EdTech Hub

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The use of ‘building blocks’ to develop digital platforms for education in sub-Saharan Africa

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About this document

Recommended citation

Adam, T., El-Serafy, Y., Podea, M., & Haßler, B. (2021). *The use of 'building blocks' to develop digital platforms for education in sub-Saharan Africa*. https://doi.org/10.53832/edtechhub.0049.

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Notes

EdTech Hub is supported by UK Aid and the World Bank; however, the views expressed in this document do not necessarily reflect the views of the UK Government or the World Bank.

Reviewers

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Executive summary

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Background

We set out to investigate the existing and potential use cases of open-source, modular 'building blocks' to build digital platforms for education in sub-Saharan Africa (SSA). Building blocks fall into two main categories: teaching and learning (e.g., learning management systems) and education system management (e.g., data collection tools).

We started the investigation with the following **hypothesis:**

If...	we provide open-source, common building blocks for use when developing education platforms...
then...	we can reduce duplication of efforts and conserve resources spent on developing digital platforms...
so that...	we can lower the cost of education provision and management and increase access for more children.

To investigate this, we conducted **desktop research** and **semi-structured interviews** with donors, ministry officials, and platform developers. This document outlines the findings of our exploratory study.

What do you need to know?

Government decision-makers

Using building blocks (BB) can **de-risk procurement, conserve resources, and help build more secure platforms.** However, make sure there is a sustainability plan in place first. See when to use BB; how education systems benefit, and risks of provision.

Donors

Investing in BB (rather than bespoke platforms) could offer **better value for money**. However, no comparative analysis has been done and a sustainability plan must be in place. See key stakeholders, risks of provision, need for BB, and how donors could provide better support.

Building block developers

There could be a market for BB in sub-Saharan Africa. However, ministries need to know the **advantages and disadvantages**. Technology alone is insufficient — consider stakeholders, support, and the surrounding ecosystem. See pathways to uptake, stakeholders, and need for BB.

Cut to the chase: 8 insights

How can education systems potentially **benefit** from building blocks?

What are the pathways to **successful uptake**?

When should you **build** from scratch, use off-the-shelf solutions or use building blocks?

What roles do **key stakeholders** play?

How can **stakeholders interact** better?

What are the **risks** of provision?

Is there a **need and demand**?

How can **donors** provide better support?

Key findings

Building block benefits

- Provision of a platform that can be tailored, adapted, and customised to specific needs.
- Reduction of the costs of platform development by not developing it from scratch.
- Provision of a platform that can easily interact and integrate with other systems.
- Improved quality by building on code that has reached maturity, been debugged, and is quality assured. Time and resources being focused on advancing the field, rather than repeating basic work.
- Reduction in time taken to develop a robust solution since it is partially complete.
- Reduction in duplication of coding efforts and reinventing the wheel.

- While countries such as India have a thriving community both developing and using building blocks, this is not yet the case in sub-Saharan Africa (SSA).
- In SSA, ministries are more likely to build bespoke solutions from scratch (e.g., National Education Management Information System in Kenya) or to use off-the-shelf solutions (e.g., MS Teams). This is either because they are unaware of building blocks, or have concerns about the integrity of open-source platforms.
- While there are no homegrown examples of building blocks in SSA, there is use of building blocks that are developed by international partners (e.g., OpenEMIS used in DRC, Lesotho, Malawi, South Africa and Zambia, and DHIS2 for Education used in Eswatini, Mozambique, The Gambia, Togo, Uganda and Tanzania).
- Factors that enable effective use of building blocks include: 1) digital infrastructure maturity; 2) human capacity such as skilled developers and data analysts; 3) a supportive ecosystem; 4) sufficient funding and 5) stakeholder and policy support.
- There is a need to 'educate demand' on the use of open-source platforms and building blocks for both donors and in-country decision-makers.

Explaining the concept

This study is inspired by the concept of 'societal platforms' used in education and other sectors in India.

Complex challenges need tailored solutions. Education system needs differ based on the context, and there is no 'one-size-fits-all' solution.

