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Modernizing education management with EMIS: Building back stronger from the COVID-19 Pandemic

Satoko Yano, Sara Bin Mahfooz, Juliette Norrmén-Smith, Stefan Nippes, Pierre Chapelet and Gwang-Chol Chang
UNESCO-EDP
Mauricio Horn
UNESCO Consultant/Individual Specialist

About this publication

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Abstract

Several factors are contributing to the ongoing evolution of Education Management Information Systems (EMIS). These include increasing digitization of education sector management and education delivery, the accompanying generation of large volumes of data, including about the learning process itself, and the availability of technologies for their analysis. The pandemic-induced shift to distance learning and the post-pandemic prevalence of hybrid learning modalities accelerated the influence of these factors on EMIS systems. In light of these changes, it is important to re-formulate the expectation that a modern EMIS should not only serve as a tool for national statistical reporting but

EMIS

rather as a tool to support digitized administrative management at all levels through the provision of timely and actionable information services, and that, furthermore, it should not only support administrative management but also directly support *learning management*, including within hybrid and blended learning modalities.

However, current EMIS are often ill-equipped to harness the full potential of the wealth of data generated through digitized education delivery and sector management. The key weaknesses of the current systems are lack of integration and interoperability between existing systems, outdated EMIS technologies, inadequate scope, and the low levels of capacity for data use and analysis. The large gap between the status quo of fragmented EMIS in many countries geared primarily towards national statistical reporting and planning, and a modern EMIS that supports sector administrative *and* learning management at all levels reflects in part a lack of vision and understanding of the benefits of a modern EMIS.

Therefore, this paper seeks to spell out in more detail what a modern, re-imagined EMIS should look like as well as key areas to focus on for achieving it. In short, a modern EMIS should be integrated, modular, support administrative and learning management, provide actionable and timely information services to all levels, and focus on building human and organizational capacities within local ecosystems. This paper argues that to implement a modern EMIS, it will be important for policymakers to create the necessary (i) legal, policy and institutional frameworks, specifying key EMIS and data governance processes and providing sustained funding commitments to support a multi-year process, (ii) invest in upgrading and sustaining the technological infrastructure, and to (iii) heavily invest in human capacity building. The paper also explores the potential contributions that frontier technologies such as Artificial Intelligence and Blockchain can make to future EMIS and discusses the role of a community of practice as well as guiding principles for the further evolution of EMIS. The paper concludes with detailed explorations of EMIS in Latin America and the Caribbean.

1. Introduction

Faced with changing learning environments, Education Management Information Systems (EMIS) are evolving rapidly. The pace of this evolution has differed around the world, resulting in a lack of consensus on the expected role of EMIS over the past decade (Abdul-Hamid et al., 2017). The COVID-19 pandemic triggered an international dialogue to define the expectations for a modern EMIS. UNESCO has been at the forefront of this critical debate on what EMIS can — and should — do to support learning and minimize future educational disruptions. In the present day, one point is strikingly clear: EMIS must move beyond routine administrative tasks and student headcounts. A modern EMIS should not be viewed as an ancillary tool in an education system, but rather as the eyes that see, analyze, and support all aspects of the system.

The growing complexity of today's education systems sets a high bar for EMIS. Even prior to the Pandemic, national, regional, and international SDG monitoring requirements were becoming increasingly urgent, as has the need for real-time data to support learning at all times, including during crises (e.g., UNESCO-UIS, 2019). Furthermore, educational ecosystems have expanded in scope. Various non-state and public stakeholders are responsible for delivering education along a lifelong learning continuum that spans early childhood, primary, secondary, technical and vocational, higher education, and adult/continuing learning in both formal and non-formal settings. Pressures on EMIS to adapt to present needs have not gone unnoticed by Ministries of Education around the world (UNESCO-UIS, 2020). Education institutions are expected to answer questions not only about enrolment and performance, but also about the well-being, teaching and learning processes, learning outcomes, pathways, diversity, equity, inclusion, and the long-term outcomes of all students. Moreover, EMIS must support learning continuity and monitoring to plan for and facilitate continuous, uninterrupted access to quality education to all.

The challenges of the COVID-19 pandemic brought the importance of education information management into stark relief. It is widely acknowledged that data drives the post-pandemic "new normal". Technology use in all aspects of our lives, including in education, has skyrocketed. How can our management systems keep up? How can they modernize to be able to collect, validate, and analyze the ever-growing pools of available data? How can this data analysis be used to improve equity and make evidence-based decisions at all levels of our education systems? These are pressing and important questions because without strong data systems, we cannot see the problems — nor the progress. That is the role of a modern EMIS: it opens our eyes to really see all parts of the education system, to help us make sense of it, and most importantly, to help us make it better for everyone. With the international community invested in the importance of EMIS, now is the time to rethink both the definition and design of EMIS to better learning management around the world.

This paper addresses some of these key questions and presents UNESCO's plans to move forward. It draws from previous work, mainly UNESCO's working paper "Re-imagining the future of Education Management Information Systems: Ways Forward to transform education data systems to support inclusive, quality learning for all", a product of UNESCO's 2021 Seminar on the future of EMIS which took place from 26 to 28 May 2021. During the seminar, countries and partners shared stories of data management challenges and discussed the opportunities for system hybridization, digitization, integration, and optimization with frontier technologies. Through the lens of the COVID-19 crisis, the seminar examined the limitations of past conceptions of EMIS in order to stimulate discussion and preparation for more resilient, integrated, innovative futures of EMIS. In addition, this paper provides more details on the trends and lessons learned from EMIS in Latin American and the Caribbean.

2. Education data challenges and COVID-19

Before the COVID-19 pandemic, challenges faced by many countries have been widely documented (e.g. World Bank, 2015, UNESCO & GPE, 2020, UNESCO-UIS, 2020). The COVID-19 crisis highlighted these shortcomings and challenges, revealing that many EMIS lacked the ability to help governments ensure the continuous management and monitoring of inclusive learning for all. Education data and indicators were needed for immediate use to monitor and respond to the constantly evolving ebbs and flows of the pandemic. Often, EMIS was not suited for this purpose. The EMIS challenges exacerbated by COVID-19 can be organized around four dimensions of data quality:

1. timeliness,
2. relevance and completeness,
3. accessibility and use, and
4. interoperability and adaptability.

2.1. Data Timeliness

Many existing EMIS lack the ability to capture real-time data on schools, students and teachers. The COVID-19 crisis revealed that this affects the ability of authorities to effectively and efficiently decide on school closures, shift to distance/hybrid learning, track participation, determine drop-out risk, plan to prevent learning loss, and encourage the safe return to schools. Many countries struggled to respond to urgent educational needs, as data from EMIS often suffer from a significant time lag and are not updated sufficiently over the course of an academic year.

In Argentina, for example, COVID-19 shed light on the connectivity and timeliness issues of the existing system. To address these challenges, new EMIS tools were developed, including: SINIDE *Acompañar* to monitor attendance and performance of students in secondary education, a teacher vaccination registry, and *Cuidar Escuelas*, a nominal registry to register COVID-19 suspect cases of students, teachers, and staff in order to plan for school reopening.

2.2. Data Relevance and Completeness

Monitoring students who are not within school walls was one of the key data challenges faced by most countries during COVID-19. Even prior to the pandemic, EMIS struggled to provide data on all children, especially underserved populations like displaced learners, refugee, internal and external migrants, out-of-school children, or children with disabilities. The pandemic required EMIS to extend monitoring beyond the school walls, but most EMIS were not originally designed to collect data from other settings like the household. As such, many EMIS did not possess the agility or adaptability to respond to the new demands on data brought on by the pandemic.

