

COMPUTER AIDED TEACHING IN PHOTOGRAMMETRY REMOTE SENSING AND GEOMATICS– A STATUS REVIEW

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ABSTRACT:

Education and training play vital role in the utilization of the technology. Shared and coordinated knowledge that geospatial technology and GIS deliver provides a deeper understanding of our present and will also help to better understand our future development. But it is not enough to explain new technological developments during congresses or workshops; it is also necessary to promote these new ideas and to distribute the knowledge by applying new learning strategies.

This paper will review the status of computer aided teaching advances during the last decade, with a particular emphasis on photogrammetry, remote sensing, and geomatics. Some best practise examples will be presented featuring prominently recent Massive Open Online Courses (MOOCs) related to our fields. The consideration of mainly free online learning resources will include a commentary on quality and perceived effectiveness.

1. INTRODUCTION

During the last two decades a number of factors have forced the adoption of new teaching and learning methods in tertiary education:

- The rapidly evolving hard- and software development,
- The Internet-driven boost in the volume and complexity of the available information,
- The rapid increase in the demand by employers and authorities for life-long learning.

The reactions of tertiary educators to bridge the gap between supply and demand and between quality and quantity are manifold. University academics are embracing techniques such as the provision of online information resources and the introduction of multimedia delivery to improve the efficiency and effectiveness of teaching.

Universities are of course not the only providers of computer aided teaching resources. Commercial organisations and companies have early reckoned Internet's benefits and have turned to computer-based presentations for customers and computer-based training for staff replacing traditional in-house courses. The catalogue of resources is many and varied, but at a high level of categorisation, includes:

- Videos and multimedia tutorials,
- Simulations and virtual environments,
- Information packages or data sets, and
- Application software.

2. TRENDS IN E-LEARNING

In the beginning online education was mostly offered by universities. Students were encouraged to improve their knowledge or to repeat lecture content by using mainly text based course material. Consequently learners were mostly made

up of young well-educated individuals with a high affinity to computer applications. But now a shift in user demographics can be identified resulting in an increasing average of end-users' age. This is amongst others caused by companies' demand for continuing education from their employees and due to the broad variety of training offers in the Internet. Life-long learning now plays an important role and even will gain more significance. Moreover, simple textbook based or PowerPoint presentations will no longer be accepted, participants are demanding for professionally designed courses offering attractive and high-resolution graphics and videos including more diversity and interactivity.

2.1 Use of Mobile Devices

Another clear trend becomes apparent that mobile devices have grown tremendously in popularity over the last few years. Sales figures in Germany for example indicate that the growth rate of tablet PCs and smartphones has increased considerably. White (2013) analysed that in just three years, tablets have overtaken smartphones in the amount of traffic they drive and that Internet users view 70% more pages per visit when browsing on a tablet vs. a smartphone. This will go along with a transition towards mobile learning. Developers have to consider this fact and make every e-learning application not only available for desktop applications but also take care of multi-device compatibility.

2.2 HTML5

For Web based cross platform developments HTML5 is the best choice. The HTML5 technology introduces several new elements that allow to better structure complex websites and adds helpful functions (W3C, 2014). Up-to-date browsers support audio and video information natively; a (Flash) plugin is no longer needed. HTML5 includes established web technologies such as the Mathematical Markup Language

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(MathML) for integrating mathematical formulae or Scalable Vector Graphics (SVG) for placing static, interactive, and animated two-dimensional vector objects. The specification now provides easy to use attributes and events for drag and drop. With the canvas element dynamic, scriptable rendering of 2D shapes and bitmap images is possible. Supported by browsers that conform to the W3C standards HTML5 can be used for an optimal adjustment across the wide range of devices. The same code works on PC, Mac, Linux, and also on a mobile devices' operating systems like Android, BlackBerry QNX, iOS, and with some restrictions on Windows Phone 8. Although work on the final HTML5 W3C Recommendation is still in progress most features are already implemented in up-to-date browsers. Browser functionality is analysed continuously. The website <http://www.html5test.com>, maintained by Niels Leenheer, a Dutch software developer, lists how well browsers support the new HTML version.

