Delivering ICT Security Courses over 5.944 km

Experience of Czech-Kenyan Co-operation

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***Abstract*—This paper presents practical experience with remote delivery of ICT courses taught by Czech teachers for students at Strathmore University in Kenya. Although e-learning and remote course delivery technologies have been successfully applied to distance education many years ago, their application for ICT courses requires additional instruments as virtualized labs, on-site boot camps, etc. that help students in achieving practical skills. The paper demonstrates different teaching strategies that were implemented to deliver ICT security courses for Kenyan students in 2015-2017. The paper discusses the implementation from the perspective of the learner, mode of delivery, and expected learning outcomes.**

Keywords—ICT courses; remote course delivery; e-learning; virtualized lab

I. Introduction

In 2014 Strathmore University in Nairobi, Kenya launched a new Master program in Information Systems Security (MSc. ISS)[1]. This program responded to an increasing demand for ICT security experts on the emerging African job market. Due to a lack of lecturers for specialized courses of the program, several institutions including Brno University of Technology, Czech Republic (BUT) has been asked to co-operate on teaching specialized ICT courses for Kenya students using video conferencing and advanced ICT technologies.

Remote mode of delivery [1] included not only online lectures, but also participation in virtual lab assignments, work on case studies, etc. The co-operation was implemented using both traditional e-learning technologies like Skype, Moodle or document sharing via Google Docs, and also advanced approaches that included virtualized lab environment and practical assignments. The combination of different approaches and methods of delivery helped to overcome typical limitations of remote teaching and covered higher levels of cognitive domains as defined by revised Bloom's taxonomy [2].

The paper describes the MSc. ISS study program, its structure, objectives, and implementation. It also specifies used technologies and shows the results of the pilot phase of the program. Success of implementation has been evaluated using students and teachers survey. Also, the paper presents advanced teaching activities as summer schools, on-site boot camps and mobility programs that improve the learning outcomes of remote education. Both benefits and challenges of cross-country education are discussed.

[1] See http://fit.strathmore.edu/study-at-fit/our-programmes/master-of-science-in-information-system-security-msc-iss [last access in April 2017]

II. MSc. ISS Study Program at Strathmore University

A. Description of the Study Program

The MSc. ISS program is a two-year study program that contains seven modules, see Figure 1. Each module is scheduled for 10 to 11 weeks including a study and exam weeks. The program is delivered on part-time basis. Classes are running on afternoons and evenings which makes the program accessible to full-time and part-time students. Students can connect to classes from the university, their homes or work. Course activities mostly include online lectures, projects, continuous assessments, case studies, etc.

B. Specifics and Requirements on Course Delivery

The annual intake of this two-year study program is about 25 to 30 students. Most of the students have already received

Schedule	Units/Courses	Hours
Module 1	Mobile Computing	35 hrs
	Cloud Computing	35 hrs
	Introduction to Information Security	20 hrs
	Software Laboratory Experience I	50 hrs
Module 2	Cryptography	20 hrs
	Policy Formulation and Implementation	10 hrs
	Advanced Databases and Enterprise Systems	35 hrs
	Software Laboratory Experience II	50 hrs
Module 3	IT Entrepreneurship	10 hrs
	Enterprise Security	20 hrs
	Penetration Testing	60 hrs
	Cloud Computing Security	10 hrs
	Soft Computing / Advanced Network Security / Digital Forensic	35 hrs
Module 4	Advanced Information System Audit	20 hrs
	Software Modelling	30 hrs
	Business Resilience	20 hrs
	Research Methods	20 hrs
	Mobile Computing Security / Wireless Security / Forensics Data Acquisition	35 hrs
Module 5	IT Professional Ethics	20 hrs
	Biometrics Systems Security	20 hrs
	IT Security Project	50 hrs
	Special Topics in Software Security/ Network Security / Digital Forensics	35 hrs
Module 6	Information Security Management	20 hrs
	Cyber Crime, Law and Investigation	10 hrs
	Emerging Trends of IT security	10 hrs
Module 7	Final Dissertation	180 hrs
Total Hours		860 hrs

Figure 1: MSc. ISS Curriculum

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their degree in previous study programs: IT, administration, science, etc. Many students work partly or fully in ICT companies or governmental agencies and take advantage of improving their qualification through studying MSc. ISS. Because of remotely delivered, the program is also accessible to students that come from distant areas so that they do not have to travel to the campus.

