Prospects and Considerations for Internet-based Distance GIS Education in Saudi Arabia

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Abstract

The demand for GIS education is very high in the Kingdom of Saudi Arabia. Use of GIS is increasing steadily among government and private organizations and therefore the demand for GIS personnel is rising. To fulfill this demand, online courses may be particularly useful for in-service personnel and women. The present study was done to explore the advantages and potential problems of a distance education system for teaching GIS and to formulate design criteria for such a system. A literature search was conducted to find the current status of on-line or distance education of GIS technology. Further, a survey of Websites offering GIS study material was carried out. It was revealed that the Internet-based distance education of GIS has a number of advantages provided the system to do so, including the content and delivery mechanism, is carefully crafted. Based on the lessons of these surveys and the personal experience of the authors in teaching GIS for over a decade and a half, the criteria for an on-line GIS education system were determined, including the profiles of the prospective learners. These would help in the development an effective model.

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Introduction

A number of universities in Saudi Arabia offer GIS courses in their educational programs. For example, the Department of Urban and Regional Planning in the College of Architecture and Planning of the University of Dammam has been imparting GIS education to its students for around two decades. King Abdulaziz University in Jeddah has a full-fledged Geomatics Department that combines education of GIS, Remote Sensing, Satellite-based positioning and surveying.

However, there is still a lot of unmet demand for GIS education in the Kingdom. Use of GIS is increasing steadily among government and private organizations and therefore the demand for GIS personnel is rising. This trend is expected to continue well into the future, and the number of university graduates trained in GIS will not be enough to meet the demand. Internet-based distance education, may offer an alternate method to ensure an adequate supply of GIS personnel in the years to come. This may particularly be useful for professionals working in different organizations that use or are planning to use GIS. GIS, unlike many other subjects taught in distance education programs, requires not only the study of texts, but also a lot of hands-on exercises under supervision of instructors. Implementing such a program would require thorough studies and careful planning of an effective mechanism, including appropriate teaching material and teacher-learner interaction modalities.

The present study was done to explore and evaluate the possibilities of and formulate the criteria for effective distance education in GIS in the context of the Kingdom of Saudi Arabia.

The specific objectives of the study were:

a. To explore the potential, benefits and problems of Internet-based GIS education.
b. To profile possible users of such an education system.
c. To formulate measures to mitigate potential problems and identify issues to be considered in designing the system.

A literature search was conducted to analyze existing distance education mechanisms and evaluate their effectiveness/weaknesses for delivering GIS education. In additions, A survey of GIS education sites on the Internet was carried out to assess the state of the art of online GIS education. Also, based on the classroom teaching experience of the authors, the potential problems of distance education was assessed. These surveys led to the formulation of design criteria for an Internet-based GIS education system.

Basic Concepts

Geographic Information System (GIS)

Tomlin (1990) has defined GIS as

> "A geographic information system is a facility for preparing, presenting, and interpreting facts that pertain to the surface of the earth. This is a broad definition . . . a considerably narrower definition, however, is more often employed. In common parlance, a geographic information system or GIS is a configuration of computer hardware and software specifically designed for the acquisition, maintenance, and use of cartographic data."

Geographic (or Geographic) Information Systems (GIS) have been used to prepare maps, analyze spatial data, visualize analytical results in diverse professional fields where spatial or geographical data (data and information related to locations on the Earth's surface) is widely used. The technology behind GIS, however, has made great progress since Tomlin put forward his definition. GIS is now gearing towards dealing with spatial data in general, not just specifically from the surface of the Earth. Consequently, some prefer to use the term 'spatial' (instead of 'geographical') and the acronym 'SIS.'

GIS has also moved forward from stand alone applications to network-based, and more importantly, Web-based applications for data analysis and dissemination. Related technologies such Remote Sensing, Digital Surveying, Global Navigation Satellite Systems are increasingly converging to a unified field of academic study. From this

perspective, many find the term GIS too restrictive and prefer to use term like Geomatics or Geoinformatics.

To emphasize the study of the theoretical underpinnings of spatial analysis, modeling, using state of the art technology, instead of just the use of a tool or set of hardware-software, the acronym 'GIS' is often expanded as Geographical Information Science. This is especially true in academic circles involved in the education of GIS. It is this broader academic sense, encompassing the theory and all related technology, that we use the term GIS in this study.