2.3 Massive Open Online Courses – MOOCs

Another development that highly influences the structure of e-learning is the emergence of Massive Open Online Courses (MOOCs). MOOC platforms like *Udacity*, *Coursera* or *edX* have gained an enormous media attention and financial support caused by a rapidly increasing number of users. Coursera for example has been able to raise medium to high double-digit millions US dollar in venture capital. It seems that MOOCs gain ground in education; actually the first German universities cooperate with Coursera whose platform already attracts more than 4 million registered users. The main characteristics of MOOCs are:

- There are no restrictions to the number of participants.
- There are no entry requirements. The classes are open to everyone and are offered free of charge. In most cases free educational material is used.
- The courses are carried out completely online.
- The courses are conducted according to a fixed class schedule every week, for 6-8 weeks in total.
- Most teachers provide several short lectures in video format on one day a week. In sum, they correspond to one hour of lecture approximately (45 min).
- Forums in which the participants can communicate to seek for or help others supplement video lectures.
- The video sequences are interrupted by a series of tests and end with a final one. In addition there is an exam in the middle and at the end of the MOOCs. Multiple-choice tests are standard practice.
- Teachers of the MOOCs in most cases give the certificates for passed tests. The universities, whose teachers participate in MOOCs, in general don't issue a certificate or grant credits for students, even if they are offered by contract with Udacity, Coursera or edX.
- User identity is not controlled in most cases, but in some courses an optional "Signature Track" is introduced. After successful participation a "Verified Certificate" is issued. This business model is liable for costs: users have to pay a course dependent fee that varies around US\$ 50.

Further future trends and technologies are discussed by Pappas (2013).

3. BEST PRACTICE EXAMPLES

Links to learning material are listed on ISPRS website <http://www.isprs.org/education/tutorials.aspx>.

There are still many tutorials identified, based on textbooks that are often a valuable resource to download data, images, etc.

3.1 Landsat Education

Landsat Education: Landsat Education offers a wide range of educational material, including Landsat images, animations, K-14 classroom exercises, data tutorials, fact sheets, and more.



Figure 1: NASA education resources
http://landsat.gsfc.nasa.gov/?page_id=11

3.2 E-learning Initiatives by IIRS: The Indian Institute

The Indian Institute of Remote Sensing (IIRS), Dehradun has initiated its interactive distance education based capacity building under IIRS outreach programme in the year 2007, wherein over 10,000 students and researchers from 112 universities/institutes across the country have been trained in the field of geospatial technology. This was accomplished through ISRO's communication satellites, satellite interactive terminals and A-View software.



Figure 2: Indian Institute of Remote Sensing
<http://www.iirs.gov.in/node/>

The contents for e-learning courses are being developed for various target user groups. The course contents include: image statistics, basics of remote sensing, photogrammetry and cartography, digital image processing, geographical information system, global navigation satellite systems, customization of geospatial tools, and applications of geospatial technologies.

The learning is made available through interactive 2D and 3D animations, audio, video for practical demonstrations, and software operations with free data applications.

3.3 ESRI Virtual Campus

High quality eLearning material is available from ESRI since many years. ESRI *Virtual Campus* offers self-paced step-by-step training combined with hands-on-exercises, rich instructional resources, and optional exams with personalized completion certificates. Instructor-led courses are subject to a fee (US\$ 1000 to 1500). Some e-learning courses are for free, but cost mostly US\$32. But faculty, staff, and students of education organisations participating in the ESRI Site License Program have free access to all premium courses. Last but not least ESRI offers free training seminars (video presentations), usually including software demonstrations and recorded question and answer sessions. Courses take between 3-20 hours to complete. See <http://www.esri.com/training/main>.

3.4 Victorian Resources Online

The Victorian Resources Online (VRO) website is the principal means for accessing landscape based information in Victoria, Australia. It offers the user a wide range of information and associated maps related to Victoria's soil and landscapes. Visualisation is a key component of knowledge management activities associated with VRO – proving useful for both "knowledge capture" (from subject matter specialists) and "knowledge transfer" to a diverse user base. High quality visualisations explain the nature and distribution of Victoria's landforms and soils as well as associated processes. They include landscape panoramas, animations of soil and landscape processes and videos of experts explaining features in the field as well as landscape "flyovers". Based on Flash they provide the potential to improve user's appreciation and understanding of soil and landscapes.

VRO was honoured with the Computer Assisted Teaching Contest (CATCON) Gold Award of ISPRS in 2012.

