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Brief on ICT Trend

ICT in Education

Correspondence concerning this report should be addressed to the email: apcict@un.org

Contact:

Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT/ESCAP)
5th Floor G-Tower, 175 Art Center Daero,
Yeonsu-gu, Incheon, Republic of Korea
Tel +82 32 458 6650
Fax +82 32 458 6691/2
Email apcict@un.org
http://www.unapcict.org

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Table of Contents

List of figures

1. Introduction

The Universal Declaration of Human Rights, which was proclaimed by the United Nations General Assembly in 1948, stated that everyone has a right to education bringing the hope of universal access to education.[1] However, in the decades that followed, the reality proved far from what was envisaged. At the turn of the century, it was noted that only 8% of South Asia's children proceed beyond secondary education.[2] With the rise of the internet and world wide web (WWW), there has been a growing interest in adopting information and communication technologies (ICTs) to solve problems that plagued the education sector. ICTs have been used to address issues such as access to education and improving the quality of education. In the last two decades, there have been several ICT-based interventions in education – the experience and learnings from these efforts can help understand the role of ICTs in the education system. Therefore, the purpose of this write-up is to facilitate sharing of country experiences based on established good practices on the role of ICT in education.

1.1 Education and the SDGs

Goal 4 of the Sustainable Development Goals (SDGs) focuses on 'Quality education' – it aims to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all'.[3] According to the 2017 Annual Report of UNICEF, though 79 per cent of children from the poorest households are now attending primary school, access to quality education is not equitable for those with disabilities; living in remote areas; from poor families or communities affected by conflict; or who are girls.[4]

Therefore, SDG 4 lays out a set of goals and corresponding indicators towards achieving inclusive quality education. Specifically, Target 4.4 (and indicator 4.4.1) as well as Target 4.a (and indicator 4.a.1) emphasise the use of ICTs for creating effective learning environments and for skill development.[5] Target 4.4 aims to increase the number of youth and adults with relevant skills for employment and entrepreneurship. This skill development target is tracked through the proportion of youth and adults with ICT skills (indicator 4.4.1). This recognises the need to adapt education to prepare tomorrow's workforce in using ICT skills for employment and entrepreneurship.

Target 4.a aims to improve and transform educational facilities into child, disability and gender sensitive facilities providing "safe, non-violent, inclusive and effective learning environments for all." One of the indicators of this goal is the proportion of schools with access to computers and internet for pedagogical purposes. This establishes the role that ICTs can play in facilitating effective learning.

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[1] United Nations, "Universal Declaration of Human Rights". Available from http://www.un.org/en/universal-declaration-human-rights/.

[2] Watkins, K. (2000). The Oxfam education report. Oxfam.

[3] United Nations Development Programme, " Goal 4: Quality education". Available from http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-4-quality-education.html

[4] United Nations International Children's Emergency Fund, "Annual Report 2017". Available from https://www.unicef.org/publications/files/UNICEF_Annual_Report_2017.pdf.

[5] Global Indicator Framework For The Sustainable Development Goals And Targets Of The 2030 Agenda For Sustainable Development. (2018). Available from https://unstats.un.org/sdgs/indicators/indicators-list/. Accessed 10 Dec 2018.

The SDGs set the target of 2030 to achieve inclusive and quality education for all with the belief that education will be a driver of sustainable development. Several initiatives and projects, such as the UNESCO-Weidong Group Funds-in-Trust Project, are leveraging ICTs to achieve the 2030 target[6].

1.2 Role of ICT in Education

With respect to education, ICTs have been used to improve access to education in remote areas, enable distance education, create multimedia educational content, improve teacher-student interaction and enhance training in the workplace. The use of ICT in education can be perceived at five hierarchical levels: presentation, demonstration, drill and practice, interaction, and collaboration[7] as given in Figure 1.

Figure 1: Uses of technologies in education

	TECHNOLOGY				
USE	**TEXT**	**AUDIO**	**VIDEO**	**COMPUTER**	**INTERNET**
PRESENTATION	x	x	x	x	x
DEMONSTRATION	x	x	x	x	x
DRILL & PRACTICE	x	(e.g., Language lab)		x	x
INTERACTIVE	hyperlink			x	x
COLLABORATIVE				networked	x

Source: Haddad, W. D., & Draxler, A. (2002). The dynamics of technologies for education. *Technologies for Education Potentials, Parameters, and Prospects, ed. by Wadi D. Haddad and Alexandra Draxler*, 2-17.

The term 'e-learning' is frequently used in the context of ICT in education. It refers to use of computer network technology, such as the internet or local area networks (within an organization), to facilitate different aspects of learning – including delivery of education material and instruction, communication with instructor and interaction among peers.[8] In its simplest form, use of Microsoft PowerPoint slides can be thought of as an example of e-learning. However, e-learning may also include more sophisticated use of digital devices and the internet in higher education and organizational trainings. It has emerged as a common term to refer to computer-based learning as well as web-based learning.

[6] United Nations Educational, Scientific and Cultural Organization, "Leveraging ICT to achieve Education 2030". Available from https://en.unesco.org/themes/ict-education/weidong

[7] Haddad, W. D., & Draxler, A. (2002). The dynamics of technologies for education. Technologies for Education Potentials, Parameters, and Prospects, ed. by Wadi D. Haddad and Alexandra Draxler, 2-17

[8] Welsh, E. T., Wanberg, C. R., Brown, K. G., & Simmering, M. J. (2003). E-learning: emerging uses, empirical results and future directions. *International Journal of Training and Development*, *7*(4), 245-258.

E-learning does not happen in isolation. In most cases, e-learning technologies are integrated into existing classroom practices. This integration of digital tools with face-to-face learning experience is referred to as 'blended learning'. It recognises the value in face-to-face learning and compliments this with ICT tools to facilitate effective interaction and collaboration.[9] As an approach, blended learning acknowledges the role of the teacher, peers, the classroom and school while designing and implementing ICT interventions in education.

