



Education without borders

Lessons on technology-mediated teaching

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Executive summary

Technology-mediated teaching is a key strategy for expanding access to education in remote locations. Isolated communities in places such as the “Legal Amazon” region in Brazil have faced historical challenges, including long distances, limited infrastructure, and the scarcity of trained teachers. In such contexts, alternative educational models emerge as feasible alternatives for ensuring quality education, independently of the existing geographic barriers.

The present Technical Note analyzes concrete technology-mediated teaching implementation experiences and provides evidence and recommendations to public managers and policy makers. It also examines two case studies from Brazil's Legal Amazon - the state of Amazonas and the city of Manaus -, as well as three successful international references – the CEIBAL center in Uruguay, the CARNET network in Croatia, and the Innovation Network for Hybrid Education (RIEH) in Brazil.

Our analysis is structured around three key strategic axes for assessing the success of this teaching modality: I) connectivity and technological infrastructure (Giambruno, C.; Castro Vergara, N.; et al; 2025); II) monitoring of learning outcomes and student progression; and III) the relationship between on-site teachers and distance-learning instructors.

THE STUDIED CASES

Amazonas (2007) — After implementing a pioneering policy in Brazil, the state education network of Amazonas is serving 25,000 students in 60 municipalities through the Amazonas Educational Media Center (CEMEAM). It has a synchronous satellite virtual lesson model, which combines 277 remote instructors (based in different localities) and 1,938 on-site teachers (based in a central location). The CEMEAM became a national and international reference for its ability to enable and expand educational access. However, it strives to be strengthened, so that it may attain a more efficient monitoring of data on learning, while bridging technological gaps and fostering integration between distance-learning instructors and on-site teachers.

Manaus (2021) — Initially established during the COVID-19 pandemic, Manaus' distance-learning strategy has become a permanent policy of its municipal teaching network. It currently serves 36,175 students at 330 schools through an asynchronous model with specialized teachers, who record video lessons and produce gamified materials to be added to local teaching strategies, thereby contributing to accelerating remedial learning processes. The network currently strives to strengthen the structured monitoring of impact and real-time interactions among students and teachers, to bolster their commitment and educational bonds.

CEIBAL (Uruguay, 2007) — The CEIBAL Plan is an innovative Uruguayan policy that centralizes the availability, management, and maintenance of digital equipment and its pedagogical use. It includes innovations such as taking English teaching and programming to public schools, even in the absence of specialized teachers. It serves 75,000 students at 650 schools through a collaborative pedagogical model that combines the geographical flexibility of remote teachers, systematic follow-up procedures and frequent adaptative assessments. The CEIBAL Plan shows that moderate investment together with high levels of pedagogical collaboration can generate scalable outcomes.

CARNET (Croatia, 1991) — The CARNET network is one of the best structured transformation initiatives in education in Europe, which was able to ensure access to learning, even in regions with poor connectivity. It stands out for its ability to provide continuous training on digital skills to teachers, through a student ambassadors' program to foster digital culture at schools, as well as for combining different technological platforms to provide student follow-up and assistance.

Innovation Network for Hybrid Education - RIEH (Brazil, 2022) — RIEH is a reference initiative launched by the Ministry of Education of Brazil to bolster an educational focus aligned to the requirements of the 21st century, connecting institutions and professionals through an inter-institutional cooperation model. It supports educational networks by providing training, as well as by setting up spaces to produce audiovisual materials, while adapting activities to regional realities and collecting data to monitor its advances.

BEST PRACTICES

Although the Brazilian and international initiatives examined in this study differ in context and maturity level, they yield relevant lessons that can guide other education networks:

I) Connectivity and technological infrastructure

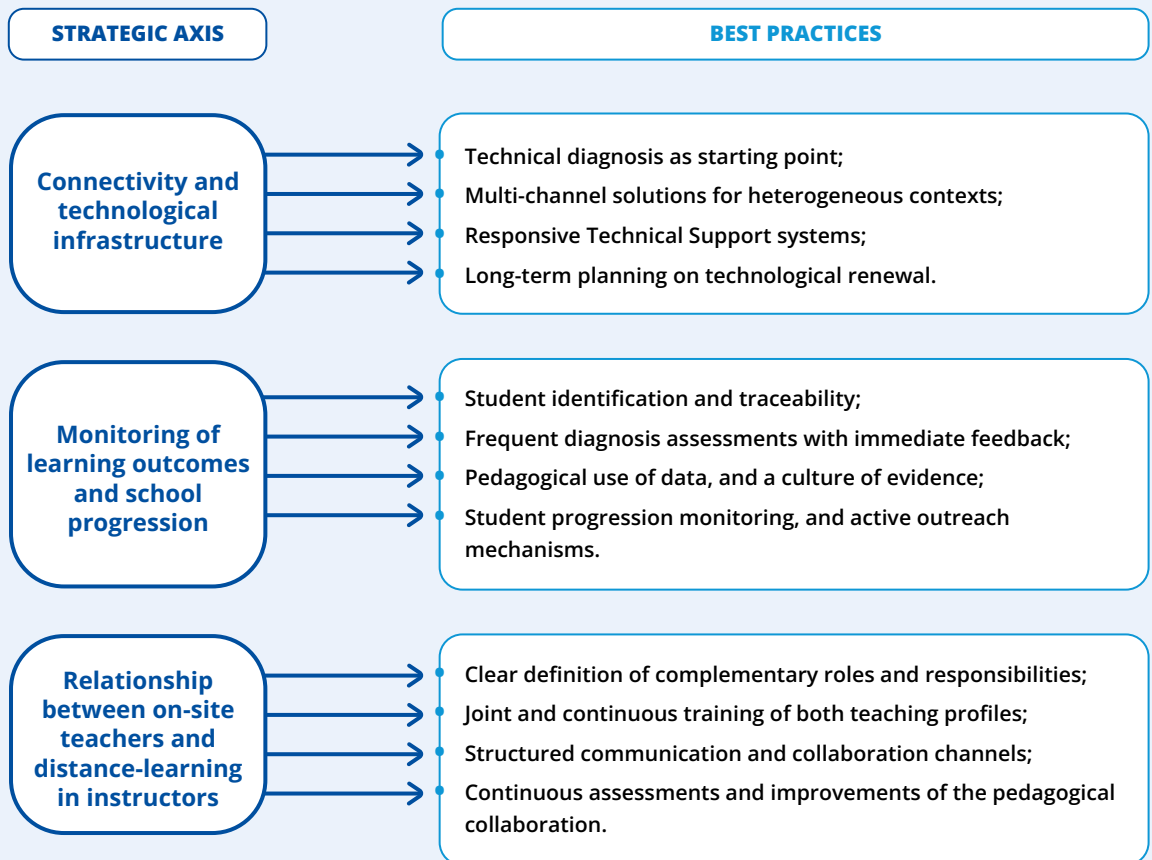
Connectivity is a necessary but not sufficient condition for the success of technology-mediated teaching. The experiences above revealed that investments in infrastructure must be conceived in systemic ways and formats adapted to local realities. It is desirable to invest in adaptive infrastructure, while prioritizing technologies such as low orbit satellites, offline kits with educational content, and public-private partnerships to increase connectivity in remote regions.

II) Monitoring of learning outcomes and school progression

The cases show that robust monitoring systems are essential for attaining effective educational policies. The collection of data on technology-mediated teaching is a key requirement, together with the strengthening of linkages between relevant indicators and active policies to halt school dropout, and active outreach campaigns, for instance, through community radio stations. Learning assessments must be a crucial component of monitoring activities, to enable the identification of gaps in current knowledge, as well as the adjustment of pedagogical strategies to ensure adequate student progress.

III) Relationship between on-site teachers and distance-learning instructors

Technology-mediated teaching necessarily requires collaboration between two teaching profiles: distance-learning instructors and on-site teachers. The establishment of linkages between these two professional groups is a crucial element for determining the learning-experience's quality. On the other hand, fragmentation between them is one of the main challenges identified in all cases studied. Teachers' training must be strengthened through hybrid programs that combine technical knowledge, mentorship activities, and curricular adaptation to local cultures, to ensure that on-site teachers and remote instructors act in complementary and collaborative ways. The maintenance of steady communication channels between these two groups is essential for aligning pedagogical practices and bolstering technology-mediated teaching. Moreover, a clear definition of their roles and responsibilities is a crucial feature to ensure their effective and cohesive work throughout the students' learning process.



Successful technology-mediated education at once preserves and strengthens the human linkages in the relationships between students and teachers, ensuring that every student, independently of their geographical location, has access to quality content and the necessary learning support. It is this combination of technological innovation and pedagogical zeal that can effectively contribute to overcoming educational inequalities and ensuring the right to education for all. ■

1.

Context and object of this study

Technology-mediated teaching has established itself as a promising approach for increasing the provision of education in remote regions and overcoming geographical barriers. For this reason, it is an effective option for rural, Indigenous, riparian, and other geographically isolated communities.

In Brazil's "Legal Amazon" region, historically isolated communities face persistent educational challenges. Limited transportation and long travel distances restrict access to schools and make regular instruction difficult. School infrastructure is often inadequate, with shortages of teaching materials and, in some cases, even basic classroom furniture. The region also faces a shortage of qualified teachers, and numerous educators lack specialized training and stable employment status (Cossi, J.; Pérez Alfaro, M., et al., 2024). Together, these factors affect both learning outcomes and students' ability to remain in school.

Technology-mediated teaching emerges in response to these logistical and structural restrictions. Alternative educational models, including synchronous remote teaching and hybrid learning experiences, may contribute to solving issues such as interrupted learning trajectories and access barriers in distant regions (Cossi, J.; Pérez Alfaro, M., 2024).