MSc. ISS study program requires students to be able to:

- Understand network communication and configure devices.
- Implement security in ICT, use tools for management and security monitoring.
- Be able to develop simple applications.
- Retrieve and analyze data from security incidents.
- Understand ethical and lawful concepts of security.

To achieve these requirements in the context of remote course delivery, following technologies have been selected for teaching:

- Online lectures are delivered using video conferencing technology Skype for Business that transmits voice and video, enables sharing of presentation, provides chat box, and recording.
- Class administration is done in Moodle that enables to share presentations and other teaching resources.
- Continuous online assessments, case studies, and other activities are also delivered through Moodle.
- For special hands-on labs, a virtualized environment is provided. Students can use either their own equipment or computers in university laboratories.

III. Implementing Remote Teaching

Remote teaching is not only about technologies. Tomei's theoretical model [3] uses different perspectives to design a successful online education supporting lifelong learning. While describing the implementation of remote ICT courses for Kenyan students, we consider three main aspects: the learner, the mode of delivery and the learning outcomes as proposed by Tomei's model.

A. Focus on the Learner

The ultimate goal of education is to promote student learning. To achieve this, the teacher combines different learning strategies based on traditional and non-traditional learning theories that are focused on adults and considers distance learners [4]. Traditional learning models employ repetition, student responses, cognitive-based teaching, or positive communication. Distance learning model promotes social interaction, experiential teaching, problem-solving, case studies, role playing and other activities that motivate students and encourage them to continue in their studies.

Remote teaching puts additional requirements on the participants. Based on various studies[2], following common traits have been identified for successful online learners:

1. *Interest in learning*: inquisitive nature, ability to look for details, ask application questions.
2. *Persistence*: online presence, focus on the topic, responsibility even when not under direct control, able to stay on task, overcome technical problems, etc.
3. *Motivation*: focus on personal or professional goals, deep-seated desire to achieve the goal.
4. *Effective in communication*: good interaction between a teacher and a student, ability to ask a teacher for further explanation, etc.
5. *Strong time-management skills*: create a study plan, meet deadlines.
6. *Basic technical skills*: mastering remote delivery technologies, the ability to work in the virtual environment.

These traits can be fostered in collaboration with the teacher. Teachers should be encouraged to motivate students to work on their assignments progressively, give them tools for online self-evaluation, help them to create a viable plan for in-class activities, provide manuals and examples how to work with technologies, demonstrate problem-solving approaches, etc.

The importance of above-mentioned recommendations was proved by the survey among Kenyan students. Following are the selected opinions on the course delivery method from the students' perspective.:

- Online learning gives me flexibility, reduces my traveling.
- It would be good to have a combination of online learning and physical classes.
- Dissemination of course information should be improved.
- Time for submitting is not adequate. I feel that I have been rushed into doing assignments just to meet the deadline not to learn.
- Practical classes should be well prepared in advanced and lecturers should tell us what apps or configuration is needed.
- Early notification of cancellation of classes or changes should be done.

Based on the teachers' survey, the most important issue mentioned there was a lack of personal contact with students, no immediate feedback to a lecture, and no control over student concentration during lectures.

[2] See, for example, http://www.onlinecollege.org/2011/07/14/10-traits-of-a-successful-online-learner/ [last access in April 2017]

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TABLE 1: VIRTUALIZED LAB ENVIRONMENT

Type of software	Application
Virtualized Lab Environment	VMWare, Virtual Box, Vagrant
Installed Packages	Wireshark, tcpdump, hexdump, XPlico, Network Miner
	Oracle, SQL browser
	Security Audit Tools, UFW Firewall, snort, ngrep, tcpxtract

B. *Focus on Delivery*

Remote content delivery includes technologies that transmit online lectures, enable student-teacher interaction, provide a platform for collaboration, assessment, resource delivery, student registration, class management, scheduling, etc. These technologies support either synchronous communication (video conferencing tools) or asynchronous communication (repositories, LMS, e-mails).

Besides technologies, focus on delivery also includes different types of activities that create a successful teacher-to-student transfer of knowledge, skills, and abilities as defined by the learning outcomes. Description of such activities is described in part *C* of this section.

