

Universal Access to Technology Central Role of Internet in Education Our Reflections and Perspectives

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Abstract—This paper is a consolidated sharing of different types of experiences in using internet for specific purposes that include online teaching, meetings, conferences, webinars, developing interactive internet-based sessions and discussion panels, writing e-books or connecting the unconnected. It is written by a diverse group of members of three committees sponsoring this paper: IEEE Control Systems Society (CSS) Technical Committee on Stochastic Systems and Control (SSC), IEEE Society for Social Implications of Technology (SSIT) Technical Activity on Universal Access of Technology (UAT) and IEEE Systems Council Committee on DEI. The paper is presented in the form of the collection of sections ending with open discussion on reflections and perspectives. The contributors represent seven different cultures on four continents. This diverse group of co-authors reflects beautifully and powerfully a multidisciplinary character of control as a field that spans all STEM fields.

Index Terms—Internet based sessions, Virtual Conferences, Virtual Tracks, Online Interactions.

I. INTRODUCTION

Universal access to technology, particularly the internet, plays a pivotal role in modern education and research. The internet's vast repository of information and resources democratizes learning, making quality education accessible to individuals regardless of geographical location or socioeconomic status. In educational settings, it facilitates interactive learning, broadens perspectives, and fosters global collaboration among students and researchers Gernsbacher, Morton (2015). The availability of online courses and digital libraries breaks down barriers to education, enabling lifelong learning and continuous professional development. Moreover, the internet accelerates research by providing access to current studies, datasets, and collaborative tools, thereby driving innovation and academic progress. Ensuring universal access to these technological resources is essential for building an equitable, informed and progressive society.

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II. DELAY-TOLERANT ONLINE TECHING USING AUDIO-ENABLED MESSAGING IN AFRICA BY TEMBINE HAMIDOU

Online education has surged globally, driven by the accessibility of digital platforms and the need for remote learning solutions, particularly during crises like the COVID-19 pandemic. However, underserved areas, particularly in Africa, face unique challenges in adopting traditional online learning due to infrastructure limitations, including unreliable internet access, lack of electricity, and scarcity of digital devices. Most of the African regions do not have yet High-Speed Downlink Packet Access (HSDPA) and High-Speed Uplink Packet Access (HSUPA) that extend the performance of existing 3G mobile telecommunication networks, while urban centers are implementing 5G networks. Delay-tolerant online teaching using image and audio-enabled messaging platforms offers a promising solution to these challenges by leveraging technologies that can function effectively in environments with intermittent connectivity and limited resources. Delay-Tolerant Networks and Image-Audio-Enabled Messaging Platforms are designed to operate effectively in environments where network connectivity is inconsistent and delays are expected. These networks use a store-and-forward approach, where data is stored locally and forwarded when connectivity is available, ensuring information eventually reaches its destination. This approach is particularly suitable for rural and remote areas in Africa, where internet access can be sporadic. Audio-enabled messaging platforms, such as Viber, WhatsApp, Telegram, and local radio broadcast systems, are widely used in many African countries. These platforms allow for asynchronous communication, meaning that learners can receive, listen to, and respond to educational content at their convenience, without the need for real-time interaction. By integrating audio content into these platforms, educators can deliver lessons in a format that is accessible and engaging, even in low-bandwidth scenarios. Below we provide some pros and cons of the approach.

A. Pros. Image and Audio-enabled messaging platforms are often more accessible than text-based or video-based content, especially for learners with low literacy levels or those without access to high-speed internet. Mobile phones, which are ubiquitous in many parts of Africa, can be used to access

these platforms, making basic education more inclusive. The asynchronous nature of audio messaging allows students to learn at their own pace and at times that are convenient for them. Audio messages require less data than video content, making them more affordable for students and their families. Additionally, many audio-enabled messaging platforms are free to use, reducing the financial barriers to education. They can be delivered in local languages and dialects, making it more culturally relevant and easier for students to understand. This is particularly important in multilingual regions like Africa with 2000+ local languages where students struggle with content delivered in a non-native language and for students with disabilities.