Figure 2: Blended learning methodology

Source: By 24x7learning.com [Public domain], via Wikimedia Commons

2. Use of ICT in Education - Regional Trends and Case Studies

2.1 Regional trends in ICT in Education

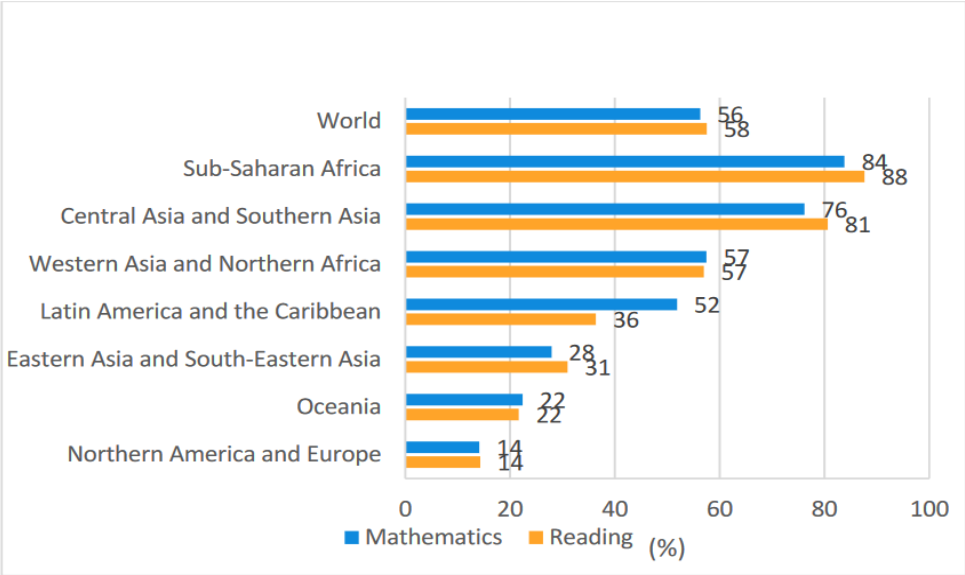
SDG 4's focus on quality education brought the learning outcomes of school education under scrutiny. It was found that more than 617 million children and adolescents, worldwide, did not achieve minimum proficiency levels (MPLs) in reading and mathematics.[10] As seen in Figure 3, countries in Central and Southern Asia reported the second-highest proportion of children and adolescents not reaching proficiency levels with 81% of them unable to read well. This ratio stands even higher when assessing boys only with 84% of them being unable to read proficiently.[11] About one half of the children and adolescents in Western Asia (along with Northern Africa) and nearly about one-third of them in Eastern and South-Eastern Asia are unable to read proficiently.

[9] Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The internet and higher education*, *7*(2), 95-105.

[10] UNESCO Institute for Statistics, "More Than One-Half of Children and Adolescents Are Not Learning Worldwide". Available from http://uis.unesco.org/sites/default/files/documents/fs46-more-than-half-children-not-learning-en-2017.pdf.

[11] Ibid.

Figure 3: Proportion of children and adolescents not achieving MPLs in mathematics and reading, by SDG region