However... ministries of education around the world build digital platforms using common functionalities. These can include data collection systems, resource libraries, and information management systems.

Local solutions need to be designed locally. For solutions to work, they need to be designed alongside local stakeholders and users.

However... developing digital platforms from scratch is resource- and skill-intensive and does not always align with the existing resources and skills in a given place.

We can co-create solutions with local stakeholders. By building common functionalities using open-source codes, we can support local stakeholders to take what they need, adapt and develop it, integrate it into existing systems or build tailored solutions to fit their needs.

What we mean by digital platform building blocks

We **define** building blocks according to the following:

- Building blocks are open source, modular, interoperable pieces of code or software that can be (re)used to build or tailor platforms. They are the middle ground between building bespoke platforms and using off-the-shelf platforms.
- They can either provide functionality on their own (standalone) or be integrated into other applications (interdependent).
- They provide configurations to customise their functionality based on the use case.
- They provide a piece of functionality that could be non-user-facing (e.g., functions to send an email or display data in a specific format) or user-facing (e.g., a reporting tool, quiz module, or login feature).
- They provide points of integration with other platforms, usually achieved through an Application Protocol Interface (API).

The following features are **preferable**:

- Availability in multiple programming languages to increase reusability.
- Support community for functional and technical questions.
- Built on globally-used standards for software development.
- Regular testing by the developer community or the original owners, version-control, and quality-assurance from a functional and security standpoint.

Examples of solutions that are *not* building blocks are plugins or application stores created for *a specific platform (e.g., creating a feature for WordPress)*.

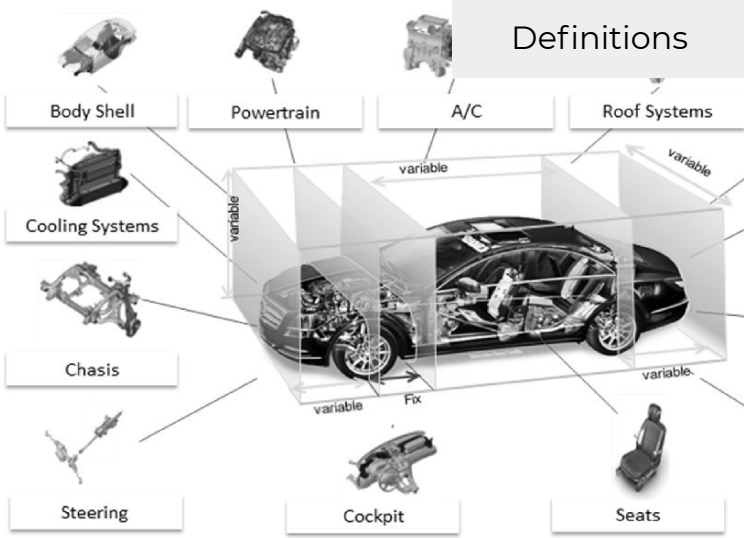
Explaining modular design

'Modular design' means that different parts are constructed separately, and used to construct a 'whole piece'.

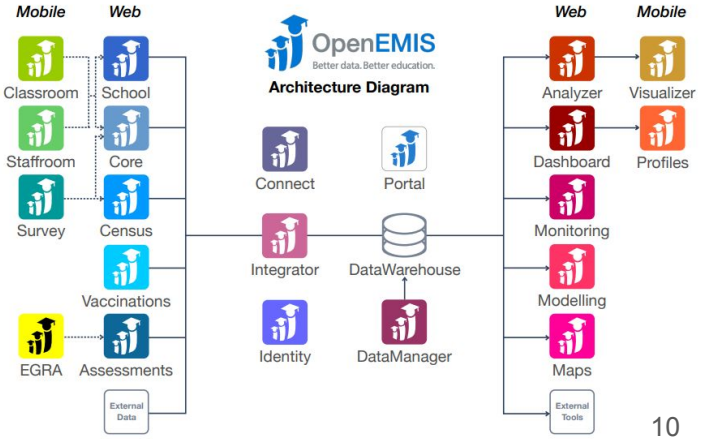
Think of a car. Car manufacturers design the overall 'car', however, they do not manufacture the individual 'parts'. Instead, the 'parts' are manufactured by different companies. Each 'part' can be used in different models of cars to contribute to different overall pieces. **Each part fulfills an independent function (such as steering), yet works with other parts to make the whole car work.**

Similarly, each digital platform 'building block' performs a particular function (such as data collection), like the 'parts' of the car. This 'building block' works with other parts to make the entire 'platform' work.

