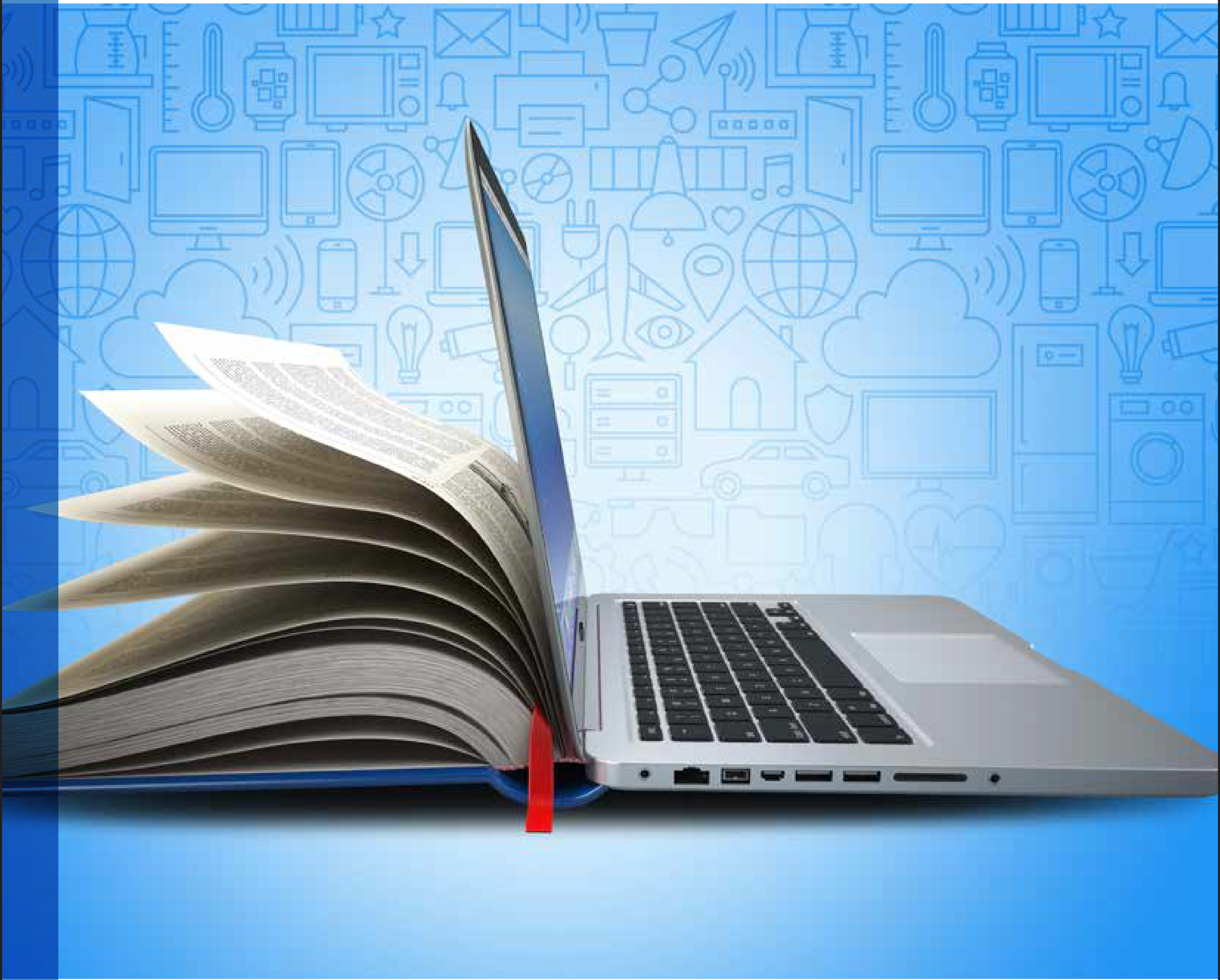

Capacity Building in a Changing ICT Environment

2018

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Foreword

I am pleased to present to you the second issue of **Capacity Building in a Changing ICT Environment,** an ITU publication which focuses on capacity building and skills development issues arising from the current and future telecommunication/information and communication technology environment.

At the World Telecommunication Development Conference 2017, ITU member states reiterated the importance of capacity development and re-emphasized the need for ITU to strengthen institutional capacity and human skills development of the ITU membership in order for the latter to more effectively tap into the opportunities offered by ICT. As technological advancements continue to outpace the ability of society to fully utilise emerging technologies, the importance of building capacity to learn and acquire knowledge also grows.

This second issue of the **Capacity Building in a Changing ICT Environment** publication features contributions in an analytical, critical and conceptual approach from international experts on the subject of skills development in a digital era. The articles in this issue contribute to the ongoing discussions on how emerging technologies are transforming job markets, determining new skills sets requirements and driving the digital economy requirements for re-skilling. The articles highlight different levels of skills required, from basic digital skills that are aimed at raising ICT awareness and enabling use of simple applications to advanced digital skills targeted at more complex tasks such as network management and data analytics. Specific topics such as IPv6, cloud computing, Internet of Things (IoT), quality of service, big data, Artificial Intelligence (AI) and related skills requirements are also discussed. The articles also cover the role of digital technologies in facilitating teaching and learning across national boundaries enabling learners to participate in training activities without being restricted by their geographical location or that of the teachers or experts.

The discussions raise key questions on the speed at which skills needs emerge compared to the pace of training, changes in teaching and learning approaches, the changing role of academia and industry in view of those developments and the role of digital technologies on skills development, which will require a reassessment of prevalent skills development approaches.

The articles present a number of concrete examples in capacity building projects carried out across different regions of the world. These projects illustrate how the use of emerging technologies for developing new skills has made an impact, such as how training in IoT led to the development of products that are cost effective, easily deployable and attract investment, or how smart learning practices have been implemented successfully in different countries.

I trust that the ideas presented in this publication will support present and future discussions on the impact of ICT on skills and training as well as new developments in this area.

Brahima Sanou
Director, Telecommunication Development Bureau (BDT)
International Telecommunication Union

About this publication

“Capacity Building in a Changing ICT Environment” is an online publication which puts together scholarly articles with a focus on the impact of ICT on capacity and skills development. It covers a wide range of topics that may affect people and their skills development, such as artificial intelligence (AI), the Internet of Things (IoT), big data, telecommunication regulatory issues, smart cities/societies, digital competencies, open source learning and intellectual property rights, etc.

The publication seeks to provide a body of knowledge that will facilitate academic research and innovation exploring the linkages between emerging ICT issues and capacity development. It features current and new thinking that will contribute to informed policy debates and decisions among policymakers and regulators, as well as help the private sector to anticipate and plan for human capital requirements and skills development in order to remain competitive in a rapidly changing ICT environment.

The publication, which is released annually, is based on voluntary contributions from academic scholars and other researchers from all over the world. The purpose of the articles is to share views and scholarly opinions that will stimulate debate among its readers. Articles published are subjected to a quality assurance process by well acclaimed experts through a peer review exercise.

This publication is available on the ITU Academy platform. The published articles will also be subject to discussion at forums organized from time to time for Academia members of ITU.

Those interested in submitting an article for consideration in future editions of “Capacity Building in a Changing ICT Environment” should contact the ITU Human Capacity Building Division at hcbmail@itu.int.

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Introduction

By Suella Hansen

Capacity building and skills development are integral to harnessing the transformative potential of the ongoing development and increasing sophistication of information and communication technologies (ICT). Over the last two decades, explosive worldwide growth in mobile service penetration, coupled with increasing availability of Internet access, has significantly extended opportunities to access information, communicate and collaborate, and to improve economic and social circumstances. Beneficiaries include a growing number of individuals and communities in developing countries previously unable to communicate effectively in the absence of key infrastructure and a lack of affordable services. The next challenge is to ensure that all members of the extended digital community are able to take advantage of the ever-expanding number of opportunities on offer. Innovative capacity building initiatives and the strengthening of digital skills will play a pivotal role in meeting this challenge.

Building human capacity is critical for achieving the United Nations' 2030 Sustainable Development Goals (SDGs). SDG 17 calls for enhanced 'international support for implementing effective and targeted capacity building in developing countries to support national plans to implement all the sustainable development goals'[1]. As ICT acts as an enabler, the ongoing need for ICT capacity building and skills development is evident in most of the SDGs. In some cases this is explicit – for example, in SDG 5, one of the goals is to 'enhance the use of enabling technology, in particular information and communications technologies, to promote the empowerment of women'. In other instances ICT capacity building is required implicitly – for example, SDG 4 focuses on ensuring inclusive and equitable quality education and promoting universal lifelong learning opportunities. One of the specific targets of SDG 4 is to: 'by 2030 substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship'.

Ensuring that digital skills keep pace with technology is extremely challenging given the dynamic nature of ICT, reflected in the rapid development of networks, modes of service delivery, technology speeds and devices. Today multiple services are delivered on smart devices using converged networks. While traditionally separate networks delivered telephony, television and Internet services, now all of these services can be performed over an IP network. This network convergence has led to the emergence of triple- and quad-play packages – providing VoIP, IPTV, video chat, video and photo sharing, social networking and other applications – which are becoming increasingly popular. A growing number of people are now using over-the-top (OTT) communication services and accessing Internet, watching videos/TV and interacting with others on personal smart devices.

Devices continue to evolve significantly over time, from initial large mainframe computers to the current light and portable smartphones, tablets and wearables, such as smart watches and glasses. Device developments align with the increasing customer demand for anytime, anywhere and anything access. Current and expected future developments aim to meet these requirements with availability of on-demand content which can be accessed anywhere (indoors/outdoors and stationary/moving). In addition, communications will no longer be restricted to humans and will incorporate machines and devices. The evolution of machine to machine (M2M) communications can enable networked devices to directly exchange information and perform required actions. This is also related to the emerging Internet of Things (IoT) which allows anything (including people, machines, animals and plants) to transfer data over a network.

Another key trend is the development of numerous sophisticated applications across many sectors, driven by significant increases in the speeds of fixed and mobile technologies. Fixed Internet speeds have increased radically from dial-up Internet (via telephone lines and providing 56kbit/s) to gigabit passive optical networks (GPON) which are based on fibre technology and are capable of delivering 10Gbit/s.

Similarly, the data speeds of mobile technologies have multiplied over the last decade. In fact, the economic and social impact of mobile technologies is arguably far greater than fixed technologies, as mobile technologies enable anytime, anywhere access to resources on personal portable smart devices. The data speed for second generation technologies (2G) was comparable to dial-up Internet but fourth generation (4G) technologies can provide 1Gbit/s. LTE Advanced (LTE-A) has revolutionised mobile speeds as it can combine spectrum over multiple bands to provide high speed Internet along with VoIP over LTE (VoLTE). The next generation of mobile technology is already on the horizon, promising to bring revolutionary change to user experience which will rival the performance of fixed networks[2]. Key performance targets of 5G compared to 4G include: a threefold increase in spectrum efficiency, a tenfold increase in both the end-user data rate and the connection density, and a twentyfold increase in the peak data rate.

Mobile technology development is supporting faster and easier Internet access which has in turn enabled explosive growth in social media interactions and OTT applications. Converged services and cloud computing are gaining popularity, allowing people to save and use data online – providing anytime anywhere access to data across multiple devices. It is likely that big data analytics (extraction and analysis of hidden patterns and correlations), encryption and disruptive influences (such as IoT) will further revolutionise the future of ICT, with the potential to affect user experiences significantly across many areas of life, enhancing the social and economic well-being of the global population. In the education sector these developments could potentially transform the learning experience, and open new opportunities for young people for whom access to secondary or tertiary education has previously been impossible. In the commercial world, a plethora of new job opportunities may become available.

In many cases capitalising on these opportunities will depend not only on availability of networks, services and devices, but crucially on the acquisition of skills to become proficient with both the technology and applications. There is a fundamental role to be played by the education system in improving skills and promoting digital inclusion. The recent advances in ICT and associated opportunities are so significant that to achieve digital inclusion capacity building should occur at all levels of learning and instruction, including both formal and informal education. This, in turn, will require ongoing tuition for teachers or trainers.

This edition of "Capacity Building in a Changing ICT Environment" consists of five academic articles with a focus on developing skills for the twenty-first century digital economy. It is the second edition of an annual ITU series dedicated to the exploring the impact of ICTs on capacity building and skills development.

The current issue investigates changing skill requirements driven by major digital transformations, such as machine learning, IoT, big data analytics and Artificial Intelligence (AI). Using a variety of approaches, the articles explore the impact of these changing requirements on capacity building and skill development with two major themes: ICT for development and ICT in education.

The digital skill-set: what is required?

Following the birth of the Internet and the rise of Internet-based technologies, the last two decades have been characterised by the increasing global availability of fixed and / or mobile broadband access. The diffusion of broadband access continues to extend the range and reach of ICT services and applications to communities, businesses and key sectors, including education. However, the content of effective capacity building programmes requires frequent re-evaluation, as new ICT trends and technologies now appear over ever shorter time-periods. New challenges for these programmes have been presented by the appearance of next generation networks (NGNs), IPv6, cloud computing, the Internet of Things (IoT), big data and Artificial Intelligence (AI). Toni Janevski provides an overview of these challenges, in addition to an examination of the implications of important associated issues, Quality of Service (QoS) and cybersecurity.

For the new technologies, services and applications, Janevski identifies the particular digital skill-set required for different groups encompassing:

– individual digital literacy
– the general digital workforce
– ICT professionals.

His article provides insights on required technical, operational, management, regulatory and, most importantly, user skills, and highlights the importance of continuous ICT skill development through different channels.

Capacity building for IoT in development

The features of emerging smart services and applications, supported by IoT and AI, offer promising new solutions to challenges faced by individuals, businesses, communities and Government across both developed and developing countries. In their article, Kumaran and Zennaro identify numerous possibilities for addressing developmental issues with IoT applications, including monitoring and managing health and safety risks, such as food safety, water and air quality, and potential natural hazards. The possibilities continue to expand, as a growing number of technologies converge into IoT, and the number of smart wireless devices continues to grow globally. However, Kumaran and Zennaro find that a lack of skilled workers is hindering progress with IoT applications and implementation in developing countries, in comparison to developed countries.

Valuable lessons for identifying IoT capacity building requirements may be learnt from recent training activities in Africa, Asia and South America conducted by the Telecommunications/ICT for Development Laboratory of the Abdus Salam International Centre for Theoretical Physics (ICTP). Kumaran and Zennaro identify the need to capture the multidisciplinary nature of IoT, and to provide insights into the main concepts of IoT networks and regulation, rather than focus on any one specific application. The aim of the training should be to ensure that the knowledge and capability of trainees is sufficient to develop applications tailored to match market requirements and demand in their own countries. A market-driven, demand-oriented approach will support the development and deployment of solutions appropriate for individual country circumstances. Moreover, the chances of IoT applications succeeding in solving developmental challenges will be greater in an environment in which technology is deployed in response to the needs of individual countries.

Digital pathways for distance learning

In the digital era, the demands of the typical student in higher education include the use of ICT in teaching methods, flexible timing and location to complete studies, and real world applicability of courses. Such demands lead to pressure on universities and other higher learning institutions to introduce new processes and resources, while teachers may be expected to modify teaching methods in the absence of any additional training.

In her article, Paula Alexandra Silva considers ways of accommodating and adapting to today's students' learning expectations: namely, to be taught anything, anywhere, anytime. She explores capacity building in the context of distance education, using case study evidence from her own experience of teaching the same module with two different approaches: entirely online, and with a blend of online and face-to-face sessions. She reports successful results from both approaches, with the support of commonplace software solutions rather than any formal e-learning technologies. She uses this result to encourage teachers to experiment with such approaches, employing simple software tools, even with no formal training. A key recommendation for the teacher is to identify course goals prior to choosing technologies, since the technology should be regarded as a facilitator.

One potential negative implication of reliance on distance learning is the lack of human interaction which may foster isolation. It is important to note that Silva identifies the synchronous class time which occurred in both approaches as extremely valuable to both teacher and students, particularly in relation to creating opportunities for review and feedback. Furthermore, she highlights communication, collaboration, problem solving, critical thinking and creativity as key competencies for success in today's job market. As such, teachers have a responsibility to ensure opportunities exist to develop such skills in the context of the new online distance learning environment.