Distance Education

Distance education (also known as distance learning) has been defined as "a process to create and provide access to learning when the source of information and the learners are separated by time and distance, or both (Honeyman & Miller, 1993)." Distance learning has a very long history and evolved as a reaction to certain limitations of traditional classroom learning, most important of which is the inability of certain learners to attend regular classes due to preoccupation or remote location. At its inception, postal service was the medium to transmit course material between the instructors and the learners. With the development of electronic media, and Information and Communication Technology, the modus operandi has become much more efficient, speedier and more effective over the last few decades. Distance learning, when facilitated by Websites, as is the case in most current instances in regions with extensive Internet infrastructure, is also known as e-learning.

There are two main types of distance learning: synchronous and asynchronous. In the synchronous mode, all learners have to accept lessons at fixed schedules. The media of instruction in this category are mainly radio, television, teleconference and Web conference. In the asynchronous mode, the learners can time and pace their lessons at their own convenience. The media of instruction and course delivery in this mode are traditional mail, fax, email, Websites, video and audio recordings etc.

Pettit and Pullar (2009) have identified three viewpoints of online education among its proponents as listed below.

i. It is the delivery of teaching material using the Web as a substitute for face-to-face instructions of the traditional classroom.

ii. It is an enhancement of existing course and curricula, rather than a replacement for them.

iii. It requires significant changes in delivery of education in terms of interaction among all involved (student, educator, institution) and in the way learning happens.

The following advantages of distance education can be discerned, especially in the context of Saudi Arabia.

- Offers flexibility to learners in terms of timing and pace of learning.
- Alleviates demand on physical infrastructure (such as buildings, parking lots etc.) of the course offering institution.
- Facilitates learning by persons with physical disabilities or long-term illness who find it difficult to use classrooms, laboratories and other conventional educational infrastructure.
- Facilitates learning by persons who live far from an educational institution offering courses they are interested in.
- Facilitates learning by girls/women in the Saudi context, as facilities for their education is limited.
- In the same context, it saves institutions from investing in exclusive infrastructure for female education.

GIS Education

In spite of the proliferation of GIS in public sector planning agencies and private planning firms, planning schools have been slow to adapt their curricula to ensure that all students gain some exposure to this technology (Godshalk & MacMohan, 1992; Chapin, 2003). This was not an isolated case in planning education. GIS education at the university level did not start until the late 1980s (Bakker & Bakker, 2000), although there were some graduate level courses in very specialized universities since as early as the 1970s (Kemp & Wiggins, 2003).

The issue of GIS education at the tertiary level has been fraught with debate from the beginning (Bakker & Bakker, 2000). Some educators prefer a training approach, where the emphasis is on developing skills in operating GIS software, while others prefer a more theory-based approach. Rapper and Green (1992) advocated Computer Aided Learning (CAL) tools for GIS education to offer attractive self-paced learning opportunities for students. Piscedda (1994) feels that GIS education can be achieved through theory, exercise and applications. Cremers (1996) suggested that workshop and laboratory teaching are especially important for this kind of education since GIS education involves complicated technology, a rapidly changing field of study, and strong application orientation. Unwin (1997) has noted that there are different styles of GIS

laboratory instructions, each with a different level of independence given to students and a different level of appropriateness with respect to the intended educational objectives.

Montagu (2001) has explored the pedagogical issues associated with reconstructing GIS instruction into a form more directly linked to the substantive heart of the planning discipline and described the challenges of repackaging GIS instruction into a form that is more relevant to planning. It is of vital importance to find a balance between theoretical aspects and practical training in GIS education (Kubbara and Maniruzzaman, 2011). Bakker and Bakker (2000) have noted, "Although the developments like distance learning (Virtual Campus, UNIGIS etc.) changed the education a lot; fundamental questions still arise about content and methods." Therefore there is a need to address these questions.

In summary, what is revealed from the above literature review is the fact to find a balance among theory, exercise and application in GIS education. It is important demonstrate the potential use of GIS in solving professional job requirements. The style of instruction and the leeway allowed to students will depend on the educational objectives, which should be clearly set.