Following technologies have been provided for online teaching and remote course delivery:

- *Moodle*: a learning management system (LMS) that provides student registration, class scheduling, distribution of course content, online assessment, submission of assignments, and many others. Moodle helps students to access all necessary resources, to check deadlines and evaluations of their activities.
- *Skype for Business (former Lynx)* is a tool for delivering online lectures. Skype for Business offers a collaborative environment where the teacher shares his presentation with students. Skype also provides video and audio transmission, defines different roles for users (presenter, participants), provides chat box for students to teacher communication, supports session recording, etc.
- *Virtualized lab environment*: Since MSc. ISS program promotes practical skills of students in network communication and security technologies, the teachers created a virtualized environment where students work out on their hands-on labs assignments and case studies. This environment includes images of different operating systems with pre-installed software that run either at Strathmore labs or on students' laptops. During online sessions, students are advised how to use the environment. Then, they are challenged to work on hands-on lab assignments incorporated into the environment. Table 1 shows software that is a part of virtualized lab environment.
- *Google Docs Collaborative Environment:* Student work often includes writing papers, case study reports, and other texts. For an interactive consultation with the remote teacher, students can share documents via Google Docs which enables the teacher to put his or her comments to the student's work, correct his or her mistakes and help to improve his or her writing skills. Since Google Docs can be accessed from different platforms as laptops, tablets or smartphone, it easily works for students with limited Internet connection.

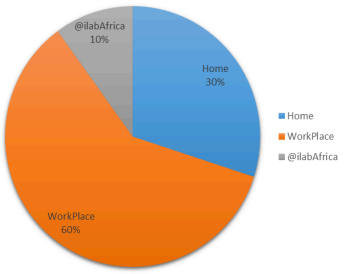

Figure 2: Where students join the class from?

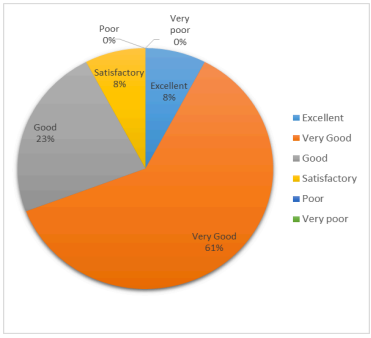

Figure 3: How is the usability of Skype for Business?

Figure 2 shows at what places the students connect to online lessons. Most of them connect from their working places. Some of them also use the connection at homes or the University (@ilabAfrica lab). Concerning the quality of delivery using Skype for Business, the majority of students is very satisfied, see Figure 3.

Students attend a class using a different type of devices, see Figure 4. The majority of devices are laptops; there is also a significant number of tablets and smartphones which bring flexibility and easy access for students.

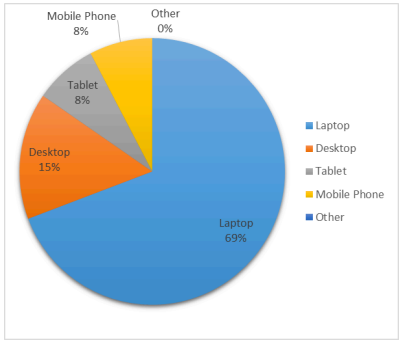

Figure 4: What devices did you use to attend classes

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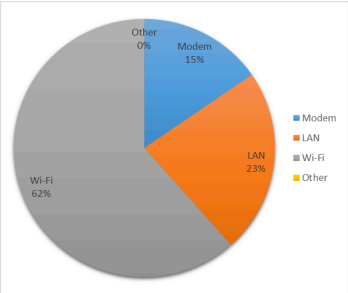

Figure 5: What type of connectivity do you use?

When thinking about the remote content delivery, it is important to consider technological requirements on the necessary equipment and environment, especially network bandwidth for audio and video transmission. For virtual labs, CPU performance and memory size are important. As we see in Figure 5, there are still students connecting using a modem connection. Because of this, lecturers need to be aware of this limitation and be prepared for some difficulties in course material dissemination.

When evaluating communication platform and class delivery, students provided following comments in the survey:

- *Sharing recorded classes is important for me.*
- *It works great on mobile too.*
- *Audio and chat are great. Some lecturers use video which is also good.*
- *It is great to have a platform where collaborative features enable me to share thoughts and comments.*
- *There is no possibility to raise up hands on Skype for Business. However, one can use instant messaging instead, and lecturers can see any incoming chat immediately.*
- *Skype for Business provides a feel similar to class. However, we may complete the course without actually knowing each other as most students attend classes only remotely.*

From the answers above and Figure 6, we can see that students are mostly satisfied with the platform of delivery. They are familiar with used technologies and appreciate when they see the teacher during online sessions. However, they miss a social contact with the teacher and their schoolmates. Their interaction is often limited to video conferencing. In section IV we will discuss how to overcome such limitations.

