




Offline Internet for Remote Learning in Low-Resource Environments

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Abstract

Offline Internet is a specially designed computer system that stores information in very large quantities for learning in low-resource regions, either by direct retrieval of information from a storage device, a Wi-Fi-enabled seeder sharing its resources with leech-computers or a device that periodically updates its local information contents whenever it goes online. The offline population faces barriers to Internet adoption spanning four categories: incentives, low incomes and affordability, user capability and infrastructure. The taxonomy of offline Internet is classified functionally under three major groupings: completely offline systems, hybridised offline systems and offline servers. The problems of offline Internet include a learning analytics challenges, what learning metric to measure, device divide, gender divide, institutional technophobia, and the need for greater local technical competency. Recommendations made include enabling offline Internet interventions to supply data on user's learning activities for educational data mining goals, building in of learning analytics component that simulates the academic performance of users, memory retention, learner engagement and self-regulated learning, and the use of existing technological devices that are owned by the majority of the target population. Women should be necessarily included in technological interventions for remote learning, and they should be ensured of meaningful benefits from such projects; thus, schools and educators should encourage both bring-your-own-device and use-your-own-device (UYOD) initiatives as practical

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steps to overcoming the digital divide and a smart way to utilise digital literacy skills, and efforts should be made to expose some driven students to the technologies so that in the absence of technicians, meaningful solutions can still be realised.

Keywords: offline internet, remote learning, SDG 4, low-resource environments, emergencies.

Introduction

Offline Internet is that specially designed computer system that stores information in very large quantities for learning in low-resource regions and/or emergencies, either by direct retrieval of information from a storage device, a Wi-Fi-enabled seeder sharing its resources with leech-computers or a device that periodically updates its local information contents whenever it goes online. We are in the age of “device store width” and no longer Internet bandwidth; thus, the amount of relevant information a non-human device can store offline is more important than Internet speed which is unavailable in most parts of the Global South and emergencies.

According to Sprague *et al.*, (2014), the offline population faces barriers to Internet adoption spanning four categories: incentives, low incomes and affordability, user capability and infrastructure. For incentives, barriers in this category include a lack of awareness of the Internet or use cases that create value for the offline user, a lack of relevant (local or localised) content and services, and a lack of cultural or social acceptance. The root causes of these consumer barriers include the high costs that content and service providers face in developing and localising relevant content and services and their associated business model constraints, low awareness or interest from certain audiences, limited Internet freedom and information security (Sprague *et al.*, 2014).

The second barrier in the category is low income and affordability. In this area, the predominant barrier is the low income of individuals in the offline population. This barrier is exacerbated by the high costs associated with providing access to the Internet for disproportionately rural populations. The low incomes reflect the poor economic circumstances of large segments of the offline population, often including unemployment and the need for economic development, employment, and income growth opportunities in their regions. At the same time, there is often a lack of adjacent infrastructure (such as roads and electricity), thereby increasing the costs faced by network operators in extending coverage. Several other factors can contribute to high service costs for device manufacturers and network operators, including taxes and fees and, in the case of some countries, an unfavourable market structure (Sprague *et al.*, 2014).

The third barrier in the category is user capability. This category includes barriers such as a lack of digital literacy: unfamiliarity with or discomfort in using digital technologies to access and use information, and a lack of language literacy: the inability to read and write. The root cause of such literacy barriers is often an under-resourced education system (Sprague *et al.*, 2014).

Infrastructure is the fourth barrier in the category. Barriers in this area include a lack of mobile Internet coverage or network access in addition to a lack of adjacent infrastructure such as grid electricity. The root causes of these consumer barriers include limited access to international bandwidth; an underdeveloped national core network, backhaul, and access infrastructure; limited spectrum availability; a national information and communications technology (ICT) strategy that does not effectively address the issue of broadband access; and under-resourced infrastructure development (Sprague *et al.*, 2014).