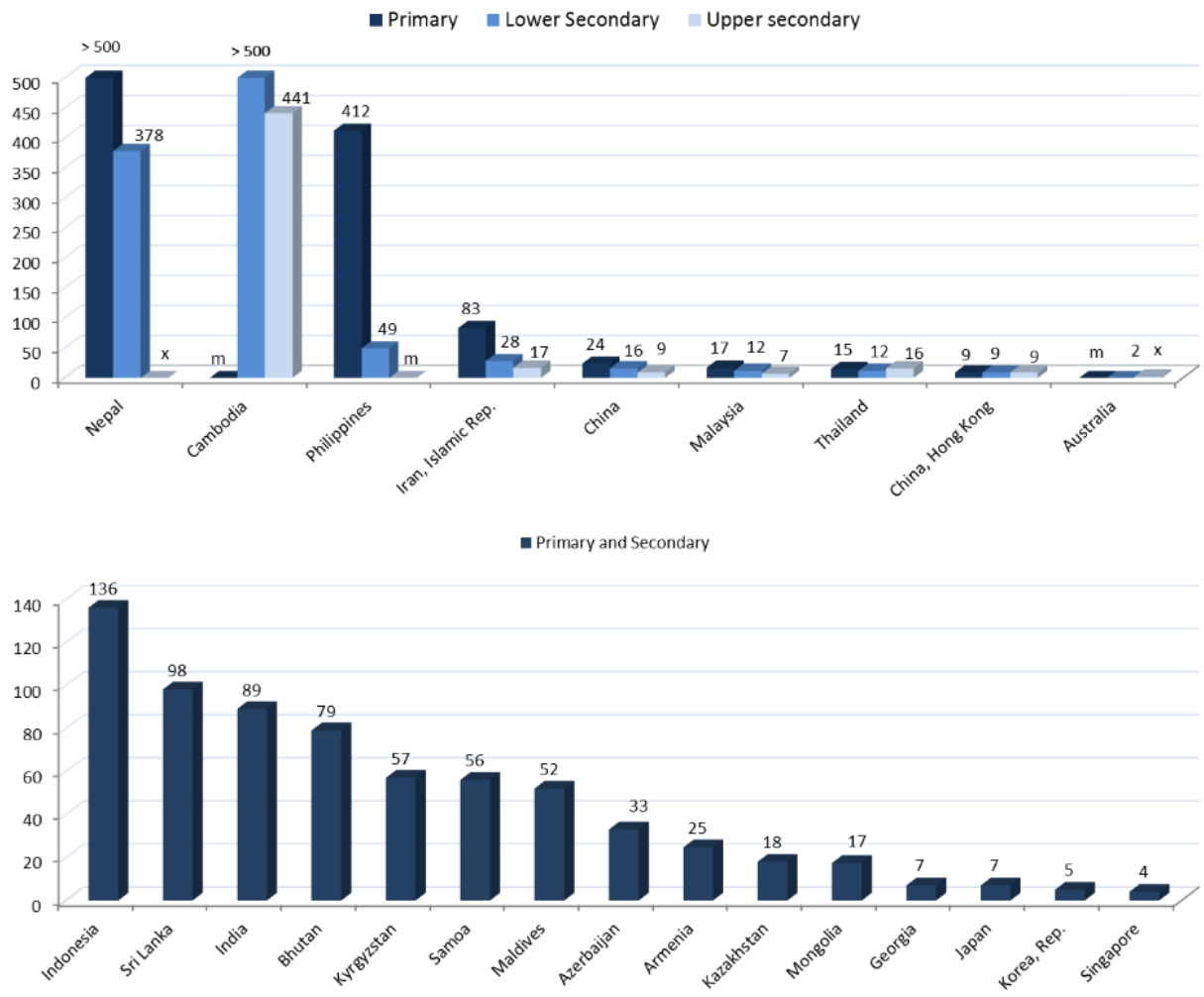


Source: UNESCO Institute for Statistics, "More Than One-Half of Children and Adolescents Are Not Learning Worldwide". Available from http://uis.unesco.org/sites/default/files/documents/fs46-more-than-half-children-not-learning-en-2017.pdf.

It is in this context that ICTs are introduced, with the hope of improving the quality of education. Asia has witnessed a high level of integration of ICTs in high-income countries and those that are considered developed. However, the lower-income and developing countries lag behind in the use and integration of ICTs in education. This can be seen in Figure 4, which shows the learner-computer ratio (LCR) across schools in different countries. In countries like Singapore, Republic of Korea and Australia the LCR is below 5. This means that less than 5 students share a computer in these countries, whereas in Nepal, Cambodia and Philippines the learner-computer ratio is very high. This may mean that the computer time of each student may be very limited.[12]

[12] Wallet, P., & Melgar, B. V. (2014). INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN EDUCATION IN ASIA: A comparative analysis of ICT integration and e-readiness in schools across Asia. UNESCO Institute for Statistics, http://dx. doi. org/10.15220/978-92-9189-148-1-en.

Figure 4: Learner-to-computer ratio (LCR) by level of education



Source: Wallet, P., & Melgar, B. V. (2014). INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN EDUCATION IN ASIA: A comparative analysis of ICT integration and e-readiness in schools across Asia. UNESCO Institute for Statistics, http://dx. doi. org/10.15220/978-92-9189-148-1-en.

This does not automatically mean that ICTs are not well integrated into education in those countries. Computers are only one type of ICTs; radio, television, internet, mobile phones, games, apps, videos, simulations are also ICTs that have played a significant role in education. Several initiatives in different countries have tried to introduce ICTs in education to improve quality and/or access to education. The rest of this section presents few case studies to highlight the varied use of ICTs in education.

2.2 Digital aids in the classroom

Early use of computers in classrooms was limited to higher education in institutions in the United States. Over the years, computers and other digital technologies have found their way into classrooms, not only in the United States, but also in other countries. These technologies have been used in the classroom setting for varied purposes – ranging from simply displaying slides, images and videos on a computer or projector to dedicated devices for each student for interaction and collaboration purposes.

It is said that the use of ICTs has also enabled the concept of flipped classrooms (see Figure 5). In a regular classroom, a teacher addresses the students to introduce a new lesson and at the end of the lesson, the students are given homework based on the day's lesson. The following day, minimal class time is spent on clarifying doubts and discussing the homework. A flipped classroom reverses this traditional model of classroom instruction. What is usually done in class (such as teaching a new topic) happens at home through online videos and what is typically given as homework is done during class.[13]

Students watch the lesson's videos before the class and work on related assignments or activities during class. New concepts are presented in the videos, and the Q&A time (mentioned in Figure 5) in class, the following day, serves to clarify doubts and hold discussions. In a flipped classroom, the videos are primarily used as a presentation tool (as seen in Figure 1) that provide a starting point for discussions and interaction. Classroom time is thus spent on teacher-student interaction rather than the teacher just delivering information. The flipped classroom model requires students and teachers to have access to a computer or smartphone as well as internet to post videos for each course topic and watch the videos at home, respectively.

Figure 5: Comparison of class time in traditional versus flipped classrooms

Traditional Classroom		Flipped Classroom	
Activity	*Time*	*Activity*	*Time*
Warm-up activity	5 min.	Warm-up activity	5 min.
Go over previous night's homework	20 min.	Q&A time on video	10 min.
Lecture new content	30–45 min.	Guided and independent practice and/or lab activity	75 min.
Guided and independent practice and/or lab activity	20–35 min.		

Source: Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. International society for technology in education.

Case: One Laptop Per Child (OLPC)

One Laptop Per Child (OLPC) is an international project which was launched with the mission of putting a laptop in every child's hands. It was based on the principle that owning a laptop would empower self-learning.[14] OLPC distributes low cost laptops (called laptop XO) to children in schools as a means to access knowledge available on the internet. The project has been implemented at a large scale in Latin America, with roughly 2 million students and teachers being a part of OLPC. In Asia, the project has been

[13] Bergmann, J., & Sams, A. (2012). Flip your classroom: Reach every student in every class every day. International society for technology in education.

[14] One laptop per child, "Mission". Available from http://one.laptop.org/about/mission.

implemented in Afghanistan, Nepal and Mongolia.[15] Developing countries showed enthusiasm and pledged support to implement OLPC as a move towards improving the standard of education. However, the cost it incurred deterred governments from spending on the project. OLPC was criticised, not just for the expense overhead it placed on developing countries but also for indirectly discouraging the shared use of devices[16] among children. OLPC's belief that a laptop, by itself, would cause revolutionary change was also criticised for overlooking the context in which the devices would be used. Though the laptop was generally well-received, there were issues of lack of repair support, teacher training and availability of internet.[17]

2.3 Learning management systems

Learning management system (LMS) refers to software systems used to manage several aspects of the learning process.[18] As an application, an LMS is used to deliver and manage instructional content, assess individual learning, track progress towards (academic) goals and supervise the learning process.[19] It is mostly used in universities and educational organizations. Apart from managing course content, it can also handle course registration and administration.[20] There are several LMS software applications available, both proprietary as well as open source. The following example is a popular open source LMS software called Moodle.[21]

Case: Moodle

Moodle is a widely used e-learning platform which allows online exchange of information among students and teachers through chats and discussion forums. It also includes features for student assessment, content sharing and other tools to support the learning and teaching process.[22] Moodle is a free and open-source application. This allows any school, university, organisation or independent teacher to use the application as it is or customize it according to their specific needs. They are not liable to pay any licence fee. Therefore, it can be considered more accessible and a viable choice for developing countries, compared to commercial software such as *Blackboard* and *WebCT*. Moodle can be linked to other systems such as mail servers or student directories.[23]

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[15] One laptop per child, "Countries". Available from http://one.laptop.org/about/countries.