The 'platform' is the final tool you would use, such as a web page or application. Just like the car, it is the sum of its parts.



Source: ↑Toepfer & Naumann (2016)



Source: ↑OpenEMIS (2020)

Building blocks used in sub-Saharan Africa

Here, you will find a list of building blocks currently being used (or platforms that are made up of building blocks). These illustrate what is available for countries to adapt and tailor according to their education system needs. We have tagged these building blocks so you can easily see their characteristics.

Teaching and learning

- Sunbird
- Sakai
- OpenedX
- Tsugi
- Kolibri*
- Moodle*

Education system management

- OpenEMIS
- DHIS2
- Kobo Toolbox
- RapidPro
- Shiny
- RapidSMS
- Tangerine
- ODK

Click here for detailed mapping definitions

Click here for mapping process

Click here for a full mapping of these tools

*These platforms / tools do not strictly meet the definition of a building block but as they are open-source and interoperable, we've included them here.

Tagging Categories
Openness
API availability
Microservices architecture
Extensibility
Offline support
Technology stack
Product support
Developer community
Functional modularity
Technical support
Interoperability

Country readiness considerations — 1 of 2

Through our research, we established the following non-exhaustive list of considerations to assess a country's readiness to use digital platform building blocks. You do not need to answer 'yes' or 'no' to these questions; they are guiding considerations to keep in mind as you assess the possibility of using building blocks. The answers are often relative, and will differ by context.

Questions to consider	Details
Is the digital infrastructure mature enough?	• Implementers of the platform that is being integrated need to understand the infrastructural conditions (e.g., connectivity, hardware, power) of the **context and tailor** it accordingly. These conditions will inform **design decisions** such as where to store data (e.g., in a local data centre or in a cloud) and what types of data collection tools are appropriate.
Is there sufficient human capacity?	• **Ministries of Education** need in-house capacity to understand how to effectively implement, use, and maintain platforms. • Personnel with **software development** skills are needed. • Personnel who understand how to **collect, process,** and **analyse data** are needed. • Support and **continuous professional development** is needed for all personnel to ensure sustainability of the platforms implemented.
Is there a supportive ecosystem?	• The local **developer community** needs to have an open-source mindset and needs to understand how to code in a modular way. • Communication within the **donor community** is essential as they will need to invest collectively in centralised systems. • The **education community** (from the ministry and district officials to principals, coaches, teachers, parents, and learners) needs to 'buy in' to the concept. To achieve this, user needs and preferences need to be met.

Country readiness considerations — 2 of 2

Questions to consider	Details
Is sufficient funding available?	Funding is needed to: • **tinker** and test 'alpha' building blocks and ideas to support local innovation; • **develop** homegrown building blocks; • **adapt** and tailor pre-existing building blocks to the context; • **maintain** platforms, particularly after donor funding depletes; • **retain** trained personnel.
Is there support from political economy stakeholders and policy?	• Governments need to fully **understand the benefits and risks** of building blocks to ensure their **buy-in** and support. • Stakeholder **fears need to be allayed**, particularly around security and ethical concerns. • **Local demand** across levels of the education system is needed for the platform (as opposed to platforms implemented for donor needs). • **Policies** need to be in place to support open data, open products, open access etc.

We applied these considerations to seven countries. See the links below to read the country case studies.

OpenEMIS in Jordan | OpenEMIS in South Africa | DHIS2 in Uganda | DHIS2 in Tanzania | Kenya | Sierra Leone | South Sudan

Overview of platforms reviewed

We did a more intensive review of three building block platforms. Each review outlines the platform's technical and educational features and their use cases.