While EMIS cannot be expected to produce data on everything due to the cost and capacity requirements of data collection, EMIS should identify and monitor, more than ever, student, learning outcomes and teacher capacity to participate in alternative distance education programmes, including digital, TV, radio, and paper-based platforms. EMIS must be dynamic and agile enough to quickly evolve and address new data demands as they become relevant, enabling equitable educational planning by including the most vulnerable learners in data collection.

2.3. Data Availability and Use

Due to lack of a strong and open data culture coupled with weak data literacy, many EMIS did not include mechanisms to disseminate data back to data providers (including schools, parents and communities) in frequent, user-friendly ways. The pandemic revealed the need for a culture of data-informed decision making by identifying the roles of responsibilities at all levels of the education and outside education system. Many systems could not effectively implement and monitor crisis responses due to weak use and accessibility of data, coupled with a lack of capacity for data analysis.

Collecting data for education indicators amid a crisis is very difficult. Teachers may struggle to report attendance in the same way as they did under normal conditions; students may not have access to the same tools used by the school system to deliver daily lessons and homework. Not all teachers may have received the same skills training to comfortably and successfully navigate the demands of different data platforms used in education delivery. Non-traditional methods of data collection may be needed for the sake of expediency. Moreover, the responsibility of data collection should not reside solely on the teacher. The negative economic impact of the COVID-19 crisis may have forced teachers to leave the profession, move to other places or stop teaching to take care of family members. EMIS should be primed to support teaching staff with simplified data collection processes.

2.4. Data Beyond School Census

The COVID-19 crisis showed that coordination and linkages with other data systems, such as health, are critically important. The data from the health sector need to be communicated to the education sector immediately so that the decisions can be made based on the latest public health information. Prior to the pandemic, few EMIS incorporated other sources of educational data beyond school census data, such as learning monitoring, household surveys, inspection reports, school observation checklists, learning assessments, finance data, Human Resources, and more. The use of unique IDs for both learners and teachers between such integrated systems can help manage the movement of students and teachers between schools, as well facilitate the transfer of achievement records, credentials and professional development.

For most countries, the educational disruptions of COVID-19 also led to the interruption of essential health, nutrition, social and protection services provided by many schools. This can put significant strain on the well-being of learners and their families, increasing the risk of the most vulnerable learners to leave education early (UNESCO, 2021). This is especially true of most marginalized

groups, such as girls, out-of-school children, and learners affected by displacement and disabilities. The lack of interoperability and data sharing protocols across stakeholders within the education sector prevented easy identification of the most vulnerable children and youth struggling to access educational services during the pandemic.

Additionally, the increasing availability and use of learner-level data in management systems could have positive implications for the quality of both teaching and learning. Greater levels of personalized learning, and by extension the monitoring of student achievement, are made possible by coordinating EMIS with LMS that leverage AI-powered educational technologies that assess student academic performance and learning patterns. Such programs can yield predictive analytic capacity that could coordinate data points from different sectors, such as test scores, socioeconomic status, gender, race, and age, to generate warning systems that, in theory, could curtail student dropout rates. In the United States, for example, school districts with integrated LMS and EMIS are using such data analytic capacity to predict and prevent early school leaving for at-risk students (Vincent-Lancrin, S. and R. van der Vlies, 2020).

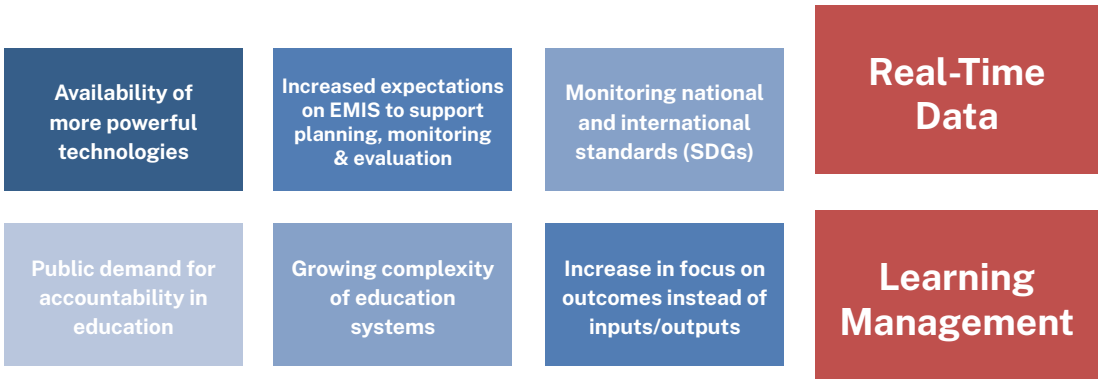
3. Evolving expectations of EMIS in a post-pandemic new normal

Reliable and accurate data are the lifeblood of every management information system. Data and information enable the evidence-based decision making that is necessary to increase the coordination, accountability, and equitability of increasingly complex education systems. Recently, data use in the education sector has changed dramatically, and with it, the expectations of EMIS. In the past decade, the collection and analysis of digitized educational data has widely been seen as the ideal method for informed decision-making to solve issues of schooling on both within and across nations (Ozga, 2015). With an abundance of digitized data, accessible information, and ever-expanding global networks, new orders of magnitude in data capture, search, sharing, storage, analysis and presentation have emerged. However, "with more data comes more noise" (Prinsloo, 2015, p. 296), and increasingly, EMIS is expected not only to capture and process, but also to aggregate data from all levels of the education system.

In 2018, the education company Pearson stated that "increasingly, data will be the foundation of the education landscape" (Deegan & Nathan, 2018, p. 61). In 2021, this prediction has proven true, for the pandemic caused a rapid increase in the pace of education datafication and digitalization worldwide. Private educational companies, especially EdTech providers, have expanded their reach into education systems, raising new questions of data privacy, ownership, and safety that EMIS must also account for. In the past few years, climate displacement threats have further pushed education services to move away from traditional institution-based learning environments in the future. In their efforts to deploy distance and hybrid learning programmes, many education systems and their EMIS were unprepared to reach beyond the walls of the school building to support teaching, learning and monitoring during COVID-19 school closures. Additionally, the pandemic triggered an unprecedented convergence of education building blocks and social systems, blurring the lines between the responsibilities of different sectors' information systems (e.g., learning, health, labour market and social security).

As such, EMIS around the world face barriers to ensuring learning continuity and to monitoring high quality, safe educational opportunities for all in unpredictable educational environments. In 2018, UNESCO and GPE hosted the first international conference that explored the major trends driving the evolution of EMIS. The key challenges across different countries and contexts were discussed, and six factors driving the evolution of EMIS were identified, as seen in the blue boxes in below Figure 1. The key words then were: availability of technology, monitoring of SDGs, complexity of education systems, EMIS role to support planning, monitoring and evaluation, accountability and focus on outcomes.