Distance Education on GIS

Godschalk and Lacey (2001) had conducted a survey of planning education programs in the US through the program chairs. It revealed that the majority of respondents believed that online learning mechanisms are important and will most likely be utilized in the next five years in a range of introductory courses. The literature on the subject provides examples of both the positive and negative aspects of the attempts to develop and implement distance education programs for GIS.

Deadman et al. (2000) used a multi-media approach to teach GIS interactively using a high-resolution, computer-based classroom for delivering lecture-based live presentations of the GIS software. Their hardware configuration provided high-speed, high-quality video linkages to broadcast GIS demos to distance education students at remote sites.

Márkus (2001), for example reported the experience of the College of Surveying and Land Management (CSLM) of the University of West-Hungary in developing distance learning material and suggests that for the staff of GIS companies, distance learning offers a particularly flexible and effective way of training, eliminating most of the barriers, providing much better accessibility than traditional education.

Roccatagliata et al. (2002) have discussed the experience of the Geographical Information Systems International Group (GISIG) and the Istituto Universitario di Architettura di Venezia (IUAV) in implementing a distance GIS education program for

Italian Regional Government officials. The program was multimedia CD-ROM-based complemented by tutors at a call centre. A tutorial GIS software was provided in the CD-ROM, as well as the study material. A Website provided extra support with a section only accessible to the registered learners that provide educational tools for the program. There were also three workshops spread along the 3-4 month duration of the course. Project and module tutors communicated with learners via email (sometimes via fax).There were different levels of acceptance of the learners, but in general, they were satisfied.

Zerger et al. (2002) commented upon the lack of interaction within web courses. They state that such courses are best described as Internet-based clearinghouse of curriculum development. However, limited online activity is to some extent offset through discussion forums and chats.

Clarka et al. (2007) evaluated impacts of web-based learning (WBL) for a geographic information system (GIS) course in which self-paced interactive learning modules replaced lectures to prepare students for GIS laboratory activities. They compared student laboratory, mid-term, final exam and overall scores before and after introduction of WBL. They found that laboratory scores improved significantly though course grades did not change significantly overall. Most students were receptive to WBL.

Breetzkea (2007) reported that the advancement of distance learning as an educational tool for GIS has been at the forefront of educational development at tertiary institutions in the preceding decade in South Africa. Distance education is envisaged as a means whereby previously disadvantaged members of society, of all ages, can enrol either directly or remotely at a tertiary education institution at a reduced cost. The experiences of the distance learning program at the University of Pretoria in South Africa have shown that logistical, technical and practical problems, including a high cancellation rate and the delayed completion of the program in its entirety, abound when attempts are made to reproduce an internationally recognized distance-based course in a developing world environment.

Murai (2008) described a three year-project of JICA NET Distance Education on remote sensing and GIS for developing countries initiated by the Japan International Cooperation Agency (JICA) since 2004 in cooperation with Japan Society of Photogrammetry and Remote Sensing (JSPRS). The teaching contents consisted of 12 modules each of remote sensing and GIS. A module of the distance education is composed of 30 minutes lecture presented with power point images in video and voice, 30 minutes video conference for question and answer (Q&A) session. JICA NET Distance Education was implemented nine times in the first three year project for 2004-2006 with 661 participants in RS and 665 in GIS from 13 countries. The examination was implemented in cooperation with a site facilitator in each country. Murai (2008) evaluated the program as successful in terms

of systematic education to governmental and university staff in developing countries who are working in the field of remote sensing and GIS.

Grunwald et al. (2009a; 2009b) have discussed the hardware and networking issues regarding the development and implementation of a virtual learning environment to teach GIS and spatial sciences to graduate distance education students. Criteria that were used for the purpose included: (i) Facilitating student-instructor, student-computer, and student-student interactivity using a mix of synchronous and asynchronous communication tools; (ii) Developing an interactive online learning environment in which students have access to a suite of passive and active multi-media tools; and (iii) Allowing student access to a mixed web-facilitated/hybrid architecture that stimulates their cognitive geographic skills and provides hands-on experience in using GIS.