B. Cons of Delay-Tolerant Online Teaching in Underserved Areas. One of the main drawbacks of audio-enabled messaging platforms is the limited scope for interactive learning which can hinder spontaneous question-and-answer sessions and dynamic discussions. Evaluating student performance and providing feedback can be challenging. Producing high-quality audio content requires skills and resources that may not be readily available. Teachers need to be trained in effective audio communication and may require access to recording equipment and editing software. While mobile phones are widespread, not all students may have access to devices capable of handling audio content, particularly in the poorest regions. Additionally, the availability of electricity to charge devices can be a significant barrier. In an audio-based, delay-tolerant environment. Keeping students engaged is another challenge, especially for younger learners who may require more visual stimulation and hands-on activities to maintain their interest and comprehension.

C. Case Studies. We present some experiments that address the Educational Crisis in Conflict Zones in Africa. In Burkina Faso, Mali, and Niger, over 2,000 schools are closed due to ongoing conflicts and insecurity. Some of these schools have been for five years. In these regions, traditional in-person education is often impossible due to the danger posed to students and teachers. Delay-tolerant online teaching using audio-enabled messaging platforms have been conducted by startups such Timadie, Grabal, Guinaga, SK1 Sogoloton and WETE and has proven helpful in some of these areas where insecurity remains high. By providing a safe and flexible learning option, these platforms ensure that basic education can continue despite the challenges posed by conflict. In Kenya, Senegal, Uganda, South Africa, WhatsApp has been used effectively to deliver educational content to students in remote areas. Teachers record lessons and share them via WhatsApp groups, allowing students to download and listen to them at their convenience. In Nigeria, Burkina Faso, Mali, the use of radio broadcasting for educational purposes has a long history. During the COVID-19 pandemic, radio lessons were revived to reach students who were unable to access online classes. Radio is an effective medium for disseminating basic educational content to large audiences, especially in areas with limited internet access. In 25 African countries,

Telegram has been utilized to distribute pre-recorded lessons and supplementary materials to students. Telegrams ability to handle large file sizes and its encryption features make it a secure and reliable platform for educational purposes.

D. Recommendations for Implementation. Providing training for teachers in creating and delivering engaging audio content is essential. This includes technical training in using recording equipment and software, as well as pedagogical training in effective audio instruction techniques. Investment in infrastructure, such as solar-powered charging stations, can help mitigate the challenges posed by unreliable electricity. Additionally, partnerships with telecommunications companies to offer subsidized data plans for educational purposes can enhance accessibility. Developing content in local languages and contexts can improve comprehension and engagement. Involving local educators and community leaders in content creation ensures that the material is culturally relevant and resonates with the target audience. Combining audio-enabled messaging with other forms of communication, such as printed materials and face-to-face tutoring, can provide a more holistic educational experience. This blended approach can cater to different learning styles and needs. Implementing robust systems for monitoring and evaluating the effectiveness of audio-enabled learning is crucial. This includes collecting feedback from students and teachers, tracking student progress, and making data-driven adjustments to the program Fang Wang et.al 2015.

E. Conclusion. Overall, delay-tolerant online teaching using audio-enabled messaging platforms offers a viable solution for delivering education in underserved areas of Africa, including conflict zones such as Burkina Faso, Mali, and Niger. While there are challenges to overcome, the benefits of increased accessibility, flexibility, and cultural relevance make this approach worth pursuing. With the right support and investment, audio-enabled learning can play a crucial role in bridging the educational gap and providing quality education to all students, regardless of their geographic or socio-economic circumstances.

III. UNDERGRANTE STUDENT CONFERENCE CONDUCTED VIA INTERNET BY PARASANTA GHOSH, BOZENNA PASIK-DUNCAN AND STEPHANIE M. WHITE

The IEEE Systems Council held an inspiring virtual conference where undergraduate students presented their research via the internet, using slide presentations. This undergraduate internet-based conference was associated with the in-person IEEE Systems Council conference, SYSCON 2024, held in Montreal. The one-day student conference was organized with the goal of providing a platform to undergraduate students for showcasing their innovative research and at the same time have an opportunity to interact with the IEEE Systems Council community and other students. Conducting the conference virtually allowed undergraduate students from many different countries to interact synchronously, without having to incur travel expenses. We advertised the conference on the Systems