As higher education institutions seek to integrate technology, pedagogy and content knowledge into effective online teaching environments, more resources are being devoted to the professional development of staff. However, adjunct faculty staff – the section of the professional academic workforce outside the tenured system – present particular challenges for building online teaching capacity. In contrast to permanent full-time teaching staff, adjunct staff typically are offered fewer opportunities for professional development. In their article, Singh and Singh investigate possible interventions to build online teaching capacity amongst adjunct faculty staff.

Based on an analysis of questionnaire responses from tutors at an established online university in Malaysia, the authors found that the tutors' knowledge of different technologies is a major gap, compared to pedagogy and content knowledge. Moreover, a high degree of uncertainty was found with respect to knowledge of combining technology and pedagogy. To remedy these issues, study participants indicated that the preferred intervention would be based on a fully asynchronous e-learning professional development programme. Underlying reasons included the autonomy to undertake the course at one's own pace, either with or without assistance from an instructor, together with flexibility of timing to complete the programme. The insights provided by this original research will assist professional developers to craft design principles to support appropriate interventions for capacity building of online adjunct faculty.

Education in the future: smart learning

The digital transformation, heralded by IoT, AI and big data analytics, is already bringing innovation to learning methodologies and tools, through "smart learning" practices. The amalgamation of smart devices and intelligent technologies offers a powerful means of enhancing and extending the learning experience. In the last article of this issue of the publication, Singh, Camacho, Gates, Kumaran and Khalid, note that successful utilization of AI, analytics and big data will facilitate the development of smarter learning systems which accommodate individual learning needs. The authors differentiate the characteristics of smart learning environments from common digital learning environments, in terms of learning resources, tools and methods, teaching methods, and learning and teaching communities. Using this context they then examine a series of smart learning initiatives from Malaysia, Peru, Rwanda, Spain and the United Arab Emirates (UAE).

The analysis of these initiatives illustrates smart learning systems and practices in action in many different guises, including personalized mobile learning initiatives, designing learning through gamification, curation of e-content, and the use of communities of learning to enhance the pedagogical impact. The examples demonstrate that, while moving from common digital learning to smart learning environments may be challenging, smart practices add new dimensions to the learning experience by prioritizing the individual learner. Further advances in this area will be achieved through efficient planning and the dissemination of effective international smart learning practices and examples. The authors of this article commit to undertake further research to create a framework for international smart learning practices, including practical and affordable examples.

Designing effective capacity building programmes

Advances in ICT can potentially expand educational opportunities from non-existent to lifelong learning possibilities. Similar revolutionary change is possible in other sectors, providing powerful impetus for substantive improvements in the social and economic welfare of disadvantaged groups, communities and countries. However, while the opportunities afforded by ICT may be relatively straightforward to identify, the implementation of sustainable initiatives often presents major challenges. As such, in designing capacity building programmes, it is particularly useful to build on previous experience and to engage in collaborative efforts whenever possible.

The articles in this publication are particularly rich in case study evidence and examples from many different jurisdictions, including both developing and developed countries. The snapshots of experience in different environments encompass valuable practical examples. Not only are these examples informative, but they could form a basis for reuse and improvement. Key lessons that may be distilled from the articles include:

– in designing effective distance education programmes, engagement with and feedback from the learner is critical, and open source solutions may be effective in meeting teaching objectives

– in training initiatives for IoT in developing countries it is imperative for trainees to understand the relevance of the technology for the existing ecosystem and build for sustainability through the development of demand-driven country-specific applications.

A powerful message which emerges from the articles is that the chances of successfully building human capacity are greatly improved when the focus in designing programmes is on meeting learners' specific needs and preferences. As further evidence of the enabling nature of ICT, recent advances have even provided tools which can assist in developing individual and personalized educational programmes. Successful widespread implementation of these tools may be key to achieving most, if not all, of the 2030 Sustainable Development Goals.

Endnotes

1 https://sustainabledevelopment.un.org/post2015/transformingourworld

2 Framework and overall objectives of the future development of IMT for 2020 and beyond (Recommendation ITU-R M.2083-0).

Teaching in the digital era: perspectives from personal experience

By Paula Alexandra Silva

Introduction

A clear trend in contemporary education is increasing interest in the field of e-learning solutions[1]. Typically, those solutions require complex ICT infrastructure, involving hardware and software installation and maintenance, licences, and local management. However, nowadays teachers and students can also rely on the multiple solutions available online to create tailored teaching and learning scenarios and spaces. This is only possible as a result of the pervasive use and availability of digital technologies and the proliferation and reliability of today's ICT infrastructure. In other words, robust and ubiquitous ICT infrastructure and services are critical for online teaching and learning.

Since 2001 there has been a steady increase across the globe in cellular subscriptions, active mobile- and fixed-broadband subscriptions, and households with Internet access[2]. According to ITU statistics, from 2001 until 2016, the proportion of individuals using the Internet in the United States has increased from 49% to 76%; in the developed world the proportion in 2016 reached 79.6%.

The profound digital transformation that is taking place is paving the way for many changes across multiple sectors of society, such as business, banking, and healthcare. The revolution is touching nearly every field and discipline, including education. In the educational arena, change is already taking place and the implications for teaching can no longer be ignored. Arguably, the evolution of ICT will continue to be a driving force behind the creation of new industries, careers, and academic disciplines.

The student of today expects to be able to learn and be taught anything, anywhere, anytime, and demands that both universities and teachers carefully consider and adapt to these new needs[3].

It is well understood that universities and other teaching and learning organizations alike need to adapt, in order to accommodate the student and overall market demands of today[4]. The role of the teacher in the digital world has also been extensively discussed[5]. While there are many specific teaching resources available, rarely does one come across reports of teachers who have had to make the digital teaching and learning experience work; this is the subject of this article. The article will present and discuss examples of tools and strategies used in one module, taught either online or partially online over the summer and fall semester of 2013, at the Department of Information and Computer Sciences of the University of Hawai'i at Manoa. From the numerous lessons distilled from this experience, a positive outlook and a constant dialogue with students was revealed as vital for a successful teaching and learning experience.

This article begins with contextualizing education in the twenty-first century, an era that is characterized by the pervasive presence of digital technologies and the associated societal changes. It discusses the expectations and demands of the student of today, and the role of the teacher and universities in addressing students' requests. The article then introduces the case study, detailing the module, the context, and the supporting technologies. Finally, concluding remarks focus on the lessons learned, as well as the challenges and opportunities for the future.

Education in the digital era

For several thousand years, the main goal of education was to prepare good and obedient professionals, and to ensure knowledge was transferred between generations. Mostly centred on the teacher, education models did not significantly change for a long time. Recent advances in science, technology, and culture have generated a dramatically different model, introducing a networked structure for education, in which students, teachers, and institutions need to embrace new roles, and quickly adapt to new processes and resources.

In more recent years, higher education has become a mass worldwide phenomenon[6], creating new educational and economic challenges, and forcing educators and policy-makers to rethink the old education paradigm. In the digital world of today, outcomes from distance education are comparable to those of face-to-face classes or better[7,8]. Distance education benefits institutions, not only because online learning requires no physical location, but also because it offers the possibility of increased enrolment compared to classroom-based education[9].

While distance education alleviates many of the inconveniences of face-to-face education, it needs to be carefully implemented. Textbooks, articles, and the Web are overflowing with terminology on educational approaches and teaching and learning methodologies. From e-learning, to m-learning, collaborative and co-creation learning, experiential learning, Massive Open Online Courses (MOOCs), distant learning to the flipped classroom, there is a plethora of terms, many used interchangeably.

An abundance of pedagogies floods today's classrooms, each with countless followers and evidence of efficiency, such as wikis, blogs and podcasts, just to name a few[10]. With a multitude of possible teaching and learning methodologies and combinations of pedagogies, programmes can also be delivered face-to-face, online, or in some form of blended learning[11]. This leaves the teacher with an infinite number of possibilities.

The student

The cohort of students today is extremely diverse[12]. It is not unusual now to have students, in the same classroom, from different nationalities, age ranges, socioeconomic statuses, etc.

However diverse, that same cohort expects universities to provide the necessary flexibility to successfully complete their education[13]. This student not only calls for flexible time, but also wants assignments tailored to her or his specific needs and expects teachers to include a diverse set of technologies in their teaching.

Furthermore, the student of today demands course objectives to be relevant to employability, and to have some sort of real world application. In parallel, the job market and society overall, stress the importance of developing communication skills, independent learning abilities, ethics and responsibility, teamwork and flexibility competences, thinking skills, and digital skills. There is an expectation that all these skills should be embedded within the knowledge domain in which learning takes place[14].

As teachers remain at the centre of learning and universities are still regarded as the arena in which qualified higher education takes place, the new expectations of today's students place a significant responsibility on both teachers and universities.

The teacher

Ever since technology reached schools, the role of the teacher has been a topic of debate[15]. It is not rare to find discussions on the perspective of tutoring versus mentoring or of instructor versus facilitator, among many others.

It is well accepted that teachers are required to cater for different students' learning styles. Many academics are now being persuaded to embed digital technologies into their classes, be they face-to-face, online, or blended[16]. The fact is that technology evolves at an extremely fast pace and, as the ITU Secretary-General notes, technological developments in ICT create both opportunities and challenges, and "increasingly, our ability to leverage the benefits of ICTs depends upon our capacity to learn and acquire new knowledge"[17].

Under increasing pressure to change and adapt, the teachers of today are required to employ skills they have not been taught, while under the constant threat of seeing their classroom expertise undermined by the information available from the Web. In a networked world, where much happens online, teaching and learning included, new theories emerge, such as Connectivism[18], and new roles are identified for teachers that include: amplifying, curating, wayfinding and socially-driven sensemaking, aggregating, filtering, modelling, and maintaining a persistent presence[19].

The role of the teacher in today's digital world is, then, quite challenging. The teacher of today must have the ability to adapt quickly to new processes, resources, and organizations, in order to survive and thrive in a fast-changing world. In other words, the need to engage in the process of capacity building is no longer optional for teachers.

Adapting to a changing environment: a case study

From an experience-based perspective**,** this article reports on the structure, organization, activities, and digital tools used to teach a tertiary education module using two different approaches: one following a blended learning methodology, and the second an entirely online one. After introducing the context and module, the focus is then on the technology.

The context

The experience presented in this article took place at the University of Hawai'i (UH) at Manoa. Founded in 1907, the University of Hawai'i System has ten campuses across the Hawaiian Islands, including three universities, and seven community colleges, and community-based learning centres across Hawai'i. The latter rely on Internet, audio, video, cable TV, and a diversity of computer technologies, using an approach, which is somewhat similar to the face-to-face courses, offered by the ITU Academy.

As an archipelago with eight main islands, Hawai'i has long had a tradition of distance education and remote teaching and learning experiences. Online education offerings have become available, as infrastructure development occurred and interest in online learning soared. The University therefore offers students from the various islands of Hawai'i, or elsewhere, the option of enrolling in UH degrees that are offered face-face or based on a distant learning modality.

The module

The case study module is ICS 491 Special Topics: Designing for Gamification (Table 1.1), which was an elective introductory class of 39 hours taught in the summer and fall of 2013 at the Department of Information and Computer Sciences of the University of Hawai'i at Manoa. Despite being fundamentally the same module, with the same structure, organization, and contents, the mode of delivery of the module changed over its two instances. The summer session took place over seven weeks, while the module in the fall extended to eleven weeks. The summer session was a blended learning class and with classes both online and face-to-face every week, while in fall the course was fully delivered online. Nevertheless, in both instances, a synchronous meeting was held online every week. Offering the class as blended and online learning was both a result of the university, students, and teacher's interest as well as a matter of practicality, related to the significant number of work trips the teacher had scheduled for the class period.

Table 1.1: Case study modules, organization, and digital tools

General Info	ICS 491, Summer 2013	ICS 491, Fall 2013
Schedule and type of class	Wednesday and Friday 2 to 4 p.m. – Face-to-face Monday 2 to 5 p.m. – Online, synchronous.	Tuesday 10 to 11 a.m. – Online, synchronous.
Number of weeks	7 weeks From 19 May to 5 July	11 weeks From 13 September to 24 November
Teacher's location during class period	1 week in Japan- Japan Standard Time (JST) 6 weeks in the United States, Hawaii (Hawaii-Aleutian Standard)	2 weeks in Portugal, Western European Time 2 weeks in Sweden, Central European Time 7 weeks in the United States, Hawaii (Hawaii-Aleutian Standard)
Technology used	Wordpress™, E-mail, Google™ Hangouts, Google™ Groups, Microsoft™ PowerPoint	Wordpress™, E-mail, Google™ Hangouts, Google™ Groups, Microsoft™ PowerPoint, AdobeConnect.

Source: Authors own 2018, unpublished

Grades were A to E (A: 90-100; B: 80-89; C: 70-79; D: 55-70; E: 0-54) and the assessment of the module was completed through a set of weekly activities, three assignments, and one quiz.

The weekly activities were designed to motivate the student to keep up with the contents of the course and consisted of short and simple tasks (for example, commenting on a video), related to the topics highlighted in class that same week. The activities were then marked on a 'Yes' or 'No' basis: that is, the activity had to be completed and attain a sufficient standard to be marked as a 'Yes', otherwise no points would be assigned to it, whether it had been submitted or not. The activities of each student were to be submitted via Google™ groups, where subsequently both teachers and students could leave comments and suggestions.

Assignment 1 consisted of an individual report that required the student to review and critically analyze a gamified system, including the gamified components of the system. Students were expected to write their individual report only after analyzing the system together with a fellow classmate, with whom they would choose the system to review. It was necessary to identify the main contributions of the classmate to the exploration and understanding of the system under analysis. Once concluded, the report would be submitted to the teacher by e-mail.

Assignment 2 was an individual essay in which the students were asked to propose a set of motivational mechanisms to use in a given gamified system and develop an argument and discussion for their choice. As with Assignment 1, this assignment was also submitted via e-mail.

Assignment 3 consisted of a group project of three to four people that targeted the complete design and implementation of a gamified system (for which students could use any free Website builders such as Wix™ or Wordpress™), and the presentation of the outcome in class online. Each student was also expected to write a short individual report showing how she or he had contributed to the project. The report was sent by e-mail, indicating the URL for the website developed by the students, while the presentation took place face-to-face for the summer semester and through Google™ Hangouts in the fall semester.

The quiz was a regular quiz, with multiple-choice questions given at midterm. In both cases the students undertook the quiz in their study time and submitted it via e-mail.

In addition to meeting out-of-class, students were advised to work on the assignments during class time. Clear indications of these requirements would be included in the class handouts.

Technologies and strategies

This section provides an overview of the organization of class materials and activities, and the technologies which were used to support the same (Table 1.2).

The teacher created a module website to display general information about the module, the contents and presentations (grouped by week), additional links and references. The website also included a section for students' projects and discussions that led to the Google Groups™,

Table 1.2: Technologies used for delivering the module and purposes

Technology used	Purpose and by whom
Wordpress™	Course website by teacher and students. Assignment 3 project by students*.
E-mail	Communication in general, between teacher and students and between students.
Google™ Hangouts	Synchronous online classes with video, audio and messaging; students' and teacher's, presentations; and general chatting, between teacher and students and between students.
Google™ Groups	Students to post weekly activities and students and teacher to comment on posts.
Microsoft™ PowerPoint	Presentations by teacher and by students**.
AdobeConnect™	Record online classes, with synchronous interactions between students and between teacher and students.
* Some students used Wix™; ** Google Slides™	

Source: Authors own 2018, unpublished

where students posted their weekly activities and teacher and students could comment on the same. Handouts were prepared in Microsoft™ PowerPoint and saved in PDF format, to then be made available on the module website on a weekly basis each Monday.

It is important to highlight some of the details of the class handouts, as these were iterated based on the students' feedback and the careful observation of their behaviour. The slides would:

– follow a modular and clear organization with very precise indications of any given change of topic/module;

– maintain a story line and include a slide at the beginning with the topics covered in the previous week and another at the end with a brief summary of the topics covered in the current week;

– include a short activity, roughly every five slides, to keep students engaged and focused;

– point to external resources, videos, articles.

It is also important to note that the teacher would always provide feedback on the weekly activities of one week before entering a new one. After agreement with the class, feedback about each student's weekly activity was always provided both to the student and the whole class simultaneously. This followed the structure of a *crit* session[20], as defined by the studio-based learning methodology[21].