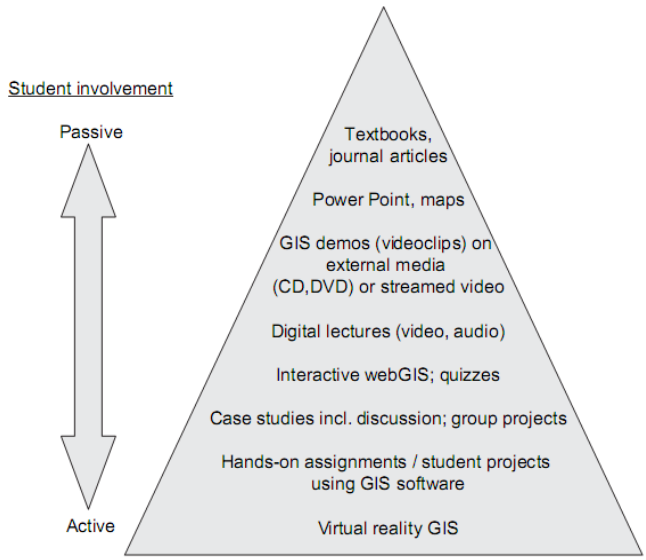

Fig. 1. Pyramid of delivery types of content of courses to teach GIS courses

Grunwald et al. (2009a) described the different types of course delivery modes and the level of student involvement for each in the form of a pyramid as shown in Figure 1.

Pettit and Pullar (2009) described a frame work for spatial planning tasks and pedagogical underpinnings for the development of an online course for introductory urban and regional planning using GIS. The course covers theoretical planning concepts, which are supplemented with practical examples and exercises. The course was made available through a commercial GIS vendor in 2001 and has been completed by a large number of professionals and university students. Citing Govindasamy (2002) he states that in the distant mode of education, concepts should be presented in small chunks of manageable learning objects (LO) with links and references to more detailed knowledge.

In summary, what is revealed from the above literature survey on distance education is the widespread confidence in the efficacy of distance education as a mode of teaching GIS. Some problems are pointed out, which are minor in nature, but requires careful attention to ensure successful implementation. One crucial factor is to ensure adequate interaction between the learner and the instructor. Another point of concern is preparation of educational material. These should fundamentally different from those used in traditional classroom based teaching. The different mode of delivery deserves a different approach to prepare material to use the full potential of the advanced mode. Knowledge should be delivered in small modules with directions to more detailed information. To ensure the success of distance learning on GIS programs, it is important to identify the critical factors like these and take care to address these issues in the program.

Current Programs and Resources

To assess the state of the art of GIS education Websites, a survey of such sites was carried out. The objectives of the survey were:

1. To get an overview of the breadth and depth of Websites providing educational material for GIS.
2. To judge the strong and weak aspects of such Websites in terms of design, content and functionality.
3. To explore resources available on the Web in the public domain (with or without use restrictions) for GIS education.

The sample was selected from a Google search on the keywords ‘GIS’, ‘Website’ and ‘education’ on 11 April 2012. The sites listed in the first ten pages (ten sites on each page) of the search result were visited and categorized. Some of the sites were listed multiple times and some sites were totally unrelated to GIS. The Categories of the 100 Websites are summarized in Table 1. The entire list is attached in Appendix A.

Next, the sites that were deemed relevant to GIS education were revisited and explored in depth, and an attempt was made to learn the lessons these sites offered in terms of guidelines for the development of a new site.

The vast majority of the sites (50) were related to government organizations (mostly US local governments) that use GIS and use the Website for dissemination or viewing of GIS data. Some Federal (US) agencies have material introducing GIS, but otherwise GIS education is not a concern for these sites. Many sites, however, offer free GIS data that may be utilized for developing exercises in an education context.

Table 1. Distribution of 100 Websites by category

Category	**No. of sites**
Encyclopedia	1
Commercial Software Vendors	2
Non Commercial Software Developers	6
GIS Portal	5
Education (Formal)	1
Education (Non-formal)	1
Dictionary	2
GIS Service Provider	1
GIS Data site	2
Government Organizations (GIS Users)	50
Jobs site	4
Miscellaneous	5
Unrelated to GIS	20

Some sites (two in the survey) are exclusively developed to provide GIS data or links to sites that provide such data.

Most of the GIS portals surveyed (five in total) feature material on learning GIS. However, most provide only a brief overview of GIS, while others have disparate articles, not threaded in a logical and thematic sequence.

Eight of the sites surveyed were related to commercial or non-commercial GIS software developers (two and six respectively). GIS education/tutorial material on these sites, if any, is not general but software specific.