However, hybrid teaching must not be considered as an emergency-solution only, but also as a structuring educational strategy aimed at decreasing inequalities and improving quality and equity in education (Arias Ortiz, E., Brechner, M., Pérez Alfaro, M., 2020). To be effective, it must draw on the support of multiple pillars such as connectivity and digital infrastructure, adjusted curricula and methodologies, specialized training for teachers, and monitoring and support systems.



This Technical Note aims at **contributing to current discussions, as well as to the successful implementation of technology-mediated teaching in basic education by casting a systematic and structured look at best practices and challenges faced by networks that implement these policies.** In so doing, the Note presents experiences of educational networks that have established technological solutions adjusted to their regional particularities and converted them into strategic instruments in support of decision-making by public managers, educational policy designers and international technical cooperation institutions. The evidence, analysis, and recommendations in the following pages describe possible models and the practical lessons that can be learned from their implementation trajectories.

This study conducts an in-depth analysis of two cases from Brazil's "Legal Amazon" region: the experiences of the departments of education [named *Secretarias*] of the state of Amazonas and of its capital city, Manaus. Amazonas pioneered the adoption of Technology-Mediated On-Site Teaching by establishing the Amazonas State Educational Media Center (CEMEAM) in 2007. The city of Manaus, in turn, established its municipal Educational Media Center in 2021, initially conceived as an emergency response to the COVID-19 pandemic, and subsequently consolidated as a permanent pedagogical innovation policy. In their processes, these two networks were able to overcome challenges and continue to strive to improve the maturity level of their operational arrangements, while facing practical dilemmas in implementation processes.

In addition to these case studies, this Technical Note describes three benchmarking cases, that is, three national and international reference programs that inspire best practices. First, the CEIBAL Program in English - an innovative response to the lack of English teachers in Uruguay -, which attained scalable and sustain-

able outcomes through the strategic use of technology. Second, the Croatian Academic and Research Network (CARNET) in Croatia, which invested in innovative technological platforms and pedagogical strategies, ensuring thereby access to inclusive learning in regions with low connectivity. Finally, the Innovation Network for Hybrid Education (RIEH), a Brazilian federal initiative, which provides technical support and infrastructure to the implementation of hybrid education at all federative levels nationwide. ■

Amazonas pioneered the adoption of Technology-Mediated On-Site Teaching by establishing the Amazonas State Educational Media Center (CEMEAM) in 2007.

The city of Manaus, in turn, established its municipal Educational Media Center in 2021, initially conceived as an emergency response to the COVID-19 pandemic.

2.

Background and methodology

This study resumes a 2019 survey conducted by the institute Interdisciplinarity and Evidence in the Educational Debate (IEDE) in partnership with the Inter-American Development Bank (IDB), which covered key features and challenges faced by the Amazonas State Educational Media Center (CEMEAM) and the Pará State Interactive Educational System (SEI) with a descriptive approach.

Whereas the early study's hypothesis was related to the impact of technology-mediated teaching on the increase of educational coverage and access to learning, as well as to the improvement of educational outcomes, the present Note is focused on three strategic axes and aims at attaining a deeper level of understanding about their relevance for the effectiveness of technology-mediated teaching. It comprises the following axes:

I) Connectivity and technological infrastructure

To what extent is technology a requirement for the successful implementation of mediated teaching, and how does it support or define the format (synchronous, asynchronous, and so on) of interventions to be implemented?

II) Monitoring of learning outcomes and school progression

How can customized assistance to students and the quality of education be ensured in technology-mediated teaching?

III) Relationship between on-site teachers and distance-learning instructors

Is there any distinction based on the number of, or relationship between on-site teachers and distance-learning instructors, and their locations? What role does their interaction play for the effectiveness of policy implementation and policy outcomes?



In addition to the diagnosis of the two cases studied - including the CEMEAM case, which had been covered by the initial survey -, this Technical Note presents three reference cases and some recommendations. It aims at enabling a new step towards providing inputs to the implementation and improvement of technology-mediated teaching, considering that the COVID-19 pandemic produced the demand for increasingly connected teaching formats, including hybrid teaching models in all educational networks.

This note's assessment draws on a qualitative approach and a mixed data-collection methodology that combines systematic document analysis and in-depth (on-line and on-site) interviews. Virtual meetings were held with representatives of educational networks of the state of Amazonas and of the city of Manaus, and administrative data and educational indicators were analyzed. Finally, the authors interviewed key representatives involved in the programs at each governmental level. In Amazonas, an additional field visit was conducted to enable on-site experience at schools. And in the cases of the selected benchmarking networks, virtual meetings were held, in addition to the collection of data on laws and reference materials related to their respective educational policies. ■

3.

Technology-mediated teaching modalities

Technology-mediated teaching comprises the use of technological resources to facilitate learning. It may take place in on-site, hybrid or fully remote formats. Each of these formats can be adapted to local realities and educational aims. Before turning to the practical examples at issue, it is worth systematizing the following possible modalities:

Technology-mediated educational modalities

Synchronous Teaching	Synchronous teaching comprises real-time interactions between teachers and students. This category covers live lessons in videoconference format, group discussions, and online tutoring activities – thus favoring involvement and immediate interaction.
Asynchronous Teaching	In this modality, no simultaneous connection is made between students and teachers. Students have more flexibility to access content and conduct activities. This category includes recorded video lessons, learning forums and interactive materials. It contributes to students' autonomy by facilitating the customization of teaching, especially in case of connectivity issues or restrictive routines (Ortiz et al., 2020).
Hybrid Teaching	This modality combines on-site and remote activities, integrating synchronous and asynchronous components.
Technology-Mediated On-Site Teaching	In this model, students physically attend class at their schools and learn through lessons transmitted in videoconference-format or through digital platforms and other technological resources. While a distance-learning instructor is responsible for transmitting content remotely, an on-site teacher provides pedagogical support to students and mediates learning.

The next chapters illustrate these distinct forms of implementing technology-mediated teaching.

4.

The pioneering experience of the Amazonas State Educational Media Center (CEMEAM)

LOCAL CONTEXT AND EVIDENCE

The Amazonas state network comprises 5,144 public schools. 71.2% of these schools are located in urban areas¹ and serve approximately 264,000 basic education students (Censo Escolar, 2024).

The state must cope with a number of challenges related to educational provision, as a result of its geographic features. Amazonas is an extensive territory - if it were an independent country, it would be the 16th largest in the world - and its vast network of rivers imposes long distances between communities. Its low population density and precarious infrastructure, in particular, the telecommunications and electric energy infrastructure, adds to the complexity of implementing conventional educational models (Neto, 2012). Factors such as low-water seasons and the scarcity of specialized teachers further complicate the provision of regular teaching in numerous localities (Maia, 2010).

Such realities impose significant logistical obstacles to the state education network and produce a situation of complicated access to education for thousands of young people. As Table 1 below shows, Amazonas' performance indicators point to the need for structural interventions.

1. Including rural areas, settlements, Quilombos, Indigenous territories and forest areas.

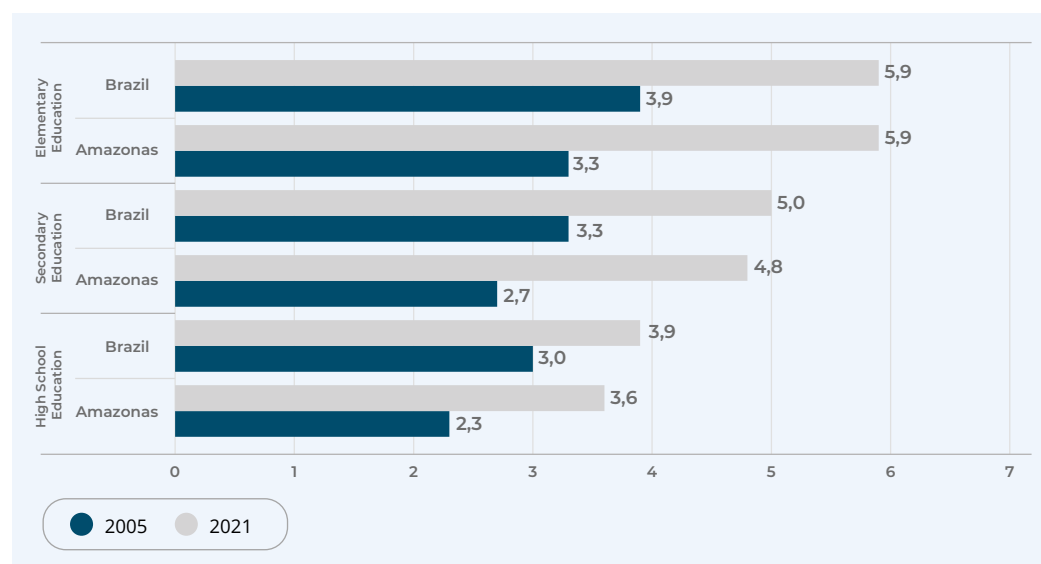
TABLE 1 – Compared Educational Indicators on Higher Secondary Education at the State of Amazonas, in the Legal Amazon region and in Brazil

INDICATOR	AMAZONAS	LEGAL AMAZON	BRAZIL
Enrollment in higher secondary education (young people aged 15 to 17)	80.4%	77%	82.8%
19-year old young people who finished higher secondary education	68%	66.7%	71%
School failure rates	6.5%	4,0%	5.5%
School dropout rates	4.4%	3.3%	3.7%
Age-grade distortion	28.7%	26.1%	19.8%
Adequate learning levels, 3rd year of higher secondary education – Portuguese language	19%	21%	29%
Adequate learning levels, 3rd year of higher secondary education – Mathematics	2%	2%	4%
<i>Escolas Conectadas</i> ²	58%	63%	72%

Sources: Censo Escolar (2024) and Basic Education Assessment System (SAEB) (2023).

