International Journal of Education and Psychological Research (IJEPR) Volume 9, Issue 4, December 2020
Print - ISSN: 2349 - 0853, e-ISSN: 2279 - 0179 Available online at www.ijepr.org
Orignal Research Article Open Access

Satellite-Connected Hotspot for Offline Learning Systems (SCHOOLS): An Innovative Approach for Universal Education

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Abstract:

Providing first-rate education for all has remained a challenge. The pandemic has further exacerbated this crisis, particularly in underserved communities. This paper proposes a satellite-enabled delivery scheme for achieving equity in education, without the need for expensive gadgets or broadband connectivity.

By riding on the existing satellite channels for TV distribution, it is possible to push centrally controlled, curated content as well as teacher resources on a lesson-by-lesson basis into a compact receiver-server at all the desired locations. Teachers and students can then access the received information on their own devices from a local hotspot.

Unlike online classrooms, which are subjected to a digital divide and possible distractions, the proposed scheme makes the pre-selected learning material available consistently to all, and for use in environments of no connectivity. If this were coupled with the satellite-delivered just in time coaching for the teachers, neither the variance of the teacher skills nor the lack of internet connectivity would hamper the provision of quality education for all.

Keyword: *NEP; Quality Education for All; Continuing Teacher Support; Broadcast Satellite; Mastery Learning; DTH*

Article History: *Submitted: 10th October, 2020, Revised: 30th November, 2020, Accepted: 04th December, 2020, Published: 31st December, 2020.*

I. INTRODUCTION

Quality education is foundational to all other aspects of human development. There is no doubt that equipping students with relevant knowledge and skills has a catalytic impact on eradicating poverty, reducing inequalities, improving health, driving economic growth and achieving gender equality. However, the sad reality is that many in schools are yet to attain the skills demanded by the twenty-first century job market. The fast changing employment landscape makes it mandatory that children learn how to think critically, how to solve problems, how to be creative, and how to adapt to changing needs. Another important obstacle to quality learning is that many teachers do not possess the appropriate content knowledge, or the right pedagogical methods, or the tools to assess the student for learning.

These challenges have been well analyzed and documented by the recent National Education Policy (NEP) of India [1]. It emphasizes on conceptual understanding and laying a solid foundation at every learning step. Advocating premier universal education starting from early childhood, the NEP repeatedly stresses equity and inclusion as the only means to reap the demographic dividend. Simply put, the national economy benefits from widespread quality education.

The challenges to equitable quality learning increased unexpectedly with the onset of COVID-19 pandemic and the resultant disruption of the school system. In addition to increasing the variance of the learning outcomes, the resource-disparity in terms of access and devices, tends to affect students from more vulnerable and disadvantaged communities. This supplementary digital divide, needs an immediate attention.

In this paper we propose a novel offline-learning scheme, with a satellite link keeping the learning resources relevant and updated constantly. This solution can be implemented immediately and is superior to other options like online classes, TV classes, App-based learning etc., especially for the students of lower classes.

II. THE CHALLENGE

It is imperative that all students must be imparted the foundational concepts. A student must achieve a significant level of mastery in prerequisite knowledge before he could be engaged into subsequent concept, a scheme pioneered by Bloom [2]. There are significant challenges in achieving this and the reasons are several, like the large numbers of students and their geographically distribution, with widely varying resources and infrastructure.

The learning process broadly consist of:

a. The learning material or Contents;

b. The transfer/access of contents, or the Connectivity; and

c. The learning of the concepts by the student, or the Consumption.

Besides making available quality contents, the teachers need to act as mentors and provide proper guidance on the manner in which the information is consumed and retained. Equally important is the need for conducting diagnostic tests in order

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to tailor the content to individual students' needs. The large variance in teacher skills is to be reckoned while arriving at a solution.

III. TECHNOLOGY CHOICE FOR QUALITY EDUCATION

There is a widespread belief that broadband Internet access is imperative for providing quality digital education. This confusion arises partly because of the feeling that to access Internet content one needs Internet connectivity at the consuming end. It is assumed that until such time this online access is available, one has to make do with poorer alternatives. Hence the problem of quality education for all is usually narrowed down to one of provisioning universal Internet access.

But there is no evidence to show that web access automatically correlates with improved learning outcomes, especially for lower grades where the students are rarely self motivated. Though the Internet is a great source for learning materials, it is also an abundant source of distractions. There is simply too much information to choose from, which results in loss of focus, time, and energy. We cannot expect the younger students to make this choice on their own.

IV. SATELLITES: THE IDEAL CANDIDATE FOR CONNECTIVITY

To determine the apropos connectivity for universal primary education, we must start by looking at the traffic demands. Traffic well suited for one type of communication link may not at all be the right choice for another. E.g. Work from home, Social media, email etc. need a good broadband Internet link. Viewing of one's favorite TV channel from anywhere got a big boost with the satellite-based Direct to Home (DTH) delivery.