[16] James, J. (2010). New technology in developing countries: A critique of the one-laptop-per-child program. *Social Science Computer Review*, *28*(3), 381-390.

[17] Kraemer, K. L., Dedrick, J., & Sharma, P. (2009). One laptop per child: vision vs. reality. *Communications of the ACM*, *52*(6), 66-73.

[18] Watson, W., & Watson, S. L. (2007). An Argument for Clarity: What are Learning Management Systems, What are They Not, and What Should They Become.

[19] Szabo, M. (2002). Cmi theory and practice: Historical roots of learning managment systems. In *E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 929-936). Association for the Advancement of Computing in Education (AACE).

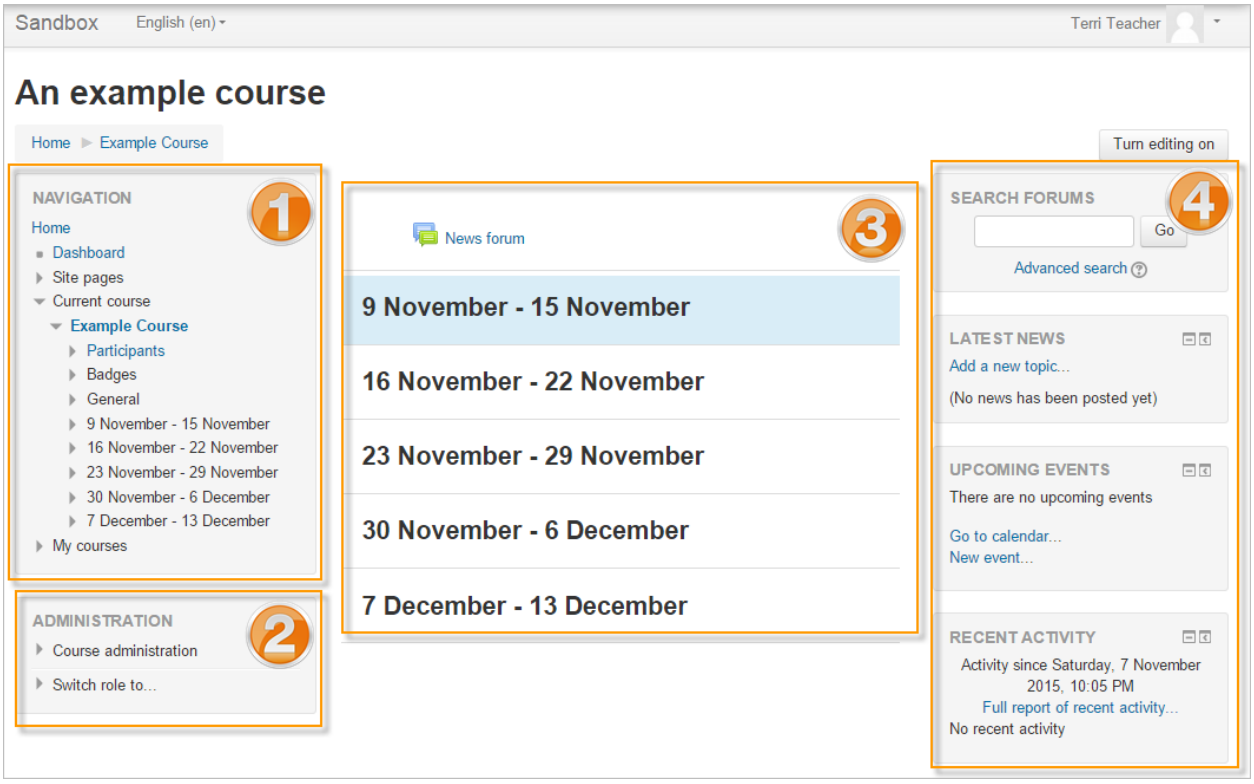
[20] Gilhooly, K. (2001). Making E-Learning Effective. *Computerworld*, *35*(29), 52-53.

[21] Moodle. Available from https://moodle.org/.

[22] Costa, C., Alvelos, H., & Teixeira, L. (2012). The use of Moodle e-learning platform: a study in a Portuguese University. *Procedia Technology*, *5*, 334-343.

[23] Dougiamas, M., & Taylor, P. (2003). Moodle: Using learning communities to create an open source course management system. In EdMedia: World Conference on Educational Media and Technology (pp. 171-178). Association for the Advancement of Computing in Education (AACE).