OpenEMIS

Education system management

Pioneered by UNESCO

Used, extended, and tailored across low- and middle-income countries

Case Studies:
Jordan
South Africa

DHIS2

Education system management

Pioneered by University of Oslo

Used, extended, and tailored across low- and middle-income countries

Case Studies:
Uganda
Tanzania

Sunbird

Teaching and learning

Pioneered by EkStep

Used, extended, and tailored in India

Case Studies:
Diksha
ShikshaLokam

OpenEMIS

Description: OpenEMIS is an open-source education management information system, owned by UNESCO and often implemented by Community Systems Foundation.

Design insights:

- OpenEMIS modules can be integrated with existing legacy systems, or used to develop new platforms.
- Contributors can develop APIs and plugins to connect OpenEMIS with other systems and database relation tools.
- OpenEMIS is funded through core UNESCO funding, as well as through funding from governments involved in implementing OpenEMIS.

Click here for an OpenEMIS deep dive

Implementation insights:

- The OpenEMIS team highlighted the following capabilities as essential to implementing their new co-development model (being piloted in South Africa):
  - software development capabilities;
  - hardware infrastructure managers with enough knowledge on managing the relevant servers
- UNESCO prefers to have a technical partner —ideally from the ministry of education. However, they often lack capacity.
- The recommended timeline for implementation technical assistance is three years, however, this differs from country to country.
- As the platform developed, UNESCO lacked the capacity to maintain OpenEMIS and support its implementation. As a result, they formed a long-term partnership with Community Systems Foundation (CSF), who now serve as the main implementation partner.
- During implementation, OpenEMIS and its implementers (such as UNESCO, CSF) do not fund hardware procurement; this is expected to be funded by ministries.
- Part of OpenEMIS implementation plans includes policy development, rollout plans, and capacity-building. The focus is on ‘people’ and ‘processes’, as much as it is on the technology.
- Prior to implementation, a needs analysis is conducted to understand the appropriate design and implementation mode of OpenEMIS in a given context.

DHIS2 for Education

Description: DHIS2 for Education is an open-source, stable, scalable, and customisable EMIS solution.

Design insights

- **Community Participatory Design (PD)** DHIS2 is developed using PD with the aim of empowering users. The idea has been to shift development away from a core developer team to a scenario where the users are the designers. This has been done successfully through in-country Health Information Systems Program (HISP) networks comprising implementers and academics.
- **Health vs education** DHIS2 for health and DHIS2 for education do not have major design differences. This is because DHIS2 was not built in a way that is specific to health. Users need to code the data such that it can be used for different purposes.
- **Funding DHIS2** As DHIS2 was developed in an academic space, it was initially funded by research grants. There are also major donors who invest in such initiatives in the health sector. The education sector is not as advanced.

Click here for a DHIS2 deep dive

Implementation insights

- **Maturity path** A common problem in countries is isolated databases. While there is a tendency to strive for ultimate interoperability, DHIS2 implementers prioritise interoperability that is most useful. They focus on first getting the basics working, noting that there is a trade off between complexity, sophistication, scaling, robustness, and capacity.
- **Quality assurance** Open-source code allows for various product derivations. However, some of the spin off versions are not coordinated centrally and are therefore not quality assured and may be incompatible with updates. Furthermore, lack of funding means there is only a small number of spin-offs in the form of Global Public Goods (GPGs).
- **Expanding in country** It is often easier to expand DHIS2 for education in a country that already uses DHIS2 for health, than implementing the education version in a new country. This is because trust in a product and political buy-in is important.
- **Donor endorsement** Having well-known donors supporting the project makes a significant difference to the perception of the product's quality.
- **Community** Building a strong developer community and academic community is key to sustainability; more so than the software itself.

Sunbird

Description: Sunbird is designed to support multiple languages and multiple teaching and learning solutions by providing the building blocks for the development of platforms and learning solutions to suit various use cases, contexts, and needs.