Ibáñez (2020) opines that remote education aims to move the in-person courses to a remote, virtual, distance, or online classroom. This method prioritises education as an emergency and looks out for the well-being of the students.

Low resource environments simply refer to places, especially in the Global South, which are beleaguered by large-scale poverty and lack of financial resources amongst the majority of the citizens. As a result of the overwhelming poverty in the region, even the educational system is underfunded and under-resourced, from a lack of adequate teachers to instructional materials and school infrastructure to poorly equipped laboratories and scanty libraries.

Emergencies refer to unforeseen situations such as armed conflict or natural disasters. Emergencies cause major disruption of education systems. Schools and colleges are often damaged during armed conflict or used for temporary accommodation of people rendered homeless or displaced by war or disasters such as earthquakes, pandemics, floods or hurricanes, and students, teachers and their families may seek safety in other countries as refugees. In situations of chronic conflict, the quality of schooling may deteriorate if governments are unable to distribute teacher salaries due to security problems and/or lack of funds (Sinclair, 2001). The common feature with all emergencies is the disruption of formal schooling; thus, governments and non-governmental organisations (NGOs) have to provide alternate means of learning remotely.

Offline Internet thus offers the panacea to the challenge of cost-efficient and cost-effective remote learning that requires no Internet data

cost or Internet connection and works with existing digital devices in low-resource environments and emergencies.

Statement of problem

There are 7.8 billion people in the world, while 3.6 billion people worldwide still lack online access (Endless OS Foundation, 2022). More so, the Alliance for Affordable Internet (A4AI) analysis has found that USD 428 billion in additional funding is needed over the next ten years to connect everyone to quality broadband by 2030, but:

- ◆ Should the unconnected population wait until 2030 before they can benefit from digital remote learning?
- ◆ How best should relevant digital remote learning be delivered to the unconnected population without incurring the cost of Internet data?
- ◆ How can an unconnected populace learn both remotely and digitally in a cost-efficient and cost-effective way?

The United Nations' Sustainable Development Goal (SDG) 4 is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all; thus, the issue of the digital divide is an unfortunate reality that contravenes the ideals of this humanist goal. In addition, the Coronavirus disease 2019 (COVID-19) pandemic exacerbated the global digital divide leading to disruption of the schooling of over 1.6 billion students with more than 192 country-wide closures resulting in interrupted learning, unequal access to digital learning portals and a rise in dropout rates.

Offline Internet thus offers the panacea to the challenge of cost-efficient and cost-effective remote learning that requires no Internet data cost, no Internet connection, and works with existing digital devices. It is the intent of the researcher to view this sensitive technology and taxonomise the emerging field of offline internet.

Purpose of study

The purpose of this study is to X-ray offline Internet for digital remote learning in low-resource environments and emergencies. Specifically, the chapter seeks to:

1. Examine the correlates of the digital divide.
2. Define offline internet.
3. Taxonomise offline internet.
4. State exemplars of the sub-categories of offline internet.
5. State the problems of offline internet.
6. Recommend solutions to the problems faced by offline Internet use.

The taxonomy of offline internet

Completely offline systems or ‘sneakernet’ are those specially designed computer systems that store information in very large quantities for learning in low-resource regions and/or emergencies by directly retrieving information from a storage device, for example, universal serial bus (USB) sticks, subscriber identity module (SIM) cards, secure digital (SD) cards, mobile applications (apps), mobile devices or even computer systems. These are mostly used for personalised digital remote learning.

Hybridised offline systems are those specially-designed computer systems that store information in very large quantities for learning in low-resource regions and/or emergencies by direct retrieval of information from a device or mobile app that periodically updates its local information contents whenever it goes online, or it goes online for user authentication purposes. This category is also used for personalised digital remote learning.

The offline server, seeder networks or nano servers refer to those specially designed computer systems that store information in very large quantities for learning in low-resource regions and/or emergencies by direct broadcasting or seeding of information from a storage device or a Wi-Fi-enabled seeder sharing its resources with leech-computers or smartphones or devices. These are mostly used in schools, communities, refugee camps and correctional facilities to enable collaborative learning while still gathering data on individual users’ learning activities.