Figure 6: Example Course Layout in Moodle



Source: Moodle, 'Example course'. Available from https://docs.moodle.org/35/en/Course_homepage

Case: Facebook as LMS

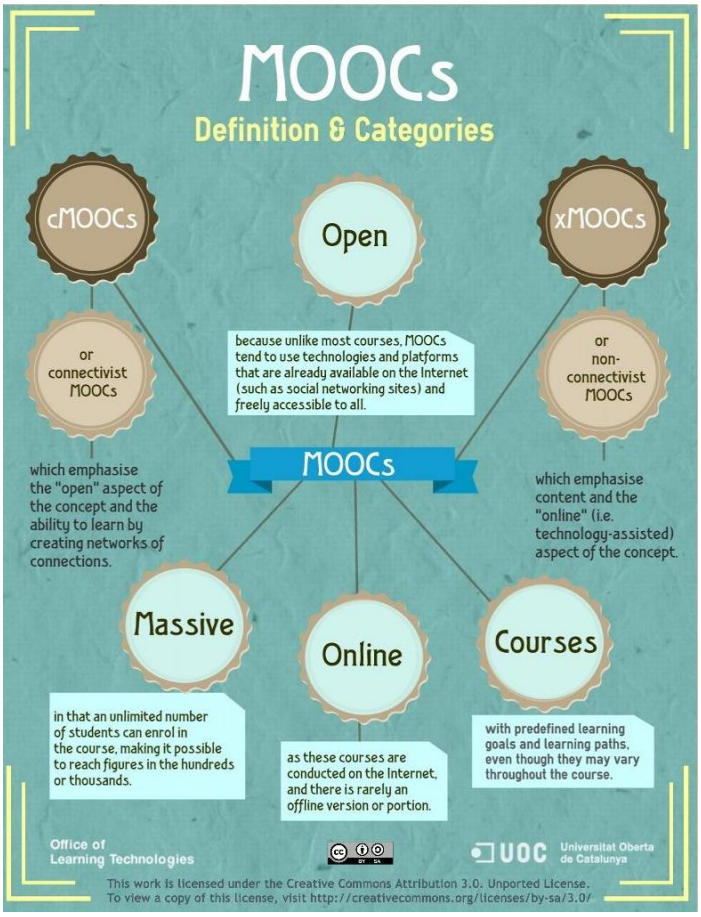
Existing LMS applications have certain limitations, which have led to the use of social media sites like Facebook as alternatives. At a teacher education institute in Singapore, a Facebook group was used as a LMS to sidestep the constraints posed by more traditional LMS.[24] For instance, trainee teachers could not access features like course creation, student enrolment and assessment as these are enabled for administrators or instructors only. Secondly, the course content would not be accessible to them once they graduate. To overcome these issues, they used a Facebook group as a LMS to post announcement, share course material and hold online discussions.

2.4 Internet-enabled distance education

ICTs play a significant role in enabling distance education. With the internet came the hope of expanding access to education with Massive Open Online Courses (MOOCs) facilitating that access. MOOCs are online courses, which are often available free of cost accessible with a computer or smartphone and internet. People from any part of the world can access the courses on a MOOC website. Popular MOOCs like Coursera, edX and Khan Academy offer hundreds of courses, in multiple languages, across diverse disciplines. Apart from these, there are other kinds of open or distance education courses offered by several universities across the world. The course management happens through their online portals.

[24] Wang, Q., Woo, H. L., Quek, C. L., Yang, Y., & Liu, M. (2012). Using the Facebook group as a learning management system: An exploratory study. British Journal of Educational Technology, 43(3), 428-438.

Figure 7: MOOCs – Definitions and Categories



Source: By Universitat Oberta de Catalunya [CC BY-SA 2.5], via Wikimedia Commons. Available from https://commons.wikimedia.org/wiki/File:MOOCsDefinition.png

Figure 7 describes the two main categories of MOOCs. Extended MOOCs (xMOOCs) are those MOOCs which are much like the traditional university courses - an instructor presents the course material through video and students follow the course online. xMOOCs are popular as it allows expanding access to university-level courses to a larger number of students. In connectivist MOOCs (cMOOCs), there is no single instructor. It is a collaborative learning environment in which all participants take on roles of both learning, as well as teaching.[25] Over the years, xMOOCs have gained wider adoption and are commonly referred to as MOOCs.

Case: Khan Academy

Khan Academy is a MOOC which offers courses in maths, science, computer science, humanities and other disciplines. Khan Academy was developed with the mission of providing "a free, world-class education for anyone, anywhere."[26] This model makes its contents available to millions of students of all

[25] Kesim, M., & Altınpulluk, H. (2015). A theoretical analysis of MOOCs types from a perspective of learning theories. *Procedia-Social and Behavioral Sciences*, *186*, 15-19.
[26] Khan Academy, "About". Available from https://www.khanacademy.org/about.

age groups. It provides the flexibility to choose any course they are interested in and learn at their own pace. Although MOOCs like Khan Academy have great patronage, studies have shown that they are heavily used only in North America and Europe.[27] Their use in Asia is limited by the lack of 'meaningful access', language constraints, computer literacy and other issues.[28]

Case: Virtual University of Pakistan

Virtual University of Pakistan (VUP) was set up in 2002 to improve nationwide access to education. VUP was specifically designed to harness the advantages of ICTs to enable distance education. Initially, VUP used four free-to-air TV channels to broadcast lectures. Since 2008, video-lectures are uploaded to YouTube. VUP enables access to additional reading materials and notes through LMS. The LMS is also used for conducting assignments, practice tests, pop-quizzes and student-teacher interaction through 'discussion boards'.[29] Renowned academics were invited to design courses and produce lecture videos. In 2011, VUP took its first step towards providing Open Educational Resources (OER) by releasing some of its courses under a Creative Commons licence. This made VUP's course content accessible to other institutions and benefitted many professors and students worldwide. The readily available content enabled some professors to adopt the flipped classroom model.[30] Within the first six months of its inauguration, VUP rolled out its first bachelors programme in computer science; currently the university offers bachelors and masters programmes in arts, computer science and information technology, science and technology, management and education.[31] Since 2015, VUP has also opened doctoral programmes in a couple of disciplines.

2.5 Multimedia content with AR/VR

Latest digital technologies such as augmented reality (AR) and virtual reality (VR) provide novel ways of creating and presenting multimedia content in education. Augmented reality technology allows computer generated virtual imagery to be laid over a real-world environment. AR has also been used in schools as well as universities to teach subjects like biology, chemistry and mathematics.[32]

Virtual reality, on the other hand, provides a completely computer-generated virtual environment. Unlike AR, virtual reality technologies do not extend the real-world environment or objects.[33] VR is popularly used in flight simulators and military training. AR and VR tools encourage students to engage with their course content in a more in-depth fashion by investigating concepts through interaction with the environment and its objects.