Until 2006, this situation was even more critical: the state of Amazonas did not yet provide higher secondary education [in Brazil, *Ensino Médio*] with full coverage to its rural communities (Souza, 2016; Mello, 2017). In 2005, the state scored lowest (2.7) in the country's Basic Education Development Index (IDEB), whereas currently its score already touches the national average. In such a context, the need was felt for innovative solutions that help overcome the barriers of local geography and ensure the right to quality education to all students, independently of their location.

GRAPH 1. IDEB Evolution, 2005-2021



2. MEC Monitoring *Painel Escolas Conectadas*. Accessed on May 14, 2026, Microsoft Power BI.



THE IMPLEMENTED MODEL

Modality: Technology-Mediated On-Site Teaching

Year: 2007

In 2007, the state of Amazonas was a Brazilian pioneer in the adoption of technology-mediated on-site teaching for the provision of basic education to remote regions. Its initiative expands and diversifies the provision of education to students of the public teaching network, by offering them an innovative digital education model using information and communication technologies, with a focus on interactivity. This model has been implemented by the Amazonas Educational Media Center (CEMEAM).

The adopted modality has a pedagogical and communicational conception which, differently from distance-learning, still maintains the students' on-site attendance. It is a synchronous strategy that incorporates real time interactivity and uses planned activities in mediated lessons.

The lessons are produced by specialized teachers and rendered as transmittable content at a central production office using media resources and communication tools. They are transmitted daily, either in real time or in simultaneous format, to all active classrooms in the regular school hours. At each classroom, an on-site teacher supervises the students and mediates their teaching and learning process, by clarifying doubts and supporting the conduction of activities. Each classroom has a technological kit that enables not only the transmission of lessons, but also interactions between students and remote instructors. The content is aimed at secondary education students.³

The transmissions take place from the CEMEAM studios in Manaus through a video conference system with high speed (200 Mbps) satellite connection. This infrastructure enables audio and video interactions between teachers and students. In addition to assisting the schools, the CEMEAM transmits social impact presentations and courses in partnership with other governmental bodies and divisions of the Department of Education.

In 2024, the network had 277 distance-learning instructors working as content specialists, and 1,938 on-site teachers – one teacher per classroom. Each instructor was responsible for assisting an average of 90 students.

3. In Brazil, "Basic Education" comprises Early Childhood Education (0 to 5 years old), Primary and Early Secondary Education (6 to 14 years old), divided into two cycles: "early years" or primary education (1st to 5th grade), and "final years" or early secondary grades (6th to 9th grade), and *Ensino Médio* (higher secondary education, 15 to 17 years old).

TABLE 2. Selected Rates and Figures Regarding Distance-Learning Instructors and On-site Teachers in the Amazonas State Network

	QUANTITATIVE DATA, AMAZONAS STATE EDUCATION NETWORK
Total students (lower and higher secondary teaching)	25,000
Classrooms with technology-mediated teaching	1,938
On-site teachers	1,938
Distance-learning instructors	277
On-site teachers per classroom	1 teacher per classroom
On-site teachers per student	1 teacher for 13 students
Distance-learning instructors per classroom	1 instructor for seven classrooms
Distance-learning instructors per students	1 instructor for 90 students

Source: Administrative data provided by the Amazonas State Network of Education (2024).

The implementation of this model requires investing in connectivity, equipment purchases and teachers training. The schools participating in their activities have classrooms equipped with TV devices and interactive transmission systems.

As regards its organizational structure, Amazonas' technology-mediated on-site teaching system encompasses the following instances:

TABLE 3. Instances of the Technology-Mediated On-Site Teaching Policy in the State of Amazonas

INSTANCE	RESPONSIBILITIES
Amazonas State Department of Education (SEDUC/AM)	The SEDUC/AM is responsible for designing, implementing, and managing its technology-mediated teaching policy, as well as for supervising and funding the necessary infrastructure, and coordinating and distributing technological equipment such as tablets and multimedia kits to students and teachers.
Amazonas Educational Media Center (CEMEAM)	The CEMEAM is connected to SEDUC/AM as the central body in charge of producing and transmitting lessons, in addition to providing technical and pedagogical support to schools and their teaching staff.
Regional Divisions of Education (CREs)	The CREs conduct the intermediation-activities between SEDUC/AM and local schools, by following up on the implementation of technology-mediated teaching in the municipalities, as well as by providing support to local management teams.
State schools (Escolas sede)	State schools function as reference centers for students' enrollment and participation in the technology-mediated teaching model's structure.
Municipal schools (Local schools)	At the municipal schools, students join and participate in the technology-mediated lessons while counting on the support of on-site teachers.
Municipal city-halls	The municipal city halls are responsible for formalizing their Technical Cooperation Agreements with the state to enable the policy's implementation through the municipal schools' infrastructure.

Source: Compiled by the authors.

The cooperation agreement between the state and the municipalities is the institutional backbone that enables this model in Amazonas. Its arrangement is focused on the need to use the municipal schools' premises for implementing the Media Center lessons at the communities. The challenges found in its implementation are related to the large diversity of management instances, since the state must simultaneously manage 60 cooperation agreements with the municipalities, leading to increased complexity in terms of coordination, management, and distribution of teams.

Benefits of the implemented initiatives

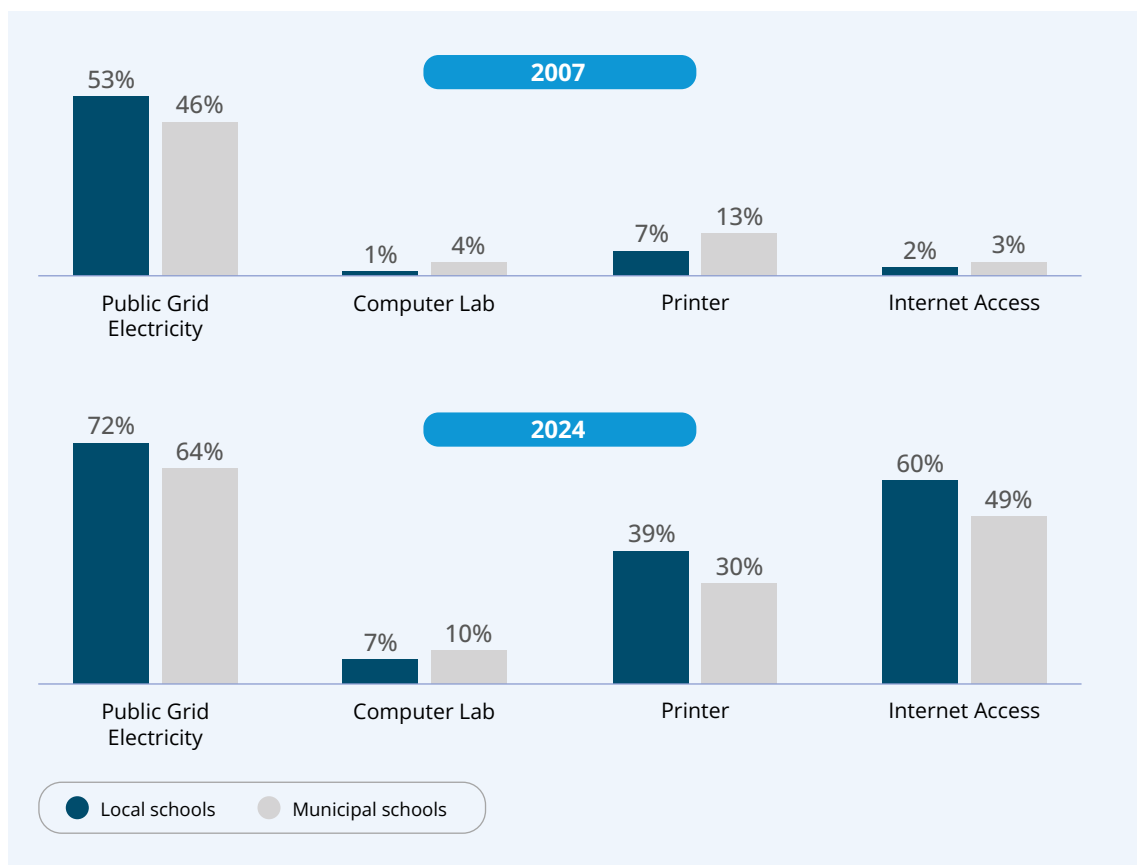
In 2024, the program served more than 25,000 students in 60 municipalities, ensuring their access to the content produced by specialized teachers, as well as to local pedagogical support.

The SEDUC/AM model has become a national and international reference. It received awards and served as a basis for the establishment of RIEH, which will be described further in this Note. It also expanded the provision of education to remote communities by incorporating technological innovations - on the one hand, by ensuring quality distance-learning instructors and, on the other, by strengthening community bonds through the presence of on-site teachers. During the COVID-19 pandemic, because of its prior work, the CEMEAM was quickly restructured and managed to help other Brazilian states, thereby sharing access to education with more than seven million students (Centro de Mídias de Educação do Amazonas, 2022).

In early 2024, its initial transmission system was replaced by a low-orbit satellite solution, leading to a considerable advance in terms of connectivity at local schools. The new technology led to an increase in Internet speed and stability, enabling synchronous resources such as video conferences and interactive platforms, even in remote regions. Improvements followed in the pedagogical experience, as both teachers and students reported a decrease in the number of lesson interruptions and an increase in the fluidity of interactions with distance-learning instructors. The new system also enabled prior access to study materials. Content sharing with on-site teachers was enabled with an anticipation of one hour, reducing anxiety among students and improving the organization of lessons.

Local schools – the places where students receive technology-mediated lessons – reached a higher percentage of Internet access compared to municipal schools throughout the state (Censo Escolar, 2024). The following graphs show the evolution of infrastructure at schools.