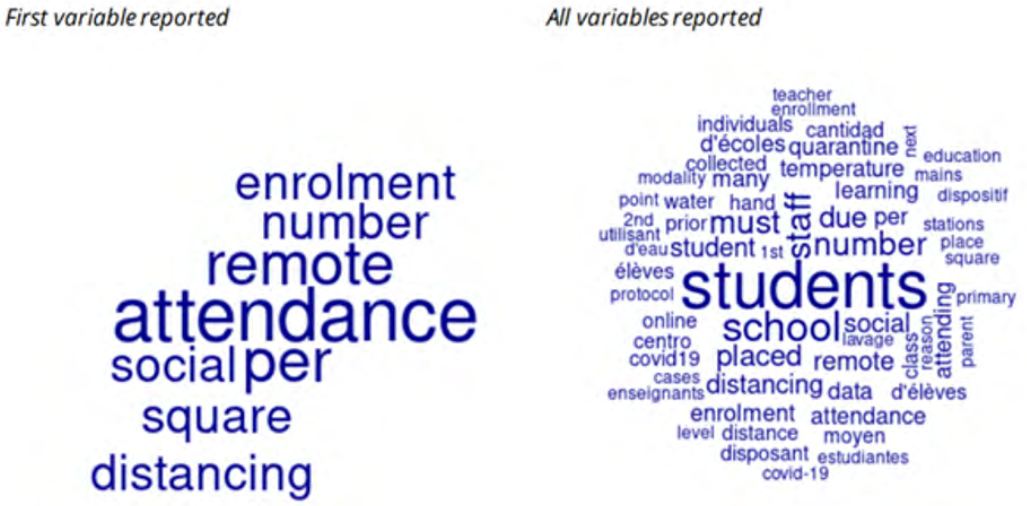
Figure 1. Factors driving the evolution of EMIS, 2018 and 2021



Note: *Compiled from UNESCO and GPE's 2018 International EMIS Seminar working paper (blue boxes) and newly identified (orange boxes).*

The UNESCO Institute for Statistics (UIS) launched a survey of COVID-19 pandemic impacts on national education planning units in July 2020 with responses from 120 countries. The survey explored the variables added to previous education data collections as their responses to the COVID-19 crisis. As shown in the Figure 2, the most frequent terms for the first variable show the emphasis on monitoring attendance and remote learning as well as terms related to physical distancing, and on the right, "students" was the most common of all variables. This shows that at its core, EMIS is about students. EMIS needs to be both bottom-up and top-down because good data management doesn't only help school leaders or central officers, but everyone, including learners.

Figure 2. New or adapted education variables collected during COVID-19



Source: UNESCO-UIS, 2020.

The UIS also administered a questionnaire on EMIS metadata to gain a better understanding of the characteristics of existing EMIS in the countries to help gauge their capacity to produce administrative data as well as assess the involvement of development partners in producing education data in the countries. Between May and August 2020, 103 countries across the world responded.

The key findings from the survey include:

- Paper is the primary mode of data collection;
- Recording student-and teacher-level data in national databases is a recent phenomenon, which made EMIS struggle to capture participations in online courses during COVID-19; and
- EMIS is not often linked with other Management Information systems, like Health, Teacher Management.

The report then provides a set of recommendations:

- Ensure resources to collect, compile and publish data on time;
- Coordinate finances among development partners and within government ministries responsible for education on EMIS at the country level;
- Collaborate to improve the knowledge hub of EMIS (http://emis.uis.unesco.org/) including EMIS questionnaires, guidelines and minimum standards for EMIS; and
- Upgrade existing EMIS with new technology to collect, compile and disseminate data.

These recent changes and additional insights led UNESCO to consider two additional factors that contribute to the further evolution of EMIS: the demand, availability, and technological possibility to process large amounts of real-time data, and learning management, including management of hybrid learning (see Figure 1, orange boxes). The need to enhance EMIS to encompass these two factors was accelerated by the educational disruption caused by the COVID-19 crisis.

The need for an integrated EMIS, both vertically across levels of the education system and horizontally across education departments and social sectors, is more apparent now than ever before. With increasingly data-driven systems of schooling in mind, the following characteristics required for a modern EMIS were agreed upon at the 2021 International EMIS Seminar:

1. Integrated. The EMIS is an integrated data system. Integration and coordination are mandated by policy frameworks and facilitated by data standards and interoperable software components. Integration with the wider government ecosystem, including other social sectors (health, social support services, labour, etc.)
2. Modular and flexible. Rather than one singly monolithic solution, the EMIS architecture should be built through a collection of independent and interoperable units that provide services for a particular function. This approach enables the system to be responsive and remain relevant as new needs arise.
3. Actionable, timely information services to all levels. Big Data analytics, using bias-free algorithms, shall provide real-time actionable information based on large volumes of data to all education stakeholders including to students, parents, teachers, and sector managers, at various levels of disaggregation, comparisons across times and between units.
4. A tool to support administrative management. While not conceptually new, it is important to stress that advanced EMIS are tools that support the digitized management of education at all levels and including both strategic as well as day-to-day routine management, and both sector and educational institution-level management.
5. A tool to support learning management, including hybrid learning. EMIS should include Learning Management Systems that support the learning process and will be tools to support delivery of hybrid and distance education. This includes the capability of an EMIS to harness more

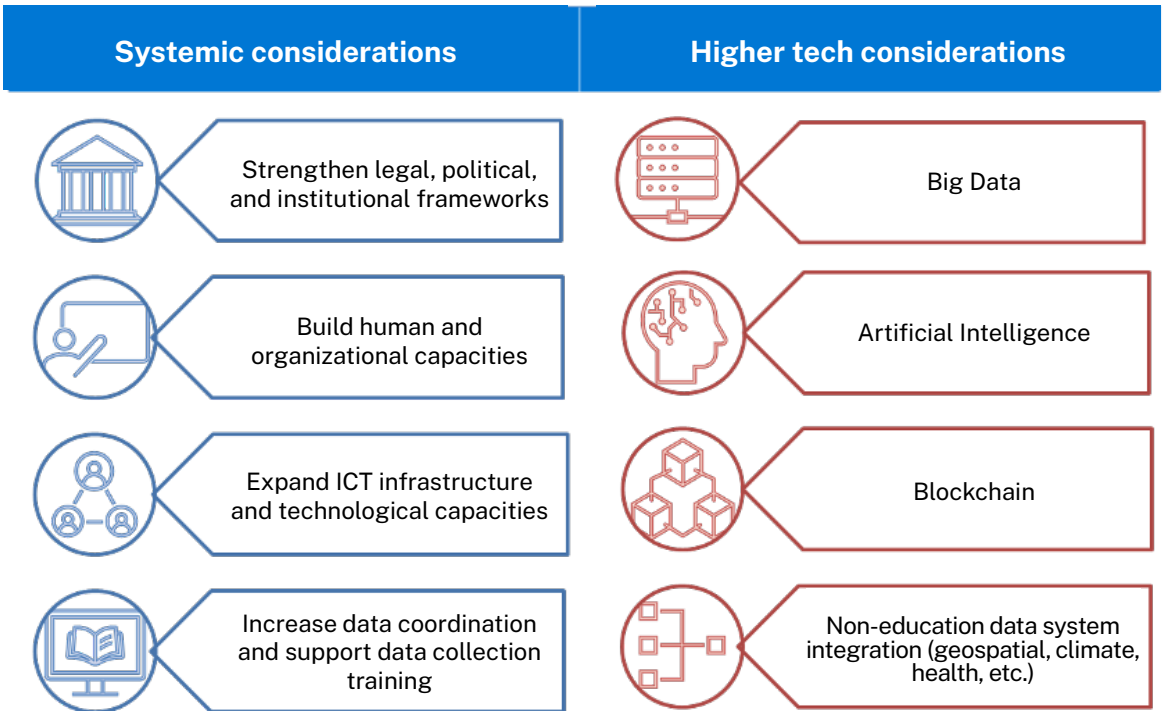
detailed information on the learning process while paying particular attention to data privacy and legal ownership.

6. Focus on capacity development and leveraging local ecosystems. Throughout the process, EMIS should focus on building human and organizational capacity at all levels of education to collect, analyze, disseminate, and use the data for decision-making. EMIS process should also develop and leverage local ecosystems to provide technical services.

4. How to meet the evolving EMIS expectations

In the previous sections, we have analyzed how the demand for and the definition of EMIS have evolved recently, especially in response to the COVID-19 crisis. How can we then meet the expectations? We may think of two groups of considerations for transforming EMIS, which are the two sides of the same coin for our reflection on the future EMIS as shown in Figure 4 below.