Completely offline systems

- ◆ **Smart TxtBks** democratises access to content by converting old SIM cards into ‘textbooks’ that students can access offline using cell phones. With the use of analogue technology, students gain access to e-books, are more engaged and are freed from the burden of carrying heavy school books. Smart TxtBks is ideal for delivering ‘bite-size’ (160 characters) learning content that can be stored in the phone’s SIM cards and retrieved as messages (Smart Communications, 2022).
- ◆ **Kiwix** is free software that brings knowledge to millions around the world by making it available offline. Wherever on Earth, learners can browse Wikipedia, read books from the Gutenberg Library, or watch technology, entertainment and design (TED) talks and much more, even if they do not have an Internet connection (Kiwix Association, 2022).
- ◆ **Two Rabbits** is an interactive audio program based on the Cameroonian official curriculum recorded via a hand-crank MPEG-1 Audio Layer 3 (MP3) player featuring songs, stories, and games performed in the Baka style and language. When an initial two-year pilot showed remarkable

results, they worked to strengthen the model based on lessons learned and expand it to twenty villages over two years (Two Rabbits, 2022).

- ◆ The **Rumie Tablet** is preloaded with high-quality educational textbooks, videos and games tailored to a student's age and curriculum. Rumie tablets are interactive digital libraries that cost less than the average textbook. All learning content can be used offline, making each tablet a portable library for students to use wherever and whenever they want (Edshelf, 2022).
- ◆ **Mavis Talking Pen and Book:** The Mavis Talking Book consists of a digital pen (Mavis Pen) and a specially printed book (Mavis Book). When the pen touches text or pictures in the book, it reads the corresponding audio, including interactive games, quizzes, multi-language translations, etc. They are talking books for literacy, numeracy, health and other subjects such as English with phonics, mathematics, rhymes, and languages (HundrED, 2022b).
- ◆ The **VPpendrive** has a complete video lecture of courses; no need for Internet connectivity. The V-Pendrive has a lifetime validity. Topic-wise, chapter-wise explanations, videos, worksheets, quizzes, and more. The V-Pendrive shows the entire content and can be viewed on televisions, laptops, tablets, projectors or smartphones.
- ◆ **Tap Tap Read** empowers low-literate youth and adults to teach themselves basic reading skills with short, interactive lessons that are fun and engaging. Lessons on alphabet, phonics, vocabulary, fluency, and comprehension help students become solid readers. Lessons work offline once the app is downloaded, and most lessons take less than five minutes to complete. The friendly, clean design helps students focus on the lesson. It is curriculum-based on the science of reading.
- ◆ The **NENA Offline e-reader** has published around 3,000 e-books in all the fields covered by African authors, half in English and half in French. Most are in electronic publication (ePub) and hypertext markup language (HTML) format for offline or online reading and on any medium (computer, tablet, smartphone, e-book reader). More complex works are in interactive portable document format (PDF) format. They all offer a rich hypertext navigation feature (African Union, 2020).
- ◆ **Sayans computers** come with educational software containing a collection of resources to enhance research even without the Internet, improving access to information and better learning outcomes. Secondly, Sayans computers have a low power consumption and are installed with a long-lasting battery bank. They are cheaper for both purchasing and continuous use as they use very little power, enabling anyone to obtain a computer. The computers are great for ICT programming and are already installed with programming software and tutorials and thus better ICT

development science, technology, engineering, and mathematics (STEM) learning outcomes (African Union, 2020)