In order to complete the module, and as detailed in the previous section, students were required, amongst other responsibilities, to submit several assignments. Students worked on these assignments partly during class-time. Assignments 1 and 3 required teamwork out-of-class. It is not possible to provide precise information on where and for how long the students met, nor how they made organizational arrangements. Nevertheless, the teacher confirmed that these meetings occurred once or twice a week, sometimes online and sometimes face-to-face at the university campus or elsewhere. Arguably, the reportedly effortless and effective meetings out-of-class were only possible because of the culture of distance learning that exists in Hawai'i.

With regard to additional technologies, e-mail was used between teacher and students to submit assignments, ask for clarifications, give and receive feedback, and also to inform students about grades. Google™ Hangouts was used for presentations. When displaying slides or other type of information, the teacher would use two computers, one on screen share mode and another to display her live video. This approach created richer, more realistic and contextual communication. Students also used Hangouts but would often prefer to display only the presentation while using the screen share functionality. Hangouts were also used to chat and maintain a constant online presence for all class members and the teacher. The choice to use Hangouts was made collaboratively with the students, who preferred this tool over other similar alternatives.

The website builders - Wordpress™ and Wix™ - were used by the teacher to build the module website for the students to implement Assignment 3.

Google™ Groups was used to post the coursework produced in the context of the weekly activities. Once posted, students and teacher alike, could read each student's contributions for further debate and discussion, if desired.

Microsoft™ PowerPoint or Google Slides were used to create and give presentations, with some students preferring the latter rather than the former.

Finally, AdobeConnect™ was used to record the synchronous online sessions in the fall semester. The purpose of this was to make the rich content of the feedback sessions available to all students, in the event that she or he was not able to attend class.

Key lessons

The teacher had not had received any formal training on online education. This increased the need for careful preparation, and to become informed and educated about the 'new' teaching and learning environment. At the same time, important discoveries were made while learning 'on the ropes' that required prompt adaptation. For example, students quickly responded negatively to the initially lengthy and wordy slides, leading to rapid replacement with shorter, more effective and interesting slides. The teacher, in addition, noticed that timing was even more important while in an online or blended learning environment. It was necessary to release materials weekly at the same time and date. Presentations online needed to be kept short and to the point, if the teacher was to maintain interest amongst the students. Ideally, synchronous class time online would focus on giving feedback, and these were particularly rich teaching moments, valued by students and teacher alike.

An active listening attitude on the part of the teacher was pivotal, as this led the teacher to incorporate students' feedback, for example with regard to the revision of the class handouts. While some may find it more difficult to maintain control of online classes, these two modules took place without any major problems. Furthermore, it was a pleasant surprise to find many students present in the same room for online synchronous sessions, since they were not required to be co-located. Possibly due to the maturity and robustness of Internet access technology in recent years, no major connection glitches were experienced, despite the teacher instructing classes from several different countries.

It is also important to acknowledge that it would have been challenging to offer the fully online class in the fall, without having the learning experience of the summer session which followed a blended learning approach. Many valuable adaptations and learning insights occurred during the blended learning summer session.

Based on the case study presented in section 3 it is challenging to elicit a definitive list of strategies as to how a teacher can adapt teaching and learning techniques and tools to cater for the life circumstances of the digital twenty-first century. Nevertheless, many lessons and recommendations can be derived from the experience of the case study, including:

- the teacher should be available to students (e.g. through e-mail, messaging apps, etc.) but adjust expectations on response times (e.g. say you will be fully available to class Mondays from 1 to 3 p.m., but that outside those times you may be less responsive);

- give regular though small activities that still go towards students' final grades in order to foster engagement with the class;

- use open discussions and forums to leverage on students' contributions and promote critical thinking skills;

- offer both individual and group/pair assignments, so that collaboration, cooperation, and teamwork are fostered, while students still experience fairness with respect to the individual's time devoted to the execution of the assignments and in the grades;

- take advantage of synchronous sessions to give feedback and the whole class will gain from fellow classmates' queries and/or difficulties, but keep discussions on topic or students are likely to lose interest;

- create and methodically follow a schedule to make materials, assignments, and feedback available so that students create a routine for class despite lack of face-to-face engagement;

- keep handouts and synchronous sessions short, as it is challenging to focus when engaging with online activities (see also recommendations on handouts in Section 3.3);

- consider desired goals, not the technology itself, because once goals are known, identifying a technology that can facilitate a given purpose will be straightforward, and may involve using something as common as e-mail or a messaging system;

- do not be afraid to try online or blended learning, even in the absence of formal training, because it is becoming commonplace to use simple existing everyday tools to support learning, and arguably students will value the natural and less formal learning experience;

- leverage on the partnership with students and learn from them; they will assist in shaping delivery of the course, and they will direct the teacher towards the skills, which are currently valued by the job market.

Future challenges and opportunities

The mode of teaching discussed in this case study was facilitated by robust and reliable network infrastructure. If it is true that students want to be able to learn anything, anywhere, anytime, in the interconnected world of today, then equally teachers can also be located anywhere. This means that, given adequate ICT infrastructure, the possibilities for a learning space to emerge are virtually infinite.

This connected world poses universities with challenges. As Gallagher and Garrett note, universities need to increase efficiency in the preparation of courses to suit the student of today to facilitate implementation of modules that follow more current models of education[22]. For such context to materialize, Gallagher and Garrett further stress that universities must encourage academic mindset change; integrate leadership training, professional placements and international experiences as part as their degrees; and to invest in technology-enabled classes and learning spaces. These learning spaces are the places where students learn, but also the spaces where they meet, share experience, and work together, thus extending the typical traditional classroom.

While a strongly connected world may pose challenges to universities, it also creates opportunities. The digital infrastructure and the services provided through it have eliminated geographical constraints. This means that universities can now offer degrees across the globe, reaching not only the conventional college student, but also adults seeking lifelong learning courses, people with disabilities, and students in remote areas or developing countries. By reaching more students, universities are not only promoting equity in access to learning, but also transforming the lives of individuals, business, and society at large. The digital infrastructure is an essential element for the future of the digital economy, therefore continued ICT investment is of paramount importance, as is researching ways to continue to improve and extend service quality and reach.

It is only natural that digital education thrives in the digital context of today. At the same time, it is important to note that the reliance on distance education further fosters isolation. It is therefore our moral and ethical responsibility as teachers to ensure that education still provides students with the necessary opportunities to practice and develop the much-demanded twenty-first century skills, such as communication, collaboration, problem solving, critical thinking, and creativity[23]. These are critical competences for today's job candidates to succeed. This new world offers an opportunity for teachers to revise curricula and create updated and improved educational offerings that cater to students and current demands of job markets. This may also be an excellent occasion for educators and policy-makers to rethink the old education paradigm, for example regarding grading systems and the attribution and recognition of diplomas.

The global digital economy and ICT environment also offers teachers the opportunity of renovating their technical skill-set, and of repurposing and experimenting with simple everyday life digital technologies in the classroom. This is likely to create a more interesting and organic teaching and learning experience, satisfying the ever-growing desire for individualized learning. Nevertheless, further research is needed to determine how to implement and deliver well-designed, accessible, and high-quality alternatives to conventional class-based education, from which students, teachers, and universities alike will benefit. This can possibly be achieved by exploring innovative ways of creating remarkable and rewarding teaching and learning experiences; the commitment of teachers is key in this endeavour.

This paper offered a set of examples of positive successful experiences in which skill sets, tools, and strategies were reinvented to suit the needs of two tertiary education classes, taking place from different locations. The author hopes this article contributes to motivating and encouraging other teachers to believe that such approaches are feasible, and even rewarding.

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Emerging trends and technologies in ICT and capacity building challenges

By Toni Janevski

Introduction

The telecommunication world has been developing rapidly in the past two decades, spurred by the public appearance and growth of the Internet and digital mobile networks in the 1990s and 2000s, which continues in the current decade. At the present time telecommunications is also referred to as ICT, which is consistent with the terminology used by the International Telecommunication Union (ITU) which is a specialized agency of the United Nations for telecommunications[1].

Since the 1990s, the ICT world has been converging to Internet-based technologies via a single broadband access (fixed or mobile/ wireless). This is being used for all services, including traditional ones, such as voice, television and business services, as well as Internet-native services, including Web, email, and many over-the-top (OTT) proprietary services. Driven by IP networks and the Internet we are now seeing in the current twenty-first century:

- Broadband and ultra-broadband access;
- Mobile broadband, which is particularly important for broadband access globally;
- Next Generation Networks (NGNs);
- The emergence of the Internet of Things (IoT);
- Cloud Computing - the basis for most of the online services;
- Big data - based on all devices and humans connected to the Internet;
- Artificial Intelligence (AI), with many potential uses in ICT technologies and services;
- Many new and emerging ICT services and applications (including those provided by telecom operators as well as OTT applications).

All services and applications are directly affected by Quality of Service (QoS) as well as security/ cybersecurity and privacy issues. Moreover, all emerging technologies require skills for different types of users, including ICT professionals, to understand, deploy and use. This brings challenges for capacity building in many different ICT areas. In the following section we examine emerging ICT trends and technologies, with the aim of identifying capacity building requirements.

Digital skills for the emerging technologies

ICT development and overall technology development over the past two decades has had a profound impact on the required skills for jobs. For example, some predictions from developed countries, such as the United Kingdom, indicate that 35% to 47% of jobs may be displaced in the next one to two decades as a result of automation in industry and other sectors[2]. ICT is one of the main contributors to this, although further advances are dependent on other areas, such as developments in electronics (for example, Moore's law states that processing power doubles every 1.5 to 2 years). This directly influences the type of software that can be run, as well as the bitrates that can be supported by network interfaces on different hosts. However, reversing the trend of job losses from the existing labour force, as well as ensuring appropriate capacity building of young people, requires the development and implementation of mechanisms for educating the young, and upskilling or reskilling existing staff.

With the spread of ICT across different sectors (such as health, agriculture, government, transportation, cities, and many more), there is an increased need for ICT capacity building, which is based on the development of digital skills.

What are digital skills? There are different possible definitions, but most converge to three main groups[3]:

- Basic digital skills (for individual digital literacy): These are skills that are required by every individual to become "digitally literate", including skills in using digital applications to communicate, and using basic Internet searches with awareness about security and/or privacy concerns.
- Intermediate digital skills (for the general workforce in the digital economy): These skills include all basic digital or ICT skills, and additionally skills required in the workplace that are generally linked to knowledge about the use of different applications which have been developed by ICT professionals. Examples of these skills include digital marketing and digital graphic design, as well as the ability to produce, analyze and interpret large amounts of data.
- Advanced digital skills (for ICT professions): These skills are targeted at more complex jobs in the ICT sector, including deployment of networks and services or development of new ICT/digital technologies. Such skills may refer to application or service development, network management or data analysis. It is anticipated that millions of jobs will emerge in the future for people with advanced digital skills, particularly in the areas of IoT, big data, AI, cybersecurity, and mobile application development. In addition to advanced technical skills, this category includes ICT entrepreneurship skills, which are interdisciplinary by nature (that is, encompassing business, finance, and digital skills and innovation).

At the same time, with ICT development soft skill intensive occupations will increase. Some recent predictions state that by 2030 soft skill intensive occupations will constitute almost two-thirds of the workforce[4]. Such soft skills will be required by managers, professionals, as well as engineers, ICT and science technicians. As such, businesses are increasingly seeking more flexible teams that can react quickly to new developments, representing a change from hierarchical business organization models based on certain expertise for each position.

In the following sections we will investigate in detail the capacity building challenges and required skills for emerging ICT trends and technologies.

Emerging ICT trends and challenges for capacity building

The 2030 Agenda of the United Nations recognizes capacity building as an integral part of the global partnership for sustainable development[5]. Capacity building in ICT is noted as important for innovation, which is fostered by broadband access and wide use of ICT applications and services. In a digital world, broadband and ICT are driving the reorganization of personal life and work environments[6]. The digital economy is already operating in developed countries, most visibly through the buying and selling of various goods online, and it is likely that eventually economic benefits from digitalization will become widely available in the developing countries.

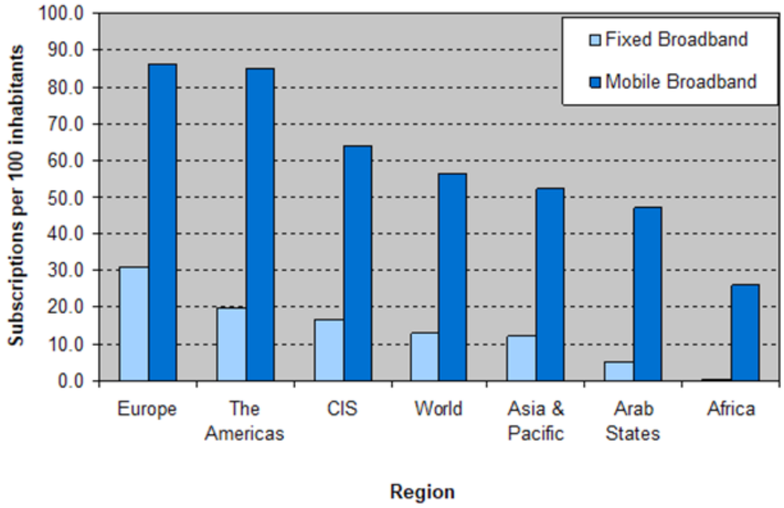
The digital economy is supported by emerging technologies such as ultra-broadband, and mobile broadband, ICT services and applications, IoT, big data, and AI, therefore definitions of digital skills should be related to such technologies[7]. Currently, one may distinguish among different challenges regarding capacity building for the emerging ICT trends, which are elaborated in the following subsections.

Broadband and ultra-broadband

Broadband access is a prerequisite for most of the services provided today. The challenge is to build capacity for existing and future fixed and mobile broadband access networks.

As shown in Figure 2.1, fixed access networks are not equally developed across regions due to historical reasons[8]. However, broadband technology is evolving, and the speeds are increasing over time. Individual access speeds over 100 Mbit/s are now referred to as ultra-broadband (according to the European 2020

Figure 2.1: Fixed vs. mobile broadband penetration in 2017



Note: CIS refers to the Commonwealth of Independent States
Source: ITU World Telecommunication/ICT Indicators database 2017, https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx

broadband targets). Each new version of DSL (e.g., ADSL2+, VDLS2), cable access (e.g., DOCSIS 3.1), Passive Optical Networks (e.g., Gigabit PON – GPON, Next Generation PON 1 and 2, etc.), active optical networks based on wavelength division multiplexing (WDM), provides higher bitrates than predecessor technologies. This trend is expected to continue.

Many countries have developed ICT strategies with the aim of extending broadband reach to the entire global population. As an example, European countries have set a target to have 100% of the population connected with a minimum 30 Mbit/s, and at least 50% of the population to be connected with a speed of 100 Mbit/s or more by 2020[9]. As usual, different targets are set in different regions around the world, but they are converging as the same broadband technologies become available everywhere. Accordingly, the required skills include the following:

– understand ultra-broadband Internet access, including xDSL access networks (ADSL2+, VDSL2), cable access, next generation passive and active optical access as well as multi protocol label switching (MPLS) and Carrier Ethernet;

– design, deploy and operate broadband and ultra-broadband networks with the required capacity for offered services (e.g., for telecom operators);

– perform technical, business and regulatory analysis regarding broadband/ultra-broadband access services, including creation/update of national broadband strategies and regulatory work for supporting broadband infrastructure investments;

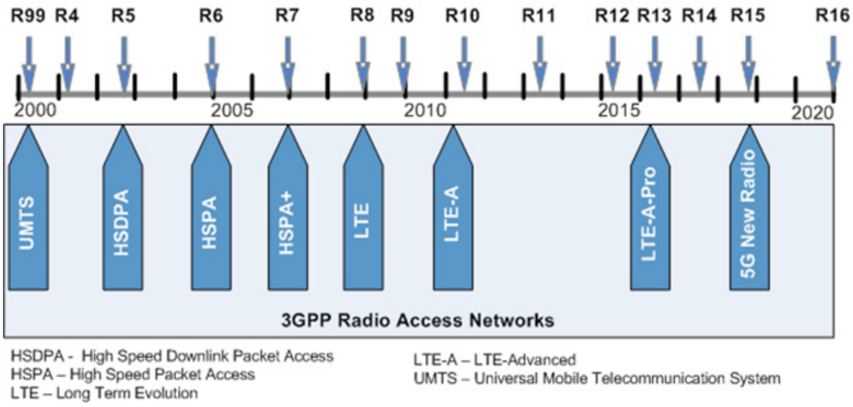
– provide different sets of services via the same broadband access, with the required QoS and security.