Technology design

- **Hosting** Countries can:
  - Download source code and install it onto their servers and structures using Kubernetes.
  - Opt for a paid, cloud-hosting service such as Azure, Amazon etc.
- **Modularity** Sunbird is built with a core functionality and specific features are integrated through building blocks such as cAdvisor, ELK stack, Prometheus and their plugin ecosystem, Grafana, Elastic Search, Play Framework etc. This is also possible because of their API being able to be consumed and integrated into other systems.

Click here for a Sunbird deep dive

Key insights

- **Problem-first approach** The Sunbird team first focuses on the problems / challenges / needs that should be addressed within educational systems and then moves on to how can technology be leveraged to resolve these issues.
- **Microservices** Sunbird uses a microservice architecture, which allows it to scale and easily integrate new building blocks in order to offer advanced functionality and user experience to the end users.
- **Funding** Sunbird is actively developed by EkStep with the funding they have at hand but also through the different locations where Sunbird has been implemented.
- **Government use** Sunbird is being used by the government of India as the building block of the DIKSHA teacher platform.
- **Community** Sunbird has a community that was developed in about five years.
- **Support** Sunbird offers both product support (e.g., through its 'How to' videos) and developer support (e.g., through its community forum).

Four country deep-dives on digital platforms used

Through our country interviews, we sought to investigate what education platforms exist in each country, how they were developed, and factors to consider in platform development. We mapped all the platforms we came across, whether bespoke building blocks, or off-the-shelf solutions. We provide early insights as to whether building blocks would address a need and whether there would be a demand for them.

Sierra Leone

Low resource context

Deep dive: Education management platforms

Tanzania

Low-to-middle-income context

Deep dive: Education management platforms

Kenya

Low-to-middle-income context

Deep dive: Teaching and learning platforms

South Sudan

Emergency context

Deep dive: Education management platforms

N.B. The information presented on the digital platform landscapes in these countries is not exhaustive. It presents what we have gathered through interviews and desktop research at an initial exploratory stage.

8 insights

1. How can education systems potentially benefit from building blocks?

Reduce the costs of platform development by not developing it from scratch.

Provide platforms that can be tailored, adapted and customised to specific needs.

Reduce time taken to develop a robust solution since it is partially complete.

Provide a platform that can easily interact and integrate with other systems.

Reduce duplication of coding efforts and avoid reinventing the wheel.

Build on code that has reached maturity, been debugged, and quality assured.

2. What are the pathways to successful uptake?

To successfully make use of building blocks for platform development, countries should keep in mind the following considerations. The specific measures of each consideration will vary depending on context.

Funding	• Have adequate **resource funding** to hire and retain the appropriate staff / consultants (e.g. developers and data scientists), run continuous professional development for staff or pay for data storage / hosting. • Have adequate **development funding** to support customisation and maintenance of platforms during the first stage and support tinkering with building block ideas and development of building blocks as GPGs during the second stage..
Infrastructure	• Have a decent level of **basic infrastructure maturity** such that funding towards platform development does not take away from more urgent funding needs. • Analyse the **digital infrastructure maturity** and choose building blocks that are compatible with the context (e.g., offline data collection, data storage).
Capacity	• Build in-house **capacity within the ministry** of education to ensure effective development, implementation, use and maintenance of the platform. • Invest in **local software developer capacity** to support local maintenance and ensure sustainability. This includes backend developers, web application developers, full-stack developers, and mobile app developers. Additionally, developers need to have advanced knowledge of modular design principles to use microservices architecture, for example.
Community	• Build **communities of practice** and an **ecosystem** around building blocks. These could be developer communities that support the maintenance of the open-source code, academic communities that support the evidence-based development of building blocks, or donor and policy communities that support the uptake of building blocks at a policy level. • Promote **local ownership.** Governments in sub-Saharan Africa need to own the platforms, source codes, and data. They also need to own the decision-making and design processes involved in developing digital platforms.
Stakeholders	• Ensure **government has full understanding** of the benefits and risks of building blocks. In particular, fears around open source being a security risk need to be allayed. • Ensure there is **local demand** and **buy-in** across levels of the education system, particularly with district officials, principals, and teachers and ensure the platform considers their user needs and preferences. • Create **information and communication feedback loops** to ensure that all stakeholders, particularly those at the school-level are continuously benefiting from the platform.