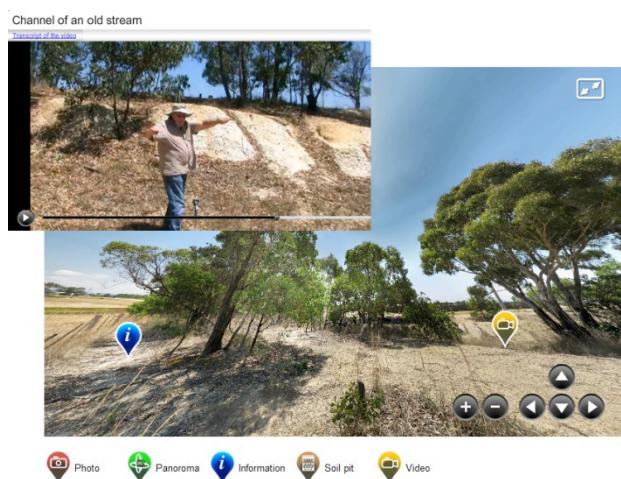


Figure 3: Victorian Resources Online
http://vro.depi.vic.gov.au/dpi/vro/wgregn.nsf/pages/wg_soil_ma_ffra_briagolong

3.5 The E-FOTO project

Scientists from Brazil have developed E-FOTO, "Free Educational Digital Photogrammetric Workstation", under the GNU/GPL paradigm. The E-FOTO software possesses

photogrammetric functionalities that allow the development of professional photogrammetric mapping projects, based on (aerial) images as data sources obtained by cartographic cameras or digital sensors. The E-FOTO Project received ISPRS' Bronze Award in 2012. Following material is available:

- E-FOTO software with source code and executable modules for Linux, Windows and MacOS,
- Data and example packages,
- Tutorials, in pdf and in video versions, and
- A guest book and a forum.

The software can be freely downloaded from the web page: <http://www.efoto.eng.uerj.br/en/>.

3.6 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), and WEBGEO applied (continuative and detailed topics beyond basic geography). All courses are taught in German language. In addition WEBGEO English offers basic learning modules to international students. Two further well-designed English training courses (to be found in WEBGEO applied - FAO_WEBGEO) were developed in cooperation with the FAO, the Asian Disaster Preparedness Center, and the University of Freiburg. All modules, enriched with multimedia elements include test questions, are of high quality.

Figure 4: WEBGEO applied
http://www.webgeo.de/fw_1/

3.7 Video podcasts

With the introduction of smartphones and tablets manufactured by different vendors, learning content can be delivered anytime at anyplace. Educational video content for students can be found amongst others in iTunes U sites based on Apple's iTunes Store infrastructure. Member institutions, colleges, universities all over the world maintain their own educational sites. Podcasts in our fields are rare, main topics focus on computer science and math, e.g. offered by Ohio State, Stanford, and Harvard University as well as The Open University. In late February 2013, iTunes U surpassed one billion downloads from more than 800 institutions (Apple Press Info, 2013). The use of iTunes software or the iTunes U app is recommended allowing convenient access to the online material.

3.7.1 Harvard University - CS50 2013: At Harvard University David J. Malan's course CS50 2013 related to "Computer Science and the art of programming" gives an idea how video podcasts could be prepared professionally. The course consist not only of recorded lectures, but also offers a variety of different material for download: audio files, slides, source code, problem sets, quizzes, seminars, short walkthroughs etc. All content is free for download if you follow the iTunes U link. By now the course is also available on edX, see <https://www.youtube.com/watch?v=DPJGJ5XOLFQ>.

3.7.2 Freed-Hardeman University – Introduction to Java:

People interested in programming languages can gain insight into Java following the podcast at Freed-Hardeman University, Henderson, Tennessee. The lessons are subdivided into 13 episodes (10 to 40 minutes each) that give an introduction to the fundamental features of Java. Topics include object-oriented programming, data types and operators, program control statements, classes, objects and methods, arrays and strings, inheritance, exception handling, I/O, multithreading, and generics.

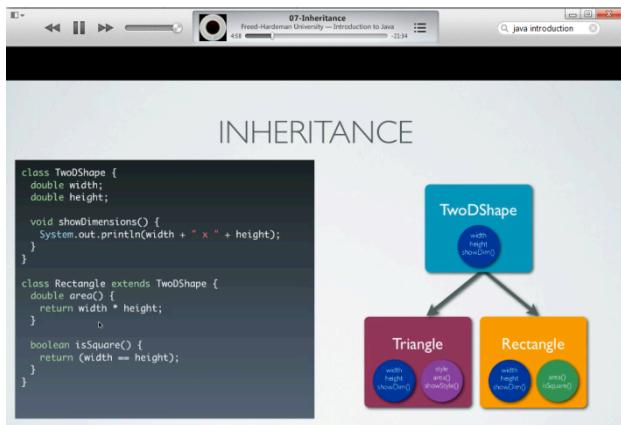


Figure 5: Podcast Introduction to Java
<https://itunes.apple.com/de/course/07-inheritance/id551000192?i=119061123&mt=2>