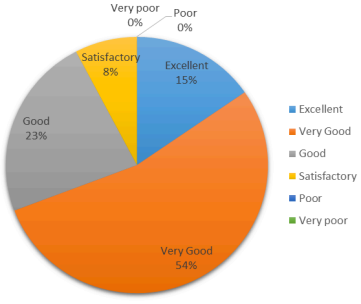

Figure 6: What is your overall experience with the platform?

Teachers expressed their experience as follows:

- *I appreciated the flexibility of teaching: I could teach from the office, home, hotel room, etc.*
- *It was great to record the lectures and provide these recordings to the students.*
- *It was beneficial to use multiple screens and video conference equipment for practical demos.*

Online teaching brings many positives for both students and teachers as apparent from the survey. When teacher and students are at different continents this is also the only option. To stimulate student responses and preserve student-teacher contact during lessons, activities as questions, quizzes, or hands-on demos are frequently used by teachers.

C. Focus on Learning Outcomes

Evaluation of learning strategies for remote course delivery is based on (1) reaching of educational objectives as expressed by Bloom's taxonomy, and (2) continuous assessment of real student outcomes. Educational objectives of each course are defined in MSc. ISS syllabus. Here we show how different learning strategies and activities have been applied in remote teaching to reach the expected objectives.

For (1) evaluation of educational objectives the revised Bloom's taxonomy [2] has been applied. The taxonomy defines six dimensions of the cognitive process in education:

1. *Remember*: Retrieving relevant knowledge from long-term memory. It includes recognizing and recalling.
2. *Understand*: Determining the meaning of instructional messages, including oral, written and graphic communication. It includes interpreting, exemplifying, classifying, inferring, comparing, explaining.
3. *Apply*: Carrying out or using a procedure in a given situation. It includes executing and implementing.
4. *Analyze*: Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose. It includes differentiating, organizing, and attributing.
5. *Evaluate*: Making judgment based on criteria and standards. It includes checking and critiquing.
6. *Create*: Putting elements together to form a novel, coherent whole or make an original product. It includes generating, planning and producing.

TABLE 2: IMPLEMENTING COGNITIVE STRATEGIES

Cognitive level	Teaching activity
1) Rembember	Online lectures, questions, quizzez
2) Understand	Questions, discussions, online assessments
3) Apply	Hands-on labs, programming projects
4) Analyze	Case studies
5) Evaluate	Final exam assignments
6) Create	Dissertation (MSc. Thesis)

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Based on this taxonomy we evaluated individual activities and parts of remote course delivery as implemented in MSc. ISS courses, see Table 2. We can see that remote course delivery meets levels 1-5 of the cognitive process. The highest level is reached by working on a dissertation. Since MSc. ISS curriculum is skills-oriented, the main focus is on level 3.

Another view (2) of learning objectives is through individual student assessment. The assessment measures the quality of a student work and level of mastery. It usually takes a form of multiple choice, true-false, or short-answer tests. Since MSc. ISS is practically focused; student skills have to be measured using programming an application, installing and running software, configure and evaluating a service, etc.

For remote courses, it is necessary to provide a frequent feedback that informs students how close or far they are from the expected outcomes. Same to educational objectives in (1), Bloom's taxonomy can be applied to the assessment. Following list of different assessment instruments describes what level of the cognitive domain on scale 1-6 can be reached using such instrument. In brackets we show a recommended percentage of the assessment in the total student evaluation:

- *Presence and activity in on-line sessions* (10%): cognitive levels 1 and 2.
- *Individual hands-on labs and reports* (15%): cognitive levels 2 and 3
- *Programming projects or case studies* (15%): cognitive levels 3 and 4
- *Continuous review test via Moodle* (10%): cognitive levels 1 and 2
- *Final exam* (50%): a combination of different type of questions with cognitive levels 1 to 5.

To help students reaching the learning outcomes teachers implemented additional instruments that encourage students to finish the course successfully:

- Two-phase submission of lab reports and case studies help students to understand teacher's requirements. During the first phase of submission, the teacher scans the work and provides feedback with a list of recommended improvements. Thus, the student can update his or her work and submit a corrected version during the second phase.
- Code examples or application prototypes are provided for programming projects. Students learn on seeing a prototype code how to create their own code using best practices.
- Review tests are organized in such way that students have several attempts to make a test until they reach final evaluation. Moodle tests support making several attempts with a penalty.