3. When to build platforms from scratch, use off-the-shelf solutions or use building blocks?

Build from scratch (bespoke solutions) if

- ✓ No product on the market addresses needs.
- ✓ Needs are very particular.
- ✓ You have developer capacity, at least for monolithic software design (non-modular; all in one piece).
- ✓ The product is not likely to interact with other platforms.
- ✓ Funding for development and maintenance is available.

Use off-the-shelf solutions if

- ✓ A product on the market addresses needs sufficiently.
- ✓ Needs are generic.
- ✓ You have low software developer capacity.
- ✓ The product is free and / or open source.
- ✓ Needs are not likely to change drastically in the future.
- ✓ The product offers support.

Use building blocks if

- ✓ Available building blocks available address needs.
- ✓ A tailored solution to a common problem is required.
- ✓ You have developer capacity skilled in modular software design.
- ✓ The product will need to be interoperable.
- ✓ Funding for development and maintenance is available.

4. Who are the key stakeholders and what are their roles?

Donors, bilateral, and multilateral organisations such as FCDO or UNESCO fund and develop international building blocks.

Technical implementing partners such as Community Systems Foundation support the implementation of building blocks in country.

Ministries of education and other relevant ministries are the core implementing partners, and ultimate decision-makers, driving platform development.

Technical consultants are involved in building similar platforms in different countries (e.g., attendance monitoring systems). Further research could investigate whether such consultants would be interested in turning their products into open-source building blocks. Initiatives that have made their products open source have shifted their business models to providing support and hosting services.

Local technical consultants and software developers In the past, consulting support tended to imply international consultants. However, our research indicates that there seems to be an increasing number of local consultants procuring work. This tapping into local expertise is encouraging as it supports the expansion of homegrown solutions.

Academic communities contribute research and evidence and support buy-in for particular platforms. They can also inform platform development, as in the case of DHIS2.

District officials, principals, teachers, and learners are the ultimate users of digital platforms. Their uptake, or lack of it, will affect the sustainability and impact of digital platforms.

5. How can stakeholders interact better?

Improved coordination between local stakeholders and donors

There is a mismatch between donor perceptions and local perceptions when it comes to implementing building blocks. For example, perceptions of international organisations implementing OpenEMIS and DHIS2 differed from perceptions of local ministries implementing these systems.

- In Jordan, developers of OpenEMIS considered the system to be highly effective, whereas local stakeholders in Jordan considered it difficult to navigate and detached from their needs.
- Developers of DHIS2 though the system was fully and easily customisable to meet local needs. However, local implementers in Tanzania leveraging DHIS2 for the annual census felt they were unable to customise it to collect data more frequently. This led implementers in Tanzania to move away from DHIS2.

Coordination and co-creation between donors and local stakeholders

There is a need for increased coordination and co-creation between donors and local stakeholders to ensure systems are built to meet local needs and complement local capacities, rather than pushing for donor agendas or creating unsustainable cycles of dependency on technical assistance. Our research showed that, in some instances, donors pushed for the development of platforms because of available or excess funding, despite local stakeholders expressing a lack of need or demand for these platforms.

Increased donor coordination

In some instances, such as in the case of Sierra Leone and South Sudan, the challenge has less to do with a 'lack of funding' as is often cited, and more to do with a 'lack of *coordination* of funding'. Multiple and different donors support the development of digital platforms that ultimately perform similar functions and target similar users. As a result, the existing data is fragmented rather than centralised, and is difficult to access. Additionally, resources are spent on developing platforms similar to those already in existence, rather than building on what exists and improving it. This is ultimately a political issue, with multiple actors wanting 'ownership' over the digital platforms they create. To mitigate the challenge of misspent resources, there is an urgent need for increased donor coordination.