3.8 Webinars

Accessibility of Internet in schools and colleges has brought the change in the form of education. Web-based seminars – or webinars – are the most popular way of conducting seminars, which aim to encourage the worldwide participation. Teaching becomes cheaper and saves on travel cost. Webinars consist of presentations, lectures, seminars or workshops. Majorly video conferencing software is used to transmit over web, but in some instances it requires installation of additional software. Attendees are able to actively participate during the webinar. This includes live polling and tweeting questions to the presenter. The capacity of a webinar is to deliver a talk with the use of slides, videos, whiteboard with annotation, etc. in real time. In general webinars are recorded for later offline use. Of course webinars have limitations. There is no physical interaction between presenter and receivers. The presenter unable to see the receivers hence cannot gauge the level of understanding among the participants. The practical skills, brainstorming and sharing of thought, are not possible hence the level of synergy is lost.

Webinars are also widely used by companies to inform customers about new product releases, to offer online workshops, or to provide user training. An extensive overview on upcoming geospatial webinars is listed on the webpage

hosted by *Directions Magazine*. Direction Magazine also maintains an archive linking to past events. See <http://www.directionsmag.com/webinars/>.

3.8.1 Intergraph/Hexagon: Intergraph/Hexagon hosts webcasts since many years. In 2013 the company offered a webinar titled "Improving the Understanding of Spatial Phenomena through 3D Thematic Mapping". The webinar explains how to use Geomedia software and its add-on Geomedia 3D to setup easy-to-interpret 3D thematic maps that can help a map-reader to better understand complex spatial phenomena.

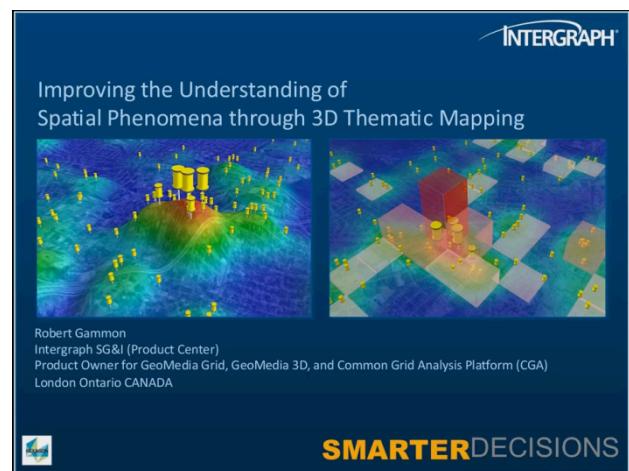


Figure 6: Intergraph webcast
<http://www.intergraph.com/sgi/webcasts/2013/3d-thematic-mapping.aspx>

3.8.2 Sparx Systems: Sparx Systems is the developer of Enterprise Architect (EA), a visual modelling and design tool based on UML. It is a powerful tool for data modelling and geodatabase design and it is able to handle various spatial databases (Oracle, PostgreSQL, ArcGIS). The platform supports the generation and reverse engineering of source code for many widely used languages, especially C and C++, Java, Python etc. Sparx's webinars explain the functionality of EA and give valuable hints about its usage. Sparx webinars are listed at <http://www.sparxsystems.com/webinars/>.

3.9 YouTube

You Tube is a highly popular video sharing website. It allows billions of people to browse simultaneously the videos and therefore is a valuable tool for storing learning content. Registered users can upload an unlimited number of videos and are owners of the content posted to the site. By default, videos to upload are restricted to 15 minutes length. This limit is expendable, even uploads exceeding 20 GB file size are allowed, provided that an up-to-date browser version is used. YouTube videos are available in three ranges of quality levels: standard quality (SQ), high quality (HQ) and high definition (HD). Uploading of 3-D video is recently added strength of You Tube. You will find lots of learning videos on remote sensing, GIS, photogrammetry, cartography, etc. mostly uploaded by universities and companies.