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[27] Adams, A., Liyanagunawardena, T., Rassool, N., & Williams, S. (2013). Use of open educational resources in higher education. British Journal of Educational Technology, 44(5), E149-E150.

[28] Liyanagunawardena, T. R., Williams, S., & Adams, A. A. (2014). The impact and reach of MOOCs: a developing countries' perspective. eLearning Papers, 38-46.

[29] Virtual University of Pakistan, "How VU Works" Available from http://orientation.vu.edu.pk/About/HowVUWorks.htm.

[30] Malik, N. (2013). The genesis of OER at the Virtual University of Pakistan. Open educational resources: an Asian perspective, 133-140.

[31] Virtual University of Pakistan, "All Academic Programs". Available from http://www.vu.edu.pk/pages/AllPrograms.aspx

[32] Lee, K. (2012). Augmented reality in education and training. *TechTrends*, *56*(2), 13-21.

[33] Ibid.

Figure 8: Use of AR in classrooms

Source: Lee, K. (2012). Augmented reality in education and training. *TechTrends*, *56*(2), 13-21.

Conventionally, three dimensional models are used in astronomy classes to capture the imagination of students. Schools often use physical models for this purpose. Primary schools in France experimented with the use of augmented reality in the place of physical models. The AR-based models not only provided a 3D view of the celestial bodies but also enabled students to touch and move the celestial bodies and investigate various astronomical phenomena.[34] Moreover, augmented textbooks provide 3D projections of diagrams and images pictured in the textbooks.

There is also evidence of the use of AR in other STEM[35] fields and healthcare[36] education. LearnAR, Zooburst, Fetch Lunch Rush, Wordlens, SkyView and Transparent Earth are some of the popular AR educational tools that have emerged in the recent years.[37]

Case: Virtual Reality Learning Environment (VRLE) in engineering

The University of Warwick in the United Kingdom set up an interactive 3D virtual reality visualisation system for engineering graduates to practically experience real industrial environments. The virtual reality environment allowed students to apply theoretical concepts to real industrial problems - this improved teaching and training of engineers and helped develop their problem-solving skills.[38]

[34] Fleck, S., & Simon, G. (2013, November). An augmented reality environment for astronomy learning in elementary grades: an exploratory study. In *Proceedings of the 25th Conference on l'Interaction Homme-Machine* (p. 14). ACM.

[35] Estapa, A., & Nadolny, L. (2015). The effect of an augmented reality enhanced mathematics lesson on student achievement and motivation. *Journal of STEM education*, *16*(3).

[36] Zhu, E., Hadadgar, A., Masiello, I., & Zary, N. (2014). Augmented reality in healthcare education: an integrative review. *PeerJ*, *2*, e469.

[37] Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented Reality in education–cases, places and potentials. *Educational Media International*, *51*(1), 1-15.

[38] Abulrub, A. H. G., Attridge, A. N., & Williams, M. A. (2011, April). Virtual reality in engineering education: The future of creative learning. In *Global Engineering Education Conference (EDUCON), 2011 IEEE* (pp. 751-757). IEEE.

As seen in the above cases, AR and VR provide opportunities for constructivist learning[39] - one where students do not merely absorb information but also understand it with respect to their existing knowledge and relate to its applications in the real world. AR and VR have to potential to support this kind of constructivist learning by facilitating exploration and experiencing of the real world. However, currently these technologies are resource intensive and potentially expensive to set up.

Figure 9: Student engineering team at Warwick using the VR system

Source: Abulrub, A. H. G., Attridge, A. N., & Williams, M. A. (2011, April). Virtual reality in engineering education: The future of creative learning. In *Global Engineering Education Conference (EDUCON), 2011 IEEE* (pp. 751-757). IEEE.

3. Technology and Other Components of ICT in Education

The implementation of ICT in education is dependent on several factors. These include the availability of computer or mobile hardware, access to internet, repair support, training new users, and creating content. Depending on the nature of the ICT intervention, a subset of or all these factors may play a significant role in the meaningful integration or use of the intervention.

3.1 Technology infrastructure

While considering the use of ICT for educational purposes, it is important to choose the appropriate technology. One of the primary considerations in almost all ICT interventions is infrastructure. This refers to the hardware devices, technologies for (internet) connectivity and software choices. It also includes dependent infrastructure like availability of electricity, physical space (like labs and classrooms), and maintenance and support services. Though these are largely technical aspects of an ICT project, the technology choices for infrastructure should be based on educational needs, pedagogical goals and budgetary constraints.[40]

[39] Huang, H. M., Rauch, U., & Liaw, S. S. (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. *Computers & Education*, *55*(3), 1171-1182.

[40] Rusten, E., & Hudson, H. E. (2002). Infrastructure: hardware, networking, software, and connectivity. WD Haddad and A. Draxler içinde, Technologies For Education Potentials, Parameters, And Prospects Washington, DC: Academy for Educational Development, 76-94.

For instance, IT @ Schools initiative in Kerala (India) uses Free and Open Source Software (FOSS). As FOSS is freely available for use and distribution, the limited public funds could be spent on hardware and supporting infrastructure. Their software choices helped cut down expenditure towards license fee, incurred in the case of proprietary software, and this propelled 100% coverage by the initiative.[41] A similar choice was also observed by adopting Moodle as the initiative LMS.

In the case of OLPC, although the XO laptops were customized to be low-battery and dirt tolerant, lack of availability of spare parts and service centres deterred the use of the laptops in several rural areas.[42] Therefore, ICT interventions require a careful consideration of educational goals and an understanding of which technologies would be best suited to facilitate those goals.