Figure 3. Key elements for EMIS transformation

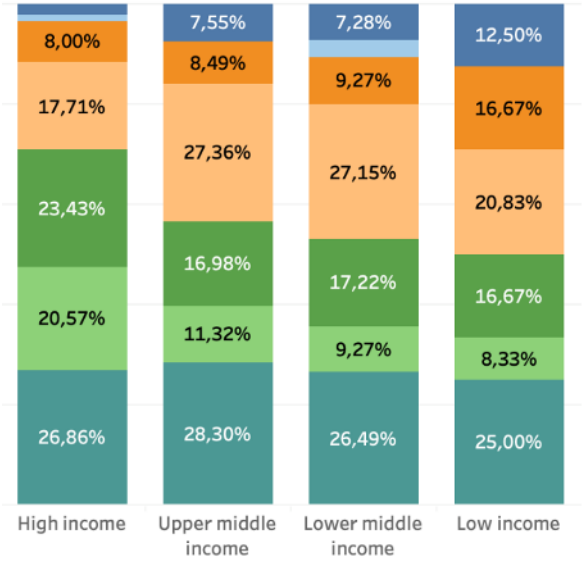


Systemic considerations are the necessary conditions for building an enabling environment for the future EMIS and the technological considerations are the ways to leverage what new technologies can offer to overcome the shortcomings of the conventional EMIS.

4.1. Systemic Considerations for enabling a modern EMIS

While technological advancement has expanded the possibilities of EMIS and drives its evolution, it is important to note that the enabling environment is as important, if not more, than technology. Prior to the 2021 EMIS Seminar, UNESCO asked the participants to share the main challenges they are facing with EMIS. As shown in the below Figure 5, of hundreds of participants, the majority chose funding and human capacity (related to statistical and IT knowledge) as the main challenges, followed by lack of coordination of data systems. On the other hand, connectivity and device were not their primary concerns.

Figure 4. EMIS main challenges by income group



Income level	Main challenges linked to EMIS	% of main challenges linked to EMIS
High income	175	36,46%
Upper middle income	106	22,08%
Lower middle income	151	31,46%
Low income	48	10,00%

To achieve the vision of an integrated EMIS that can be employed as a modern management tool, it is necessary to focus on the following key areas:

1. legal, policy and institutional frameworks,
2. data processes,
3. technological infrastructure,
4. human and organizational capacity buildingl.

Each of these domains are discussed below in conjunction with considerations for action.

4.1.1. Legal, policy and institutional frameworks

Strong frameworks are essential to ensure the roles and responsibilities of EMIS are clearly defined and enacted. In order to develop such frameworks, the following areas should be considered:

- Sound policy and legal framework for digitalization/digital transformation of education sector, in line with the overall government digital strategy.
- Adequate and sustainable funding to ensure policy implementation
- EMIS policy framework that clarifies vision, priorities, funding commitments, and EMIS and data governance, outlining roles and responsibilities of all actors within and across Ministries and agencies with the aiming of promoting integration and use of data
- Considerations of protection, privacy and security concerns must be at the core of efforts aimed to increase the sharing and

availability of data to promote accountability and feedback loops while protecting the best of interest and safety of communities. Accountabilities for crisis-relevant data collection and use need to be aligned with national data policies and EMIS frameworks, and consider legal protections related to data sharing, privacy and security.

4.1.2. IT capacity and platforms

To modernize EMIS to confront the digital divide in an increasingly digitized and data-driven environment, consider the following priorities:

- Roadmap for equitable and inclusive digitalization, especially in developing countries
- Create a modular rather than a monolithic EMIS where each module is independent and serves a particular function. The benefit of modularity lies in greater adaptability, where individual modules can be enhanced without requiring changes to the whole system.
- Review of data collection and processing tools and customised solutions that might help to improve the timeliness and coverage of data collection. A clear understanding of the context, assessment of user needs, analysis of risks, review of existing technology and considerations of cost effectiveness and sustainability should be the starting point.

4.1.3. Human and organizational capacities

Without sufficient human and organizational capacity, any plan to enhance EMIS will not be sustainable or resilient. In order to address capacity needs, the following should be considered:

- Further capacity development in line with the requirements of future EMIS (e.g., database management, cloud-based computing, data literacy and advanced data analytics, etc.)
- Capacity-building on crisis-sensitive sector analysis, policy and planning is a key aspect of strengthening EMIS. This is necessary for ensuring a comprehensive understanding of educational vulnerabilities, risks, and possible impacts in the event of an emergency that can guide the design, collection, analysis and use of relevant data.
- Developing local ecosystem(s) for interoperability and sustainability
- Data accuracy and reliability rely on a thorough understanding and documentation of the process and purpose of data collection and of the definitions and terms used among data providers and collectors; this requires training and understanding down to the level of head teachers and teachers providing and using data at schools and in classrooms.

4.1.4. Data processes

To overcome many of the data challenges outlined in Section 2, the following data processes should be considered:

- Use of unique student, teacher IDs and harmonized methods and standards that enable interoperability and connectedness
- Integration of data with non-education sectors
- Automated data collection, validation, analysis
- Linking data to business workflows.

These considerations offer contextualized solutions to EMIS challenges that enable proactive and forward-looking data systems while remaining sensitive to capacity constraint.

4.2. Technological Considerations for Future EMIS

The second group of considerations is of technology, specifically. Globally, there is a growing interest in digitizing government services, including in the education sector. We need to seriously consider some of the key frontier technologies and concepts that could transform EMIS, such as: Big Data, AI, Blockchain, and non-education data system integration, which you can see here on the right side of Figure 4.

The increased investment in data and technology in response to the COVID-19 pandemic could accelerate the digitization of education management processes as well as

the transformation of EMIS. From the management of schools to that of central administration, from teaching practices in the classroom to learning assessment, digitization has the potential not only to dramatically improve the management of the education system but also to generate the mass of big data that advance data analytics rely on. Fischer et al. (2020) review the challenges and affordances of data in recent decades, claiming that "the increased availability of big data has led to new frontiers in how we monitor, understand, and evaluate processes in educational contexts and has informed decision making and efforts to improve educational effectiveness" (p. 131). E-governance requires data consolidation and coordination of service delivery across government agencies and functions. Integrating of EMIS within larger government digital ecosystems is a critical step in the digital transformation of the education sector.

Giga Initiative, established by UNICEF and ITU, aims at connecting all schools to the internet in partnership with the private sector. The Global Education Coalition, coordinated and facilitated by UNESCO, also launched a global connectivity initiative to ensure universal connectivity by fostering partnership. Such investment for increased connectivity and devices, powered by frontier technologies, will give much needed push to transform EMIS in many countries into an integrated sector-wide EMIS.

The COVID-19 crisis presented the untapped potential of technologies that can transform EMIS into more elaborate information AND management systems. Data systems that can track each individual in the education system, rather than collecting headcounts at school level, showed their value during the crisis. As an integrated system with powerful analytics that supports real-time, data-driven decision making at all levels of education from day-to-day management operations to strategic planning functions, such EMIS are paving the way for what could be the futures of EMIS.

In the section which follows, the paper reviews some of the key frontier technologies that will contribute to the further development of EMIS. Acknowledging that these are not exhaustive, examples from UNESCO partners are incorporated to illustrate the use of these technologies in EMIS.

4.2.1. Big Data and EMIS

The era of Big Data is marked by an abundance of accessible information and ever-expanding global digital networks. Big data refers to the combination of structured, semi-structured and unstructured data that can be mined for information and used in applications of advanced analytics, such as predictive modeling, an increasingly common feature of data management architectures. In the educational context, the National Academy of Education (2017) states that "big data typically take the form of administrative data and learning process data" (p. 4); however, in the context of the COVID-19 pandemic, the scope is even greater. Today, EMIS must be up to the task of capturing and creating aggregated, actionable information from massive amounts of disaggregated data across all levels of the education system and even outside the education sector. Connecting administrative data with learning process data, for example, can "unveil nuances about educational inequities and inform actions in faster feedback cycles" (Fischer et al., 2020, p. 132) that improve the inclusivity and effectiveness of education programmes.