3.10 MOOCs

MOOCs in our fields of activity seem not to be attractive for the MOOC mass market. Topics are mainly focussing on

Humanities, Computer Science, and Business, that amount to 50% (Shah, 2013) in total. In the following paragraphs all MOOCs related to our profession are mentioned, which are known to the authors and which still can be accessed for free.

3.10.1 Duke University: In mid-January 2013, the Duke University's Pratt School of Engineering started the MOOC "Image and Video Processing: From Mars to Hollywood with a Stop at the Hospital". The course hosted by Coursera lasted 9 weeks and covered the fundamentals (image and video processing, compression, enhancement, restoration, segmentation, etc.). The course given by Guillermo Sapiro, Professor of Electrical and Computer Engineering was based on video lectures and slides. Annotations (see figure 7) given during the lectures, such as deriving formulas or adding sketches were included within the talk. The website contained quizzes (mostly multiple choice tests, also requesting results of numerical calculations, few short answer questions tasks, and optional programming exercises). At the beginning over 40,000 students signed up for the course. More than 23,000 unique students accessed at least one video. Participants decreased to an average of 7,465 unique students accessing lectures during each week after the first two weeks. About 5,000 students watched all of the lectures. At the end of the course 1,242 students earned the minimum grade to receive a Statement of Accomplishment in the course. Another 2,827 met the requirements to receive the more rigorous Statement of Accomplishment with Distinction. The MOOC was enriched by lively discussions in the forum; over 1,200 participants in the course created almost 3,000 posts. The Facebook group for the course had 111 members, another study group attracted 154 students. Below the line the students rated the course very positive, a second course repeat started in January 2014.

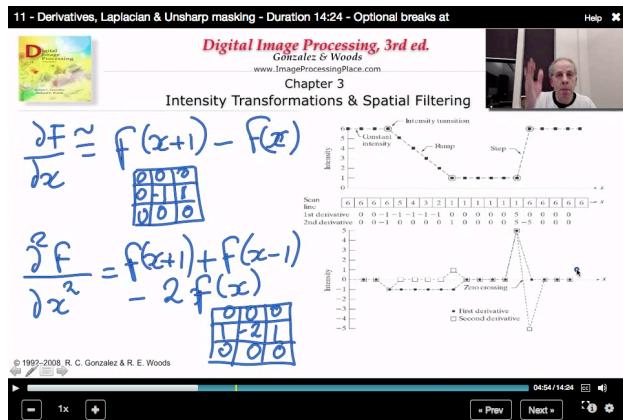


Figure 7: Image and Video Processing
<https://www.coursera.org/course/images>

3.10.2 Del Mar College: The Mini-MOOC "Geospatial Tech for STEMx Learning" (STEM is an abbreviation for science, technology, engineering and math) was held by Dr Phillip Davis, Dr Richard Smith and Mrs. Seneca Holland. The 16-hour professional development course for educators, offered as part of the HP Catalyst Academy, introduced in geospatial technology, focused on cartography and allowed building of digital maps with simple tools such as QGIS and indiemapper that had to be downloaded and installed. Additional quizzes checked participants understanding. Over 300 educators accepted the course invitation. From that, 107 were considered active and 32 completed the entire course to gain their badge of completion. See: <https://canvas.instructure.com/courses/810055>.

3.10.3 Mapping with Google: From June 10 - June 24 2013 Google offered a self-paced, online course that covered Google Maps, Maps Engine Lite and Google Earth. At the end, successful students could receive a certificate of completion. The course was based on videos or text material, projects, and activity parts. A student network provided discussion forums and hangouts. 41,455 participants registered, 53% followed the course, and 2137 students completed the last lessons activities. See <https://mapping.withgoogle.com/course>.

3.10.4 Penn State University: In July 2013 a first course titled "Maps and the Geospatial Revolution" was offered, developed by Anthony Robinson and his team. Support was given by ESRI making ArcGIS Online available to the participants. Over 48,000 students enrolled from more than 150 countries. Course content focussed on the massive changes in geospatial and mapping technology. It highlighted how spatial data is created, and how it is managed by using new technologies. Basic spatial analysis techniques were taught for solving geographic problems that take spatial relationships into account. Also knowledge on cartographic design was imparted. Similar to other MOOCs participation decreased from 37,000 active students who logged in at least once to 8,707 students in the final week of class. Class participants generated thousands of maps and nearly 96,000 forum posts in the five-week-long class session. The lessons featured short video lectures, written content, explanatory graphics, hands-on mapping activities and discussion assignments. Students were evaluated in the course through weekly quizzes, a final exam, discussion participation, and a peer review of their final mapping assignment. Based on a scoring criteria fixed by the course team each student who had sent in a completed lab assignment had to review three other classmates' work. At the end of the class, a "Statement of Accomplishment" was issued to those students who passed the course. See <https://www.coursera.org/course/maps>.