Hybridised offline systems

- ◆ The **Jara Emergency Unit** empowers children in under-resourced communities to receive a quality education anytime, anywhere. The Jara Emergency Unit is a personal education device that enables children to learn localised education content in any language without needing access to power, a quality classroom, or the Internet. The Jara Emergency Unit is built for durability and low- and no-infrastructure contexts, collaborating with e-learning platforms for locally customised content, enabling the technology to be remotely updatable, designing for data collection (Internet of Things, IoT) and designing with communities (Jara, 2022).
- ◆ The **uLesson** SD card contains the contents of the app, including the video lessons and quizzes, and a dongle (an on-the-go device that plugs into the charging port of a smartphone or tablet and enables learners to read content from the SD card). These two items enable users to watch the pre-recorded video lessons offline without worrying about expensive data streaming costs. However, the package requires that Internet data be kept on to enable an authentication process that consumes only 0.1 megabytes (MB) of mobile data, ensuring that the SD card is being used on the account it is intended for and that the contents are not being pirated. Available subjects include senior secondary school English, mathematics, physics, chemistry and biology and junior secondary school English, mathematics, basic science, business studies and basic technology (uLesson, 2022).
- ◆ **Ustad Mobile** provides a free, open-source mobile learning app that enables conflict-affected and marginalised youth to access and share educational content offline. The app is designed for limited connectivity, works on almost any Android phone, and does not require a mini server or Wi-Fi access point (NGL Education Technology Solutions, 2022).
- ◆ **Kytabu** is a textbook leasing mobile app for curriculum textbooks used by 11.8 million students in the Kenyan education system. Built to provide low-cost access to digitalised versions of all Kenyan textbooks, Kytabu enables teachers and students to rent textbooks a page at a time, a chapter at a time or full book for periods varying from one day to one week, one month and one school term (African Union, 2020).

Offline servers

- ◆ **Kolibri** is unique in that it provides offline educational content that can be curated to standards or to meet local needs while providing pedagogical support to educators. It excels in environments where mini-learning hubs can be created to replicate the experience of some tools with learning management system (LMS) functionality available online but without the Internet. Digital content is first scraped from the web and hosted in a library, which runs on a local server. From there, a curriculum developer or any other educator into channels can organise content or lists of curated content, which are then synced to instances of the app installed on local devices. The content can then run without any further Internet connection, and the teacher can work with learners through a special teacher view, which allows them to manage classes, view student progress, create exercises, and more. Synchronising content and data through peer-to-peer or storage devices is seamless (HundrED, 2022a).
- ◆ **i-Pathways Oasis** is an innovative solution that delivers all of the i-Pathways curricula, features and functionality to a computer laboratory environment on a single, unique device. Students can connect to the device wirelessly and access the i-Pathways system and curricula. Students can complete assessments, engage in all the instant feedback activities, and prepare for their high school equivalency exams. Teachers can track student progress and provide feedback (i-Pathways, 2022).
- ◆ **Internet-in-a-Box** brings the best of the world's free knowledge (Wikipedia, Khan Academy, Open Street Map, e-books and many others) to those working offline, such as anybody nearby with an old smartphone, tablet or laptop. An Internet-in-a-Box "learning hotspot" can be set up anywhere in the world, even with solar power, using very diverse hardware (Internet-in-a-Box, 2022).
- ◆ **The Ideas Cube** creates a Wi-Fi hotspot that users can connect to using a smartphone, tablet, or computer to access thousands of educational, cultural or training resources. In a library, a school or a medical dispensary in a rural area, the Ideas Cube provides content in the form of texts, videos or online courses and allows around forty simultaneous connections. The Ideas Cube can be updated to broadcast new content when connected to the Internet. The data and frequency of user use are then collected to best meet their needs in the field. The Ideas Cube emits a Wi-Fi signal with a range of up to 30 meters depending on the environment. Up to 40 users can log in simultaneously with a smartphone, tablet or computer. The battery allows up to five hours of autonomy and can be charged with solar panels (LWB, 2022).
- ◆ **KA Lite Offline Server** is lightweight web application software that allows users without Internet access to engage with Khan Academy videos and

exercises in completely offline settings. It brings the flipped classroom model to some of the most remote areas in the world. Users can track their progress through videos and exercises, and coaches can log in to check students' progress, identifying which areas the students need the most help in. If KA Lite ever reaches an Internet connection, it can synchronise this usage data with the KA Lite Hub, an online data repository that allows project administrators to view data and manage accounts remotely of offline deployments. KA Lite is no longer under active development (KA Lite, 2022).