Council Website and sent email to all Systems Council regular and student chapters, announcing the conference. As the IEEE Systems Council has 28 Chapters, and 21 Student Chapters in 17 countries, we reached a significant number of students. The ads and email invited undergraduate students working or interested in systems engineering, in its application, or in systems thinking to submit a one-page abstract or summary of their work for presentation at the 1st IEEE Systems Council Student Conference. We received a remarkable response and after reviewing submitted abstracts, selected nineteen student teams, who gave presentations of their research. Student groups from nine countries (Brazil, China, India, Nigeria, Pakistan, Uganda, United Kingdom, United States, Canada) participated in this conference. The all-day conference touched on subjects such as Robotics, Learning, Energy Management, Transportation, Medical Application, and Dance, using a zoom link. Each student team, represented by one team member, was allowed fifteen minutes for presentation followed by five minutes for questions and answers. Based on presentations, the committee awarded a \$250 Best Paper Award and Certificate to three research teams and a Best Paper - Honorable Mention Certificate to three additional teams.

The conference achieved its goals and student feedback clearly indicates appreciation of the opportunity. Some student feedback follows: Having focused on the theory of most of the math that I study, it is always a treat to see the applications that people are working on. I like to rate talks and presentations on whether I go and research the topics after the talk. This means that I am interested enough to keep on learning and researching on my own time, I also want to say that it is inspiring to see the good work that is being done at an international level. After announcing the Conference, we received a significant number of requests from universities to start new IEEE Systems Council Student Chapters. We postulate that the publicity associated with the student conference excited students and promoted interest in joining with other students to work together locally as an IEEE Systems Council Student Chapter. Such Chapters are formed to serve members by holding meetings, and provide opportunities to network and grow. After a successful 2024 student conference we are making plans and looking forward to the next systems engineering / systems thinking student conference that will be associated with SYSCON 2025.

IV. USE OF THE INTERNET FOR TECHNOLOGICAL REACH TO RURAL CHILDREN BY HARIVARDHAGINI SUBHADRA

In today's digitally connected world, where the internet is an integral part of daily life, ensuring the proper use of technology related data safety has become a paramount task for governments, organizations, and individuals. The rise in malware attacks and phishing incidents poses significant threats to both individuals and organizations in urban and rural areas Singh, R. et.al (2019). As India's cyberspace expands rapidly, it becomes essential to educate and engage both the younger and adult generations UNICEF (2020) in safeguarding themselves and their entities. Engaging the youth

in technology development and deployment by individualizing their experiences and enhancing their knowledge, has shown to foster a more informed and capable generation. Given the pervasive role of technology, understanding and mitigating cyber threats is vital. To address these concerns and promote digital literacy, iExplore Foundation for Sustainable Development along with a group of teaching professionals launched a program titled CYBER CHAMPIONS. This was launched with a vision to help the rural children to understand the importance of Technology and Internet. As the use of internet is undetachable in a child's life, the ill effects of the same must also be emphasized World Bank (2019). To achieve this, a series of animated videos with simple explanatory audio were created and introduced to them. These animated videos covered the important topics like phishing, hacking, malware, ethics of technology etc. As it is an animated one, children can easily understand, correlate and get an idea about the Pros and Cons and how to stay safe in the digital world Chen, Sherry & Chang, Yu-Ming. (2019). As India is multilingual in nature, it is important to make this reach several school children of various states, hence the videos are made in regional languages like Tamil, Malayalam, Telugu, Kannda, Marathi etc. The videos are very short in length (2- 3 minutes). A quiz is provided at the end of every video. It can be taken any number of times till the student understands the concept.

The videos, script, lecture materials are all prepared by an expert team on cyber security and was vetted by the cyber security cell of the Central Government of India. This was inaugurated in an event at Zilla Parishad High School in Patelguda, Ibrahimpatnam, Hyderabad, Telangana on 15th November, 2023. A total of 100 students attended the same and gave a very positive review. This is planned to be translated to every regional language spoken in the different states of India to promote digital literacy through technology among the young minds Dey, S. et.al (2018).