All the strategies as mentioned earlier help students to overcome limitation necessary involved with the remote course delivery.

IV. Advanced Activities

Considering limits of the remote course delivery, especially a lack of social contact, missing hands-on labs and student-teacher interaction, some additional activities have been proposed to improve the efficiency of remote teaching. These activities enrich the course delivery using on-site labs and other face-to-face activities.

A. On-site Lab Activities

Kenyan students enrolled in MSc. ISS program expressed a desire for intensive practical training in ICT technologies. Since BUT has a long-term experience with teaching ICT skills, two activities enriching the MSc. ISS program has been proposed: Information Security Summer School in Brno, Czech Republic, and on-site boot camp in Nairobi led by visiting Czech teachers.

Summer School for Kenyan students was organized for the first time in summer 2016. Because of high expenses on traveling, only ten students could participate. The Summer School comprises of 8-hours sessions within ten days in Brno lab focused on different ICT technologies, see Table 3.

After the Summer School students filled the survey where they expressed high satisfaction with provided teaching:

- *The organization of the school was very good, and hands-on labs added real life experience to me.*
- *I would appreciate Czech companies to introduce their technologies to the Summer School.*
- *The interaction with the lecturers was very warm, and they gave far more knowledge and experience.*
- *The lecturers understand the topics very well and are always willing to assist when the need arises.*
- *It was very educative, and I wish the summer school would be extended for another week.*
- *Well organized classes and excellent timing.*
- *I propose to have interaction with security industry and maybe visit a security company.*
- *The course content was very well organized and it covered the general overview of systems security.*
- *The entire experience was invaluable. I gained a lot of practical experience I am grateful for.*

TABLE 3: BRNO SUMMER SCHOOL 2016

Day 1	Configuring Cisco network devices: DHCP, NAT, routing.
Day 2	IPv6 networking. Tunneling. Capturing network data.
Day 3	Securing Networks on Layer 2.
Day 4	Network Forensic Analysis.
Day 5	Digital Forensics Analysis. Image retrieving, disk carving.
Day 6	Oracle Security Administration.
Day 7	Biometrical Systems and Technologies.
Day 8	Configuring WiFi networks. WiFi Attacks and Security.
Day 9	Configuring Firewalls.
Day 10	Security Monitoring using Syslog, SNMP and NetFlow.

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As seen from the survey above, a short-term on-site activity can be a good complement to remote course delivery. In order to make such activity available to more students, in May 2017 a pilot Boot Camp in Nairobi has been organized with a similar structure to the Brno Summer School. Comparing to the Summer School, its program was shortened to six two-hour sessions to fit MSc. ISS schedule. However, such activities have a great potential for the future.

B. Mobility Program

Another step of Czech-Kenyan cooperation in remote education is mobility. BUT applied for mobility program between the Czech Republic and Kenya in Erasmus+ call for 2017-2019. Under Erasmus+ framework, following activities have been planned:

- Regular visits of Czech teachers in Nairobi where they teach 5-days intensive hands-on labs. Because of limited lab equipment, this activity can be seen as a complement to Brno Summer School.
- Three-month visit of Czech Ph.D. students who will work on joint research topics with Kenyan students.
- Six-month visit of Kenyan Ph.D. students at BUT where these Ph.D. students work on their thesis under joint tutelage of Czech professors in BUT.

All these proposed activities give additional value to the current remote teaching strategies and offer advanced opportunities to Kenyan students to grow in their professional and academic career.

V. Conclusion and Discussion

While remote course delivery requires extra effort from teachers preparing and providing the course content, technicians ensuring the necessary technical equipment be available and students being able to stay motivated to follow the activities, it offers numerous benefits. This paper presented an experience on remote course delivery for ICT master program in information security. On-line learning approach enables to consider students that are spread around Kenya, being full-time students, part-time or full-time workers. The pilot run of the program was completed and the second run is in progress. The feedback obtained from students and teachers indicates that teaching methods are adequate to meet students' expectations. The limitations of remote course delivery were compensated by two supporting activities, namely summer school, and mobility program. Because MSc ISS program emphasizes technical skills, the strong emphasize was also put on providing the virtual environment for exercising practical skills.

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