GRAPH 2. Percentage of Schools with Public Electric Energy, Computer Labs, Printers, and Internet Access (2007 and 2024)



Sources: Censo Escolar (2007); and Censo Escolar (2024).

Opportunities for improvements

As regards **connectivity and technological infrastructure**, despite the new satellite system, Internet connection instabilities and the need for continuous equipment maintenance are still impacting on the regularity and quality of transmission.

At schools without Wi-Fi technology, the lack of a wireless network prevents the students from obtaining simultaneous access to digital materials and encumbers the use of online tools during lessons, for instance, real-time attendance logs. In some communities, the provision of electric energy depends on power generators, leading to early class interruptions for the purpose of saving fuel. Rainfall, winds, and thunderbolts continue to impact the stability of connections on an occasional basis. There are also persistent equipment failures (microphones, cameras, printers, and the lack of replacement components such as toner cartridges and paper), which compromise exam administration processes and classroom communications.

Monitoring learning outcomes and school progression continues to be a challenge for the teaching network. Monitoring has particularities when it comes to technology-mediated teaching, and it is important to distinguish between the performance of mediated teaching students and that of regular students when administering exams, to enable increasingly effective actions.

The absence of mechanisms for identifying, following up on, and assessing these students could compromise the state network's ability to design evidence-based policies aimed at developing effective pedagogical interventions.

In the case of external assessments,⁴ several schools do not disclose their outcomes, either because they do not have the minimum number of students (10 students), or because they do not reach the minimum participation rate (80%). As regards inter-

nal assessments,⁵ a persisting feature is the mismatch of administrative timings, as well as of outcomes and teachers' planning efforts, which evinces the need to improve the current ways of working with data and analyses. If teachers could access this information, they would be able to redesign their activities and annual pedagogical planning. Thus, it is a duty to ensure that distance-learning instructors and on-site teachers obtain access to data on learning outcomes.

The absence of mechanisms for identifying, following up on, and assessing these students could compromise the state network's ability to design evidence-based policies aimed at developing effective pedagogical interventions.

Student attendance is monitored through two mechanisms. First, a contracted company, with support from the CEMEAM Support Center, tracks connections in real time and responds to disconnection problems. Second, on-site teachers register attendance in the Digital Attendance Log tool. However, in areas with unstable connectivity, the system often faces failures and delays. As a result, several teachers record attendance manually and later enter the data into the digital platform from home, using their own internet connection.

An additional challenge is the fact that no structured active outreach strategy is in place to address student absenteeism in technology-mediated teaching. In countryside municipalities, monitoring is even more limited, due to the small number of available professionals, as well as to logistical difficulties and the lack of specialized equipment. During the field visit, we noticed a significant drop in the number of students in grades 1 and 3 of higher secondary education. According to local narratives heard during our visit, classrooms with technology-mediated teaching continued to experience a drop of up to 50% of their students.⁶ The reasons for such a scene include the need to work, early pregnancies and child marriage - situations that are more acute in contexts of social vulnerability and absence of interconnected school permanence policies.

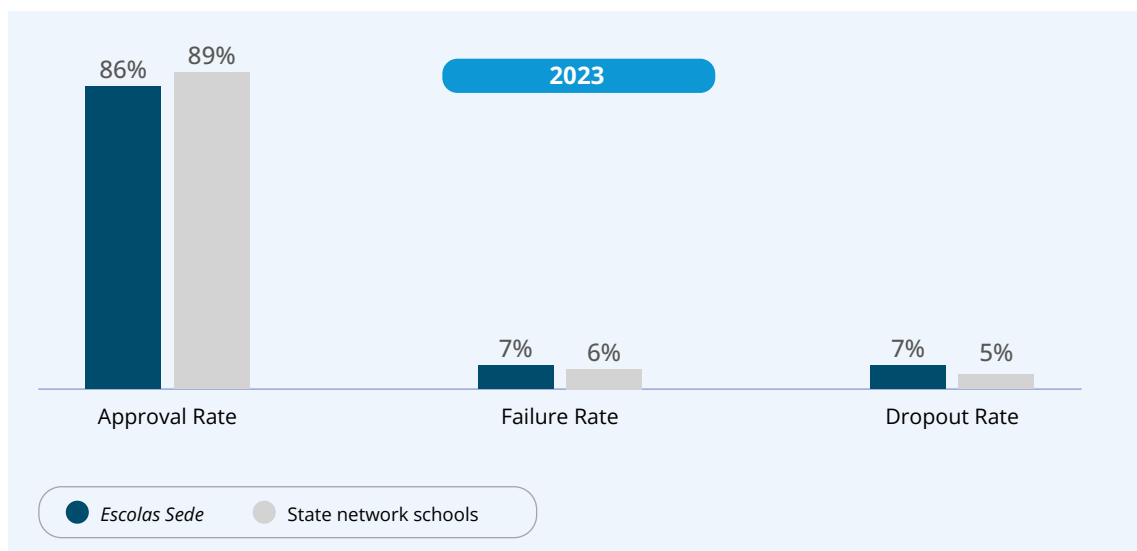
According to figures from the Socio-Economic Status Indicator (INSE) calculated by the Anísio Teixeira National Institute of Educational Studies and Research (INEP), 87% of the so-called *escolas sede* – reference schools participating in the technology-mediated structure – have a low socio-economic status, whereas among Amazonas' state schools, the percentage is 57%. At the higher secondary level, the *escolas sede* attained lower pass rates and higher failure and dropout rates, compared to the schools of Amazonas' state network (Censo Escolar, 2023).

4. Basic Education Assessment System (SAEB) and Amazonas State Assessment System on Educational Performance (SADEAM).

5. Assessed by CEMEAM.

6. To date, there is no disaggregated data on technology-mediated teaching that would enable us to go beyond the level of collected narratives. The Amazonas state dropout rate in rural higher secondary education was 6.7% (2024).

GRAPH 3. Pass, Grade Repetition and Dropout Rates at Escolas Sede and State Network Schools (2023)



Source: Indicadores Educacionais - Inep (2023).

The **relationship between on-site teachers and remote instructors** also needs to evolve to become an increasingly aligned and collaborative pedagogical practice. So far, the two teaching profiles have not interacted in significant ways, either via chat communication during class sessions or through the Local Interactive Dynamics (Portuguese initials: DLI). The DLI is an interactive moment before the closing of distance-learning lessons, but the time allotted to it (15 minutes) and the large number of participating schools lead to poor effective interactions.

Training activities to remote instructors and on-site teachers are imparted separately. In the case of remote instructors, these activities include the provision of continuous pedagogical follow-up on lessons' planning and the production of teaching materials, whereas for on-site teachers, the main activity is an annual technical capacity building event called "Pedagogical Journey". Both remote and on-site teachers express the willingness to collaborate more closely via exchanges that increase their understanding of local realities and enrich their pedagogical work.

On-site teachers also emphasize the need for additional training on educational technologies and on how to master the content imparted through them. Many teachers still face difficulties in the use of digital tools such as the Digital Attendance Log and in dealing with different types of equipment. It is reported that a portion of the teachers do not even know how to turn a computer on. An additional challenge regards the ability to reach out towards scattered teachers throughout the state. Considering the current limitations of access, online training activities are likely the best option. Yet, the above-mentioned connectivity difficulties still impose on the state's teachers, as well as the lack of available time in their schedules for participating in this type of activity. ■

5.

Manaus: an asynchronous model for learning support and continuing education

LOCAL CONTEXT

The public education network of Manaus – the capital city of the state of Amazonas – comprises a total of 753 schools, including 508 municipal schools, 240 state schools and 5 federal schools, which serve 454,736 basic education students (Censo Escolar, 2025). Most of these schools (667) are concentrated in urban areas, but the network also includes 86 schools located in rural areas.

Manaus is not only a major economic and cultural center in the north of Brazil, but also the country's second largest capital in territorial extension. This fact leads to considerable educational challenges, due to the city's territorial complexity and socio-economic disparities. Its peripheral and rural areas have limited infrastructure and unequal access to pedagogical resources, creating barriers to quality improvements in the provision of education. The irregular distribution of trained teachers, as well as displacement difficulties, produce additional inequalities, particularly involving students from riparian communities and other hard-to-reach places.

Despite recent advances in terms of its educational indicators – for instance, improvements in the municipal scores in the **Basic Education Development Index** (IDEB)⁷ in primary (an increase from 5.5 to 6.2) and early secondary grades (an increase from 4.8 to 5.2) between 2021 and 2023 –, some persisting structural challenges, such as Manaus' high age-grade distortion rates, point to the need for additional interventions.

7. Established in 2007, the IDEB index is calculated and disclosed on an annual basis by the Anísio Teixeira National Institute of Educational Studies and Research (INEP). It draws on pass rates-data from Brazil's Educational Census and average student performance-data from the Basic Education Assessment System (SAEB). The IDEB ranges from 0 to 10 - the higher, the better. To learn more about it, visit: <https://www.gov.br/inep/pt-br/areas-de-atuacao/pesquisas-estatisticas-e-indicadores/ideb>



THE IMPLEMENTED MODEL

Modality: Asynchronous Teaching

Year: 2021

Manaus' Educational Media Center was established in 2021, initially in response to the COVID-19 pandemic, as the Educational Technologies and Media Center or CEMTEDS. Further on, the CEMTEDS was consolidated as a permanent municipal technological innovation policy and incorporated into the activities of the Municipal Department of Education (SEMED). Its mission is to provide support to teaching and learning using technologies and actions such as remedial tutoring, student training for the Basic Education Assessment System (SAEB) and the production of complementary educational content.