Making sense of Big Data offers many affordances to education planning and management, in particular to understanding the mechanisms and effects of specific policies. An EMIS that can process Big Data also enables more comprehensive reform tracking, both of global indicators such as SDG4 and domestic goals. Open access to big data can increase equity by enabling all education stakeholders, including the general public, to evaluate the performance of educational systems and their impact on diverse students by monitoring inequalities (Fischer et al., 2020). Clayton and Halliday (2017) review how the democratization of big data can be used to identify and monitor equitable educational provision and outcomes.

However, transforming Big Data into information and knowledge is not without its challenges: human, technical, and ethical. Many EMIS still rely on considerable human effort for data collection and data processing. The increasing volume of information captured by educational organizations requires quick and continuous transformation of technical infrastructures, as well as political, legal, financial, and institutional frameworks that enable sound and sustainable data flows within and across sectors. In the context of distance learning, Prinsloo (2015) writes that, "We accept that harvesting more and different data may hold potential, but if we do not think critically about institutional support and operational integration with regard to the harvesting and analysis of data, we may never realize the potential of bigger data" (p. 286). Privacy concerns have reached new heights as education stakeholders are forced to navigate between public interest, personal privacy, and commercial platform providers who limit or block access to their data (Fischer et al., 2020).

The high-speed processing requirements of unprecedented amount of data during the COVID-19 era also shed the light on the limitation of traditional data analytics approaches found in many EMIS. The growing variety and amount of data collected requires new strategies and techniques by which the data is captured, stored, processed, analyzed, and visualized. While EMIS reporting functions have been often limited to the release of statistical yearbooks, the Big Data era opens a large range of new possibilities in the area of data analytics, as well as new challenges. Fluid and responsive data pipelines need to be connected to sophisticated data analytics platforms to serve the information needs of an ever-increasing variety of stakeholders. In the United Arab Emirates (UAE), the Ministry of Education rolled out an advanced data analytics platform with over 1,200 schools and over 70 higher education institutions, totaling over 1.2 million students. This data analytics system reports on curricula, teachers' professional development, learning resources, financing, operations, performance reports, teacher, student and parent feedback, and scores from international assessments like PISA and TIMSS.

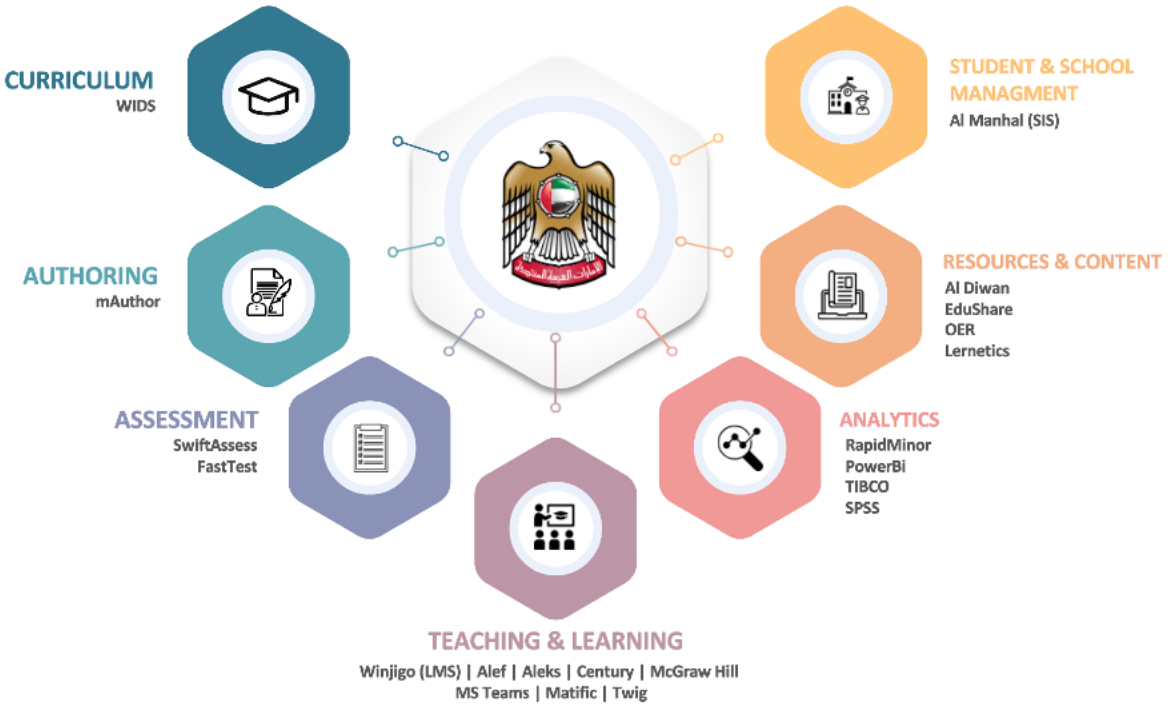
4.2.2. AI and EMIS

Artificial Intelligence (AI) is one of the most talked about frontier technologies that has significant impact on society as a whole, including education. Some countries and education systems are already moving ahead. Many states and districts in The United States are using AI-powered early warning systems to predict and prevent dropouts (Vincent-Lancrin, S. and R. van der Vlies, 2020). The Republic of Korea has developed various data analysis tools using prediction techniques such as machine learning and deep learning. The United Arab Emirates (UAE) established a data analytics section in its Ministry of Education, dedicated to developing machine learning algorithms in support of strategic studies on the country's education system.

One example of these principles put into practice is looking at the United Arab Emirates (the UAE).

The UAE introduced the UAE Ecosystem for Education, linked with other external systems. In 2013, they started planning a vision that captured all aspects of the education system and the other relevant connected systems.

Figure 5. UAE's education data system



The core of the EMIS takes a pedagogical view and can be adapted. Around it is the user view and the different activities and functions needed: plan, control, optimize, study, and so on. On top, components are selected that can service all the different views from core to user. 7 key components are: student & school management system, resources & content, analytics, teaching and learning, assessment, authoring of content, and curriculum management (mapping learning outcomes).

Some of its key features include:

- Captures all student records from birth to lifelong learning to construct unified student records for the country.
- A complete student learner portfolio, including e-learning and extra-curricular activities.
- Use of Adaptive Learning to personalize and optimize the learning experience and improve learning outcomes.
- Fully supports Distance learning, blended and hybrid learning.
- Uses APIs that allows the new systems to be smoothly integrated and data to be readily exchanged.
- Uses machine learning to produce predictive and prescriptive analysis of big data.

With more and more data becoming available for and from education, use of AI in education is expected to increase across the globe. In this context, UNESCO organized an international conference on artificial intelligence and education in Beijing, China in 2019. The conference produced the first-ever document to offer guidance and recommendations on how best to harness AI technologies for achieving the Education 2030 Agenda, Beijing Consensus on Artificial Intelligence and Education. The Consensus calls for integration and/or development of AI technologies and tools for EMIS in order to make education management and provision more equitable, inclusive, open and personalized (p. 5). At the same time, the Consensus emphasizes the importance of developing AI applications in education that are

free from gender bias and to ensuring that the data used for AI development are gender sensitive (p8). In addition, the Consensus has a dedicated section on ethical use of education data and algorithms, highlighting the key challenges including:

1. biased AI;
2. balance between open access and privacy;
3. legal and ethical risks. The Consensus also calls for further research and regulatory frameworks.

Also, in 2019, UNESCO published a working paper titled "Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development". Analyzing existing research and country cases, the paper identifies the following six major challenges and policy implications of introducing AI in education and preparing students for an AI-powered future(s).