Reflections: The CYBER CHAMPIONS program is a crucial initiative addressing the need for digital literacy and cybersecurity awareness among rural children Chakraborty, A., & Sarmah, G. (2021) in India. The engaging and accessible content of the animated videos ensures that young minds can easily understand and retain important safety information. Endorsed by the Central Government's cybersecurity cell, this initiative exemplifies the importance of collaboration in fostering a digitally literate and cyber-aware generation, enhancing the quality of life through education and awareness in the digital age.

V. INTERNET BASED PRACTICAL EDUCATION BY RAMALATHA MARIMUTHU

Practice based education has been identified as the most effective way of teaching and learning since it helps both the students as well as the teachers to learn effectively. Gernsbacher et al, (2015) suggests that shorter and more frequent learning by practice is more effective than the massed and less frequent practice, which is essentially the class room teaching and learning practiced in higher education. Fang Wang et al.,

(2015) discusses that contrary to the myth that internet will increase the competitions between industries, internet increases the industry profitability since it uses results in less competitive industry structure which is true for practice-based education as well. Introducing collaborative learning to enhance the practice-based education can increase its effectiveness, which has been proved again and again through IEEE YESIST12. IEEE Youth Endeavours on Social Innovations through Sustainable Technology (IEEE YESIST12) is a worldwide talent show run for the past 9 years on the theme of the United Nations Sustainable Development Goals (UNSDGs).

Our world is facing unprecedented challenges, from climate change to inequality, and it is our collective responsibility to address them head-on. This competition serves as a beacon of hope, bringing together brilliant minds and creative thinkers from across the globe to ideate, innovate, and implement projects that align with the UN SDGs. This competition is not merely a platform for showcasing ideas; it is a call to action. It is an opportunity for each participant to contribute meaningfully to the global pursuit of sustainability. Sherry Y Chen et al., (2019) has proved that when we introduce virtual competition, the students have significantly improved learning performance since they had to spend more time for undertaking the practical tasks.

Though the Sustainable Development Goals are important for everyone, we have not been able to reach all stakeholders, especially the individuals who has the capacity of ground level implementation on a large scale. So this competition aims to create this education to the younger generation from the school level to the professionals.

The competition covers nearly 25 countries and touches nearly 3000 students and professionals every year. Thanks to the increased usage of internet after the pandemic, the reach to countries also increased as evident in Table 1.

Table 1: ¹

Yr.	2017	2018	2019	2020	2021	2022	2023	2024
N.S.	1500	2500	3000	2000	2500	3000	3000	4000
N.C.	5	9	13	11	20	20	24	27

Innovating a solution to any of the social issues through sustainable technology and developing a prototype of the solution is the first step. Then the project is scrutinized and evaluated by a group of experts and worthy solutions are mentored and provided a platform to develop the product. Though around 3000 students participate initially, only 400 students and their mentors are selected for the presentation, evaluation and mentoring by the industry experts. The competition serves as a knowledge-sharing platform. Participants will have the chance to learn from each other's experiences, best practices, and challenges faced. This exchange of ideas is invaluable, fostering a global community dedicated to sustainable development.

This model of education paves way for the collaborative learning through peer mentoring as well as the cultural inter-

actions. When pandemic hit, the competition became virtual but for the last three years it has been converted into a hybrid model. The jury can interview the students and evaluate online and the mentors also provide technology mentorship over the internet. This enhances the quality of the solutions, since the students are given awareness on how cultural differences play an important role in the sustainability and the scalability of a solution to a social problem. More importantly, the students are encouraged to ensure the commercialization of their ideas through partner organizations and mentors. This increases the enthusiasm of the mentors to learn more about innovation and incubation. This multifaceted experiential learning for both students and teachers has been at the base of the successful sustainability of the event.

Reflections: Internet plays an important role in collaborative learning and cultural exchange which leads to successful technology education. This also proves that students are more interested in meaningful projects that can benefit the humanity. This was already proved by R. Marimuthu et al., (2016) who analyzed the impact of the competition on the career growth of the students.(4)

VI. LEVERAGING ENOLL'S INSIGHTS FOR INNOVATIVE CONTROL EDUCATION BY MEI LIN FUNG WITH ASSISTANCE FROM CHATGPT 4

A. Building on ENOLL's Learnings. Drawing from over a decade of insights from the EU Network of Living Labs (ENOLL), we have a unique opportunity to revolutionize control education. ENOLLs success is rooted in its user-centric approach, real-world applicability, and open innovation principles. By involving students, educators, industry partners, and other stakeholders in the co-creation process, we ensure that our control labs meet diverse needs. This iterative development process, characterized by continuous testing and feedback, allows for constant refinement of lab environments and educational materials.