Unlike CEMEAM's state-based model, which operates through live transmissions of synchronous lessons, Manaus' Media Center adopted an asynchronous strategy with recorded content, in which no real time interaction with distance-learning instructors is available.

Manaus's remote teachers are subject specialists: three of them in Portuguese language, and three in mathematics. These instructors produce and record video lessons, gamified content, multimedia activities, and teaching sequences. Their productions are available through digital platforms, which amplify the provided content's reach beyond regular school hours and enable students and teachers to access these materials according to their needs.

The Center is active in a diversity of pedagogical areas. Its principal activities include:

- Teaching Sequences: focused on priority skills, structured by complexity level, to enable the customization of pedagogical trajectories;
- Project 6º Tempo ["Sixth Shift"]: provides academic support in Portuguese language and math to 5th and 9th graders outside regular school hours. Their regular teachers use video lessons, gamified content, and educational diag-

noses, and receive extra remuneration for this work. They assume the role of mediators who provide support to students and clarify their doubts about the recorded content;

- Access to YouTube lessons: widens the reach of the recorded content;
- Training guidance: provides training to teachers on active methodologies and the use of technologies for lessons in the Media Center-format;
- Project *Quero Saber* ["I Want to Know It"], 2024: interactive (synchronous) joint review lessons and the provision of support materials to 9th graders;
- *Revista Digital Educativa*: ["Digital Education Magazine"], appreciates and displays the network's successful pedagogical practices;
- Project *EducAtiva*: fosters strategic partnerships to expand the reach of SEMED's actions.
- Project *Vivências Mediáticas* ["Media-Related Experiences"]: fosters the initiatives of 9th graders through media productions, by focusing on their creativity and engagement.

Continuous training is provided to strengthen linkages between the Media Center and municipal teachers through activities that draw on pedagogical and methodological guidelines for the use of materials produced by the Center, thereby improving the alignment between transmitted content and in-class pedagogical practices.

Manaus' SEMED also invested in connectivity for its public schools. In 2025, 559 schools had active internet connection, including 484 schools in urban locations and 75 schools in rural areas.

In urban areas, internet access is provided through an exclusive fiber-optic cable, whereas at rural schools – which often face access difficulties and boat displacements that last hours –, a satellite solution has been implemented. In rural areas, the connection speed also increased considerably: from 1 Mbps to 200 Mbps. This means a significant change in technological infrastructure and improved access to digital resources such as video lessons, learning platforms and multimedia content, leading to reduced inequalities between urban and rural schools.

SEMED works with a virtual support ticketing system, which enables technical follow-up on the school through their requests. In 2024, a total of 12,500 support requests were made, and nearly 10,000 of them were solved. To improve the provision of on-site assistance, a system of technical routes is in place, through which technical team routes are planned to solve multiple requests from nearby regions with optimized itineraries. Further, SEMED conducts periodical capacity-building actions to reduce the number of support requests and optimize technological efficiency.

Regarding organizational structure, the management of Manaus' technology-mediated on-site teaching policy connects diverse SEMED instances to the operational hub of the city's Educational Media Center, which received IDB funding through the Expansion and Improvement Project of the Public Education Network of Manaus (PROEMEM) (BR-L1392) executed in 2017-2024.

TABLE 4. Policy Instances of Manaus' Municipal Media Center

INSTANCE	RESPONSIBILITIES
Municipal Department of Education (SEMED/Manaus)	The Municipal Department of Education is responsible for designing the educational policy and implementing the Media Center's initiatives in the city. The Division for Educational Management Support (DAGE) plays a direct role at the Center's actions.
Manaus Educational Media Center	Manaus Educational Media Center is an operational institution under the SEMED, which reproduces educational content, including video lessons, digital learning materials, and special projects such as the "Sixth Shift" initiative.
Zonal District Divisions (DDZs)	The Zonal District Divisions perform an essential role of networking and implementation of activities under the Media Center at the educational networks' schools, connecting SEMED and the schools to ensure that the Media Center's guidelines and initiatives are effectively applied. Manaus currently has seven DDZs.
Municipal schools – School Management	Municipal school management is responsible for implementing the Media Center's activities at local schools, ensuring that their content is applied in agreement with the approved pedagogical guidelines.
Municipal schools – Teachers	Through programs such as "Sixth Shift", on-site teachers are also responsible for following up on mediated lessons, to ensure the provision of adequate pedagogical support, while earning extra remuneration for the additional work.

Source: Compiled by the authors.

BENEFITS OF THE IMPLEMENTED INITIATIVES

In 2025, program *Educa+Manaus* - which encompasses the above-mentioned actions with a focus on improved learning, and which includes the "Sixth Shift" initiative as a structural axis - served more than 36,000 students, including 22,552 5th grade students and 13,623 9th grade students. The initiative was implemented in 330 schools and 1,000 classrooms.

Manaus' Media Center represents an advancement in the integration of technology into education by assisting rural and hard-to-reach communities. Technology-mediated lessons tend to be more attractive to students and to contribute to their increased interest and engagement in the content learned. In addition to enhanced access, there have been improvements in the quality of produced materials, to meet the students' specific needs based on learning assessments' outcomes, as well as an increase in efficiency through optimized timings and teachers' planning activities in class, based on the available materials, which are harmonized with the curriculum.

Qualitative correlations have been made on the increased percentage of literate children measured by the Ministry of Education (MEC)'s *Criança Alfabetizada* ["Literate Child"] indicator after the implementation of Program *Educa+Manaus* for this group. Their literacy rate rose from 52% in 2023 to 58% in 2025. Students recently expressed their recognition and gratitude for the activities conducted by Media Center teachers, especially during the school visits, as a sign of their strengthened bonds with their schools and with the overall teaching and learning process. Likewise, gratitude was expressed by students who passed selection processes, who associated their successful performance to the Center's lessons.

OPPORTUNITIES FOR IMPROVEMENTS

As regards **connectivity and technological infrastructure**, the main reported issues were service interruptions, slow connections, network equipment failures, and difficulties of access to specific services or platforms. Obsolete equipment is frequently reported, particularly in computer labs, where a large number of computers are reaching the end of their service life, and there is a lack of logistical support, including adequate motorboats and vehicles, to assist help requests in remote areas. Further, the lack of training among school managers and teachers for solving simple issues, such as verifying energy or network connections, increases the number of unnecessary help requests. Plans were made to modernize SEMED's technology park with the support of joint projects with the IDB, bearing in mind the relevance of this structure for the progress of student engagement and learning acceleration activities.

As to **monitoring learning outcomes and student progression**, the Media Center does not yet have structured monitoring activities. It has neither a technical team to assist in this work, nor a project aimed at systematically assessing the impact of the lessons produced by the Center. The nonexistence of such mechanisms encumbers the objective measurement of this model's effectiveness.

The difficulties found in the monitoring of learning outcomes are partially related to the complementary nature of video lessons. The content studied in the lessons produced by the Media Center usually coincides with the content taught during regular classroom lessons, and student attendance in remote lessons is not controlled - making it even more difficult to assess the impact of technology-mediated lessons on learning outcomes.

Regarding the video lessons available at YouTube, there is no systematic control of their use – a fact that further restricts the ability to assess the policy's impact. To this date, no cross-referencing has been made between the platform's access data and the students' data, to assess whether the available content is effectively contributing to students' learning.

The main currently available reference is student performance in the "Sixth Shift" program, which uses the materials and video lessons produced by the Media Center. The positive outcomes found are seen as likely indicators of the effectiveness of the Center's video lessons, but the causal link is still subjective, above all, because the Media Center does not yet have accessible data on the performance of students who participate in other projects, such as project *Vivencias Mediáticas*, or of students who only watch the YouTube lessons.

In its turn, the monitoring of student progression is better structured and attendance among "Sixth Shift" students is monitored. Each teacher is responsible for guiding the mediated activities, and every 15 days, they must fill in an attendance spreadsheet, which is kept in a shared online school drive. This information is consolidated by an administrative assistant responsible for organizing the data of all schools.

At the end of each quarter, the network's schools hold evaluation meetings with their directors, teachers, and the municipal secretary of education to discuss learning outcomes and attendance with a focus on the Media Center's activities. Students with five consecutive school absences or 10 non-consecutive absences over a month are categorized as potential dropout cases. In such situations, whenever a school fails to establish direct contact with the student, the case is referred to the Socio-Pedagogical Municipal Centers (CEMASPs), which are responsible for conducting active outreach and psychosocial support tasks.

Finally, as regards the **relationship between on-site teachers and remote instructors**, since this project emerged as an asynchronous initiative, no communication exists to date between the two groups of teachers, and no direct channel is available for real time interaction between students and remote instructors. Upon the emergence of doubts that on-site teachers cannot clarify during the activity, the recommended course of action is to take note of the question, so that it may be adequately answered afterwards. Further, in the "Sixth Shift" program, it is not always the case that the teacher assisting the students of a transmitted lesson teaches the same subject daily. ■

6.

Benchmarking references

The challenges identified in the public education networks of Amazonas and Manaus are not a Brazilian particularity. A considerable number of countries and regions in the world are facing similar dilemmas while implementing technology-mediated teaching models, and some of them have developed creative solutions that may inspire improvements in the Amazonian experiences. The three cases described below - in Uruguay, in Croatia, and in a Brazilian federal policy that connects multiple states - generated proven best practices in fields such as teachers' training, use of digital platforms, connectivity in adverse contexts, and institutional networking.



6.1 CEIBAL, URUGUAY

Modality: Synchronous and/or Technology-Mediated On-Site Teaching

Year: 2007

The “CEIBAL in English” program is an innovative response to the scarcity of English teachers in Uruguay. It was established in 2007 by the Digital Technology Center for Education Innovation (CEIBAL),⁸ a Uruguayan body under the Ministry of Education, which is responsible for designing the country’s strategy to provide, manage and maintain digital education devices. The program successfully met the country’s demand and developed remote activities on specific topics with scalable and sustainable outcomes through the strategic use of technology.