Another important ICT infrastructure required to support and enhance education is internet. Reliable and affordable broadband connectivity becomes a prerequisite in this regard. However, the Asia-Pacific region continues to witness a worrying trend of digital divide with respect to the rest of the world. As of 2016, the fixed-broadband subscriptions per 100 inhabitants in the Asia-Pacific region was below the global average and far lower than Europe and North America.[43] Even within the region, significant disparities among countries exist with advanced economies (predominantly in East and North-East Asia) having improved connectivity in terms of number of subscriptions as well as quality. For instance, Republic of Korea reports more than 40 fixed-broadband subscriptions per 100 inhabitants.[44] In sharp contrast, at least 18 countries in the region still have less than 2 fixed-broadband subscriptions per 100 inhabitants.[45]

In order to harness the benefits of ICT-driven education towards "inclusive and equitable quality education" (as per SDG4), it is crucial to bridge the digital divide in the Asia-Pacific region. Only when access to ICTs is equitable, can it enable inclusive and equitable education.

3.2 Teacher training

Teachers are an important stakeholder in the context of ICT use in education. Meaningful integration of ICT into the learning process is dependent on understanding the role of the teacher in that process. Involving them as a valued participant is necessary for the sustained use of ICT in education. Historically, it has been observed that attempts to impose a technologist's or policy maker's vision of appropriate technology in schools have failed when the real needs of teachers are not adequately addressed.[46] Teachers, who are convinced about the value of ICTs in classrooms, play a critical role in the meaningful use of ICT. There is need for "orientation and training for all concerned staff in the strategic, technical, and pedagogical dimensions of the process."[47]

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[41] Kasinathan, G. (2009). ICTs in school education: outsourced versus integrated approach.

[42] Kraemer, K. L., Dedrick, J., & Sharma, P. (2009). One laptop per child: vision vs. reality. Communications of the ACM, 52(6), 66-73.

[43] United Nations Economic and Social Commission for Asia and the Pacific, "State of ICT Connectivity in Asia and the Pacific 2017". Available from https://www.unescap.org/sites/default/files/StateofICT2017_16Jan2018.pdf.

[44] Ibid.

[45] Ibid.

[46] Cuban, L. (1986). Teachers and machines: The classroom use of technology since 1920. Teachers College Press.

[47] Haddad, W. D., & Draxler, A. (2002). The dynamics of technologies for education. Technologies for Education Potentials, Parameters, and Prospects, ed. by Wadi D. Haddad and Alexandra Draxler, 2-17

Uganda's Connectivity for Educator Development (Connect-ED) project integrates the use of ICT into training programs for primary school teachers at Primary Teachers' Colleges (PTCs). Computer centres were set-up at PTCs to provide computer literacy and build an interactive online version of the curriculum.[48] By providing computer training and facilitating content creation, the aim was to motivate teachers to explore new ways to use ICT in their classrooms.[49]

3.3 Content creation

Attempts to improve the quality of education by use of ICT often involve providing multimedia content that is considered more engaging and interesting than the standard textbook. In such cases, content creation is an important part of the process. It involves the use of multimedia content such as images, audio, video, graphics and simulations to create (or transform existing) educational content. Content creation can be an intensive, time consuming process which requires technology skills as well as subject knowledge. One of the key considerations with respect to content creation is who produces the multimedia content.[50]

Centralized development of such content, by collaborating with subject matter experts, enables the delivery of the content on a large scale. Such a model would be similar to the centralized creation of textbooks. MOOCs follow a centralized model of content development. On the other hand, empowering teachers, at the institution level, to develop multimedia content creates avenues to adapt the curriculum based on their knowledge and understanding of the students. Accordingly, they would be able to provide relatable examples.

3.4 Support and management

Any ICT project involves multiple components and a diverse set of stakeholders. In most cases, the components are interdependent – for instance, availability of suitable infrastructure and skilled teachers or resource persons are pre-requisites to the content creation process. There is a need for collaboration among stakeholders at every stage of implementation. It involves communicating needs, negotiating and building consensus, providing feedback, and extending support. Efficient project management is key to the successful implementation of ICT interventions in education.

4. Policy Implications and Challenges for ICT in Education

4.1 Policy responses to ICT in education

In recent years, ICT has been heralded as an enabler of quality education. International organizations, such as UNESCO, undertake efforts "to help countries understand the role such technology can play to

[48] Farrell, G. (2007). Survey of ICT and education in Africa: Uganda country report.

[49] Fountain, M. (2001). Teacher training with technology. Notes from the field.

[50] Nunes, C., & Gaible, E. (2002). Development of multimedia materials. Technologies for education: potentials, parameters, and prospects. Paris: UNESCO, 94-117.

accelerate progress toward Sustainable Development Goal 4 (SDG4)".[51] They present evidence of successful integration of ICT in education, from different parts of the world, to guide policy making. Building on such guidance, several countries have adopted technology as a means of improving education. Their national policies reflect their motivations to turn to ICTs for education and the role envisioned for ICTs in education.

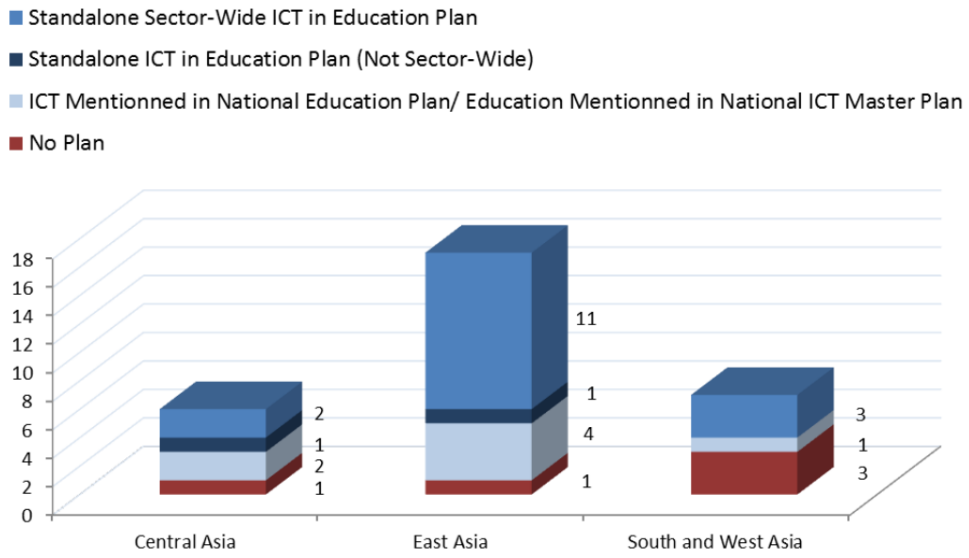
Singapore's investment in ICT for education is driven by its potential to support economic development. The ICT Master Plans strive to prepare students for the workforce.[52] Another approach towards ICT in education is to enable social change. Chile aims to address the social inequalities in the country through its educational ICT policy.[53] It specifically pays attention to ICT access in rural schools which "have been traditionally underserved by the education system."[54] Formulation of ICT policy for education is influenced by social and economic aspirations of that region.