The dictionary and encyclopedia sites are valuable resources for GIS learners as they provide definitions and explanations of various terms used in GIS which may seem unfamiliar to them. But by themselves, they are not meant to be tutorial material.

Only two of the sites surveyed were specifically related to GIS education. To overcome this paucity of GIS educational sites in the sample and study more such sites, the Colleges and Universities page of the URISA was visited (URL: http://www.urisa.org/career/colleges). URISA is the Urban and Regional Information Systems Association, but presents itself and functions as 'The Association for GIS Professionals.' At the time of access (27 April, 2012) 92 universities and colleges offering Certificate, Bachelor's, Master's or PhD programs in GIS were listed on the site.

Out of them, only 13 had online programs. These are listed below in Table 2. These sites were visited and reviewed as part of the survey. Screen shots of the home pages of two sample sites are shown in Figs. 2 and 3.

Table 2. Institutions offering online programs in GIS

University, Country	**Programs (not all are necessarily online)**
American Sentinel University, USA	Bachelor of Science in Information Systems GIS specialization (distance learning)
Curtin University, Australia	Graduate Certificate in Geographical Information Science Graduate Diploma in Geographical Information Science Master of Science (Geospatial)
Durham College, Canada	Online GIS certificate
Elmhurst College, USA	GIS certificate and Online GIS certificate
Florida State University, USA	Applied Master's Degree in GIS and Online GIS certificate
John Hopkins University, USA	Online certificate in GIS
Louisiana Technical University, USA	Distance Learning Certificate in GIScience
Northwest Missouri State University, USA	Online Master's in GIScience and Graduate Certificate (Access to ArcGIS required)
Penn State University, USA	Online Graduate Certificate in GIS Masters in GIS
University of Illinois at Chicago, USA	Public Health Geographic Information Systems Online Certificate Program
University of North Dakota, USA	GIS Graduate Certificate Program (1-year online program)
University of Southern California, USA	Geographic Information Science and Technology Certificate Master's of GIScience and Technology (Both available as online programs.)
University of W. Florida	GIS Certificate Program, Online GIS Certificate Program

The insight gained and lessons learnt from the survey can be summarized as follows.

- GIS education involves both theoretical knowledge and practical skills. While imparting theoretical knowledge from a distance learning platform poses little or no difficulty, developing skills is more problematic. Without face-to-face tutoring and on-hands exercises in a classroom environment, there is a need to develop exercise material profusely illustrated with graphics and perhaps even video clips so the learners can easily follow the instructions without confusion. Development of such material requires painstaking and time-consuming efforts.

- Some institutions require students to have access to ArcGIS software.
- Some institutions have e-desktop GIS that allows students to have access to software such as ArcGIS or ERDAS Imagine installed in the institutional server.
- Some institutions follow a hybrid approach instead, where part of the program can be pursued online, but the rest has to be taken in the traditional classroom-based method.
- If the institution offering the course possess site license for commercial GIS software and the learners are registered students, they may be able to use the software as long as their registration lasts. However, it must be noted that this may entail considerable cost, not only for the software but also for the maintenance and administration of the system.
- The duration and total credit of the different levels of courses are in general as shown in Table 3. The assumption, in general, related to the Certificate and Master's program is that the learners are part-time students who would not register for the full load of courses in a semester.

Table 3. Range of course duration and credit hours for different levels of online education

Level of Course	**Duration** (Minimum)	**Credit Hours** (Excluding project)
Bachelor's	4 years	117
Certificate (PG)	2-3 semesters / 1-1.5 yrs	11-15
Master's	6 semesters / 3 yrs.	32-25

Issues to Consider for an Effective GIS Distance Education System

Components of the System

Any program for distance education must give careful consideration to developing to broad components: content on the one hand and the container and delivery media (Website) on the other. Content includes, among other things, learning modules (text), presentation slides, exercise instructions, exercise to data, links to resources etc. The media in which the content is stored and can be accessed is the Internet through a custom-designed Website.

User Profile

To design and develop an effective Website with appropriate content for distance education in GIS, it is important to set a number of parameters including the profile of the target learners. The nature of the course and the contents should be designed with a target

profile in mind. Based on experience as educators of GIS who have often faced queries from people interested to learn GIS, the authors expect the prospective users of a GIS distance education system in Saudi Arabia to be:

- University students who may or may not have institutional facilities to learn GIS.
- Recent graduates who are looking to pad up their qualifications to improve their job prospects.
- Mid-level professionals working in organizations with GIS setups, who are interested to work more effectively with GIS and understand better how GIS can help them in their jobs, or to communicate with GIS personnel in the organization with clarity and precision.