Mobile broadband and 5G

Mobile broadband deserves particular attention because, in many countries, it is the only way to access the Internet. In each decade since the 1980s a new generation of mobile networks (or systems) has emerged. In the 2010s 4G has appeared, mainly implemented through LTE/LTE-Advanced technology, although mobile WiMAX 2.0 also belongs to the 4G family. In fact, ITU has defined the requirements for 4G in its umbrella IMT-Advanced (International Mobile Telecommunications-Advanced), while IMT-2000 was the umbrella for 3G. In the same manner, ITU's umbrella IMT-2020 will specify the requirements for 5G[10]. The first 5G standard is expected to be 3GPP Release 15, which should be complete by 2019 (Figure 2.2).

Mobile broadband has specific requirements. Mobile networks use the radiofrequency spectrum

Figure 2.2: Timeline of 3GPP mobile technologies



Source: Author's own 2018, unpublished

which is limited. Spectrum management is an important ongoing capacity building area, because usage requirements change over time. For example, in the past spectrum was dedicated to a specific mobile system, while nowadays more spectrum is shared among multiple mobile generations (referred to as IMT spectrum by ITU)[11]. ITU undertakes a crucial role for harmonization of the spectrum usage on a global scale.

The next generation of mobile broadband, 5G, is expected to support new features, such as higher bitrates than 4G, massive IoT, virtualization of network resources via the introduction of network slicing, based on software network virtualization (SDN) and network function virtualization (NFV)[12]. Consequently there is a strong need for capacity building for mobile broadband technologies including 5G. In summary, the following skills will be required:

– design of heterogeneous mobile networks for achieving gigaspeeds by utilizing new versions of current mobile networks (e.g., LTE-Advanced-Pro) and the new 5G;

– skills to design a low latency next-generation core for 5G, as well as to understand and use SDN/NFV for 5G;

– skills to perform spectrum management for the IMT network;

– business and regulatory features of 5G mobile broadband, particularly in respect to spectrum, QoS, security, and provision of mobile services.

Next Generation Networks and IPv6

The telecommunication transition to an all-IP world has been standardized by ITU via the NGN umbrella of specifications. The NGN implements the Internet principles of separation of application space from the underlying transport technologies in a telecommunication manner (with standardized signaling and QoS) through its two stratums: transport and service (Figure 2.3).

The NGN primarily includes a transition to carrier-grade Voice over IP (VoIP) as a replacement for PSTN/ISDN, and also the transition of television to IPTV, both with QoS defined end-to-end. However, NGN also includes the framework for IoT implementation as well as network virtualization.

On the other side, the transition to IPv6 has commenced, because the IPv4 address space is exhausted in four out of five Regional Internet Registries, and it is expected that IPv4 space will be exhausted everywhere by 2019[13].

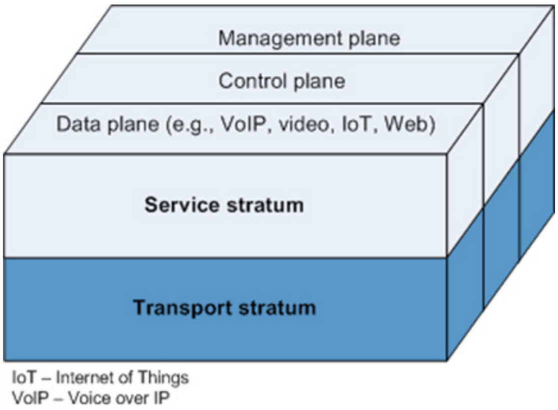
Thus the main areas of capacity building required for NGN and IPv6 are the following:

– learning NGN standards and their practical implementation;

– the use of service architecture in NGN (based on IP Multimedia Subsystem - IMS), including standardized control and signaling (SIP, Diameter), as well as VoIP and IPTV over NGN;

– implementation of IPv4 to IPv6 transition in NGN;

Figure 2.3: NGN service and transport stratums



Source: Author's own 2018, unpublished

- management of performance measurements in NGN;
- awareness of future evolution of NGN through network virtualization and network slicing;
- developing business and regulatory skills for NGNs.

So, NGN and IPv6 require intermediate and advanced skills, primarily for professionals working for telecom operators as well as regulators and governments.

Cloud computing

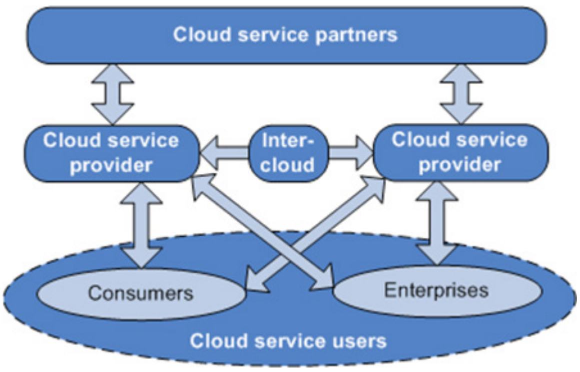
Cloud technologies are the basis for most data services. By definition, cloud computing is a paradigm for enabling access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on demand[14]. The cloud ecosystem consists of cloud service customers, cloud service providers and cloud service partners (Figure 2.4).

In general, there are three main cloud computing service categories, which include:

- Infrastructure as a Service – IaaS (customers use the cloud infrastructure resources for processing, storage or networking);
- Platform as a Service – PaaS (customers use the cloud platform with operating systems, execution environments, databases, and servers);
- Software as a Service – SaaS (providers install/manage application software in the cloud instead of running the software on end-users' devices).

Whether e-mail, file sharing, video sharing, social networking, or IoT database, such applications and services rely on cloud computing. Therefore, understanding cloud computing technologies is

Figure 2.4: Cloud computing ecosystem



Source: Author's own 2018, unpublished

crucial for the development of new services, such as OTT services which are mainly based on SaaS.

This means that capacity building for cloud computing is required on all three layers: basic (for individual users), intermediate (e.g., for corporate users) and advanced level (for developers of applications and services). Required skills include the following:

- understanding frameworks for cloud computing, including systems, architectures and service models (IaaS, PaaS, SaaS, and others such as Network as a Service – NaaS, Communication as a Service – CaaS, etc.), as well as OTT and telecom cloud implementations;
- the use of cloud computing for development of new emerging OTT services, e.g., services needed for the digital economy;
- performing technical, business and regulation analysis for cloud computing, including various OTT and telecom-based cloud computing services;
- skills to regulate security and privacy issues for cloud computing services, particularly in multi-tenancy cases.

ICT services and applications

The purpose of networks is to provide access to applications and services. There are two main types:

- services provided by telecom operators, based on QoS guarantees and service level agreements (SLAs);
- OTT services, provided typically on a proprietary basis (i.e., non-standardized applications/services) which lead the innovation "game" because they typically have shorter time to market (compared to telecom services) and greater global reach.

ICT skills for the development (advanced level) and use of services/applications are becoming crucial now in all ICT areas and in different sectors (such as health, education, agriculture, entertainment, industry, governments, homes, and cities). In this sense one of the action points for the information society is "transcending from infrastructure to applications and services: building capacity to leverage e-applications"[15].

Thus the required skills in the area of ICT services and applications are targeted to:

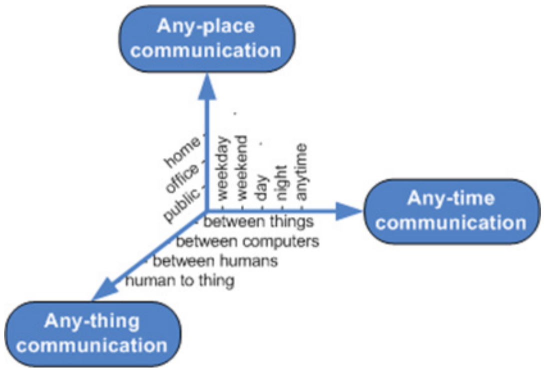
- implementation and operation of NGN services over broadband access (including VoIP, IPTV, and virtual private networks for business users);
- implementation and operation of OTT (data) services, such as OTT voice (e.g., Skype, Viber, WhatsApp), social networks (e.g., Facebook, Twitter), video sharing (e.g., YouTube), torrent applications (e.g., BitTorrent), clouds (e.g., Google drive), online gaming platforms (e.g., Steam), and many others from different application ecosystems (e.g., PlayStore, iStore);
- development of digital services for transfer of all governmental/institutional services for citizens from a paper to a digital form;
- digital economy services, such as banking, shopping, and trading over the Internet;
- business and regulatory aspects for broadband Internet services.

The target population for capacity building in this field includes government employees (ICT sector), regulators, telecom operators, service providers, as well as professionals working in ICT and ICT-related enterprises.

Internet of Things

The growth of IoT, is driven by different factors, such as widespread adoption of Internet and IP technologies, omnipresent connectivity, continuous miniaturization of various devices and sensors, and the development of cloud computing[16]. IoT has the potential to change the world to a greater extent than changes driven by the Internet over the past two decades. Consequently there is strong demand for capacity building for the planning and design of various IoT systems in different sectors, with a focus on the development and use of IoT applications and services. IoT capacity building is targeted

Figure 2.5: Internet of Things (IoT) dimensions



Source: Author's own 2018, unpublished

at standards and architectures, policies and regulation, IoT security, privacy and trust, IoT applications for mobile networks (including existing 2G to 4G technologies, and future 5G technology with its anticipated massive growth in IoT).

The IoT is expected to have a long-term influence on technologies as well as society. It adds another dimension to the ICT world, which is referred to as "any-thing communication", in parallel with the other two dimensions, "any-time communication" and "any-where communication" (Figure 2.5)[17].

IoT is also directly related to the digital economy, because it supports a variety of smart uses in practice, bringing further capacity building challenges. For example, many smart services are based on IoT and require interdisciplinary skills for their implementation or use. As such, the IoT requires capacity building in different areas, including the following:

- Smart grid and energy require skills to provide smart energy distribution, with perimeter access controlled by IoT sensors.

- For driverless cars a plethora of technologies are required, including wireless and mobile technologies, IoT sensors on vehicles and road infrastructure, as well as centralized or distributed databases and services, which require advanced ICT skills.

- The next industry revolution (Industry 4.0) requires IoT experts to take the leading role in the development of so-called smart factories which will be self-sufficient regarding their assets, as well as inventory and supplies.

- Development and deployment of augmented traffic control, intelligent agriculture (e.g., IoT sensors used to check the soil moisture, nutrition, etc.), smart health (e.g., use of health-related data), smart government (general use of IoT and ICT for the better quality of living of citizens, including smart health, smart education, smart cities, etc.), smart homes (use of ICT and IoT devices in different home appliances and objects)[18].

- Another challenge related to IoT is practical deployment and business models. In particular, skills are required for identification, understanding and implementation of different possible business models for various IoT services.

Quality of Service (QoS)

Telecommunication networks require interconnection on a local, regional and global scale to support end-to-end transfer of information, and to facilitate global telecommunication and ICT services. Therefore, the QoS which is applied in a single network (or in a single country) affects end-to-end QoS. This means that quality cannot be considered only at the national or regional level, but should be considered in global terms. Today, citizens around the world rely on telecommunications and ICT to conduct everyday activities in personal or business life, and this requires the implementation of certain QoS parameters. Achieving QoS standards is particularly significant for critical services such as direct automation, remote control or intelligent transport systems.

Overall, QoS is directly related to network planning and design, as well as monitoring and enforcement, which is especially important in the mobile network environment. So, the main required skills for QoS issues include the following:

- understanding QoS, Quality of Experience (QoE) and network performance in different fixed and mobile networks and for different types of services (real-time and non-real-time, critical and non-critical), and selecting the proper set of key performance indicators (KPIs);
- skills for planning and design of fixed and mobile networks with given QoS constraints, because it is always better to prevent degradation than to face the imposition of QoS enforcement by governments or regulators;
- skills to perform QoS regulation regarding the ICT/telecom market and the requirements for different groups of end-users, including human users as well as machines as end-devices;
- understanding network neutrality and implementing it in practice;
- skills to analyze and develop appropriate business models for services that require certain QoS guarantees, together with traffic management techniques applied by telecom operators to different types of traffic (e.g., voice, video, and various data).

Cybersecurity

ICT networks, devices and services are becoming critical for day-to-day life, including both personal and business. As in the real physical world, the cyberworld (i.e., the public Internet) is subject to various security threats that can cause damage. According to ITU's definition, cybersecurity is the collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyberenvironment as well as organizations' and users' assets[19].

The ITU Global Cybersecurity Index (GCI) has five pillars which are legal, technical, organizational, capacity building, and cooperation[20]. The capacity building pillar is an intrinsic part of cybersecurity and refers to the home-grown cybersecurity industry, incentive mechanisms, national education programmes and university curricula, professional training courses, public awareness campaigns, research and development programmes, using good practices, as well as cooperation with standardization bodies such as ITU and others.

There is a need to respond to cybersecurity capacity building challenges on multiple levels, as follows:

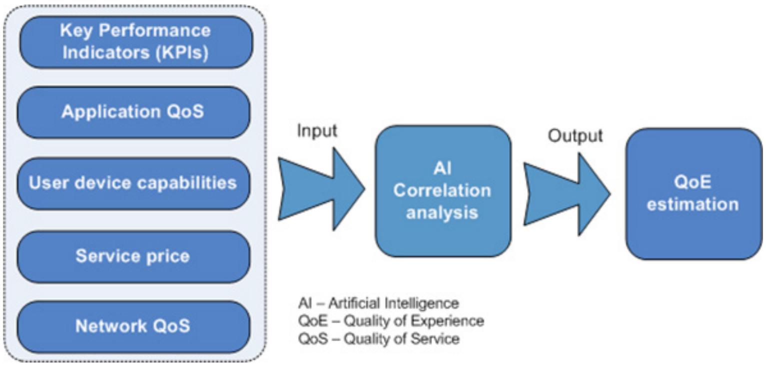
- on a national level skills are required for the development of national cybersecurity strategies, policies and response capabilities;
- on a regional level skills are needed for harmonization of different policies, national legal frameworks, as well as good practices in any given region;
- on the international level human capacity is required for building international cooperation frameworks and exchange of information on cybersecurity issues (e.g., cyber-attacks and counter measures);
- skills for development of security solutions for the new services such as IoT;
- skills to provide secure networks and services by telecom operators and OTT service providers.

Cybersecurity capacity building should be targeted to development of basic skills for all ICT users, as well as intermediate and advanced skills for security tool/solution developers and for governments and regulators that deal with security and privacy issues.

Big Data and Artificial Intelligence

Big data refers to a data set that is so large or complex that traditional computational analysis and processing cannot be used[21]. However, big data can use "help" from AI and Machine Learning (ML), both of which are gaining momentum in the ICT world[22]. It is expected that AI will find wider application in communication systems and networks with the appearance of 5G mobile networks around 2020 and beyond. Meanwhile,

Figure 2.6: Use of AI for estimation of QoE based on measured QoS



Source: Author's own 2018, unpublished

ML in 5G can be used for improved network efficiency.

AI has many different uses. As an example, for smart cities AI (together with IoT) can provide human-like applications, which can make informed predictions and decisions (e.g., energy-efficient city functions). Furthermore, Figure 6 shows the application of AI in the field of QoS and QoE. Bearing in mind that QoE is difficult to measure, unlike QoS (which can be measured based on defined set of KPIs), AI can be used to undertake analysis of network QoS and application QoS to provide the QoE estimation as an output.

With a focus on the use of AI and ML in ICT as well as big data, the required skills include the following:

- skills for AI-based automation for network design, operation and maintenance, as well as increased efficiency with network self-optimization;

- use of AI for support of different services, including digital assistants for better customization of services, smart use of data (e.g., through ML) for smart homes, smart cities, smart transportation, or smart industry;

- skills for use of big data techniques, which can improve decision making or improve real-world processes in different sectors (such as education, emergency services, healthcare) over short, medium and longer terms;

- educating governments, businesses and customers, as to how to use big data and AI with the aim of introducing new business models, or improving services, to increase productivity and generally to improve wellbeing for all humans.

Conclusions

The rapid development of telecommunications in the past two decades was triggered by the appearance and spread of the Internet, as well as the use of Internet technologies for building all networks and all services.