4. Developing a comprehensive view of public policy on AI for sustainable development.
5. Ensuring inclusion and equity for AI in education.
6. Preparing teachers for an AI-powered education.
7. Developing quality and inclusive data systems.
8. Enhancing research on AI in education.
9. Dealing with ethics and transparency in data collection, use and dissemination.

Although all these six challenges are relevant to EMIS, the working paper gives special attention to the specific challenges of integrating AI to EMIS (the fourth challenge). In order to address the challenges, the recommendations of the working paper include:

- Make educational data open and usable at the school level.
- Enable EMIS to generate analyses that are granular enough to help teachers and education administrators understand the key challenges while also being able to aggregate data to reveal trends that can inform policy development.
- Ensure that data are complete and account for inequities (e.g., disabilities, refugees & IDPs).
- Integrate EMIS to other data sources such as household surveys and data from other ministries.
- Where data systems are weak or incomplete, countries should focus on strengthening their data systems and bridging their data gaps.
- Be mindful about cost of investment and pay sufficient attention to institutional and organizational capacities of using AI, rather than focusing on procurement of more sophisticated data reporting technologies.

A useful example from the private sector is Microsoft, which is transforming education with EMIS and AI projects. The knowledge economy is prompting education systems to meet national and international targets using data. EMIS architecture should respond to MoE architecture. Project EMIS will support a community of leading education systems to develop modern data architectures for education reporting and analytics. Complexity creates dependencies on multiple data sources and databases, creating duplication, security risks, and slowing the system. We must build capacity using a clear roadmap for education systems built upon informed decisions from discussions between donors and development partners. The project is aligned with the GPE and UIS guidelines and have an open-source creative.

In 2021, UNESCO issued "AI and Education: Guidance for Policy Makers" aiming at supporting education policy makers better understand the possibilities and implications of AI for teaching and learning, and therefore make informed decisions. This comprehensive guidance document also has a dedicated section for EMIS, with the below key recommendations.

- Explore how AI technologies can improve EMIS.
- Enable the holistic transformation of EMIS and their integration with learning management systems (LMS).
- Empower managers, teachers and students to promote the application of AI-powered EMIS and LMS.

This guidance document also calls for the provision of low-cost models for developing AI technologies and for assurance that the interests of developing countries are fully represented in key debates and decisions. It also emphasizes the importance of creating a "bridge" between developing countries and countries with advance AI implementation.

4.2.3. Blockchain and EMIS

Blockchain technology can be used in many ways that can enhance EMIS, including: creating and managing unique IDs for learners and teachers; tracing of resources; managing students transfer between schools; facilitating teacher deployment; and tracking service delivery. Also, blockchain technology can make records more resilient, as they will be protected from physical destructions (e.g., natural disasters, conflicts) that may destroy many other record keeping systems.

In addition, with blockchain technology, digital, portable, verifiable lifelong credentials will be available for individuals. This is particularly important and useful in case of cross-border education, which is expected to continue growing despite the temporary halt due to the travel restrictions caused by COVID-19. It is also considered that such digital credentials can facilitate lifelong learning, where individual learning paths are becoming more diverse and less linear. In addition, blockchain technology is often cited as a possible technological 'fix' for privacy and security concerns surrounding learning credentials and other educational records to give individuals more ownership and control of their own data.

4.2.4. Integrating non-education data with EMIS

As stated above, prior to the pandemic, few EMIS incorporated other sources of educational data beyond school census data. Today, existing technologies and recent progress in advanced computational techniques have the potential to allow for an even greater and more beneficial use of EMIS beyond education data. For example, in the context of climate change adaptation and mitigation efforts and disaster risk reduction through and in education, it is indispensable to make use of non-educational data such earth observation and geospatial data, climate hazards data, population movements, social media data, public health data, etc. This has the potential to not only allow for richer and more advanced analysis, especially for predicting, preventing and responding to disasters such as pandemics, but also to allow for more integrated and effective collaboration between the education sector and other line ministries.

The future of EMIS will therefore involve the integration of EMIS with data from other disparate sources (such as those mentioned above) and formats (including images, texts, etc.). For this to become a reality however, digital connectivity, data sharing mechanisms and protocols need to be put in place, in addition to strengthened IT and staffing capacities. The good news is that this is now more feasible than ever, mainly due the emergence of open-source software solutions and training coupled with relatively reduced cost related to digitalization, cloud-based data management and computing.

5. EMIS Case Studies in Latin America and the Caribbean: Uruguay and Peru

The current landscape of the EMIS in Latin American and Caribbean countries is underway shifts resulting from their intrinsic advancement as well as from pressing demands in wake of the more disruptive pandemic conditions, followed by the plans aiming for a safe return to school. From this, the profusely examined preexisting variations in the EMIS across the region (Cassidy, 2006) have derived into new kinds of differences subject to countries' COVID-19 response policies and actions. To a ranging extent, some systems have been stressed demonstrating responsiveness and were enhanced with new characteristics, yet others have cast unreadiness to face dynamic scenarios and efficiently manage the crisis, in addition to manifesting some persisting shortcomings diagnosed over the last decades.

Consequently, the challenges and the avenues to improve EMIS are presently different compared to merely two years back; not only because LAC countries have significant lessons to draw from the recent and ongoing COVID-19 response, but additionally as a result of the speedy emergence of advanced technologies, especially in edge computing, wireless telecommunications, blockchain, artificial intelligence, and cybersecurity. Therefore, what were latterly good solutions for EMIS development have quickly turned outdated for the present and near future. A holistic comprehension of EMIS development that accounts for the multiple facets of this complex and dynamic scenario in LAC, comprising the enabling conditions, the latest data demands, the prospective needs, global trends and standards, and the emerging modes of using data in educational administration, is required more than ever.

Many of those facets have been accurately characterized by experts in the last two decades and remain valid (Cassidy, 2006; UNESCO, 2018). The absence of a standard definition and vision of EMIS, the limitations from nonintegrated and non-interoperable across data subsystems, the gaps of technical and human resources, the barriers out of complex organizational structures and educational administrative jurisdictions, are just a few of those long-standing and enduring challenges. Acknowledging them is greatly relevant, though, as consolidated traits in the agenda, in this brief incursion into the EMIS of LAC we aim to introduce a selection of latest regional experiences in EMIS from which it is possible to start drawing up reflections and analysis more attuned to the education management in a post-COVID world.

To this end, cases from Uruguay and Peru are presented in the below section. They, without detriment of the copious developments from other countries, can contribute to navigating the discussions on enabling conditions for this region.

5.1. Uruguay: Ceibal and ANEP

EMIS in Uruguay are well-developed, as it is extensively depicted (Arias Ortiz et al., 2021) and stands out as one of the most advanced systems applied to students' learning processes, digital content, and schools' administration.

The data systems have mainly operated along two concurrent lanes: the Ceibal Plan and the National Public Education Administration (ANEP). The former has pioneered the creation of digital learning content and technologic infrastructure development and the latter is responsible for school governance and management. Together, the two have led to the development of integrated administrative and data systems.

Ceibal was launched in 2006 as a nationwide policy aimed at decreasing the digital divide with a One-Laptop-per-Child (OLPC) model and granting internet access to students and teachers. Its objectives evolved to incorporate digital literacy, pedagogic research and development of innovative methods. It has become an ambitious policy comprising multiple platforms, resources, and technologies for which it is internationally praised (Cyranek, 2011; Fernández, 2021; Fowler & Vegas, 2021; Jara, 2016; Mateu et al., 2018; Murray, 2020). Ceibal is a learning platform, which is included in the modern understanding of an integrated EMIS that includes digital resource management for student learning and teacher training. This initiative demonstrates how concurrent policies can enable the enhancement of EMIS capabilities. Ceibal has driven the expansion of internet connectivity, provided broadband access for students, teachers, and professors, ensured the provision of equipment and infrastructure, and has extensively built digital capacities and computer literacy.