The program’s current objective is to ensure the teaching of English language at public schools around the country, particularly in primary education, while coping with the lack of a sufficient number of specialized teachers. Before the program was implemented, the coverage only reached 27% of all enrolled students.

Initially aimed at secondary teaching, the CEIBAL program offered three weekly hours of English lessons. It was expanded in 2015 to cover higher secondary and technical teaching through its *Conversation Class*. In 2023, it reached more than 650 schools and 75,000 students.

The “CEIBAL in English” program is conducted by a multifunctional integrated structure based on collaboration among professionals, the intensive use of technology and the provision of learning support. The synergies between its participants ensure the continuous flow of data, as well as the alignment between planning and execution, and the constant updating of pedagogical practices.

TABLE 5. Functional Elements, CEIBAL in English

Instance	RESPONSIBILITIES
Pedagogical workshop	As the guiding structure for the digital transformation of education in Uruguay, the CEIBAL center has a division responsible for executing the CEIBAL program, which includes a team in charge of designing the curriculum and additional educational materials in harmony with the Common European Framework of Reference for Languages (CEFR), as well as of conducting (remote and on-site) lessons’ planning, training teachers and monitoring students’ progress.
Mentors	CEIBAL mentors promote linkages between local schools and the central team by visiting schools, assisting on-site teachers, fostering communities of practice, and providing continuous online support.
Quality management	The quality management team supervises remote lessons, assesses teachers’ performance, and analyzes pedagogical data to enable constant evidence-based improvements.
Administration / Management	Management teams are responsible for logistical aspects (equipment distribution), financial management routines, payments and networking activities with partners and providers.

Source: Compiled by the authors.

8. The CEIBAL Program currently has a budget of nearly USD 50 million by the Government of Uruguay and additional support by the Inter-American Development Bank (IDB) to conduct four programs: i) Support Program for the Consolidation and Expansion of Plan CEIBAL (2260/OC-UR, USD8.5M), executed in 2010-2014; ii) Support Program for Primary and Secondary Math and English Education (3225/OCUR, USD6.9M) in 2014-2018, with the aim of contributing to the use of new technologies to improve math and English learning in primary and secondary teaching; iii) Generation C: Consolidating Educational Innovations for 21st-Century Skills and Competencies (4290/OC-UR, USD30M), which ended in 2021, to improve learning levels and competencies among primary and secondary students; and iv) Generation D: Developing Digital Skills with Equity in the Knowledge Era (USD30M) to expand access to resources that improve teaching practices through technology and innovation.

The “CEIBAL in English” program is a robust and interconnected educational ecosystem in which technology, teachers’ training, assessment, and cooperation ensure an inclusive, innovative, and high-level provision of English teaching. The program’s outcomes show how investments in technology, together with effective pedagogical models, can generate successful outcomes: the adaptive English assessment applied at the program’s outset in 2015 showed that 66% of 6th-grade students attained the expected knowledge levels in reading and comprehension. The program’s key features and best practices are presented below:

I) Connectivity and technological infrastructure

In addition to its pedagogical structure, the “CEIBAL in English” program is maintained through a universal connectivity policy⁹ at public schools, with monitored video conference equipment and the provision of continuous training to participating teachers.

II) Monitoring of learning outcomes and school progression

Student progress is systematically monitored. Adaptive assessments adjust the difficulty level of questions according to each student’s performance, to produce precise and customized diagnoses. This assessment was created to meet the needs of the program and is applied in partnership with the National Public Education Administration (ANEP), strengthening the alignment with national educational policies. In addition to systematic monitoring, CEIBAL has conducted impact assessments¹⁰ that underscore the positive effects of paying attention to its learning outcomes over time. The assessments also showed that the effectiveness of remote teachers hinged more on their practices than training level. These practices had a significant impact on the students’ academic outcomes.

III) Relationship between on-site teachers and distance-learning instructors

The “CEIBAL in English” program’s collaborative pedagogical model has two teachers working in close partnership. Its remote instructor is a teacher with expertise in English language, who transmits the first weekly lesson (lesson A) in videoconference-format. And its on-site teacher, in turn, is responsible for guiding two additional lessons (lessons B and C), even if he or she is not a fluent English practitioner, counting on the support of structured plans and mentorship follow-up activities.

The integration of these two teachers is strengthened by weekly pedagogical alignment meetings. A working platform centralizes the program’s teaching materials, fosters their exchanges, and enables follow-up on student progress. Students’ learning is fostered through videos, games, and interactive digital activities.

A culture of collaboration permeates all layers of the program, ranging from its central managers to students in their classrooms – who are also encouraged to collaborate with one another. Yet, such collaboration requires the management of divergences, since (remote and on-site) teachers may have different views on teaching, culture, and technology. CEIBAL welcomes this diversity of views as opportunities for developing joint solutions with a focus on student learning.

9. <https://publications.iadb.org/publications/portuguese/document/O-BID-e-a-tecnologia-para-melhorar-a-aprendizagem-Como-promover-programas-eficazes.pdf>

10. Plan CEIBAL (2017). Estudio sobre la calidad de la enseñanza de inglés: características y prácticas docentes, interacciones en el aula y aprendizajes; and Perera, M. (2017), Evaluación del Sistema CEIBAL de Enseñanza en Inglés: Informe de Resultados del Análisis Económico.

Another highlight in this program is the geographical flexibility of its remote instructors, who can be available from different countries - a feature that enables hiring quality professionals and the intercultural enrichment of lessons. Differently from the case in which instructors provide their service from a central location, using a media center structure, in this specific case, the “lesson” is also remote. The program’s integration with private institutions is also relevant: more than 200 private-sector teachers are hired through partnerships to provide remote lessons, while additional organizations provide educational platforms and technical support.

Further, “CEIBAL in English” implemented actions to support improvements and bridge learning gaps within each socio-economic context, based on a model that intentionally assigns higher performing teachers to vulnerable locations, based on the findings of its research activities.¹¹

6.2 CARNET, CROATIA

Modality: Hybrid Teaching

Year: 1991

The Croatian Academic and Research Network (CARNET) is one of the best-structured digital transformation initiatives in education in Europe. By investing in robust technological platforms and innovative pedagogical strategies, Croatia managed to ensure access to learning, even in regions with low connectivity.

CARNET was established in 1991 by the Croatian Ministry of Science and Technology as the first and only Internet provider of the country in the early years of its operations. In 1995, it was consolidated as a public institution with the mission of modernizing the educational system and bolstering digital transformation through the strategic use of information and communication technologies (ICTs). In the present, the CARNET network is responsible for expanding connectivity and digital infrastructure. It operates as a private network that connects academic, scientific, and educational institutions, including primary and secondary schools. It provides technical support and pedagogical innovation and develops digital solutions for the educational sector. It offers online teaching and learning tools, and provides equipment such as servers, Wi-Fi access points, and cybersecurity systems.

Its infrastructure covers 4,130 access points throughout the Croatian territory, including schools, universities, hospitals, and other public institutions. Its workforce includes more than 200 professionals based in eight cities.

CARNET’s organizational structure is divided into specialized sectors¹² working in an integrated way to enable a coordinated and efficient response to the educational system’s demands.

Between 2015 and 2023, the CARNET network led the *e-Schools* program, an initiative aimed at modernizing basic education in Croatia. Its first stage (2015-2018) was piloted in 150 schools; and its second stage (2019-2023) expanded access to

¹¹. CEIBAL (2017). According to the initial estimates, the benefit of a teacher in the 75th quality distribution percentile, compared to the benefit of a teacher in the 25th percentile, is equivalent to the benefit enjoyed by an average student upon rising from a basic level to a higher level (Perera, 2017).

¹². Business Support Sector; Network Infrastructure Sector; Computer Infrastructure and Services Sector; National CERT Sector; National Services and Support Sector; Education Support Sector; Artificial Intelligence Sector; National Coordination Center for Cybersecurity Industry, Technology and Research; and the Office of the CEO.

nearly 1,300 schools. Implemented actions included modernizing the digital infrastructure, training teachers on the pedagogical use of ICTs, developing interactive digital content, implementing the *e-Class Register* electronic attendance log, and using learning management systems (LMS) to monitor student performance.

The network's key features and best practices are described below:

I) Connectivity and technological infrastructure

As regards technology, CARNET adopted artificial intelligence chatbots to provide automated student support - above all, for those who must assimilate lessons in an asynchronous format. Students have the chance of accessing the chatbots to obtain prompt answers to their questions about the proposed activities, technical difficulties, or instructions for the use of digital tools. The system also suggests customized resources, such as video lessons, educational texts or thematic revisions, based on their performance. The tool reduces the dependency on direct interactions with teachers and tutors, while ensuring continuous real-time support, even outside school hours. The chatbots also operate as an automated technical support tool. By automatizing the provision of clarifications about frequent questions, it alleviates the workload of pedagogical and IT teams.

II) Monitoring of learning outcomes and school progression

The use of learning management systems (LMS)¹³ is one of pillars of this model. The available functions include educational materials, video lessons, and assessments; interactions between teachers and students in dialogue forums, chats, and video conferences; monitoring of academic progress through automated reports; the administration of assessments with automatic correction and immediate feedback features. The overall combination of these tools enables a far-reaching digital solution that can be adapted to different school realities.

An additional resource is the *e-Class Register*, a web application that replaces school records in paper for an integrated digital version. This system is currently in use throughout the country and enables school managers to monitor classroom and student performance in real time. Teachers can ascribe scores, take attendance and add remarks directly in the platform, while students and their parents have access to customized reports through exclusive interfaces. Additional highlights of this app are its interface with the national enrollment system (*e-Matica*), the safety of its data and its remote accessibility.