The expected profile of the prospective learners is described below.

Age

It is expected that most learners will be relatively young. Most would be young graduates seeking to learn GIS to improve their job prospects. Some will be midlevel professionals working in organizations that use GIS. The latter group will be interested to improve their knowledge and skills in GIS to improve their job performance.

Education and skills

The prospective learners will hold at least a bachelor degree from a science or technology department. They are likely to be versatile computer users.

Gender

Most will be male, but some may be female, if there is no face-to-face or classroom component.

Language

Most prospective learners will be citizens of Saudi Arabia, therefore they will be proficient in Arabic. However, since they will be university graduates, they will also have at least a minimum level of proficiency in English. There can also be some non-Arab expatriate learners who would require the lessons and learning material in English.

Motive

There is a variety of reasons why people may be interested to learn about GIS, as already mentioned, and the level of understanding, or the focus of knowledge required by them can be different. Some would be looking for academic/training credentials, others may be interested to learn about the basics of GIS. There can also be advanced users interested in building up their expertise in specific areas of GIS.

The Content

Preparing the content (educational material) involves a time-consuming, painstaking process. The material usually evolves over a few cycles of delivery and with feedback from learners and instructors. This is especially true for distance or e-learning, where more visuals (screen shots, video clips, animation etc.) and hyperlinks in documents are required.

As revealed in the literature survey on distance education described above, the content should be delivered in short modules, each explaining a small part of the total course content.

Software for Exercises

GIS education has to combine teaching of theoretical knowledge and the training of practical skills. The use of GIS software is necessary for the latter. There are many of GIS software available that can be used. ArcGIS, by ESRI, is obvious choice because most learners who have some idea of GIS would probably be interested in learning this software as it is the market leader in the Kingdom as well as the world over. ArcGIS is an expensive software that few may be expected to own personally. However, those working in an organization with an ArcGIS setup may have the opportunity to learn in their office environment. A fully-featured trial version of the software is often available with limited period of validity, but the availability of it cannot be guaranteed at all times.

Recently, ESRI, the makers of ArcGIS has announced in its Website the introduction of a low cost ($100 annual fee) but fully functional version of the software for home users in the US. According to contacts with ESRI Saudi Arabia the fee in the Kingdom has been set at SAR 700, which is much higher than the fee in US but still affordable.

For those who cannot be expected to have access to ArcGIS, the alternative is to use an open source and gratis software that can be acquired by anyone interested in it without a price or fee. Examples of such software are QuantumGIS and MapWindow.

Instructor-learner Interaction

It is possible to deliver the course material, even the exercise material and data, over the Internet. Instructors and learners may communicate with each other through emails on a one-to-one or one-to-many basis. In addition, there may be Internet-based discussion forums where participants may discuss issues and problems related to the course material.

It is possible to design and administer real time tests of theoretical knowledge learnt by the learners on the Internet as well. However, it may be difficult to ascertain the level of practical skills acquired by the learners based on remotely administered tests. Therefore,

a hybrid system where some practical tests are conducted in a classroom may be preferred.

Conclusion

Internet-based GIS education is not only feasible, but has a number of advantages vis-à-vis the traditional classroom mode of education. In addition to the advantages that are universal, there are special advantages for the Saudi context such as the convenience it offers for women's education. They will not be restricted by problems of mobility on the one hand, and education providers will not be required to invest in separate facilities for them on the other hand.

The course material for distance education should be specially designed with shorter modules and more visuals than traditionally used in classroom education. This is a time consuming process that may need several cycles of delivery and piloting before the course content takes an acceptable form.

This study was done as a precursor to developing a distance education system for GIS at the University of Dammam. Some course material including handouts, presentations and exercise guides with data was developed and uploaded on the university Blackboard (e-learning site). Students of the Department of Urban and Regional Planning used the material for their GIS education. Although the mode was not that of distance education, it provided feedback for modifying and fine tuning the material. The next phase of the study would involve designing a dedicated Website for the purpose and piloting the course delivery.

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