6. What are the risks of providing building blocks? (1 of 2)

Risk	Mitigation
Sustainability There is a risk of building blocks being developed, tailored, and used by ministries, but facing challenges with sustainability. Generally, there has been a high turnover of digital platforms due to funding structures, political turnover, lack of capacity for maintenance, and lack of buy-in.	Comprehensive infrastructural assessments conducted at programme inception to assess sustainability. Sustainability plans developed alongside programme development to account for fundings, policy, and maintenance.
Capacity There is a risk that ministries of education may lack the capacity to manage, maintain, and further develop building blocks.	Comprehensive assessments conducted at programme inception to assess ministry capacity for management, maintenance, and further development. Platforms developed in iterations, using agile processes, to identify capacity challenges early on, prior to excessive spending.
Buy-in The perceived lack of security of open-source systems may lead to a lack of use by important stakeholders, and lack of buy-in. This feeds back into the risk of the lack of sustainability.	Educating demand on the benefits of open-source systems. If stakeholders are not receptive to the use of open-source solutions in spite of this, then alternative systems should be explored to avoid stakeholder drop-out.
Ownership If building blocks are internationally-developed, there is a risk that local stakeholders will lack genuine ownership. This risk is exacerbated if local stakeholders lack the capacity to manage and maintain the platforms. The lack of ownership can additionally lead to dependence on international organisations, technical assistance, and donors.	Factoring local ownership into plans at programme inception. Ensuring local stakeholders have direct ownership over data. Development of sustainability plans to include effective handover to local stakeholders from international partners.

6. What are the risks of providing building blocks? (2 of 2)

Risk	Mitigation
Integration There is a risk that building blocks may not easily integrate with legacy systems. This is exacerbated if the building blocks use languages that are unfamiliar to the relevant IT teams within ministries of education. It is also exacerbated if the source code behind legacy systems is owned by technical consultants and not by the ministries. Lack of integration with existing systems risks leading to the proliferation of unused platforms.	Comprehensive landscape assessments at programme inception to assess existing legacy systems, developer capacities, and gaps. If building blocks do not integrate with legacy systems, effective operational plans need to be in place to manage the different systems. Languages used should be familiar to local IT teams, and if this is not possible then capacity-building plans need to be integrated into programme design.
Competing visions Competing visions between donors, implementers, and local stakeholders risk leading to delays and compromises with implementation. This risks sub-optimal use of resources.	Adoption of participatory and agile approaches from programme inception to ensure alignment of different stakeholder visions. Development of the platform in iterations to identify challenges prior to full platform rollout.
Overlooking people and processes Excessive focus on ‘technology’ risks overlooking ‘people’ and ‘processes’. The latter two can be more important for scalable and sustainable implementation of digital platforms.	Digital platform development plans (and associated Terms of Reference, etc.) to include focus on people and process.

7. Is there a need and demand for building blocks?

Tailored needs In most cases, countries mentioned having tailored needs that led them to building bespoke solutions. This was a need that building blocks could address but there was lack of awareness about the concept of building blocks and thus little demand.

Educating demand The countries we interviewed did not know about the concept of building blocks. When they were presented with the use cases, their interest peaked, increasing demand.

Address a need When governments are presented with how building blocks address a specific need or gap they have, their interest increases. Governments in sub-Saharan Africa are highly receptive to the idea of building blocks to save time and resources and to deploy systems faster.

Managing expectations Expectations need to be managed on how the use of building blocks will (not) affect the other challenges a country faces. E.g., in the case of South Sudan, a lack of donor alignment is leading to multiple segmented platforms. Building blocks can be used to build an integrated platform, however, the use of building blocks alone will not lead to donor alignment. This is a political issue.

Cost-benefit analysis Ministries want a cost-benefit analysis to help them decide whether or not to use building blocks. Cost reduction is thus an important factor in driving demand.

Security concerns There is a perception among stakeholders that open-source platforms are less secure. This decreases demand.

