. Of special interest are courses in Mathemetics and Computer Science (http://nptel.iitm.ac.in/). Lectures for example are focussing on Digital Image Processing and Remote Sensing in Engineering Geology.

Also distributed via YouTube is a short video explaining GPS tools, recorded at the Abu Dhabi Men's College (see figure 13).

Figure 13: YouTube lecture video
http://www.youtube.com/watch?v=0xNfmfG1OOg

With the success of Apples *iPod* free educational podcasts for teaching and learning are widespread. *iTunes U* was created as special service for colleges and universities in order to manage, distribute, and control access to educational audio and video content. The online service is without cost to those uploading or downloading material. In contrast to traditional podcasting access to content can be restricted in iTunes U, so that only students enrolled in a specific class are allowed to use this podcast.

According to the statement of Apple more than 150,000 lectures, presentations, videos, readings, and podcasts from all over the world are available for free. Students can access iTunes U content directly on their iPhone and iPod touch over both cellular and Wi-Fi networks through the iTunes Store.

Usage of podcasts in photogrammetry, remote sensing, and GIS is not widespread yet, A report on podcasting photogrammetry is given in Fritsch (2007).

Most enterprise professionals (ESRI, Erdas, Trimble, Fugro, Intermap, Oracle …) recognize that virtual events are becoming an integral part of their marketing and communication toolbox (see fig. 14). Training of software skills or presentations of new products are often organised as *webinars*. Again communication is typically one-way, but unlike webcasts limited participation between the audience and the presenter is possible. This includes polling and question & answer sessions. In general, these webinars are archived for later access to everybody.

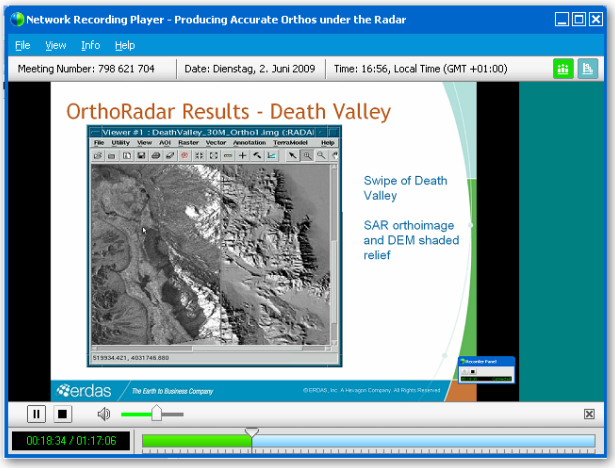

Figure 14: Erdas Webinar on Orthophoto Production
http://www.erdas.com/Company/Webinars/tabid/91/Default.aspx

Curriculum material is becoming richer and more detailed because of improved development tools, more powerful computers and the wider availability of source materials such as high-resolution images. E-learning material is becoming more and more interactive to increase engagement with the user and improve the effectiveness and depth of learning.

As the new generations of students assimilate the ubiquitous new media and Internet technologies, demand for communication and collaborative work will rapidly increase. Software tools for discussion forums, wikis and blogs are now part of most learning management systems. Students, in addition to teachers, will contribute to the learning experience and process.

Moreover, students' desire to play can be used for a digital game based learning approach. Serious games developed for training and education build on the young people's experience with computer games and may help to drastically increase the students' motivation and improve the learning success for a fast and sustainable learning effect. It is also clear that all these trends will continue and the use of immersive environments such as Second Life will expand rapidly in near future.

6. CONCLUSIONS

This paper has reviewed several specific examples of different types of online learning content illustrating the state of the art in e-learning, with a particular emphasis on geography, photogrammetry, remote sensing and GIS. E-learning has made, and will continue to make, an extremely valuable contribution to teaching and learning within the discipline at all levels of education and training. Trends toward the predominance of convenient Internet delivery, greater richness of the content, enhanced user-centred learning and the availability of effective quality evaluations will ensure the expanded use of e-learning in the future.

Since content development is growing rapidly, it becomes more difficult to remain focussed in the continuous change. A solution to keep track may be the installation of an e-learning wiki in our fields. International cooperation and partnerships in education will help to get knowledge about new developments and will be open for integration or exchange of learning material for sharing and re-use.

Another important aspect of e-learning material that will become increasingly important in the future is the quality of the resources provided. As with all web-based information, access is rarely guided by the quality of the information available on a web site, but more frequently by the popularity of the site or proactive manipulation of search engines by the organisation. A number of different approaches are possible to determine quality indicators, such as the reputation of the site or organisation, the number of citations of the material or an objective evaluation by professional reviewers. However, there is an emerging trend for Internet sites to be reviewed, either anonymously or by invitation.

7. ACKNOWLEDGMENTS

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8. REFERENCES

Balz, T., Fritsch, D., 2008: High-Performance SAR Simulation on Retail Video Gaming Consoles for Education and Training Purposes, Int. Arch. of Photogrammetry, Remote Sensing and Spatial Information Science, 37(B6a): 213-219.

Cho, K., Chujo, T., Tada, T., Shimoda, H., 2008. Strategic Approach for Sharing Educational Materials on Remote Sensing. Int. Arch. of Photogrammetry, Remote Sensing and Spatial Information Science, 37(B6a): 65-72.

Cho, K., Komaki, A., Shimoda, H., 2007. Development of GT-Simulator for Remote Sensing Education. Proceeding of MJISAT2007, 12-15th November, 2007: 1-6.

Fritsch, D., 2007. Podcasting Photogrammetry – A Contribution to Life-Long Learning. Photogrammetric Week ’07, Wichmann, Heidelberg: pp. 335-344.

Grendus, B., 2008. FerGI@KMU: Berufliche, zertifizierte Weiterbildung mit E-Learning-Modulen zur Geoinformatik. Proccedings of the logOS 2008 „Lernen, Organisation, Gesellschaft - Das eCampus-Symposium der Osnabrücker Hochschulen“, Osnabrück, Germany, pp. 19-23.

König, G.; Schiewe, J., 2006. E-Learning courses for GIS and Remote Sensing in Germany: Status and perspectives. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, 36(6):.

Katterfeld, C., König, G. 2008. Analysis of e-learning software and guidelines for quality assurance in photogrammetry, remote sensing and GIS. *Int. Arch. of Photogrammetry, Remote Sensing and Spatial Information Science*, 36(6): 65-70.

König, G., Shortis, M. R. and Katterfeld, C., 2008. ISPRS activities on e-learning in photogrammetry and remote sensing and GIS - Status and challenges. In: Groenendijk, Liza, Lemmen, Christiaan: Sharing Good Practices: E-learning in Surveying, Geo-information Sciences and Land Administration, Proceedings FIG International Workshop 11-13 June 2008, ITC, Enschede, The Netherlands. pp. 283-301.

All links cited in the paper are accessed on June 12, 2009.