3.10.5 University of New Mexico: "Web Application Architectures" is the topic of a MOOC initiated by the University of New Mexico.

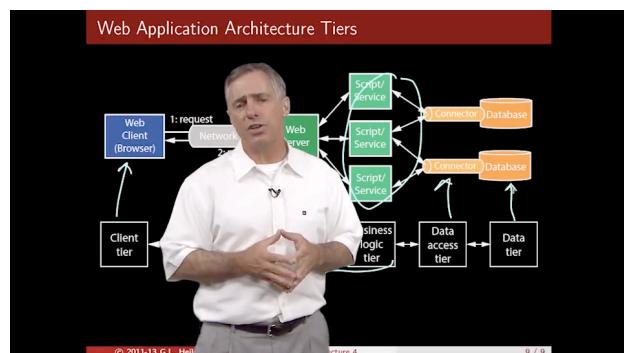


Figure 8: Web Application Architectures
<https://www.coursera.org/course/webapplications>

The six-week course started end of March 2014 and is still in progress during writing this paper. Participants learn how to design, build, and deploy modern web applications that require being familiar with relational databases, adopting software engineering techniques and applying programming skills. It's therefore the aim to impart knowledge in database interaction, web services, and visualisation, all based on the Ruby framework. Lessons learned will lead to applications that run over the Internet, in the "cloud," using a browser as the user interface.

3.10.6 Northwestern University: “Fundamentals of Digital Image and Video Processing” held by Prof. Aggelos Katsaggelos starts on March 31st 2014. The 12 weeks course provides a mathematical framework to describe and analyse images and videos as two- and three-dimensional signals in the spatial, spatio-temporal, and frequency domains. The class consists of video lectures broken into short chunks, each between 10 and 15 minutes long. In addition standalone quizzes and programming assignments will be added. The workload is estimated to 6-8 hours per week.

See <https://www.coursera.org/course/digital>.

4. QUALITY EVALUATION

Quality evaluation and quality standards are a continuous struggle. To start a discussion in our community a short-term project was funded by ISPRS. The analysis and in particular the discussion on 42 criteria for quality evaluation of e-learning material are 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.

The results of the review can be accessed at the webpage of Commission VI / WG 2 (see figure 9).



Figure 9: Review results for RS education modules
<http://misc.gis.tu-berlin.de/typo3-igg/index.php?id=1624>

However the authors are aware of the subjectivity of such personal review. Hence the online questionnaire is still open for public evaluation. See
<http://misc.gis.tu-berlin.de/typo3-igg/ISPRS/quality/questionnaire.php>.

5. CONCLUSION AND OUTLOOK

The delivery of educational material or tutorials has been adopted by the learning community and supports the demand for life-long learning. Most companies use the Internet as a tool for advertisement, information, and for employees or customer training. In higher education e-learning is mainly offered for supporting students in preparation or repetition of lecture content and in combination with blended learning. The appearance of MOOCs instantly gained high public attention, especially in US. Caused by high tuition fees the calls for the

opening of higher education and the democratization of education emerged. In terms of enrolment rates, the proportion of those who successfully complete the course is very small. The vast majority of users are just dropping in to take free courses and not all who take a course, want to finish it.

After the first hype in the beginning MOOCs now face a big discussion and opposition as for example listed in EDUCAUSE Review. See <http://www.educause.edu/ero/article/five-myths-about-moocs>. Main points are:

- MOOCs “fail to engage students in effective pedagogical practices
- Deny students mentoring experiences with scholars passionate about their research
- Lack the rigor of an on-campus curriculum
- Provide, at best, superficial and narrowly defined training rather than deep understanding
- Are an attempt to replace faculty”

In addition qualitative exam questions (in most cases of multiple-choice type) are still beyond the current state of the art and have to be improved.

Low course completion rates are evidence that MOOCs are not suitable for everyone. Last but not least assessments for those who hanged on are disputable. Although students mostly have to sign honour codes asserting that answers to homework, quizzes, and exams are their own work, doubts could not be dispelled. Summing up MOOCs will just be another tool to advance education and not to replace what was done in the past but to add it.

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