The Internet spearheaded the separation of services from the underlying transport infrastructures, while ITU has undertaken this in a similar manner for the traditional telecom world with the standardization of NGN and later the Future Networks. In Europe and other parts of the world policy-makers are setting targets for implementation of ultra-broadband access by 2020, while cloud computing is used for almost all Internet services and applications. Continuously emerging mobile technologies have already made communications personal and individualized, and have also facilitated the spread of broadband Internet to places where it was previously unavailable due to a lack of fixed infrastructure. A new wave of mobile innovation will see 5G appear around 2020. With next generation mobile, massive growth in IoT applications and use is expected. Further, network virtualization (NFV, SDN, network slicing) are emerging ICT trends for both mobile and fixed networks. All of these developments will bring capacity building challenges as the emerging ICT technologies require new skills.

The emergence of IoT and AI will create new smart things and services, such as smart homes, smart cars, smart cities, – indeed, simply smart everything. This is by no means the complete list of emerging ICT trends and technologies, all of which will require continuous development of ICT skills through different channels for capacity building.

Overall, new issues and new challenges arise continually in the ICT/telecommunication world in relation to technology, regulation and business. In response, initiatives are put in place such as the ITU Centres of Excellence network with the ITU Academy platform which provides timely and quality capacity building for all emerging ICT trends and technologies around the globe[23].

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Capacity building initiatives in IoT in developing countries: lessons learned and way forward

by Marco Zennaro and Santhi Kumaran

Introduction

The Internet of Things (IoT) refers to the networked interconnection of objects in addition to traditional networked devices, as explained in Rose et al.[1]. The IoT is expanding, as the continual decrease in size, cost and energy consumption of wireless devices boosts the number of deployed wireless devices dramatically. The number of mobile objects composing the IoT will be huge: in 2020 between 12 to 50 billion devices are expected to connect with each other, a 12- to 50-fold growth from 2012[2]. Several different technologies will converge into IoT, such as RFID systems, wireless sensor and actuator networks, and personal and body area networks, each using its own access solution. As there are many developmental challenges that the IoT can address, the technology has huge potential in developing countries: food safety can be checked, water quality can be monitored, air quality can be measured, landslides can be detected and mosquitoes can be counted in cities in real time, as described in the Information Society Report[3]. Thus, with the advancement of the IoT, there is a worldwide need for technical professionals involved in developing communication and embedded systems. To boost economic conditions and to compete in the global marketplace, developing countries should invest in training IoT professionals who can develop and deploy innovative products, and services, and provide complete solutions for a wide array of applications across a diverse range of industries.

IoT and its development

According to ITU-T Recommendation Y.2060 IoT is "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving, interoperable information and communication technologies"[4]. Wireless sensor networks (WSN) form the backbone of IoT networks by deploying large quantities of self-configuring small nodes, also known as motes, to sense the physical world and report to a specific centre where the remote information is analyzed and processed. These tiny electronic devices can easily be integrated into our daily life to support a wide number of applications ranging from environmental, agriculture, and health care to disaster monitoring.

We have been advocating the use of IoT and WSN for development, given the wide range of potential applications that can benefit communities and at the same time help to bridge the scientific divide, as stated in Zennaro et al.[5].

From a technical point of view, IoT nodes are low-cost and low-power devices, making them ideal for applications in environments where affordability is paramount and where power is unreliable. Nodes do not require an existing infrastructure as they can auto-configure and form a network, which makes these devices an ideal solution for remote areas. They are also flexible in terms of their use of different networking technologies. As regards the user interface, researchers have been using different strategies to communicate with illiterate communities such as audio messages or blinking lights.

When considering applications that are relevant to developing countries, IoT solutions are emerging in many fields, including water quality, agriculture, air quality monitoring, animal tracking, and disease mapping, as explained in the Harnessing the Internet of Things report[6]. IoT can also benefit scientists from developing countries in bridging the so-called scientific divide. If the digital divide is defined as the gap between those with regular and effective access to digital technologies and those without, then the scientific divide can be defined as the gap between those with access to scientific data and those without. Collection of empirical data has enabled advances in science and contributed to improvements in the quality of life. Until recently, especially in environmental applications, data collection has been based mainly on a limited amount of expensive equipment using wired infrastructure. Data collection was a costly and difficult task, limited to a relatively small number of fixed, sparsely distributed locations, and maintained by organizations with large budgets. As a result, the data gathered is often incomplete, especially for developing countries and remote areas. IoT could change that radically: it is a low-cost and low-power technology that does not require any pre-existing infrastructure and can be deployed in most remote regions. The vast range of sensors that can be connected to the nodes supports many different scientific applications, such as air-quality, water-quality and soil-moisture monitoring.

To realize these benefits for communities and scientists, a broad portfolio of deployments will be needed as a proof of concept. It is important that deployment of IoT networks considers both the potential scientific impact as well as the impact on local society. Wider dissemination is needed to engage a greater audience for sensor development activities.

Short in-situ IoT training activities

In this section we will discuss the lessons learned from short training in IoT organized by the Abdus Salam International Centre for Theoretical Physics (ICTP), a UNESCO Category 1 Institution[7]. The mission of the ICTP is to foster advanced studies and research in developing countries. While the name of the Centre reflects its beginnings, its activities today encompass most areas of theoretical and applied sciences, including information and communication technologies (ICT). ICTP embraces a large community of scientists worldwide. Since its creation, the Centre has received about 120 000 scientists, half of whom have come from the developing world. Visitors have represented some 180 nations and 40 international organizations. In recent years, more than 6 000 scientists visit ICTP annually to participate in its research and training activities, and to conduct their own research. Since 1996, the Telecommunications/ICT for Development Laboratory of the ICTP has established extensive training programmes on wireless communications technologies to facilitate Internet access to unconnected academic and other institutions[8].

Since 2010 ICTP has organized 26 training activities (Table 3.1), in the 20 countries highlighted in Figure 3.1.

We can categorize the training into three generations, as described below. All three categories share some common aspects:

- The global objective of the training activities was to provide awareness about the potential of this new technology.
- The specific objectives of the training were to:
  - provide participants with a better understanding of the IoT/WSN technology in general and of the related networking requirements;
  - provide participants with an appreciation for the interdisciplinary nature of IoT/WSN by presenting the wide range of potential applications while focusing on particular domain knowledge relevant to the country/region;
  - provide participants with the opportunity to develop practical skills through hands-on, team-based design activities. These skills are the same as those required by practicing engineers, namely critical thinking, teamwork, and good communication skills;
  - develop open course material and programming examples;
  - train a future generation of trainers who will be able to share the knowledge to create local expertise;
  - using a regional approach, develop a sense of community among participants with the expectation of giving them the feeling of excitement about WSN and increasing interest in its application to solve local problems.
- The training consisted of lectures, individual or group programming of wireless sensor

Table 3.1: Training activities organized by ICTP since 2010

Host country	Training activity year(s)
Argentina	2016
Benin	2014
Colombia	2016
Costa Rica	2015
Ecuador	2014
Egypt	2015
El Salvador	2017
Ethiopia	2017
Ghana	2011
Honduras	2017
India	2011
Indonesia	2012 and 2017
Japan	2014, 2015, 2016, and 2017 for ICT4D students
Kenya	2011
Mauritius	2015
Nepal	2018
Nicaragua	2013
Rwanda	2015
South Africa	2010
Thailand	2014, 2016 and 2017

Source: Zennaro, M., Bagula, A., Nkolomoa, M., "From Training to Projects: Wireless Sensor Networks in Africa," *Proceedings of the IEEE Global Humanitarian Technology Conference (GHTC2012)* (Seattle, Washington-USA, October 21-24, 2012).

nodes, experimenting with nodes in the laboratory and in the field, as well as collective discussions and case study presentations. The experiments took about a half of the total time.

- The training lasted five days and was targeted to about 20 participants, comprising researchers, professionals and students (both undergraduate and postgraduate) from both computer science and scientific faculties. An on-line application system was used to

Figure 3.1: Sites of IoT training activities organized by ICTP

Source: Zennaro, M., Bagula, A., Nkolomoa, M., "From Training to Projects: Wireless Sensor Networks in Africa," *Proceedings of the IEEE Global Humanitarian Technology Conference (GHTC2012)* (Seattle, Washington-USA, October 21-24, 2012).

select the participants based on a competitive criterion. This resulted in highly motivated and focused group of participants.

First generation training: WSN and short distance protocols

The first generation of training activities focused on specialized WSN boards, as reported in the ICTP-IAEA-BATAN workshop[9]. This was the time of expensive devices that worked with operating systems designed for WSN (such as TinyOS, and Contiki). The setup of the programming environment was difficult and required fine-tuning. These devices used the 2.4 GHz wireless band and had a limited range. There are few applications where such a limited range (100m maximum) can be useful, and this is particularly the case for developing countries. At that time WSN did not include GSM-based nodes and the research focus was on optimizing battery duration. Emphasis was also given to middleware as the model was to store and visualize data locally. Despite these limitations, participants in the first training activities developed interesting prototypes and new ideas, as described in Mafuta et al.[10].

Lessons learned from the first-generation training included:

- the limited range of the wireless transmission is not useful in the case of developing countries;
- middleware requires an extra piece of equipment (a PC generally) that needs to be installed and maintained;
- specialized WSN devices require a special set of skills that cannot be used anywhere else.

Second generation: open hardware and software

The second generation of training activities focused on open hardware and software devices, as briefly described by Bagula et al.[11]. This was the time of the Arduino revolution, which promised low-cost and open source solutions. By buying additional modules, one could develop useful applications. While these families of boards were cheap and well documented, they were not designed for WSN/IoT but rather for electronic prototyping. They lacked the low-power features required in developing countries. From a pedagogical point of view, they had the advantage of being very well documented in many languages.

Lessons learned from the second-generation training included:

- openness is not always the most important parameter;
- low-power is paramount for applications in areas where power supply is unstable;
- availability of documentation is a great advantage as participants can gather more information than provided during the training activity.

Third generation: rapid prototyping and data analytics

The third generation of training activities focuses on re-usable programming knowledge, on lower frequency radios and on cloud services. With the advent of microPython-based nodes, as explained in the microPython.org website, we are now able to use the same skills for programming the nodes and for analyzing data from the IoT network[12]. This makes a great difference in terms of re-usable skills. New wireless protocols in the sub-GHz bands enable long-distance applications that are particularly useful in developing countries. Finally, with the improvement of network connectivity in many countries, cloud services are being used in the training, thus lowering the initial investment barrier when deploying a complete IoT solution.

Lessons learned from the third-generation training included:

- it is advantageous to use general purpose programming languages (such as Python) that can be re-used in other contexts after the workshop;
- practical learning outcomes will be achieved through selecting equipment in the sub-GHz bands;

– policy and regulations are important when using the industrial, scientific, and medical (ISM) radiospectrum bands;

– the topics of security and privacy can now be addressed as we use "standard" programming languages and tools instead of prototyping ones;

– cloud services are a great advantage because they allow for rapid storage and visualization of the data.

Lessons learned

From the 26 training activities organized in the last eight years we learned much. Firstly, workshops should not focus on one specific application but should present the main concepts in IoT. Participants will then develop their own applications, which will differ from country to country. Secondly, regulatory issues are important if IoT networks are to be deployed outside academic environments. While radio regulations are clear (in respect to which frequencies should be used), regulations pertaining to IoT are not clear. One example is duty cycle limitations which are valid in Europe but are not defined in many African countries. Type approval is also a topic to be presented, as participants will seek to order equipment after the training activities. Finally, production of written material is useful as many participants act as trainers and want to reproduce the workshop in their own institution. A handbook/guide developed in a modular way would certainly be utilized.

Training needs identified and proposed solutions

The main training need is related to the multidisciplinary nature of IoT. It is challenging to present IoT in a short training course as the required background knowledge is very wide, ranging from wireless concepts to network protocols, from programming to databases, and from data science to sensor electronics. Electrical engineers lack the programming knowledge, while computer scientists lack the basic radiofrequency (RF) engineering concepts. We found a solution in using Python-based IoT nodes. By learning Python (the second most used programming language in the world, with many online courses and freely available resources), participants can program the IoT nodes, manage the database and analyze the data. We can therefore focus on RF concepts without devoting too much time to presenting different programming languages/environments. Another advantage of using a high-level programming language is that participants can start prototyping their application on the first day of the workshops. This gives them time to make improvements during the week and to make modifications based on lessons from the lecture classes.

Long Term training at the African Centre of Excellence in Internet of Things (ACEIoT) in Rwanda.

Although universities in the developing countries have contributed significantly to reducing the human capital gap in the field of science and technology, their much needed contribution to the relevant science, technology and innovation (STI) degree programmes, focusing on hands-on skills to accelerate economic transformation and competitiveness, has been limited. For developing countries, ICT investment is an essential driver for economic development. With the advancement of the IoT, intelligent products that operate and exchange information efficiently have created a worldwide need for technical professionals involved in developing communication and embedded systems. To boost economic conditions and to compete in the global marketplace, developing countries should invest in training IoT professionals who can develop and deploy innovative products and services, and provide complete solutions for a wide array of applications across a diverse range of industries.

Consistent with these requirements, the University of Rwanda - College of Science and Technology was selected to establish an African Centre of Excellence in IoT (ACEIoT) by the World Bank's ACE II project. The Centre is aimed at Masters and PhD training in the field of IoT, bringing together researchers and practitioners whose work will have an impact on the development of IoT-driven service provisioning solutions for a developing nation like Rwanda, and for Africa as a whole.

Although much progress has been made in the field of IoT by developed nations, the developing countries are lagging due to the lack of skilled people. There is huge demand for WSN and embedded systems professionals. Embedded computing systems are now pervasive and ubiquitous. They are found in personal digital assistants (including smart phones), biomedical devices, networked sensors, mobile robotics, automotive and airlines systems, smart cards and RFID tags amongst others. The IoT market is driven by tomorrow's digital cities, Industry 4.0 and cyber-physical systems (CPS). As modern systems are yet to be deployed in many industries, millions of new jobs are forecasted in this field in the near future.

PhD and Masters Programmes offered at ACEIoT

In order to address the skill gaps, ACEIoT offers PhD programmes in two specializations: PhD in Wireless Sensor Networks (WSN), and PhD in Embedded Computing Systems, and two Masters programmes: MSc in IoT - Wireless Intelligent Sensor Networking (WISeNet) and MSc in IoT - Embedded Computing Systems (ECS). These graduate programmes and the other capacity building interventions of ACEIoT are clearly aimed at addressing the skills priorities of the region, so that graduates from ACEIoT may fill the ICT skills gap of the region. All students of the Centre will undertake market-oriented, demand-driven, and problem-solving research for their project/dissertation work. Skills learned by the students will be directly applicable to the needs of the various sectors, including smart meters for the energy sector; precision agriculture for the agricultural sector; smart wearable health monitoring devices for the health sector; and even early warning systems where different sensors are developed for detection and timely alert of various disasters including landslides, and potential volcanic eruptions. Students will be trained to acquire sufficient entrepreneurial skills to become job creators rather than job seekers. Projects can be simulation-based or experimental but are expected to demonstrate innovations or solutions suitable for local needs.

Real life examples of IoT application

Embedded devices, such as sensors, are used to monitor the use of renewable energy sources, such as photovoltaic. As this is the only available technology to provide access to electricity in many regions, it is possible to use these devices to monitor the state of batteries, the usage of energy during the day and the status of the panels. Thus, embedded devices drastically reduce the cost of human transportation to measure such parameters. Moreover, sensors are integrated into all forms of energy consuming household devices (such as switches, power outlets, bulbs and televisions) and can communicate real-time data to the utility supply company so that power generation and energy usage may be balanced effectively.

Many global companies from the developed world are already investing in the African market with products for the energy sector, and drones for various applications, but they are generally very expensive. The human capital trained through degree programmes at ACEIoT should develop products and services for the local market which are both cost effective and easily deployable.

Another example of a real use scenario is from the health sector. Most rural and remote health centres in sub-Saharan African countries are still facing a critical shortage of nurses and doctors. This deficit is often manifested in long queues of patients in waiting rooms over many hours. Traditionally, health centres apply a first-come-first-served (FCFS) rule to schedule patient consultations with the limited pool of healthcare specialists (doctors or nurses) without considering the severity of each individual patient's health condition. This is not an efficient use of scarce healthcare resources. To solve the problem the ACEIoT is planning to design a smart vital signs acquisition chair (integrating various embedded bio sensors) that enables prioritization in the scheduling of queuing patients by assessing the health condition of a patient. This is estimated using the measurement of vital signs, together with the waiting time and distance between the centre and the patient's home. The proposed system may also be upgraded to provide queuing information at a given health centre, either by SMS or Internet, so that patients can schedule a health centre visit by considering the likely wait time at the target centre.