Moreover, the CARNET network has a student ambassadors' program, which mobilizes students more familiar with educational technologies to help in activities with lessons and foster digital culture in their schools. These students provide support in the resolution of simple technical issues, while helping with the school attendance log and fostering engagement in digital activities.

13. The principal systems include: Loomen, Microsoft Teams, Google Classroom, Yammer, Edutorij, and e-Class Register.

III) Relationship between on-site teachers and distance-learning instructors

A key CARNET feature is the provision of continuous teachers' training in digital competencies through online courses, webinars, and face-to-face workshops on educational technologies, digital tools, and active methodologies. Its modular courses impart instruction on topics ranging from basic notions to the advanced use of digital platforms. Training trajectories include co-teaching workshops¹⁴ and the joint production of lesson plans. Certificates of participation are issued to further encourage teachers' participation.

6.3 RIEH, BRAZIL

Modality: Hybrid Teaching

Year: 2022

The Innovation Network for Hybrid Education (RIEH) is a Brazilian federal initiative with the objective of equitably and effectively expanding strategies to implement hybrid education in all federative levels of the country through adequate technical support and infrastructure. It became a national reference for fostering an educational approach more aligned to the 21st century's requirements, by connecting institutions and professionals through inter-institutional cooperation. It was established in 2022 and launched in March 2023 by the Ministry of Education (MEC) as part of the National Post-Pandemic Learning Acceleration Policy (Brasil, 2022a).

RIEH's proposal is that each federative entity develops its own implementation plan on hybrid education based on a local diagnosis. Such a diagnosis would lead to technical solutions adapted to the regional particularities, including support to the establishment of media centers inspired by the Amazonas-experience. This model enables a flexible and customized type of education that combines on-site activities and the use of digital technologies and online resources. It also fosters exchanges of knowledge and pedagogical / technological resources, strengthening the integrated activities of educational networks.

As regards infrastructure, the RIEH-network provides essential technologies for implementing the hybrid model, such as high speed Internet, servers, cameras, and microphones. It also provides technical support to the development of local plans by fostering workshops, meetings, and the production of instructive materials with the assistance of specialized consultants.

RIEH operates through a collaborative structure that comprises different levels and institutions to ensure the deployment of hybrid education throughout the national territory, while respecting its local realities.

14. Whenever two or more teachers share class responsibilities.

TABLE 6. RIEH's Administrative Instances

INSTANCE	RESPONSIBILITIES
Ministry of Education (MEC)	The Ministry of Education is responsible for the network's overall coordination. It supervises and guides the RIEH-policy.
NEES/UFAL	The Federal University of Alagoas' Center of Excellence in Social Technologies (NEES) is responsible for developing methodologies and digital content, as well as for providing teachers' training. It operates as a leading partner of the MEC and Brazilian states.
State Departments of Education	The state departments of education are responsible for implementing RIEH locally and managing innovation centers.
Technical and Pedagogical Teams	Technical and pedagogical teams work at the centers to ensure the necessary technological infrastructure, as well as the provision of teachers' training and teaching support.

Source: Compiled by the authors.

RIEH has supported Brazilian states such as Mato Grosso and Tocantins with actions to address the challenges of poor Internet access and the lack of specialized teachers. In Mato Grosso, since the beginning of its activities in November 2024, its network has a studio to centralize the production and development of lessons. Its pilot project aimed at preparing students for Brazil's National High School Exam (ENEM) benefited approximately 15,000 students by offering them both synchronous and asynchronous lessons.

Also in 2024, the state of Tocantins launched its RIEH Educational Media Center. The center's team is primarily active in the production of asynchronous teaching content, with the objective of preparing students for the ENEM and transmitting live remedial lessons in Portuguese language and mathematics outside the regular school hours. The program currently serves more than 13,000 students from 130 state schools. The same teachers who are active in the regular classrooms are responsible for conducting technology-mediated lessons transmitted from the Media Center, thus contributing to the curricular and pedagogical integration of different teaching formats.

RIEH's key features and best practices are described below:

I) Connectivity and technological infrastructure

The education departments that adhere to the network establish innovation centers - physical and digital spaces aimed at the production of synchronous and asynchronous audio visual materials. They also establish virtual learning environments (VLEs) for synchronous and asynchronous educational activities, as well as a digital educational repository, to make available the content produced and shared by network members.

II) Monitoring of learning outcomes and school progression

RIEH develops indicators for continuous student learning monitoring. This practice may be adapted by media centers through assessment systems that operate even in remote areas. Tools such as Moodle can be configured to include offline

questionnaires and reports, among other functions, which enable the monitoring of student performance and the provision of guidance to local educational policies.

Further, partnering universities contribute to RIEH by conducting research work, developing pedagogical innovations, and producing content.

III) Relationship between on-site teachers and distance-learning instructors

RIEH fosters the provision of continuous training to educational professionals by offering them online courses, face-to-face workshops and webinars on the use of digital technologies, active methodologies, and teaching customization strategies. Training processes include capacity building activities for the technical teams of innovation centers on the provision of training to the schools' pedagogical teams.

RIEH enables adapting materials and pedagogical strategies to the individual, regional, and infrastructural realities of each location. Through its digital repository, teachers based in different states can share and adapt lesson plans. For instance, a teacher in São Paulo may create a lesson on chemistry, which can be accessed by another teacher in Alagoas and customized to their local reality without the need to begin from scratch, inasmuch as every piece of content is based on the National Common Core Curriculum (Portuguese initials: BNCC) - the document that guides Brazilian education as a whole. Moreover, RIEH fosters the development of custom-made training trajectories that consider the students' interests, skills, and needs, thereby promoting increasingly significant and flexible educational trajectories.

6.4 LESSONS LEARNED THROUGH THE BENCHMARKING CASES

The comparative analysis of the three reference programs above - CEIBAL in Uruguay, CARNET in Croatia, and RIEH in Brazil - reveals relevant convergences that can serve as guidance for the improvement of technology-mediated teaching policies.

The following tables summarize the lessons learned in relation to each of the three axes on which this study is structured.

I) Connectivity and technological infrastructure

RECOMMENDATION	BEST PRACTICES	REFERENCE EXPERIENCES
Connectivity mapping	Collecting data on access, speed, and availability of equipment in each school.	CARNET and RIEH conduct detailed technical diagnoses on school conditions, to guide decision-making on digital teaching infrastructure and strategies.
Partnerships and expansion of Internet access	Seeking the support of governmental programs and providers, to expand Internet access, particularly in remote areas.	CEIBAL in English draws on public-private partnerships with the support of the Uruguayan government to expand school connectivity. CARNET establishes partnerships with local operators to ensure the minimum necessary coverage for isolated schools.
Hybrid networks	Adopting internal Wi-Fi at schools and offline solutions with local servers, USB memory devices, and specific apps.	CARNET uses local servers to store and distribute offline content, thus complementing online access whenever it is not available.

RECOMMENDATION	BEST PRACTICES	REFERENCE EXPERIENCES
Equipment and network management	Distributing tablets and notebooks and observing a maintenance and replacement plan. Controlling Internet use, prioritizing pedagogical content, and using band-pass filters.	In Uruguay, CEIBAL in English distributes notebooks and tablets, controls their use and observes specific replacement and maintenance policies. CARNET has a similar strategy, through the delivery of technological kits to schools and centralized equipment management.
Access in low connectivity-contexts	Providing content through community radio stations, TV sets, and USB devices, and establishing spaces for Internet access at libraries or schools.	CARNET has a multi-channel focus that includes content distribution by radio, television, and physical media. RIEH also establishes the use of alternative media in limited connectivity-contexts, using printed materials and shared digital access centers.
Technological training	Providing continuous training and certificates on the pedagogical use of technology, as well as technical support and instructive materials (such as FAQs and tutorials).	RIEH structures technological training trajectories focused on the pedagogical use of technological tools. CARNET provides online and in-person courses, and issues certificates of participation, in addition to the provision of tutorials and permanent technical support. CEIBAL in English also invests in continuous teachers' training and digital support.
Low-cost chatbots	Using automated assistance with interactive menus (through video, WhatsApp, SMS, or Telegram) to clarify students' questions through asynchronous activities.	In CARNET, artificial intelligence chatbots provide automated support to students in asynchronous activities, in response to their frequent questions on teaching, technology, and educational platforms.

The cases show that initiatives can take advantage of AI technological advances, like chatbots, to strengthen activities and participant engagement.



II) Monitoring of learning outcomes and school progression

RECOMMENDATION	BEST PRACTICES	REFERENCE EXPERIENCES
Implementing Virtual Learning Environments (VLEs)	Using platforms such as Moodle, Google Classroom, Microsoft Teams, or in-house solutions to monitor students' attendance, participation, and performance. Using interactive dashboards, forums, and chats to bolster interactions and monitoring.	CEIBAL in English has the CREA platform, which is based on the Schoology LMS, to monitor student attendance, participation, and progress. CARNET has integrated platforms and dashboards for real time monitoring. RIEH uses a VLE as a minimum essential infrastructure that may be customized to monitor the hybrid model.
Student assistants	Stimulating students more familiar with technological knowledge to help as digital tutors, providing support to their classmates and teachers.	CARNET's model includes the help of students acting as digital ambassadors to provide technical and pedagogical support to their classmates and teachers during remote activities.
Short formative assessments	Administering quick (online or offline) tests at the end of each lesson and periodically organizing the relevant data to guide pedagogical interventions and remedial actions.	In CEIBAL in English, students undergo frequent assessments aimed at monitoring their progress and identifying points for improvement. CARNET administers short systematic assessments along the educational process with immediate feedback and the use of data to guide lesson plans.