Although it was not deliberately created as a crisis response, Ceibal proved immensely useful during the COVID-19 outbreak, facilitating the quick migration to remote learning as well as the early return to face-to-face education. Notably, a COVID-19 response partnership between Ceibal and mobile

providers permitted free data consumption on educational platforms to mitigate schooling inequalities (UNICEF, 2020). Ceibal's primary area for future improvement regards its interoperability with school-level data systems. The recent migration to online or hybrid learning revealed the value of non-traditional, real-time indicators generated by the digital platforms (e.g.: interaction, progress, and engagement). Connecting the Ceibal LMS linked with school and system-level management could yield improvements in the quality of teaching and learning across the education system by increasing the learner-level analytic capacity of EMIS.

ANEP has interoperable administration-centered subsystems for each level's administration council, aimed at supporting individuals' educational trajectories (Netto Marturet et al., 2019). Even prior to the COVID-19 outbreak, it leveraged real-time data and unique identifiers to create a student-centered monitoring strategy within and beyond the school, across institutions, levels, jurisdictions, and non-educational services. Described as a confederated database (CODICEN, 2016, p. 12), ANEP joined separate data subsystems operated by the educational councils to create the Educational Trajectories Protection System (SPTE), which identifies risk factors with corresponding intervention protocols (Netto Marturet et al., 2019, p. 19). The SPTE provides information to the Central Council (CODICEN), making it possible to design strategies and intervention protocols based on individuals' school enrollment, gradings, and attendance. This information is aggregated with the Social Security Integrated Data (SIIAS).

Numerous indicators supply the data for different modules, namely:

1. a Registration Module (SDP) aims to bridge levels assuring students' continuity when transferring schools, it informs teachers, families and triggers alerts;
2. an Attendance Module identifies intermittent attendance and enables early warnings and support strategies to prevent drop-outs;
3. a Support Module identifies students' needs for support (educational, social, counseling) and records those interventions for future follow-up;
4. a Student and Family Module integrates information relevant to involve students' parents or tutors. Mobile applications retrieving data from the EMIS are also used for a variety of management, communication and engagement purposes. For instance, VOS is the application for middle school students, parents, and legal tutors, providing real-time data on courses, schedules, grades, attendance, and notifications.

The EMIS dispenses real-time data to wide-ranging types of web access platforms with various tools including interactive analytical dashboards combined with administrative features that vary based on the type of user (e.g. staff, teachers, parents, students, public). These different tools are designed for research (gathering the demographics and the data customarily obtained from census), for providing analytics and trends for educational planning, for informing the public and prospective students, and for facilitating the school teachers' and staff administrative tasks. As such, Uruguay's integrated EMIS manages multiple aspects of the education system, including human resources, budgetary, finance, and infrastructure. The tools include a unique identifier for institutions and services, linked with their geo-reference as some key characteristics relevant to effectively inform planning and decision-making in dynamic contexts..

5.2. Peru

Peru is ranked as a well-developed EMIS in the region (level 3: emergent, paired by Uruguay, Santa Fe Province, Argentina, and Bogota District, Colombia) and stands out as one the most advanced systems applied to managing physical infrastructure and equipment (level 4: established), according to IDB's comparative study of 16 countries of Latin America and the Caribbean (Arias Ortiz et al., 2021).

Systems in Peru cover comprehensive data on infrastructure, equipment, educational services, and institutions, with a unique identifier. EMIS functionalities for the

management of schools' physical infrastructure and equipment are some of the most advanced within the region. The first Educational Infrastructure Census (CIE) carried out in 2013 provided comprehensive information on all school buildings, including georeferenced location, its spaces and characteristics, construction materials, state of conservation, utilities, furniture, equipment, services (water, electricity, sewerage, internet), transportation facilities and access, among other variables, including pictures and images. It is updated annually through the Education Census (Arias Ortiz et al., 2021). The information informs the elaboration of a long-term nationwide plan comprising investment schemes, multiparty international cooperation (MINEDU, 2017; World Bank Group, n.d., 2018), and maintenance risk-prevention projects (Marcone, 2019, p. 5).[1]

A modular code that combines building and educational service information was adopted by the MoE as the unique identifier for all information subsystems with the goal of increasing traceability of the educational institutions. This has great relevance in Peru where the shortage of infrastructure compels many schools and centers to share buildings, and likewise, can be dispersed among different venues and facilities (Arias Ortiz et al., 2021; Marcone, 2019). Since 2017, the institutional information including supporting legal documents is recorded in the decentralized ESCALE platform to compose the Register of Educational Institutions (RIE).[2]

In 2019, the Monitoring and Strategic Evaluation Office of the MoE launched Sistema Integrado de Información (SIDI) as its main instrument for planning and decision-making. The tool gathers information from different sources for the same variable to collect up-to-date data.[3] Regarded as a business intelligence tool, SIDI is designed to deliver online consolidated data of key indicators with Power BI, a Microsoft business analytics service that provides interactive visualizations, reports, and dashboards through an end-user interface. The tool covers four categories: learning, teaching, modernization of management, and infrastructure, and represents some progress in a region lacking tools for strategic management in education (Arias Ortiz et al., 2021, p. 115). SIDI includes a special dashboard retrieving the information of the program Semaforo Escuela (traffic lights in Spanish) that consolidates selected variables considered critical to structure warnings for decision-making: school principal and teacher absence rates, student attendance, instructional materials sufficiency, teachers' training, among others. While the SIDI dashboards are updated monthly, the supply of information is not necessarily available. For instance, *Semaforo Escuela*, results from two data collection field campaigns conducted in 2019, made through onsite visits to schools by survey-takers (named monitors) utilizing an electronic questionnaire directed to the principal (or school staff in its absence). This collection method, supplying information especially vital for crisis management, was interrupted with the COVID-19 lockdown, demonstrating the importance of anticipating and foreseeing the resilience of an EMIS to bear contingencies and emergencies.

As part of its COVID-19 Response, MoE of Peru conducted a Census to examine teachers' perceptions of the returning school conditions. The national teacher census (ENDO, *Encuesta Nacional de Docentes*) is conducted every two years directed to public and private school teachers since 2014. During the pandemic, it was conducted remotely (by phone) to a sample of 28,217 teachers (Universe 328,678), between November 24 and December 1, 2020. Given the extraordinary circumstances, numerous questions were added that aimed

1 The annual school census datasets, from 2000 to the present, can be found in the ANDA archive: http://sistemas02.minedu.gob.pe/anda/index.php, and *ESCALE* archive: http://escale.minedu.gob.pe/uee. General information and datasets of 2013/14 Peru School Infraestructure Census are no longer available in its website www.minedu.gob.pe/censo-infraestructura-educativa (Retrieved on November 2021), yet can be retrieved from the cached site: https://web.archive.org/web/20180811235025/http://www.minedu.gob.pe/censo-infraestructura-educativa .

2 Public access to datasets of the Register of Educational Institutions (RIE) on ESCALE Platform: http://escale.minedu.gob.pe/listadosrie (Retrieved on November 2021). The implementation of this register continuous in progress in 2021 (approximately 80% adoption rateof the Modular Code) and is monitored: http://escale.minedu.gob.pe/avance-rie (Retrieved on November 2021).