B. Real-World Context and Project-Based Learning: We can make control education more relevant and engaging by designing labs that address real-world problems and scenarios integrating project-based service learning.

C. Technological Integration and Sustainability. Our control labs will incorporate cutting-edge technologies such as IoT devices, sensors, and digital tools, offering students hands-on experience with real-time data. Virtual and remote labs will increase accessibility and flexibility, allowing students to conduct experiments from anywhere.

D. Practical Implementation Steps. Starting with pilot programs in universities or institutions, with the support of government or industry partners, these pilots can refine our approach and gather insights. Designing strong focused and participative feedback loops with all stakeholders will help us understand what works and what doesn't, allowing for iterative development.

¹Yr.= Year; N.S. No of students; N.C.: No of countries

E. Long-Term Vision and Global Collaboration. Developing a long-term roadmap for the growth and evolution of control education labs will ensure alignment with technological advancements and industry needs. A significant challenge in resource allocation and control theory is the lack of data from the informal economy, particularly the contributions of women, the elderly, family support, and support for people with disabilities which is essential to monitor economic activity.

F. Quantifying and Integrating Informal Contributions: To address this, we will conduct surveys by conversational AI and analyze the aggregated data on informal economic activities, utilizing big data analytics to estimate their scale and impact in different communities. Blockchain-based digital asset registries and IoT devices will securely record and validate these activities, ensuring transparency and data integrity. (Global Symposium of Regulators July 3 2024 Panel: Safe and Inclusive Financial Services.docx - Google Docs) AI and machine learning will analyze this data, identifying trends and anomalies in the informal economy, thus informing more effective policy decisions and resource distribution.

G. Empowering Communities. Community engagement is the key to our approach. By creating digital dashboards and participatory mechanisms, we can foster transparency and encourage community involvement in data collection and analysis. 6.8 Conclusion: By building on the proven strategies of ENOLL, integrating modern technologies, and recognizing the vital contributions of the informal economy, we can create innovative, inclusive, and effective control education labs. These labs will not only prepare students for future challenges but also contribute positively to society, embodying a truly people-centered approach to education and innovation.

VII. REFLECTIONS AND PERSPECTIVES ON TECHNOLOGY FOR BLENDED CONFERENCE - EXPERIENCE OF IFAC TECIS 2024 BY BRENDA O'NEILL, JOHN ORGAN AND MARY DOYLE-KENT

A. Technology used Zoom for authors presenting or panel discussions. YouTube for live streaming and questions via chat

B. Pros:

- 1) Opens up the conference for those who may not be able to travel or who are on limited funds.
- 2) A panel discussion can be held online also and potentially opened up to audience members in the room.
- 3) A benefit is that recordings are online for people to view in their own time (particularly if there were parallel sessions).
- 4) Technicians on hand in each room to provide assistance.
- 5) People watching the live stream can ask questions on the chat so there is someone required to monitor this also.

C. Cons.

- 1) Much heavier workload for the organizers as a lot of planning is required.
- 2) Technical requirements need to be discussed with technicians well in advance so that they can be prepared.

- 3) Errors can occur mix-up in time zones, technology on the users side failing, lack of familiarity with technology on the users side. These are things that the organisers have no control of.

- 4) Need to keep rigidly to the schedule as people will be coming in at the time given on the zoom link.

D. Upon reflection. Definitely worth the effort to include those who may not be able to attend in person as it enriches the conference experience for all. If anyone feels nervous about using the technology to present they could be offered the option to video record in advance just in case something goes wrong. (They may be able to get a friend or colleague to assist them with this). We would be wary of offering video recording for everyone though as this can limit engagement and to us does not represent value for money or value experience wise. Have a vacant time slot on the last day as a backup for any online presenters that missed their slot through technical difficulty or some other factor during the conference up to that time. Whilst there are pros and cons to running a blended conference it is worth the extra work to increase diversity and inclusion.