- ◆ **Scolaryx**, an educational box, is a micro server containing the equivalent of 10 000 lessons available offline. Its administration is relatively simple and can be performed by the head of the school, the learner or a parent. The Scolaryx box contains a Wi-Fi card to connect to a computer and access educational content without the Internet. The Scolaryx mini box also has high-definition multimedia interface (HDMI) access for classroom class screenings. Scolaryx can also be used with a mobile phone or tablet and thus enjoys the intuitiveness of mobile technologies to enable learners to feel the reality they are entering the classroom. The diversity of educational resources (videos, animations, sounds, quizzes, games, etc.) offers learners an exhilarating learning experience (African Union, 2022).
- ◆ **EDBox** is a nano server that allows students, teachers and parents to access tens of thousands of educational content without access to the Internet. Teachers can use these digital resources in class. Accompanied by a mini projector, the EDBox can be used to simulate difficult concepts that need to be represented and to show or demonstrate the operation of mathematical, biological, physical, and chemical processes. The box is also a library of downloadable resources that enable students to have documentary resources in various disciplines and formats from developed countries. This affords students an equal opportunity to access knowledge. The pedagogical uses of this device are numerous: self- or teacher training, course preparation, classes before pupils, and provision of free educational content to download on Wi-Fi smartphones for teachers, parents and students (African Union, 2022).
- ◆ **Kekelitheque** is a virtual library accessible via a web platform or a mobile application without necessarily requiring an Internet connection. A virtual library is a collection of digital documents such as texts, images and sounds, digitised or born-digital, accessible remotely, especially via the Internet, offering different public information access modalities. Kekelitheque offers several advantages:
 - a very easy “offline” access to educational resources (without a need for Internet access),

- easy installation of the Kekelitheque chest,
 - a library suited to rural areas,
 - the effective preservation and classification of educational resources, and
 - a reduced budget for the installation and maintenance of Kekelitheque (African Union, 2022).
- ◆ **RACHEL Pi** is an acronym for remote area community hotspot for education and learning. RACHEL Pi is a portable, plug-and-play server that can connect a whole classroom of computers to a world of educational content with a single click. It stores copies of open educational websites such as Wikipedia, Khan Academy and physics education technology (PhET) simulations and makes that content available over a local wireless connection (HundrED, 2022c).
- ◆ The **Corrections Off-Line Education Platform (COEP)** is an offline digital library that provides a full Internet-like experience for users in detention, treatment and other institutions that lack Internet access. Rich with millions of resources for the General Educational Development (GED) test, high school, secondary, and post-secondary education, it is in use at dozens of correctional facilities around the US (Amini, DiVittorio & Clarke, 2022).

Problems of offline internet

1. Learning analytics challenge: Offline Internet usage poses a challenge in providing data on users' learning outcomes since they do not have the learning analytics component and connectivity of feedbacking learners' data to the server for educational data mining goals. The inability of an offline Internet system to capture learners' activities will only lead to uninformed decision-making by the organisation behind the project because if an offline Internet intervention cannot be evaluated on the learner's terms, its impact cannot be quantified and qualified. Data must be collected to comprehensively review the impact of educational technology interventions, as there is a bias within studies to focus on the positive impact of educational technologies. This often means "unintended consequences are ignored or simply not looked for". Only through providing more balanced findings can education stakeholders better understand the actual effects of educational technology interventions on marginalised learners (Zubairi, Kreimeia, Jefferies & Nicolai, 2021).
2. What learning metric to measure: Most offline Internet interventions are only interested in measuring the number of downloads or the opening of files contained. Few offline Internet interventions have a learning

analytics component that reports or simulates academic performance, self-regulated learning, learner engagement, retention of learnt content, etc. (Zoom, 2020; Dele-Ajayi, 2020).