Drones or Unmanned Aerial Vehicles (UAVs) technology is another emerging and rapidly evolving technology. There are many innovative applications of drones for the African region. In Rwanda and Tanzania drones are used by Zipline to transport blood to remote areas and to deliver essential medical supplies. Livestock farmers will also benefit from livestock vaccines delivered on the farms to control outbreaks of disease.

Drones also have an impact on the agricultural sector. In countries with hilly terrain, such as Rwanda, farming takes place on steep slopes and sometimes it is very difficult to reach some of the areas. The use of modern technology such as drones can improve farming and crop production. Applications include seed sowing, smart irrigation and soil analysis. Various types of embedded devices such as sensors and other devices will be integrated to the standard drone structure, which can provide live data from a range of sensors, collect soil samples and undertake agricultural surveys. Kenya is using drones to end the Rhino poaching crisis, while Zanzibar uses drones for geo-spatial mapping of Zanzibar islands.

The design of sensor systems for drones is an important application of WSN and ECS, requiring dedicated electronics for signal acquisition and amplification. By means of digital signal processing, measurement information can be extracted and transmitted. Decisions about hardware and software realization of system functionality requires experts educated in both fields. The ACEIoT graduate programmes will equip the students with the necessary skills in the design and development of embedded devices, like sensors and other devices, and in the integration of these to the basic drone structure for various drone applications.

The above real-life examples represent only a small subset of the possibilities offered by IoT for solving developmental challenges. As the ACEIoT is a regional centre of excellence, the partners of the consortium and the region will identify many more challenges where IoT could play a role in providing innovative solutions.

The World Bank funding for the ACEIoT supports the procurement of required cutting-edge research equipment for the wireless sensing laboratories and ECS laboratories, and the upgrading of research facilities for the efficient delivery of the PhD and Masters programmes. This will also encourage international collaborators to conduct studies at the Centre.

ACEIoT's partnerships with regional and international universities and research institutions will enable collaborative research studies of relevance to global, regional and national development needs in the IoT application domain. Technical papers describing original ideas, ground-breaking results, and/or real-world experiences involving innovative IoT applications can be published in widely respected journals, thus improving the ranking of the partnering universities and improving the University of Rwanda's world ranking.

Conclusion and next steps

The promise of IoT is connecting billions of devices for multiple uses as we have seen in the above sections. It is believed that a large quantity of low-cost sensors with long battery life will allow much more data to be collected and more insights to be gathered from big data, which can help the government and people of developing countries to become globally competitive. As the economics of IoT changes, IoT sensors will become inexpensive (less than a few dollars), and micro-controllers and edge computing will reduce in price. RF communication and the scalability of IoT will enable millions of sensors to be deployed in a country, facilitating big data analytics and AI, Machine Learning, new business models and application programming interfaces (APIs) – all created from simple payloads of data from the sensors. Therefore, the key task for trained professionals undertaking short- and long-term training is to examine possible uses of the technology and/or develop or deploy solutions.

We presented our experience in training participants from developing countries in IoT. While the short workshops can ignite interest in this new technology, a complete academic course will create the foundation for future success with a new generation of experts. The main lesson is that IoT will succeed when the deployment of technology is generated by country needs. There is also a need for coordination of vertical applications that can fulfill the needs of developing countries, and ITU can certainly play a role in this. Given ITU-D's role in fostering capacity building initiatives and in supporting sustainable ICT initiatives, a virtual environment could be created for the exchange of lessons learned in IoT4D projects.

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Building online adjunct faculty capacity: investigating preferred interventions for effective online teaching

This paper is based on one part of a Doctoral dissertation by Gurdip Kaur Saminder Singh, "Development and evaluation of a professional development intervention for online adjunct faculty", Open University Malaysia, 2017.

By Gurdip Kaur Saminder Singh and Abtar Singh

Introduction

Although the online environment has developed over the years, very little research and practice has focused on the task of preparing faculty to teach online[1]. A literature review has indicated that although some of the schemes and *modus operandi* used in face-to-face delivery can be transferred to an online setting, online instruction deviates significantly from face-to-face instruction and can present numerous challenges for instructors transitioning to a virtual environment[2]. To address online learners' requirements, instructors must obtain new skills, roles, strategies, and techniques[3]. The literature review indicates that a gap exists in the extent and intensity of capacity building for adjunct faculty, which in turn affects their knowledge of integrating technology, pedagogy and content to teach online effectively. Although several researchers have made allusions to the factors influencing faculty adoption of technology integration practices, no further studies have been conducted to determine the kind of professional development model and the types of knowledge online adjunct faculty will require to adopt technology effectively in online classrooms[4]. As Wolf noted, "Effective programs survey their faculty to determine what type of support is most desired"[5]. Mishra and Koehler have presented their views that twenty-first century educators need three kinds of knowledge for effective adoption of technology in virtual classrooms, namely: technology, pedagogy and content[6]. Training of adjunct academics in contemporary educational practices is thus a key aspect in almost every education improvement strategy and constitutes the main component of online educational reform programmes[7].

Professional development models that do not take into consideration subject-specific pedagogy and the context of application will lead to difficulties for faculty in linking technology with pedagogy[8]. This explains why many academics, having received online instructional training as part of their professional development, still lack the confidence needed to integrate technology in the teaching and learning process[9]. Holland suggested that improvement in technological pedagogical content knowledge (TPACK) is one of the most imperative investments for any educational system[10]. Harris and Hoffer remarked that for faculty to integrate technology across different subject areas in the curriculum, requires a firm mastery of TPACK[11]. TPACK is an incorporation of faculty knowledge of curriculum content, general pedagogies, technologies, and contextual factors that influence learning[12]. It is a theoretical framework that illustrates the types of knowledge teachers are expected to possess to adopt technology effectively in their classrooms[13]. Therefore, there is a need to assess online adjunct faculty training needs in terms of TPACK to develop a professional development intervention that builds capacity for effective online teaching.

Literature review

Online adjunct faculty

Online adjunct faculty, according to Carnevale and Bedford are outside the tenured system and consist of individuals who seek flexibility in work and for contributing their professional knowledge, facilitated through the deployment of digital technologies in universities and college worldwide[14] Brand frequently describes this adjunct faculty as the lost/invisible tribe as they are not seen as being. a part of the core team which develops and delivers the course of study[15]. Brand believes that although they are rarely included in structural changes or developments and frequently work in the shadows with minimal support and recognition, many higher education institutions (HEIs) today are unable to function without the input of online adjunct faculty.

Online teaching and learning is widely recognized as involving a high proportion of adjuncts and requiring tutors to have consistent training in technology, since all online learning requires the use of web-enabled digital tools and a growing range of software applications[16]. Compared to other sections of the academic workforce, professional learning, development and support for online adjunct faculty differs greatly and has important ramifications for teaching and learning quality[17].

Building online adjunct faculty capacity

A common challenge that institutions face is how to build staff capacity to integrate technology and to manage and facilitate their online offerings[18]. The vast differences between traditional classroom teaching and virtual classroom offerings may inhibit adjuncts from engaging in online instructions effectively. Furthermore, faculty needs change over time, and as such, institutional faculty development initiatives must shift focus in response to maturing faculty needs[19]. It is therefore important to design a capacity building programme that is aligned to the needs and/or readiness of online adjunct faculty. To produce effective online faculty, institutions must develop the most desired and effective staff capacity intervention.

Emerging issues on adjunct faculty professional development

Research on various online teaching and learning areas over the past several years has clearly indicated that online learning has increased significantly[20]. One critical area of focus in addressing the increasing numbers of students includes faculty professional development as a means to improve learning outcomes for students[21]. Unlike many full-time faculty, adjunct faculty rarely receive the same level of professional development and training on best practice in online instruction[22].

The following section of this paper reports on the problems faced by online adjunct faculty in terms of TPACK as well as identifying the preferred intervention for capacity building through survey questionnaires. These findings have contributed towards designing a solution, which was the second part of the doctoral dissertation.

Methodology

Context

The study was carried out at a branch campus of a well-known established online university, the Open University of Malaysia, which offers a comprehensive range of undergraduate and postgraduate programmes via the hybrid mode. In the semester studied, 75 tutors were employed to teach students from various faculties and programmes ranging from diploma, bachelors, masters as well as Doctorate.

Instruments and procedure

The study consists of two phases. The first phase reviewed gaps in tutors' TPACK while the second phase considered practical problems tutors faced in online teaching as well as their preferred intervention. Prior to study commencement, two distinctive sets of data-collection instruments were developed and pilot tested, namely: TPACK gap analysis (TPACK GA) which was used at phase one, and professional development model preferences (PDMP) which was used at phase two. TPACK GA consisted of 36 questions pertaining to the tutors' ability and capability to engage technology, pedagogy and content as an amalgamation in the online teaching environment. PDMP consisted of 20 questions with regard to tutors' preferred intervention in terms of approach, general and specific knowledge required and preferences for evaluation methods. Following pilot testing, TPACK GA and PDMP were then used in phase one and phase two respectively to collect data from tutors. Based on the data collected, the capacity building intervention for online adjunct faculty was designed.

Statistical Package for Social Sciences (SPSS) version 22 was used to analyse the quantitative data. The quantitative data from the TPACK-GA and PDMP questionnaires was analysed using frequency counts and percentages.

Participants

For the first and second phase, a set of questionnaires were distributed and collected from 3 to 24 April 2016. All respondents were briefed on the nature of study, aims, requirements of the participant, timeline for study and the benefits of participation. Of the total population (75 tutors), 63 responded to the questionnaires, which represents an 84% response rate, reflecting a 95% confidence level[23].

Table 4.1: Practical problems associated with technology, content and pedagogy knowledge

Statement	Disagree	Agree	Rank (from highest to lowest problem)
Technology			
I know how to solve minor computer problems while teaching online.	22.2% (14)	77.8% (49)	12
I can learn technology easily without help.	44.4% (28)	55.6% (35)	4
I have the technical skills I need to use technology in an online classroom.	38.1% (24)	61.9% (39)	7
I have a vast knowledge of different technologies that can be used for teaching online	58.7% (37)	41.3% (26)	1
I follow-up new developments in technology from time to time.	44.5% (28)	55.5% (35)	3
I frequently use different types of technology while teaching online students.	56.5% (35)	43.5% (27)	2
Content			
I have sufficient knowledge about the content I am teaching	20.7% (13)	79.3% (50)	13
I have various ways and strategies of developing my understanding of the content to teach online.	31.8% (20)	68.2% (43)	9
Online Pedagogy			
I know how to assess students' performance in an online classroom.	30.2% (19)	69.8% (44)	10
I can adapt my teaching based upon students understanding or misunderstanding.	30.2% (19)	69.8% (44)	10
I can adapt my teaching style to different categories of learners	27.0% (17)	73.0% (46)	11
I can assess students learning in multiple ways.	41.3% (26)	58.7% (37)	6
I can use a wide range of teaching approaches in a blended learning classroom setting.	27.0% (17)	73.0% (46)	11
I am familiar with common misconceptions students have.	43.5% (27)	56.5% (35)	5
I know how to organize and manage my lessons online.	34.9% (22)	65.1% (41)	8

Source: Author's own 2017, unpublished

Major findings

The major findings were:

- With regard to practical problems associated with TPACK, tutors lacked knowledge on different technologies for online teaching (58.7%) compared to other aspects of TPACK (Table 4.1).
- On combining technology, pedagogy and content, a high proportion reported weaknesses with combining technology and pedagogy (TPK) as compared to technology and content (TCK) or pedagogy and content (PCK) (Table 4.2).
- In terms of preferred interventions to enhance their knowledge of TPACK, the majority of participants (80.9%) preferred a fully asynchronous professional development intervention (Table 4.3) that included:
  - Learning Management System skills
  - basic instructional design principles
  - facilitating online discussions
  - synchronous and asynchronous technologies
  - various assessment methods
  - rubrics for online task
  - continuous feedback strategies on assessments (Table 4.4).

Table 4.2: Combining pedagogical-content, technological-content and technological-pedagogical knowledge

Statement	Disagree	Agree	Rank (based on average calculations)
Pedagogical Content Knowledge (PCK)			
I am aware of misconceptions, prior knowledge, and particular problems students may have when learning my subject area.	39.7% (25)	60.3% (38)	3
I can select effective teaching approaches to guide students' thinking and learning in my subject area.	17.5% (11)	82.5% (52)	
Technological Content Knowledge (TCK)			
I know about technologies that I can use for understanding and teaching my subject area.	27.0% (17)	73.0% (46)	2
I can use multiple technologies simultaneously for teaching and learning in my subject area.	31.7% (20)	68.3% (43)	
Technological Pedagogical Knowledge (TPK)			
I know how to choose technologies that enhance different teaching approaches for a lesson.	34.9% (22)	65.1% (41)	1
I know how to choose technologies that enhance students' learning in a lesson.	36.5% (23)	63.5% (40)	
I can choose technologies that enhance the content of a lesson.	38.1% (24)	61.9% (39)	
I can think critically about how to use technology in my blended learning classroom.	41.3% (26)	58.7% (37)	
I can adapt the technologies I know in different teaching activities.	28.6% (18)	71.4% (45)	

Source: Author's own 2017, unpublished

Table 4.3: Preferences on approach for a professional development model

Preferences on approach for a professional development model	Disagree	Agree	Neutral	Rank
I prefer a complete face-to-face professional development model.	9.5% (6)	76.2% (48)	14.3% (9)	2
I prefer a fully asynchronous professional development model.	9.5% (6)	81.0% (51)	9.5% (6)	1
I prefer a blended mode professional development model.	8.0% (5)	69.8% (44)	22.2% (14)	3

Source: Author's own 2017, unpublished

Discussion

Technological-Pedagogical Knowledge

The findings (Table 4.1 and Table 4.2) indicated that adjunct faculty experience weaknesses in three constructs, notably Technology Knowledge (TK), and Technological Pedagogical Knowledge (TPK). A number of reasons can be proposed for such phenomena. Firstly, these weaknesses may be explained by the fact that most adjunct faculty teaching at the branch campus graduated from higher education institutions when technology had not been completely introduced in their curriculum, at a time when only basic computer skills using Microsoft Office applications were taught and practised. Courses in computer skills, however, are not sufficient for teaching online courses effectively. Several researchers have warned that although basic computing skills constitute the cornerstone of knowledge of information and communication technology (ICT), such skills are insufficient to prepare faculty for integrating technology in online instruction as these are usually taught in isolation from a pedagogical context[24].

It was also discovered from the study demographic information that most tutors did not attend any professional development programme on teaching online, hence their lack of knowledge on combining technology and online pedagogy. In terms of professional development opportunities, research had also repeatedly indicated that unlike full-time faculty, adjunct faculty rarely receive the same level of professional development and training on best practices in online instruction[25]. Similarly the findings in this research, indicating weaknesses in adjunct faculty knowledge of TK, PK and TPK, concur with current literature[26].

Asynchronous online training model

Findings (Table 4.3) indicated that online adjunct faculty preferred a fully asynchronous professional development model to enhance online teaching effectiveness. These findings agree with Noonan, McCall, Zheng and Erickson's research, which examined the effect of asynchronous online professional development for special education teachers. Participants reported greater satisfaction in the asynchronous professional development than that experienced during traditional professional development programmes[27].

Online adjunct faculty participants preferred the asynchronous e-learning approach as it enabled them to complete the course at their own pace, by using the Internet merely as a support tool rather than opting for e-learning software or online interactive classes. In addition, the researcher strongly believes that due to the nature and various backgrounds of online adjunct faculty, a fully asynchronous professional development model supported the work relations among participants and instructors, even when participants cannot be online simultaneously. As identified by Hrastinski and O'Neil, asynchronous e-learning enables learners to access an e-learning environment at any time and download documents or send messages to instructors or peers[28].