To arrive at the best connectivity configuration for primary education, we note their common curriculum and a common schedule so that their needs are mostly simultaneous across multiple schools in a region. Satellites have an extensive geographical coverage, inherent multicast capabilities, low-cost terminals, limited demand on infrastructure, and accessibility by an unlimited number of terminals. A satellite signal is broadcast by nature and effectively supports a one-to-many architecture [3]. We can then deliver the best of the selected curricular content to as many students all at once, and as needed without worrying about network congestion and costs. In fact, directed content delivery via a broadcast satellite should be the first choice for the connectivity solution for primary education. Only if such satellites are not there, one has to consider options like Internet or mobile networks for delivery, with its limitations.

Among satellite systems, there are several types of satellite payloads for different categories of services. The most important orbit types in this context are Geostationary (GEO), and Low Earth Orbit (LEO) constellations. Since LEO systems have lower latency than GEO, they are preferred for applications like online gaming, videoconferencing etc. GEO systems have wide geographical coverage and are the best for applications like DTH. For educational applications, Direct to Person (DTP) broadcast satellites are ideal [4]. As the market gets established such DTP payloads will be built as the space segment for education. In the meanwhile it is possible to piggyback on the present DTH service as explained below. It is noted that in the proposed offline mode of using the delivered educational contents, effects like latency or signal interruptions due to rain etc would not affect the service.

There already exists a satellite footprint all over the globe to distribute TV channels (DTH). There are also other Ku band downlink channels like the Edusat in India. These channels can be leveraged such that the desired education content is encapsulated as an IP stream in Multi-Protocol Encapsulation (MPE) format and multiplexed with audio video streams [5]. This can be received at home or the school or in a community. On the receive side, the IP stream can be tapped from the LNBC port and decapsulated to recover the transmitted educational content, without affecting the DTH channels and their reception on the TV.

Especially in the context of the pandemic constraints, it may be desirable to have a portable receiver for the education delivery service addressed to the teachers and students. One can then receive the satellite signal with a much lower gain antenna and use appropriate spread spectrum modulation techniques, for example like Othernet [6} to obtain a reasonable, always ON, bit rate for the file transfers. In addition to delivering curricular learning material, the same link can deliver age-appropriate digital story books to keep the students interested and engaged. It could also be used for addressable alert delivery.

The curated education content so delivered is received by a special module that also stores the content and makes it available on a WiFi link to nearby digital devices of the teacher and/or students. The local server then acts as a content library for the students to browse the content that has been received via the satellite, using their own device, which is ideally a tablet with just WiFi connection. This choice of the device is superior to smartphones, as the screen sizes could be bigger for media consumption, and the students can use it exclusively as their personal education device to store contents, taking notes etc., and avoiding all distractions. In the proposed scheme, instead of each student having to download his requirements from a web link, we adopt the "push" mode where the sender controls the type of and timing of the content. This lowers the capital outlay and ensures its uniform availability, as well as content control which is so essential for the younger children.

Table 1 presents the most commonly adopted technologies for education, comparing their merits and ideal use cases.

Table 1 Candidate Technologies for Education

Scheme	Technology	Merits	Limitations	Comments
Remote live classes	Live stream on Internet	Preserves the classroom paradigm	Reach is limited to those with high speed Internet connection	Many teachers do not have the training/experience in conducting live classes
Social Media based learning	Data plans on mobile devices, with high data usage	Covers all classes; Practice tests; Curriculum aligned	Exclusive availability of the device for the student cannot be assumed in low resource environments	Students tend to get distracted with other options on these phones
Classes conducted on TV channels	Broadcast TV	No additional costs	TV viewing is not the best medium for learning; Schedule could clash with other users of TV at home	Other programmes on TV get higher priorities. Difficult to engage students continuously for a full class
Lectures on DTH channels	Multiple live DTH channels	The lectures are given by eminent speakers on diverse topics. The content can be viewed offline as well	Topics do not cover lower classes	Not linked to any course, or curriculum; Useful for high level education
The proposed SCHOOLS initiative	Curated contents delivered via a satellite link to a wireless local server for use by teachers and students	Coverage is 100%. No distractions for the students. No traffic congestion or usage charges	None	Immediately implementable and scalable

V. THE PROPOSED SCHEME

The solution is built around guided learning locally with select digital contents delivered as per a timetable, with features like:

- Internet contents without Internet connectivity
- Universally available content, irrespective of location or local infrastructure
- Students study at their own pace, under the local teachers' control
- The best resources available to all, and keeping the teacher-pupil ratio reasonable
- Unequivocal support for teachers in all their functions, including tools for continuous student assessment
- Teachers progressively becoming better in the pedagogy and subject matter
- Student education through Teacher education

Fig. 1 depicts the overall schematic. A team of expert educators select/develop the contents for each of the concepts and the selected content can be delivered as files via the satellite, labeled by the class, topic, subject etc., to all locations in just one transmission so that the best content and methods are available to all. This mode of transmission is referred to as "asynchronous", unlike online classes, which demand a synchronous or uninterrupted connectivity, and which becomes more difficult in resource-starved locations.