Policies to incorporate ICT in education have taken different shapes in different countries. As seen in Figure 10, some countries such as Nepal, Bangladesh, Malaysia, the Philippines and New Zealand have developed formal standalone plans on ICT in education, while Iran has added ICT in education within the ambit of the National ICT Master Plan and countries like Kyrgyzstan and Mongolia have included an ICT component in the National Education Policy.[55] Moreover, policies in these countries also vary in strategy.

In Bhutan and the Philippines, basic computer skills and computing are emphasised from lower secondary education, while in Sri Lanka, Myanmar and Nepal this emphasis begins only in upper secondary education. Kazakhstan's formal recommendations include using e-learning in local languages for all subjects and in all schools. This is viewed as a measure to eliminate digital divide. Bangladesh focusses on the use of ICTs in mathematics and natural sciences but not second languages, while Mongolia and Cambodia focus only on mathematics and natural sciences respectively.[56]

[51] United Nations Educational, Scientific and Cultural Organization, "ICT in education". Available from https://en.unesco.org/themes/ict-education.
[52] United Nations Educational, Scientific and Cultural Organization, "ICT Masterplans in the Singapore Education System". Available from http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/ED/images/singapore.pdf.
[53] Kozma, R. B. (2008). Comparative analysis of policies for ICT in education. In International handbook of information technology in primary and secondary education (pp. 1083-1096). Springer, Boston, MA.
[54] Ibid.
[55] Wallet, P., & Melgar, B. V. (2014). INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN EDUCATION IN ASIA: A comparative analysis of ICT integration and e-readiness in schools across Asia. UNESCO Institute for Statistics, http://dx. doi. org/10.15220/978-92-9189-148-1-en.
[56] Ibid.

Figure 10: National plans to implement ICT in education



Source: Wallet, P., & Melgar, B. V. (2014). INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN EDUCATION IN ASIA: A comparative analysis of ICT integration and e-readiness in schools across Asia. *UNESCO Institute for Statistics, http://dx.doi. org/10.15220/978-92-9189-148-1-en*.

4.2 Policy recommendations

The initial adoption of ICT was fuelled by hope and theoretical possibilities. The last 20 years of ICT use in education provide rich experiences to reflect upon. The collective experiences, from various parts of the world, over the years can contribute towards evidence-based policy and decision making.

Based on these experiences, it is evident that ICT-based interventions in education have worked well in cases where they have followed a constructivist approach - laying emphasis on the learners and their experiences which shape their knowledge. This approach regards learners as active members and learning as a social activity; learners are not confine to passively consume information presented to them. Evidence from case studies shows that efforts which have introduced ICTs in the learning environment for mere information consumption have met with little success. On the other hand, those which have meaningfully integrated ICTs into the social activity of learning with adequate opportunities for the students to interact, explore and discover knowledge have had more meaningful impact. Therefore, it may be useful to adopt a constructivist approach to embed the use of ICTs in existing learning and teaching practices.

There is also a lack of adequate evidence of ICT's role itself in improved learning outcomes.[57] Lack of adequate data, especially in Asia-Pacific countries, for ICT-related indicators for SDG 4 has been a major challenge to track and monitor the progress towards SDG 4. While considering the future of ICT in education, particularly in the SDG context, it is important to realise the role of statistics in evidence-based policy making. Therefore, another recommendation is for national policies to recognise the

[57] Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. Oxford review of education, 38(1), 9-24.

importance of tracking the penetration of ICT in their respective countries and the use of ICTs in education. As a step towards this, the UNESCO Institute for Statistics (UIS) recently launched the 'SDG 4 Data Digest 2018: Data to Nurture Learning' which provides internationally-comparable data to track progress towards SDG 4.[58]

Countries may benefit by having an ICT development strategy that looks at least 10 years into the future and policies which lay emphasis on:

i. a curriculum that effectively integrates ICT in subject syllabuses,
ii. provision of ICT hardware (computers and peripherals) in classrooms to increase access of students and teachers,
iii. reliable power supply to all schools,
iv. teacher training strategies that strengthen their role in the ICT classrooms,
v. access to professional and affordable maintenance and support services, and
vi. a detailed total cost of ownership assessment for ICT in education initiatives to ensure such measures are affordable and sustainable.

[58] UNESCO Institute for Statistics, "Launch of the SDG 4 Data Digest: Data to Nurture Learning". Available from http://uis.unesco.org/en/news/launch-sdg-4-data-digest-data-nurture-learning.

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Glossary

Disability: An umbrella term for impairments, activity limitations and participation restrictions.

Distance education: The education of students who may not always be physically present at a school. These are offered as correspondence courses.

Hardware: The physical, tangible parts or components of a computer or other electronic devices.

Open source: A decentralized model of software development that encourages open collaboration.

Projector: A device that projects an image onto a surface, most often a screen.

Software: It is a collection of data or computer instructions that is used to direct the operations of a computer.

Acronyms

E-learning	Electronic learning
FOSS	Free and Open Source Software
ICT	Information and Communication Technology
LMS	Learning Management System
M-learning	Mobile Learning
MOOC	Massive Online Open Course
OLPC	One Laptop Per Child
SDG	Sustainable Development Goal
SMS	Short Message Service
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Educational Fund