As noted by Slatinski, a crucial step in the instructional design process is the analysis phase consisting of audience analysis as well as instructional and content analysis, where it is important to determine what method and content of training will be most beneficial to the audience. This also considers practical matters such as Internet accessibility or instructor availability[29]. Asynchronous training or self-paced training does not require the online adjunct faculty instructor and participants to be online or in person at the

Table 4.4: Preferences for general content, specific content and assessment method in a professional development model

Statement	Disagree	Agree	Rank (from highest to lowest problem)
General content			
I prefer the professional development model to start the programmes with basic instructional design principles for an online instructor.	28.6% (18)	71.4% (45)	6
I prefer the professional development model to include synchronous and asynchronous technologies in an online learning environment as a training content.	27.0% (17)	73.0% (46)	5
I prefer the professional development model to include Learning Management System skills required by instructors in the online classroom.	20.6% (13)	79.4% (50)	4
I prefer the professional development model to include facilitating online discussions successfully.	17.5% (11)	82.5% (52)	2
I prefer the professional development model to include various assessment techniques as training content for measuring individual and group student performance.	12.7% (8)	87.3% (55)	1
I prefer the professional development model to include basic legal issues of teaching online.	19.1% (12)	80.9% (51)	3
Specific content			
I prefer the professional development model to focus on technology knowledge rather than content and pedagogy knowledge to enhance online teaching effectiveness.	19.1% (12)	80.9% (51)	2
I prefer the professional model to focus on pedagogy knowledge rather than content and technology knowledge to enhance online teaching effectiveness.	30.2% (19)	69.8% (44)	3
I prefer the professional development model to focus on content knowledge rather than pedagogy and technology knowledge to enhance online teaching effectiveness.	30.2% (19)	69.8% (44)	3
I prefer the professional development model to focus on all three knowledge areas: technology, content and pedagogy knowledge to enhance teaching effectiveness.	15.9% (10)	84.1% (53)	1
Assessment method			
I prefer the professional development model to include a variety of assessment methods to ensure mastery of competencies and to familiarize participants with diverse online assessment choices.	9.5% (6)	90.5% (57)	1
I prefer the professional development model to conduct all assessments face-to-face only.	55.6% (35)	44.4% (28)	4
I prefer the professional development model to conduct assessment both, online and face-to-face, to acquaint participants with varied assessment approaches.	9.5% (6)	90.5% (57)	1
I prefer the professional development model to use rubrics to assist participants in knowing how their work will be assessed.	14.3% (9)	85.7% (54)	3
I prefer the professional development model to provide continuous feedbacks on all assessments through the Learning Management System.	11.1% (7)	88.9% (56)	2

Source: Author's own 2017, unpublished

same time for instruction. This allows flexibility where participants have the option of completing the training on their own with little or no help from the instructor[30].

Need-specific professional development intervention

The need for instructor preparation to teach online has been established in the online education literature[31]. As shown in Table 4.4, this research

Table 4.5: Demographic data of online adjunct faculty

Description	Frequency (n)	Percentage (%)
Participants		
Male	31	49
Female	32	51
Qualifications		
Master	40	63
Bachelor	15	24
PhD/Doctorate	4	6
Diploma	2	3
Postgraduate Diploma	1	2
Others	1	2
Age		
18 – 25	-	-
26 – 35	18	29
36 – 45	19	30
Above 46	26	41
Traditional teaching experience (years)		
0 – 1	12	19
2 – 10	14	22
11 – 15	10	16
Above 16	27	43
Online teaching experience (years)		
0 – 1	28	44
2 – 10	27	43
11 – 15	7	11
Above 16	1	2

Source: Author's own 2017, unpublished

Table 4.6: Prior professional development for teaching online attended

Questionnaire	Response	Frequency (n)	Percentage (%)
Have you ever attended any professional development courses on teaching online?	Yes	29	46
	No	34	54
If YES, what was its duration?	1 – 2 days	7	24
	3 – 5 days	19	66
	More than a week	3	10

Source: Author's own 2017, unpublished

captured the needs for a specific professional development programme preferred by the online adjunct faculty.

Similar to the findings in this study (Table 4.5), the literature also found that adjunct faculty have various backgrounds with the majority accustomed to the traditional, face-to-face course instruction, although they may not be certified teachers[32]. Many may not have the classroom management skills and teaching strategies to lead the continuous online learning environment, making it more difficult to provide quality online courses[33].

Findings in this study (Table 4.6) indicate that most online adjunct faculty have never attended professional development training on online teaching and learning.

This concurs with findings from literature affirming online adjunct faculty rarely receive training on best practices in virtual classroom management, while traditional classroom management skills for the virtual world are hardly effective[34].

Adjunct faculty play an important role, yet are seldom provided need-specific professional development opportunities, compared to full-time faculty[35]. Apart from research on the quality of online education, a significant body of literature also identifies a critical need for appropriate online adjunct faculty professional development[36]. For this reason, a design-based research (DBR) methodology was carefully selected for this study as it captured the most significant characteristics for a need-specific professional development intervention as endorsed by Wang and Hannafin[37]. For developing an effective intervention, it was necessary to consider online adjunct faculty preferences prior to developing the intervention.

Conclusion

The findings from this study have contributed to closing the gap in the literature by determining the preferences of online adjunct faculty in a professional development intervention. Based on findings, online adjunct faculty required training that revolved around three knowledge areas – technological and pedagogical knowledge (TK, PK and TPK), as well as blending content with technology (TC). The findings in this study also concur with those of Mishra and Koeler, namely that twenty-first century educators need three kinds of knowledge to teach a virtual classroom effectively, notably on blending technology, pedagogy and content[38]. As indicated the literature, teaching online will be more effective if online adjunct faculty is capable of associating technology, pedagogy and content in a way that promotes learning amongst learners[39].

This paper reported findings on a preferred capacity building intervention to enable adjunct faculty to teach online effectively. Phase one findings on practical problems in terms of technology, pedagogy and content knowledge, combined with phase two findings on online adjunct faculty preferences for a professional development intervention, provided powerful insights for professional developers to position design principles to create the most appropriate intervention for capacity building of the online adjunct faculty. The findings from this research will enable Open University Malaysia's (OUM) Institute for Teaching and Learning Advancement (ITLA) to further redesign their online tutor training programme by closing gaps between current practice and the findings of this research. To enable wider capacity building, the intervention would be best implemented in the online mode.

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Emerging practices in smart learning across diverse cultural communities: a global analysis

by Abtar Darshan Singh, Mar Camacho, Carmen Evarista Oriondo, Santhi Kumaran, Halimatolhanin Mohd Khalid

Introduction

The ability to own and use smart technologies cuts across socioeconomic status boundaries, as these tools become a part of our everyday life survival tools. The practice of including emerging smart technologies in classrooms and corporate training has enabled students worldwide to learn from some of the best instructors, especially through Massive Open Online Courses (MOOCs) and other such endeavours. As we progress through the second decade of the millennium, we see more major digital transformations such as Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT) and big data analytics. These rapid changes, which are affecting the learning landscape, are enabling learners to become more engaged, innovative and empowered. The changes that are being implemented in today's classrooms, based on technological developments, accord with the demands of learners. Today's students are more prepared and more willing than previously for innovative teaching and learning to be part of their daily lifestyle. Recently, the demand for learning, from early childhood to tertiary levels, in the workplace and as a lifelong pursuit, has become much more personalized. Academia and industry are focusing on how to create innovative learning practices which will affect future skills development and capacity building. Likewise, learning methodologies and tools have evolved immensely. The design of learning worldwide is rapidly changing to address some of these questions:

- How can we enable each learner to capitalize on her or his multiple intelligences and learning styles to learn and solve problems creatively?
- How can we push these learners beyond their proximal learning zones?
- Do we need to re-invent the wheel or are there systems in place that can facilitate better sharing of existing practices?

Problem statement

Smart learning practices are abundant in different parts of the world within the higher education realm. The different practices applied by faculty members are a result of institutional vision and mission, learner needs, cultural nuances, and the need to contribute to a body of knowledge via research which is expanding at a rapid rate. So, what are these smart practices and how are these practices applied differently in various parts of the world? Knowledge of these contextualized practices will assist adopters of smart learning to decide what to adopt and what to avoid. There is currently a gap between worldwide practice and sharing of this practice. Furthermore, there is a lack of frameworks which provide more meaning and depth to smart learning practices.

Researchers are active in this area, including Hoel and Mason[1] who aim to share existing practices in smart learning with the hope that more sub-systems, criteria and characteristics of smart learning environments will emerge and improve practices. Taking this as a departure point, this article aims to explore the way in which innovative smart learning practices are implemented across culturally diverse international settings, reflecting pedagogical experiences in the United Arab Emirates (UAE), Spain, Peru, Rwanda and Malaysia.

Literature review

Smart learning

Smart learning can be defined as the intelligent use of powerful emerging technologies to achieve learning efficiently and effectively. A scan of the literature revealed that smart learning is being actively discussed and debated. The International Association for Smart Learning Environment (SLE) defines it as an environment that features the use of innovative technologies and elements that allow greater flexibility, effectiveness, adaptation, engagement, motivation and feedback for the learner[2]. Further, Zhu et al[3]. stated that: "the objective of smart education is to improve learners' quality of lifelong learning. It focuses on contextual, personalized and seamless learning to promote learners emerging intelligence and facilitate their problem-solving ability..."

Gros[4] adds that smart learning is founded on two different types of technology: smart devices and intelligent technologies. Smart devices typically exhibit some properties of ubiquitous computing, possibly including AI, IoT and wearable technology in the form of an accessory such as glasses, a backpack, or even clothing. Intelligent technologies refer to learning analytics, cloud computing and AI capabilities, and are vital in capturing valuable learning data that can effectively enhance the development of personalized and adaptive learning, as stated by Mayer and Picciano in Singh and Hassan.[5]

In a recent publication on the UNESCO website, Singh and Hassan stated that:

"In our point of view, a Smart Learning Environment (SLE) is an adaptive system that puts the learner at the forefront; improves learning experiences for the learner based on learning traits, preferences and progress; features increased degrees of engagement, knowledge access, feedback and guidance; and uses rich-media with a seamless access to pertinent information, real-life and on-the-go mentoring, with high use of AI, neural networks and smart-technologies to continuously enhance the learning environment".[6]

This definition encapsulates many dimensions to enable differing levels of smart learning to be identified in different cultural environments.

Further, in the same paper, [7] the authors have shared a table by Huang et al. that compares smart learning environments with common digital environments across six dimensions, namely:

- learning resources
- learning tools
- learning community
- teaching community
- learning methods
- teaching methods.

In short, the core difference between the two major learning environments, is the level of intelligence that is incorporated and the level of thinking and learner centredness that is integrated into the learning design. Huang et al. also focused on the technical features of SLE, which are reflected in the four aspects of tracking, recognizing, having awareness, and connecting, which aim to promote easy, engaged, and effective learning.[8] One powerful method of smart learning is the personalized mobile learning environment.

Personalized mobile learning environments

As continuously reported in the scientific literature, mobile learning has evolved in recent years to move from a techno-centric view to a more pedagogical approach.[9] Authors such as Cochrane and Bateman[10] and Safran et al.[11] discuss mobile Web 2.0 but emphasize that the benefit of mobile learning is derived from the portability, flexibility and context of mobile technologies, allowing collaboration and encouraging independent lifelong learning. This is reflected in other research, including Naismith et al.,[12] Traxler,[13] and Dyson, Raban, Litchfield and Lawrence.[14]
In addition, as described by Wang et al. [15] and Fombona, Pascual and Madeira,[16] universality and versatility are key benefits offered by the use of mobile applications in education.

Personalized mobile learning environments are articulated and "shapeless" spaces that confluence complex relationships between tools, tasks and content, to provide mutual growth and enrichment, as stated by Castañeda and Soto.[17] Mobile and personalized technologies pose a challenge to educators and students and contribute to the development of evolving communities of practice and virtual learning communities that enrich the learning experience[18, 19].

Options for smart learning

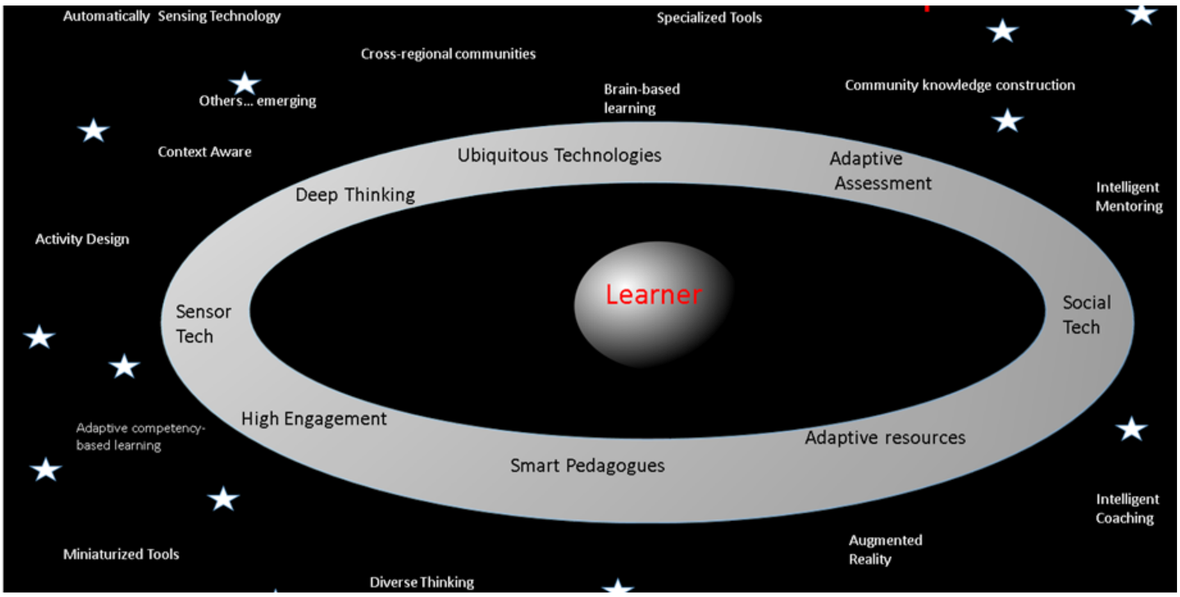
The current challenge for educators is not only to recognize the differences in how students learn, but also to distinguish the skills they need to engage effectively in tasks that will enable individuals to become global citizens. As learners become more empowered and independent, learning resources, tools and methodologies for smart learning are becoming secondary to the institutions. The most important issue now is how these institutions strategize for smart learning. For example, due to the proliferation of online communities, some online facilitators may find that learners are not active in their institutionally created forums, but this does not necessarily mean they are inactive in the use of other worldwide social platforms, such as WhatsApp, Telegram, Instagram, Twitter, LinkedIn and Facebook, for their learning needs. Thus, the question is, how does one capitalize on smart technologies to unite all these learning experiences?

Researchers and educational thinkers are open to considering the countless options that are available to them. We anticipate that the smart learning realm which combines intelligent tools and intelligent thinking to support more personalized learning will use different elements (Figure 5.1). For example, a high ability learner in the UAE with prior digital knowledge may be offered a learning route capitalizing on sensor technologies, adaptive assessment, intelligent coaching and cross-regional communities. Another learner with different experiences and prior knowledge may have a totally different learning permutation combining activity design with smart pedagogues, social technologies and natural expression recognition. We need to capitalize on AI, analytics, big data and highly efficient computations to enable the creation of smarter learning systems to accommodate each and every individual's learning needs.

Methodology and examples

We have examined a series of examples, including a concise narrative of smart learning for each country. Based on the narrative, a comparison is made against aspects of smart learning as measured against Huang et al.[20] (Table 5.1).