VIII. MY REFLECTIONS ON INTERNET BASED EDUCATION BY IVEN MAREELS

We all moved to a virtual meetings platform for internet-based education readily under the constraints imposed by Covid. It worked remarkably well, given all the objections to use this type of technology going before it. We even succeeded in inserting virtual lab-based experiences using a presenter/operator in the lab executing the lab as per the lab instructions, and audience suggestions, complete with a remote uplink of all the data that could be gathered, followed by evaluations. Nevertheless, the interaction between the students and teacher were significantly reduced, with negative consequences when this cohort of students presented for their first job interviews. Moreover, the cost to maintain the teaching resources was much higher, both in time (to prepare, to adapt to the new medium, to achieve fair assessments) as well as in actual infrastructure required (think lab augmentation). The educational outcomes were acceptable.

Newer versions of the virtual meeting platforms with an AI based virtual assistant (minute taking, video modification, speaker tracking, discussion summarization) offer new productivity enhancing tools that may make the adoption easier, and maintenance of education materials less costly. The new tools help us achieve a level of authentic assessment we struggled with before.

Nevertheless, from my personal perspective, education remains by and large a team sport, and nothing beats the interaction of teacher/expert with students in the same classroom in terms of achieving participation, responsiveness and ultimately comprehension.

IX. OUR RELECTIONS AND PERSPECTIVES ON INTERNET VERSUS IN-PERSON TEACHING MATHEMATICS COURSES BASED ON DATA ANALYSIS FOR A DIVERSE STEM STUDENTS BY DOMINIQUE DUNCAN, BOZENNA PASIK-DUNCAN AND TYRONE DUNCAN

A. From Tyrone Duncan. I have experience teaching remotely for the past few years. Initially it was the Covid pandemic but the last two years it has occurred for other reasons. I have found empirically that initially students are concerned and reluctant. However after a few classes it seems that they are satisfied with the arrangement. I believe that the students find that the remote classes can be convenient to their learning experiences. The approach develops somewhat more independence for the students. Many students missed class because everything is posted online.

B. From Bozenna Pasik-Duncan who teaches in person Math 628 - The Mathematical Statistics Theory, advanced undergraduate level course of mathematical statistics with credit for engineering, business, economics, mathematics, and all sciences in collaboration with Dominique Duncan: Students are engaged in collaborative research project-based learning. They work with real magnetic resonance imaging (MRI) data that are organized by research objectives and accessible with assistance by the team of Dr. Dominique Duncan at the University of Southern California Stevens Neuroimaging and Informatics Institute. The experience of gaining access to large quantities of data online makes students ready for industrial jobs. The experiment of using a combination of in-person and online engagement was implemented for the first time in Spring 2024 thus providing opportunities for students to have flexible timings. The online option was used for guest speakers, conference attendance and reports, and teamwork on projects. There was 100% attendance in class and 100% of students turned in assignments on time. For the first time in my 40 years of teaching at the University of Kansas, all 17 students in the class of Math 628 Spring 2024 finished the course with the highest possible grade. Students were happy, and through the 'learning to collaborate and collaborating to learn' process, they develop "lifetime friendships."

X. OVERALL PERSPECTIVES

The authors, who have culturally and ethnically different backgrounds, have provided their experiences and insights in using the internet to enable the learning of students and professionals in different scenarios. Teaching through audio enabled messaging platforms for a class of students in underserved areas of Africa seems to be a cost-effective solution while off line video education in the regional languages with on line evaluation have proved to be effective in the rural areas of India. The learning level depends on connectivity, the motivation of the students and the effectiveness of the materials delivered. For teaching hands on lab courses, development of platforms such as ENOLL has become imperative so as to provide a structured, innovative, inclusive and effective approach. A combination of online and in person teaching

seems to improve the turnout and the vibrancy of the class 100% and enhances collaboration among the students as shown in the University of Kansas. Virtual Conferences and virtual competitions such as SYSCON and YESIST12 have become successfully scalable to different continents since they provide an opportunity for students with innovative ideas to present their work without the hassle and expense of travel. We can conclude that technology and internet enhanced learning has proven to benefit the teachers, students and the organizations as a whole.

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