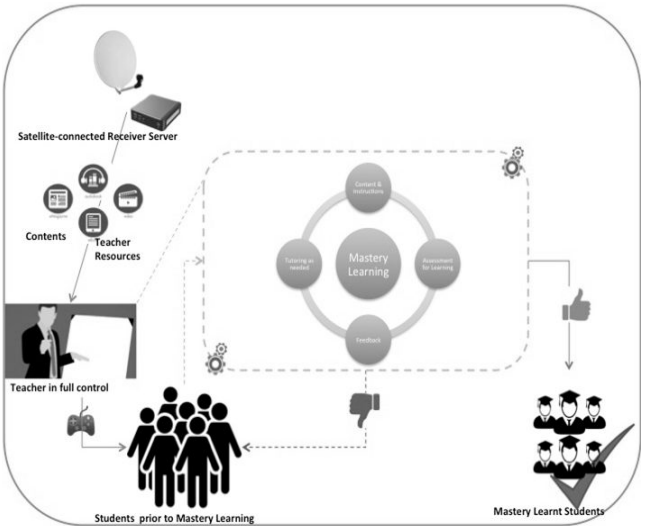

Figure 1 Schematic of Satellite-Connected Hotspot for Continuous Teacher Training and Quality Learning for All

It is noted that the proposed satellite initiative does not bypass teachers. In fact, it enhances the teacher's role by helping them become more effective educators. Realizing the wide variance in their skill levels and that it should not affect the student learning outcomes, the local teacher is provided with just-in-time coaching and tips on a lesson-by-lesson basis on how a given concept must be handled. The best expert of a particular topic can therefore guide every teacher on how that concept must be taught. For this purpose the always-on satellite link could be used in a synchronous mode to address all the teachers of that particular topic.

To help the teachers to assess the students for their proper learning, well-designed diagnostic tests can also devised centrally and delivered via the satellite to the local server for the teachers' use. This initiates the assessment-feedback loop to adapt the content to match the individual student needs, realizing that no one is mediocre and one shoe cannot fit all. The techniques used by the teacher on different students to bring them above the level of mastery thus could vary.

Teachers are in full control of the progress of the students as depicted in Fig.1 This Teacher-Assisted Individualised Learning (TAIL) scheme combines the advantages of traditional teaching with additional resources for greater success in imparting the conceptual understanding for the students. Based on the contents received, which could include videos, PowerPoint presentations, lecture notes, worked examples, reading material, quizzes, assignments etc., the teachers can be encouraged and guided to conduct blended or flipped classes. The time in class is then spent on working through the concepts to be learnt, with the guidance of the teacher and the materials and instructions sent from the master educators at the center. Using the diagnostic tools delivered to them, the teachers identify the specific concepts the student knows and does not know. Such an assessment for learning is a must for achieving uniform learning. The proposed method of scaffolding the teachers has long-term benefits of professional development of the teachers. Case studies in rural schools show the effectiveness of this scheme as well as peer-to-peer learning among students [7], and teachers have successfully deployed these methods. Thus, Satellite-Connected Hotspot for Offline Learning Systems (SCHOOLS), combined with Teacher-Assisted Individualised Learning (TAIL) is bound to take us towards Quality Learning for all.

VI. THE RESOLUTION OF THE CHALLENGES

Table 2 lists the major challenges in providing quality education to all and briefly describes how they have been addressed in the proposed intervention.

Table 2 The Challenges faced to achieve Universal Quality Education and how they are resolved in the SCHOOLS initiative

Challenge	Solution
Quality contents not available to all	The satellite's universal coverage ensures what one gets is what every other one gets. Also as it is a one-to-many distribution, the best quality content can be identified by the designated authority and made available to all.
Online distractions for students	In the "push" mode of broadcast, unwanted content, inappropriate and distracting links are avoided.
Teaching skills and the required guidance in learning not uniform	The always-on satellite link allows just in time live coaching to help teachers perform well using the curated content that is delivered and stored locally. Tools for assessment for proper learning by individual students are also disseminated. Teacher engagement and hand holding continues throughout
Online classes are unsuitable for younger students	Structured and tightly controlled offline learning with selected digital contents locally made available, under the guidance and supervision of teachers who are also supported via the satellite link.
The recent pandemic has led to school closures and further widened the learning gap	The solution is implementable immediately as the scheme uses existing satellite capacity. It can be scaled up very quickly. The receive configuration can be adapted to a school, community or individual homes, and all the social distancing guidelines can be observed.

VII. CONCLUSION

A satellite-based education delivery system negates the need for Internet penetration or expensive gadgets. Central selection of learning materials, directed delivery by an existing satellite, local hotspot and just-in-time coaching of teachers will lead to meeting the NEP goals of conceptual understanding for all, narrowing the digital divide. The proposed initiative enhances the teacher's role and supports them to be more effective in the classes. Thus, we have combined the advantages of the student-centric model with the teacher-centric.

Satellite Broadcast Solution is immediately implementable, scalable and available everywhere. Satellite ensures uniformity and central control leads to Quality. This way we can deliver quality education to every doorstep; keep all children well engaged and well educated without a break. Though we have described the intervention in the Indian context, the scheme is globally applicable as any part of the world has such satellite coverage. We have the best opportunity to turn the current disruption due to the pandemic to our advantage, and at the same time lay the right infrastructure to meet the lofty goals of NEP.

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