Figure 5.1: Diverse smart learning permutations:



Source: Singh (2018) as conceptualized and explained to HBMSU School of E-Education

Table 5.1: Comparison of common digital environments and smart learning environments

	Common Digital Learning Environment	Smart Learning Environment
Learning Resources	Digital resources based on rich media Users select resources	Digital resources independent of the devices Seamless connection or automatic Synchronization becomes fashionable Deliver on-demand resources
Learning Tools	All-function in one tool Learners judge the technology environment and the learning scenarios	Specialized tools and miniaturized tools Automatically sensing technology environment Learning scenarios are automatically recognized
Learning Community	Focus on online communication Self-selected community restricted to information skills	Combine with the mobile interconnected real community to communicate anytime and anywhere Automatically matched communities Depend on media literacy
Teaching Community	Difficult to form an automatic community Regional community	Automatically form community, based on users' experience Make the cross- regional community fashionable
Learning Methods	Focus on individual knowledge construction Interest becomes the key to the diversity of learning methods	Highlight knowledge construction of community collaboration Focus on high-level cognitive objectives Multiple assessment
Teaching Methods	Emphasize resource design Summative evaluation Observation of learning behaviours.	Emphasize activity design Adaptive evaluation of learning outcomes Intervention in learning activities

Source: Adapted and adopted from Huang et al.[21]

Smart learning in the UAE

This example is based on the efforts of Hamdan Bin Mohammed Smart University (HBMSU) to include smart learning practices into the smart campus. HBMSU is the leading university in online and smart learning in the Arab region.[22] Since its inception in 2008, HBMSU has won numerous international awards for research and development in the innovative use of ICT to enhance the learning process, culminating in an award winning smart campus system. HBMSU offers an array of common digital learning experiences, consistent with the criteria of Huang et al. However, with respect to smart learning experiences, in 2016, HBMSU introduced gamification attributes to the smart campus, whereby learners' active participation in the online environment is captured and points are awarded to the learners (Figure 5.2 and 5.3). As noted by Orosco:[23]

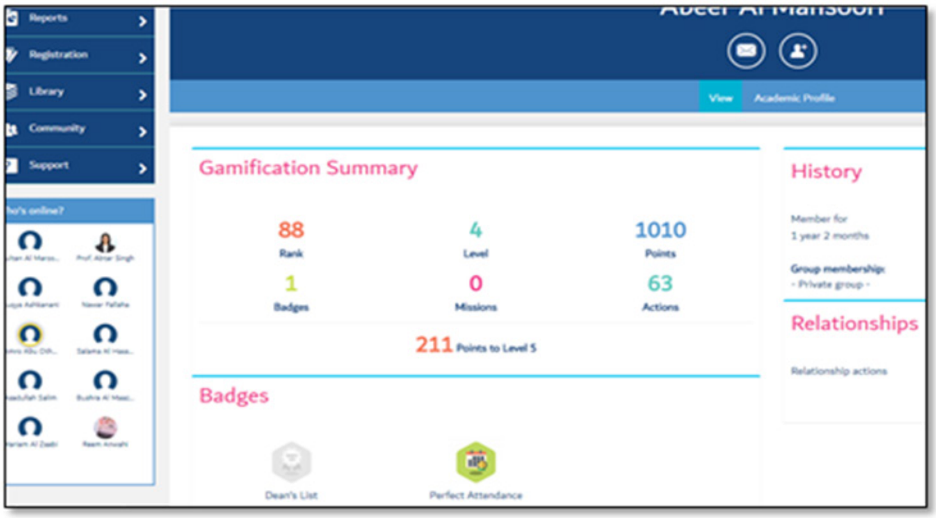
"Gamification is the use of techniques to exploit human playfulness while offering challenges, providing a sense of competition with teammates, and providing rewards and prizes. The most widely recognized gamification metaphors utilize the straightforward components of awards and leaderboards, and give little pokes and prods to motivate and engage and to modify human behavior".

There are various avenues for learners to gain points and collect badges. For example, if a learner is actively engaged in social and community activities within the university, these will be captured in the smart campus and the learners are awarded points culminating in the conferment of badges. There are various categories of engagement that have been created in the smart campus, with the most relevant in teaching and learning. Within the teaching and learning realm, points are given to learners on their active participation in the virtual learning environment, especially when they respond to online discussions and engage in activities related to achievement of learning outcomes. The illustrations below provide examples of the implementation of gamification in the smart campus.

The HBMSU example represents a smart learning environment in the categories of learning tools and learning communities, as measured against the criteria of Table 5.1. These include:

– specialized tools and miniaturized tools

Figure 5.2: Summary of learner gamification points in HBMSU smart campus



– automatically sensing technology environment

– learning scenarios are automatically recognized and use mobile technology to communicate anytime anywhere.

This example may be used to aid further the understanding of the importance of automatic sensing of learning in enabling instructors, advisors and the registrar to make faster decisions on feedback to be given to learners.

Smart learning in Catalonia, Spain: use of mobile personalized learning

The faculty of education of Universitat Rovira i Virgili has witnessed several systemic changes regarding digital competence, a key twenty-first

Figure 5.3: Summary of gamification activities in HBMSU smart campus

Source: HBMSU School of E-Education learner's gamification activities century skill, in pre-service teacher education, that is, the education and training provided to student teachers before undertaking any teaching. Among them, the concept of mobile personal learning environments (mPLEs) as a medium for developing students' understanding of the new learning environments emerged as a space for developing teaching ideas and learning approaches. During the last three academic years (2015 to 2018), pre-service teachers explored the concept of mPLEs to develop creative ideas for their later use in teaching.

This example shows the pedagogical experiences in the use of mPLEs in the context of an undergraduate course on multimodal literacy for pre-service teachers. This initiative arose from the lack of knowledge regarding the digital and social competence of pre-service teachers. Different emerging technologies (augmented reality, QR codes, gamification) and the use of manifold apps to suit specific learning outcomes were included as a part of the learning experience (Figures 5.4 and 5.5). Thus, in the pilot study pre-service teachers used mPLEs which combined their everyday life devices with social media tools to enrich their experience and deliver valuable learning experiences in preparation for real-life application. The outcome of this pilot study was that mPLEs provided suitable spaces for the development of teaching ideas and the collection of evidence of student learning outcomes.

In sum, the Spanish example illustrates early stages of the use of intelligent tools to enhance interactions within a teaching and learning community, as well as teaching methods. Some key ideas related to elements of Table 5.1 are:

- using mobile to inter-connect communities anytime, anywhere
- make cross regional community fashionable, in the sense that students interact with students belonging to other communities with the help of mobile technologies, using tools of their everyday life (for example, Instagram stories)
- highlight knowledge construction of community collaboration and media literacy.

This example demonstrates how mPLE can improve pre-service teachers' competencies with using various tools and facilitate the instant sharing process to enhance understanding and practices. These changes will have further positive effects when collaborative learning techniques are integrated into communities of practice.

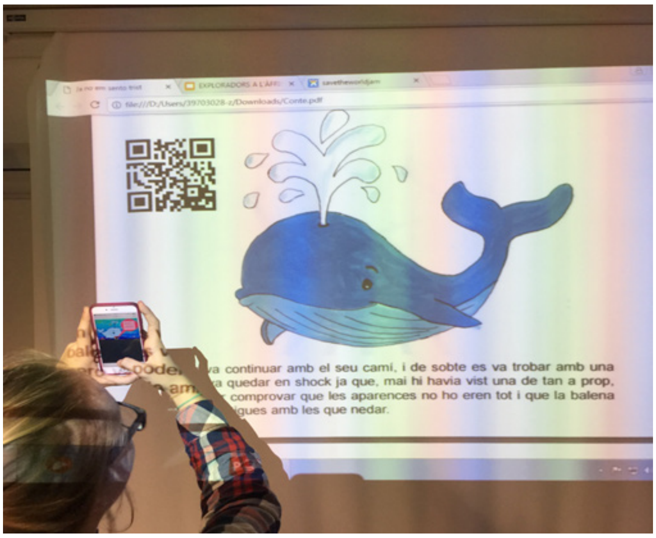
Smart learning in Peru: building a binational expert community

The Peruvian example originated with a project called INICTEL (now INICTEL-UNI), which involved the formation of an engineering-based institute 45 years ago with the goal of training Peruvian engineers in the telecommunication field. Since

Figure 5.4: Pre-service teachers' digital creations using augmented reality

Source: Mar Carmacho, 2018

Figure 5.5: Pre-service teachers' digital creations using mobile story-telling tools and QR codes



Source: Mar Carmacho, 2018

then it has evolved and currently prepares professionals to work on ICTs.

This example focuses on the data centre design programme, executed as part of the International South-South Cooperation between Peru and Colombia. The example was selected on the basis of the direct relationship between data centres and smart cities and the high familiarity of the participants with technology. The main purpose of the programme was to train Colombian professionals to design, construct, supervise, audit, manage and operate/maintain data centres for public and private entities. The learning and teaching community included a tutor and five lecturers in Lima, Peru, 14 professionals in Bogota, Colombia, and two professionals in Cajamarca, Peru. The programme was of blended nature, as it included five virtual courses delivered using both online and asynchronous modes and two specialized workshops and study tours in Bogota, Colombia, as shown in Figure 5.6.

The first session was convened with web videoconferencing to introduce interaction among the participants, provide training on the use of INICTEL-UNI's platform, the teaching methodology and the means available for community

Figure 5.6: The second study tour of data centre in Bogota-Colombia

Source: UNP (Unidad Nacional de Proteccion)- Colombia collaboration. The activities included accessing e-resources, experience sharing through forums, and discussing reports. The online (synchronous) activity was the weekly virtual classroom meeting in which the lecturer and the students participated in discussions about the given topics, focusing on their specific projects at their workplaces. This was supported by the intensive use of WhatsApp community (group) and emails, which are device independent.

The Peruvian example exhibited characteristics of smart learning, which highlighted knowledge construction from community collaboration, use of digital resources independent of the devices, and seamless connection. A key lesson from this example is that building talent for future smart projects is possible using collaborative knowledge construction if:

- there are cultural and language similarities
- the fields are highly competitive
- the turn-around time for training is short.

Emerging technologies can then provide the required support to build smart learning communities as stated in Table 5.1.

Example from Rwanda, Africa: Data modelling and visualization platform

Rwanda is in the implementation phase of the Smart City Master plan in the context of the Smart Africa Alliance.[24] Various stakeholders participate in advancing this initiative. One stakeholder is the African Centre of Excellence in Internet of Things (ACEIoT), which is a World Bank funded initiative.

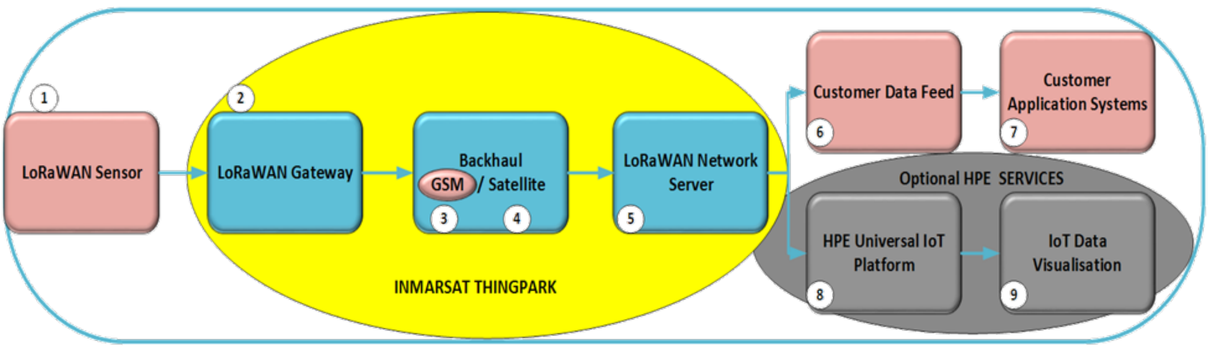
In this research project, students are trained in the field of IoT. The students work on many practical use-cases related to the smart city initiative of Rwanda.

To design and implement a digital representation of reality, the students use various open-source smart platforms that receive, process and store the data, collected from various sensor networks related to the use-cases. These smart platforms provide complex predictive algorithms based on the data collected for the modelling and visualization of data.

ACEIoT currently has signed agreements with Inmarsat, a market leader in mobile satellite services to establish the infrastructure for the IoT enabling environment that will facilitate development of smart city applications, services, and spur innovation. Inmarsat provides access to 15 ACEIoT researchers to test the Inmarsat IoT platform (Figure 5.7). Users access these open source smart platforms that handle raw data from the field and data derived from processing a single point of management of all components across the sensor networks.

The Rwandan example appears not to fit into the framework of Table 5.1, however, it is consistent with the description of smart leaning by Gros:[25] namely, that it comprises smart devices and intelligent technologies which include some properties of ubiquitous computing, AI, IoT and wearable technology. Intelligent technologies refer to learning analytics, cloud computing and AI capabilities, and are vital in capturing valuable learning data that can effectively enhance the development of personalized and adaptive learning. This example illustrates that smart learning frameworks are still in their infancy, and

Figure 5.7: Architecture of Inmarsat Smart Solutions Framework–IoT Eco System



Source: Rwanda smart city flagship project from Ministry of ICT, Rwanda (unpublished) researchers should intensify their research in this area in order to develop more robust frameworks.

Smart learning in Malaysia: experience from selected universities

The extensive use of technology in Malaysian universities today aims to support the development of digital skills to enhance human cognitive activities towards smart learning. At present, most Malaysian higher learning institutions have digital learning options for their students. Whether blended or fully online, these options are available and support aspects of smart learning. Likewise, consistent with the Malaysian government's aspirations to enhance technology integration in the education system, many of the universities have invested in creating their own e-learning platforms to support the development of digital skills for both faculty members and students. As identified by Makani et al. as online learning becomes more prevalent in universities, there is a need to identify the core skills and knowledge that will improve learning in this setting.[26]

A case study was conducted on the skills required by academic staff to make direct contributions to digital learning, and the impact on students' experiences in a smart learning environment. The aim of the case study was to determine the roles and core skills required by faculty in a smart learning environment in order to create a learning experience that will have a positive impact on the students' education. Academic staff from the faculty of education from two universities, namely the Open University Malaysia and University Malaya, Kuala Lumpur, Malaysia, were interviewed.

In this study, it was discovered that faculty members played significant roles in deploying digital learning to students, as online facilitators, programme managers and content curators. For example, in an interview with a senior faculty member who teaches mathematics at the Open University Malaysia, the faculty member indicated that her roles included: managing the university online discussion forum; and creating and curating learning so that the learner experience is unique and personalized in nature for each student taking the mathematics course. The faculty member noted that content curation is becoming more important than e-content development in smart learning systems, as the curated content is available from most cloud-based systems. Related to this, learning design skills are particularly important, and used as extensively as possible as these will enable the system in future to be built around "smart agents" (automated systems) to further search for similar required content and push this content to learners to meet their needs. As such, depending on the learning capability of the student, targeted learning support is provided so that individual students may attain specific learning outcomes.

In another interview a senior lecturer from the faculty of education, University Malaya, noted that in the blended learning approach adopted at her University, the e-learning platform allows learners to communicate with their peers and instructors through interactive tools such as Chat, Choice, Database, Feedback, Forums (two-way), Group choice, Questionnaire, Survey, and Wikis. These tools, which have some inbuilt smart elements, are important as they assist the learners in active co-construction of knowledge with peers and experts.

This example illustrates the variety of roles played by online instructors and the use of social media tools, as well as the need for further enhancement of learning systems to assist online learners in a more efficient way with the use of smart technologies. One emerging theme is the importance of curation of e-content which is not reflected in Table 5.1. This is another aspect that could be included in future emerging frameworks.

Implications and conclusions

The examples above have demonstrated a range of smart learning initiatives such as:

- gamification of smart campus to capture holistic learning experiences
- designing learning through gamification
- personalized mobile learning initiatives
- creation of IoT ecosystems
- creation of initiatives to build digital skills
- curation of e-content

- enhancing the learning impact through communities of learning
- higher and deeper thinking
- seamless connection using specialized tools.

The study of systems that are already in place for smart learning in different countries can promote better sharing of existing practices. Examples and case study experiences add new dimensions to learning and at the same time provide an opportunity for the facilitation of experiential sharing. While potentially challenging, if academics are able to perform smart practices constructively, effective learning can occur intuitively, and educators can shape other twenty-first century skills. Further, other learning processes such as spontaneity, immediacy, and agility may evolve as smart systems become easier to implement through collaborative international linkages. As we are aware, digital transformation requires new ways of thinking which capitalize on the strength of technology and human inventive thought. To move forward through the current wave of digital initiatives, technological systems can be further researched to identify ways of automating routine tasks. Enhancing systems in this way will free individuals to engage in higher levels of thinking, reasoning, decision making and creativity.

A framework for smart learning should prioritize learners. The idea behind our international research group is to create a framework of international smart learning practices which amalgamates the technology with effective and efficient learning. The overarching aim of the framework is to ensure that, alongside the theoretical constructs, there are practical examples available which can easily be implemented within the boundaries of affordable technology.

The success of any transformation process depends on proper, effective, and efficient planning. In the digital transformation of academia, leaders and team members play the most critical role in planning for success of the change process. To this end, it is hoped that the future research of our team will culminate in outcomes that can be used to mobilize technology to effect personalized and meaningful smart learning practices across diverse cultures.

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