III) Relationship between on-site teachers and distance-learning instructors

RECOMMENDATION	BEST PRACTICES	REFERENCE EXPERIENCES
Definition of roles	Establishing clear and complementary roles for onsite teachers and remote instructors, including formal guidance and training focused on pedagogical mediation.	CEIBAL in English has well defined roles: the remote instructor is responsible for transmitting content, whereas the on-site teacher works as a mediator in support of student interactions and learning. CARNET also established clear protocols to guide the distribution of responsibilities. RIEH emphasizes the need for clear roles as an essential condition for effective hybrid teaching.
Continuing education	Conducting joint training and collaborative planning activities. Developing pedagogical guidance and feedback channels between the two teaching profiles.	CEIBAL provides continuous training and periodical planning meetings with both teaching groups. CARNET promotes modular training trajectories that include workshops on co-teaching and the joint production of lesson plans. RIEH recommends training activities on integrated work and pedagogical mediation.
Communication among teachers	Fostering regular meetings, direct contact channels, and monitoring reports. Stimulating periodical visits of remote instructors to participating schools.	CEIBAL in English holds biweekly meetings and provides messaging systems for interactions among teachers. CARNET has specific platforms for communications among teachers and spaces for real-time information exchanges. RIEH recommends the use of structured communication channels by hybrid teaching practitioners.
Collaborative work	Encouraging interdisciplinary projects and mutual observation moments to foster the exchange of experiences and strengthening of teaching practices.	CARNET promotes collaborative practices such as co-teaching and integrated thematic projects with shared records. CEIBAL in English also appreciates mutual observations and integrated planning among teachers. RIEH underscores the value of a collaborative culture between teachers as a key prerequisite for strengthening pedagogical practices.
Assessments and improvements	Implementing assessment instruments based on collaboration among teachers. Using the obtained data to guide methodological adjustments and continuous improvements in the processes involving the participating teachers.	CARNET administers regular surveys to assess mutual engagement in the partnership between remote instructors and on-site teachers and adjusts its activities based on the obtained data. CEIBAL in English has collaboration-indicators and promotes adjustments based on the outcomes of pedagogical meetings. It also implemented a model of guided assignment of high-performing teachers to schools with acute vulnerability levels, to bridge learning gaps. RIEH recommends continuous self-assessment and revision cycles on teaching practices.

7.

Final remarks

Technology-mediated teaching is a valuable educational option in hard-to-reach territories, either due to their geographical isolation or structural deficiencies. However, its ability to fulfill the role of expanding access to education is necessarily linked to a few decisive variables. This Technical Note examined five cases that consolidate different experiences in implementing this model, with their respective challenges and advances.

In the two educational networks from Brazil's Legal Amazon – the state network of Amazonas and the municipal network of Manaus –, a significant evolution can be pointed in the expansion of access to education, benefiting students who did not previously have this opportunity. The state of Amazonas increased access to higher secondary teaching from 63% to 80% in the last 10 years.¹⁵ To continue strengthening its activities, our diagnosis reveals the need for contextualized strategic actions and public policies. The region is facing crucial gaps along the three axes of this analysis. As regards learning monitoring, fragmentation among systems generates difficulties for assessing the impact of specific policies. In the case of connectivity, investments continue to be necessary to strengthen infrastructure and enable the bridging of gaps that restrict the potential of technology. The relationship between on-site teachers and distance-learning instructors must also be revised based on international examples, and the relationship and availability of the two teaching profiles to assist students must be improved, as well as the availability of joint training opportunities and a clear definition of roles.

The three described benchmarking cases offer practices that can help bridge these gaps. In Uruguay, CEIBAL in English reinforces the relevance of collaboration between remote and on-site teachers, with carefully aligned pedagogical planning and continuous training actions. In its turn, Croatia's CARNET shows how digital platforms and artificial intelligence can optimize school management, even in contexts of low connectivity. Finally, Brazil's Innovation Network for Hybrid Education

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(RIEH) fosters local networks by providing financial and technical support to the establishment of adaptable repositories and collaboration networks among states, thereby ensuring increased exchanges and the replication of best practices.

Despite their different contexts and levels of maturity, the Brazilian and international experiences presented in this document offer important lessons for other education networks seeking to improve the quality of their provision. The following points highlight essential aspects that can support education managers and policy makers in designing and strengthening their initiatives.

I) Connectivity and technological infrastructure

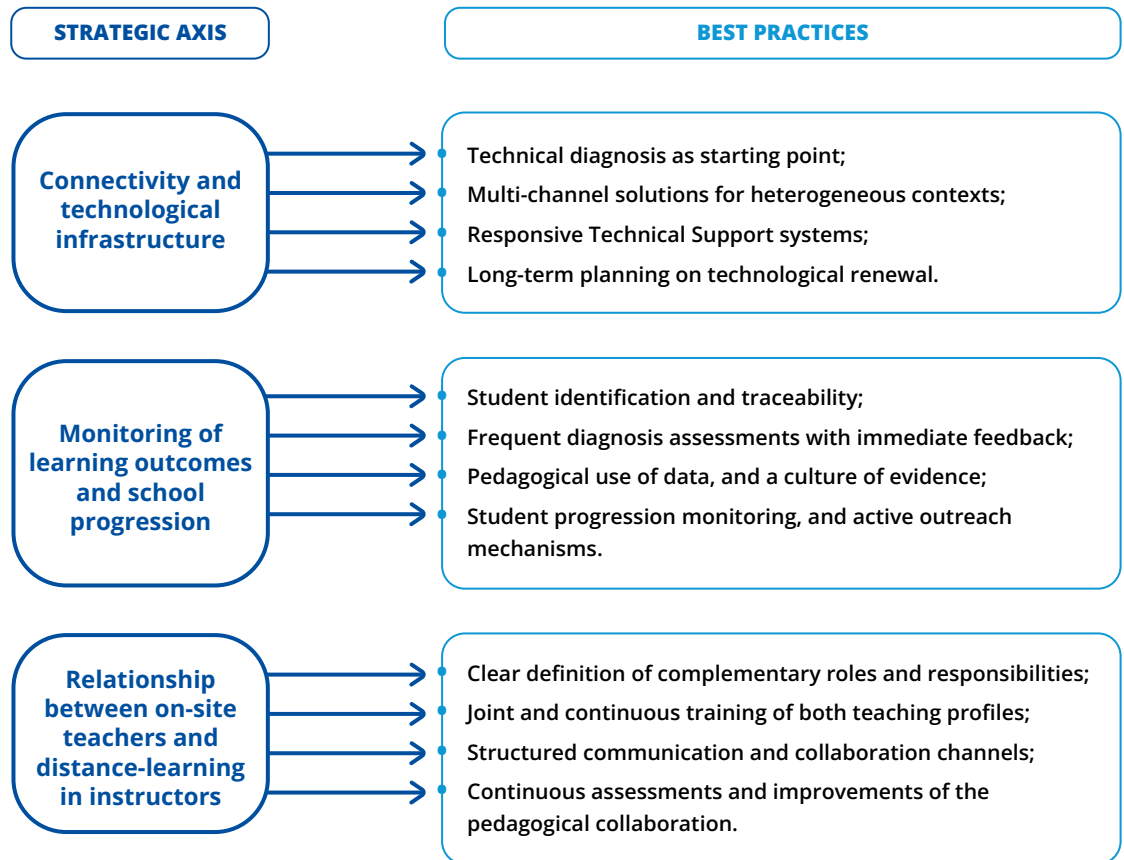
Connectivity is a necessary but not sufficient condition for the success of technology-mediated teaching. The experiences above revealed that investments in infrastructure must be conceived in systemic models and in formats adapted to local realities. It is desirable to invest in adaptive infrastructure, while prioritizing technologies such as low-orbit satellites, offline kits with educational content, and public-private partnerships to increase connectivity in remote regions.

II) Monitoring of learning outcomes and school progression

The cases show that robust monitoring systems are essential for attaining effective educational policies. The collection of data on technology-mediated teaching is a key requirement, together with the strengthening of linkages between relevant indicators and active policies to halt school dropout, and active outreach campaigns, for instance, through community radio stations. Learning assessments must be a crucial component of monitoring activities, to enable the identification of gaps in current knowledge, as well as the adjustment of pedagogical strategies to ensure adequate student progress.

III) Relationship between on-site teachers and distance-learning instructors

Technology-mediated teaching necessarily requires collaboration between two teaching profiles: distance-learning instructors and on-site teachers. The establishment of linkages between these two professional groups is a crucial element for determining the learning-experience's quality. On the other hand, fragmentation between them is one of the main challenges identified in all cases studied. Teachers' training must be strengthened through hybrid programs that combine technical knowledge, mentorship activities, and curricular adaptation to local cultures, to ensure that on-site teachers and remote instructors act in complementary and collaborative ways. The maintenance of steady communication channels between these two groups is essential for aligning pedagogical practices and bolstering technology-mediated teaching. Moreover, a clear definition of their roles and responsibilities is a crucial feature to ensure their effective and cohesive work throughout the students' learning process.



The experiences analyzed show that technological mediation is not an end in itself, but a tool to promote equity in challenging contexts. To be effective, technology-mediated teaching must be implemented with rigor, care, and a strong commitment to learning. The practical cases presented in this Technical Note show that success depends less on large investments in cutting-edge technology and more on sound planning, effective management, and the quality of pedagogical mediation.

Finally, it is essential to recognize that technology does not replace human teachers. Instead, it increases their potential. Successful technology-mediated education at once preserves and strengthens human bonds in the relationships between students and teachers, ensuring that every student, independently of their geographical location, has access to quality content and the necessary learning support. It is this combination of technological innovation and pedagogical zeal that can effectively contribute to overcoming educational inequalities and ensuring the right to education for all. ■

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