3. Device divide: The use of devices not owned by all target users or unaffordable by the majority of users of an offline Internet intervention only further embeds inequality in access instead of reducing it (Zoom, 2020). If the majority of the target learners own smartphones, then it will be wasteful to use laptops as the offline Internet intervention, as the majority of the target users will be excluded from benefiting from the educational project.
4. Gender divide: Most women are not engaged in the use of technology for learning around the world (Zoom, 2020). Crompton, Chigona, Jordan & Myers (2021) observe multiple barriers that influence gender disparities in accessing and benefiting from educational technologies, including social inequalities or norms and technological constraints (Cullen, Mallett & Murphy, 2019). Girls are often more likely to have lower levels of digital literacy than their male counterparts (Crompton *et al.*, 2021; Zubairi *et al.*, 2021). A study conducted by the Malala Fund found that fathers were 36% more likely to support and assist their sons' learning using EdTech during COVID-19 than their daughters' learning (Crompton *et al.*, 2021).
5. Institutional technophobia: In most secondary schools, there is resistance by institutions and teachers to students using their devices in schools (Onyema, 2019). The platform iCampusgh was initially designed by Ghana's Centre for National Distance and Open Learning (CENDLOS) in 2016 to be used as an intranet on the iBox, a Ghanaian-developed local server fixed into ICT laboratories in schools and with content provided as part of a wide-scale ICT development programme with funding provided by the World Bank. The content on iCampusgh/ the iBox was initially planned to provide ICT-based learning and teaching in less well-resourced senior high schools (Cullen *et al.*, 2019). However, one of the reasons for the low adoption of iBoxes in Ghanaian schools and which are particularly pertinent to teaching and learning in the senior high secondary elective sciences of biology, chemistry and physics, is government, school and parental concerns over the use of mobile phones to access ICT-based teaching and learning (Addae-Kyeremeh, Cullen, Mallet & Owusu-Agyemfra, 2021).
6. Need for greater local technical competency: Especially for offline servers or nano servers, this category requires greater local technical competency in place to support and maintain services rather than when using Internet-based services. (Kukulka-Hulme *et al.*, 2020).

Conclusion

This chapter has shown offline Internet as the panacea to the challenge of cost-efficient and cost-effective remote learning that requires no Internet data cost, no Internet connection, and works with existing digital devices in low-resource environments and emergencies. The chapter also examined the correlation of the digital divide, defined offline internet, and taxonomised offline internet, stated some exemplars of the sub-categories of offline internet, stated the problems of offline Internet and recommended solutions to the problems faced by offline Internet users. Recommendations are to ensure the optimal use of offline Internet for the achievement of sustainable development goal four which is inclusive and equitable quality education and lifelong learning for all, especially in low-resource environments and emergencies.

Recommendations

- ◆ Offline Internet providers can use short message service (SMS) technology or the Internet of Things (IoT) technology to enable offline Internet interventions to supply data on users' learning activities to a computer server for educational data mining goals.
- ◆ Offline Internet providers should build in learning analytics components that do more than just record downloads. They should also be designed to simulate the academic performance of users, memory retention, learner engagement and self-regulated learning.
- ◆ Governments, NGOs and providers of offline Internet interventions should use existing technological devices that are already popular and owned by the majority of the target population, as it makes it easy to onboard the majority, if not all.
- ◆ Women should be necessarily included in technological interventions for learning, and extra effort should be made to ensure they benefit meaningfully from such projects.
- ◆ Schools and educators should encourage both bring-your-own-device and UYOD initiatives as practical steps to overcoming the digital divide, institutional and instructional inadequacies, and a smart way to utilise digital literacy skills.
- ◆ Most completely offline interventions do not require standby technicians; however, for offline servers, efforts should be made to expose some driven students to the technologies so that in the absence of technicians, meaningful solutions can still be realised.

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