3 SIDI and *Semaforo Escuela.*

to understand the effects of COVID, the feasibility of returning to school, and the preferred conditions for such return.4 The Tracking and Alert System for Safe Return (SARES) was developed in light of a gradual reopening of schools starting in April 2021. This system is fed with the information provided by school principals who are asked to register their return-to-school plan, implementation, and monitoring following MoE guidelines. SARES retrieves preexisting information of the principal and the school from the administrative system SIAGIE, and, based on the completion of several variables, it will warn if schools' safety conditions are not met. The main purpose of this tool is to oversee and audit the compliance of principals' planning with MoE policies based on, for example, the rate of students per square meter in a classroom, proper ventilation, and documented consultations with the community.[5]

Peru's case illustrates the challenges of upgrading a longstanding EMIS that consists of aggregated platforms, applications, and databases, with an overall architecture that eclipses its own technological progress. The most recent comprehensive study describes it in detail, stating: The EMIS is made up of a virtual space created by more than 130 applications that the Office of Information and Communication Technologies (OTIC) hosts within its technological infrastructure. 20% of these were developed before the year 2000 and less than 50% have had been updated in the last 5 years. These applications involve 10 development platforms, 14 programming languages, and 6 database engines. The corresponding technical documentation is available for only 55% of these applications. This extensive variety of applications responds to having been created upon the request of various offices, each with its specific need. In the past, OTIC was limited to operating as a service desk for developing applications without adding them value or strategic vision. For this reason, there is significant duplication of functions and underutilization of resources (Marcone, 2019).

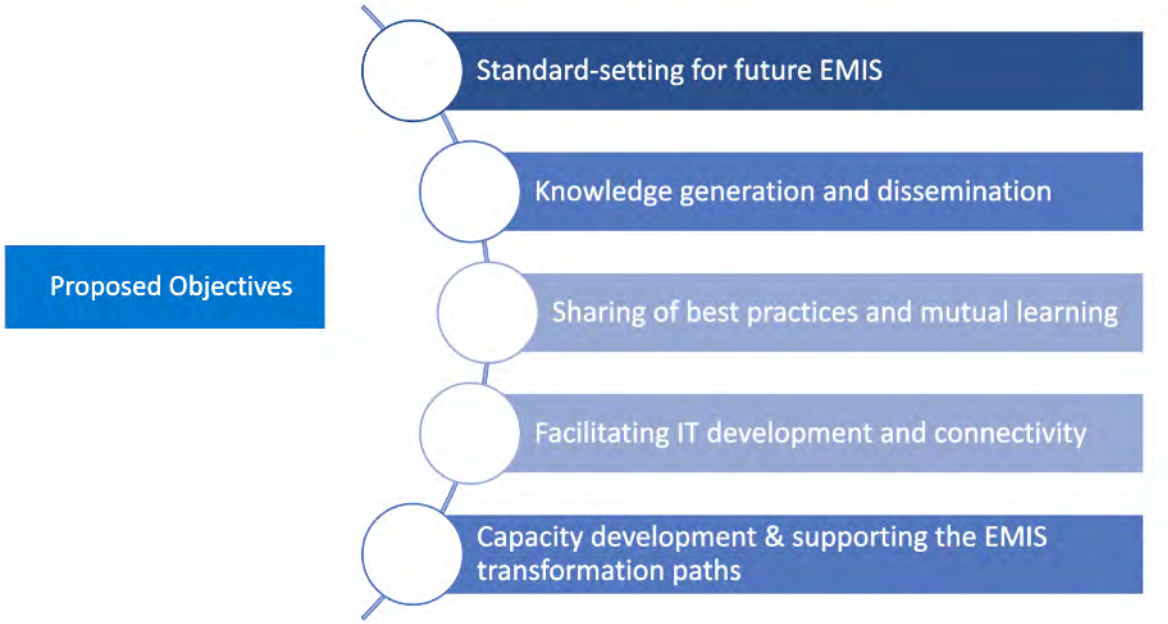
6. UNESCO's contribution to building the Future EMIS

Envisioning and realizing future EMIS will take a concerted effort from a wide range of experts who share the same goal of transforming EMIS for better learning for all. UNESCO will create an international Community of Practice (CoP) comprised of education planners and policy makers, development partners (including civil society organizations), IT experts, statistics and learning analytics experts, and private sector partners. The proposed objectives of the CoP are presented in Figure 7.

4 Teachers' Census (ENDO) access to Datasets Archive: http://escale.minedu.gob.pe/uee/-/document_library_display/GMv7/view/4385260

5 Supplementary information on SARES:
SARES Manual: http://directivos.minedu.gob.pe/wp-content/uploads/2021/09/Manual_SARES-Mod-1-2-ficha.pdf
SARES FAQ: http://directivos.minedu.gob.pe/wp-content/uploads/2021/09/Preguntas-frecuentes.pdf
SARES Guides: http://directivos.minedu.gob.pe/wp-content/uploads/2021/05/Orientacion-4.pdf
http://directivos.minedu.gob.pe/recursos-de-gestion/orientaciones-para-el-ano-escolar-2021/buen-retorno-del-ano-escolar/
SARES Access: https://sares.minedu.gob.pe/login

Figure 6. Proposed objectives of UNESCO EMIS Community of Practice



6.1. Building a vibrant community of practice for future EMIS

Sustained partnerships fused with common purpose and vision are essential to enabling future EMIS. Information sharing must be used as a tool to support the EMIS enhancing process at local, national, and international levels. The local level is of distinct importance and should be leveraged to understand the potential to leapfrog, as well as contextualized limitations. A great example of such a partnership is found within the African Union, where there is a leadership partnership to allow member states to learn from each other's data management practices.

Overall, there must be a shift from collecting data to providing services, making sure that systems are school-centered, simple, accessible, user-friendly and not more complex. Building trust is essential. Users should be involved in the design of the solution. That way, EMIS is not guided by a policy maker far away from the local context, but by experts within the region with school-based users in mind. Although future EMIS technologies are complex, partnerships with local universities can support the long-term building of local expertise in future technologies. Open-source solutions should be used as much as possible to be shared with different stakeholders. Therefore, EMIS needs to be transparent with interoperable standards that are flexible, adaptable, and capable of evolution.

Participants of the international EMIS seminar discussed how such a Community of Practice could be formulated and facilitated to collaborate towards the shared goal of enabling modern EMIS around the world. The following recommendations were compiled:

- Provide access to a compilation of technical information on practical and sustainable solutions through a global EMIS portal - principles, guidelines, standards + objective and technical validation checklist to aid decision-making. Avoid misinformation by presenting an objective, community driven approach to tools and technology.
- Create an online EMIS training academy for capacity building and certification of implementing partners, users, trainers, developers

- Organize annual global and regional EMIS technical meetings for countries to share their experiences, collaborate and explore solutions together.
- Organize study tours among MoEs to learn more about how other countries are implementing EMIS solutions
- Commit to pooled resources to build, maintain and sustain global public goods, made available to all.

UNESCO has developed its own EMIS international Community of Practice that discusses and shares knowledge of this flexible, adaptable, integrated EMIS. Such an EMIS will ensure continuity of teaching and learning, inclusion and equity in education, the timely collection of data on vulnerable and marginalized learners, and eventually, the improvement of learning outcomes for all. UNESCO is transforming the lessons learned from its second international seminar and from its Community of Practice on LinkedIn into a knowledge piece about what EMIS can do for specific users, to be published in 2022.

Additionally, the Regional Bureau for Education in Latin America and the Caribbean (OREALC/UNESCO Santiago) have been actively engaged in EMIS discussions and knowledge sharing. In August 2021, the document Educational information systems in the face of the COVID-19 pandemic was released, which presents reflections on the way in which EMIS have had to adapt to the COVID-19 crisis scenario. The report offers a synthetic review of the main challenges and dilemmas at stake. Such initiatives have permitted experience sharing among key educational stakeholders and specialists of Latin America and the Caribbean, thereby enhancing the community of practitioners that shape the regional framework and vision, indispensable to progress toward the 2030 Agenda goals.

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