Existing solutions If a platform that meets specific needs already exists, the demand for building blocks will go down. E.g., in Tanzania, the School information System (SIS) already had offline capabilities so DHIS2 — configurable to be used offline — was deemed unnecessary.

High platform turnover In some countries, there is a level of fatigue from the amount of platforms changes and the amount of different platforms in existence at the same time. Thus, there is some hesitance at the thought of yet another platform / type of platform. The argument for using building blocks needs to be strong.

Using building blocks to support existing systems If bespoke platforms are built in a way that they could still benefit from building blocks to tailor them and add functionality, this is high in demand.

8. How could donors provide better support?

Donor endorsement Having well-known donors supporting the project makes a significant difference in the perception of a product's quality. This was the case with OpenEMIS having UNESCO's endorsement. Donors can seek support from experts to discern which platforms to endorse.

Educating donors A large number of bespoke platforms are being developed with donor funding. Sharing information regarding the benefits of building blocks in spaces like Building Evidence in Education (BE2) would be useful.

Providing evidence for in-country decision-makers Similarly, decision-makers are choosing to build bespoke platforms as they have little evidence to suggest this is not the right approach. They are interested in knowing more about the cost-benefit of building block platforms.

Funding Building blocks will not succeed without funding for capacity building, software development, maintenance, software and hardware procurement, hosting and data management, technical assistance to develop policies and action plans for rollout, scale, and sustainability.

Investing in building blocks for teaching and learning Most investment in building blocks has focused on education system management. By contrast, there has been limited investment in building blocks for teaching and learning. For example, there is a lack of building blocks for Learning Management Systems (LMSs) at a national level. One clear exception is Sunbird.

Mismatched perceptions on the success of building blocks There is a mismatch between donor and local perceptions when it comes to implementations of building blocks. For example, international organisations tended to present implementation success stories while the experiences of local ministries in implementing these systems told a more challenging story.

Coordination of donor funding — In Sierra Leone and South Sudan in particular, there are a number of donors running different pilots and projects of a similar nature. This has resulted in a fragmented data that can even produce conflicting findings. Donor projects and funding needs to be coordinated such that they invest in building central and / or integratable platforms.

Longer-term maintenance support Currently, donors pay for maintenance support, such as cloud hosting, for one or two years. This time is insufficient for countries to find alternative funding sources and therefore, these platforms collapse. It would be more useful for donors to pay for longer-term hosting to ensure platform sustainability.

End of executive summary

Detailed report

Keep reading for detailed insights into the study’s findings.

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Study overview

Overview

This study explores the use of 'building blocks' to develop **digital platforms** for education. **Digital platforms** for education include learning management systems and data collection systems.

What are digital platform building blocks?

Open source, modular, interoperable pieces of code or software that can be used to build or tailor platforms.

In this presentation we use the following definitions.
'Building block' refers to a single-purpose, modular building block (e.g., a piece of code, software or a tool) that can either be used on it's own or when integrated into a platform.

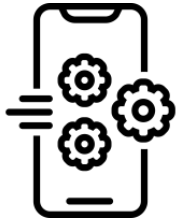
'Building block platforms' refers to a suite of modular building blocks packaged together in a platform. Although they are packaged together, each building block can independently plug into another platform.

Our key findings

- Countries in sub-Saharan Africa do not tend to use building blocks for education platforms.
- They are more likely to build bespoke solutions from scratch or use off-the-shelf solutions (e.g., MS Teams).
- The key providers of building blocks are international actors.
- Within education management, notable building block platforms are DHIS2 and OpenEMIS in SSA.
- Capacity of software developers to build and maintain platforms is crucial.
- There is a need to 'educate demand' on the use of open-source platforms and building blocks.

Illustrative case study: Building blocks in India

The EkStep Foundation in India built Sunbird, a collection of building blocks used to create education digital platforms.



Sunbird has open-source codes for functionalities, including:

- Notifications
- Analytics
- Reports
- Surveys
- Video players
- Certificate registry
- Content editor

Each functionality is a standalone component, and can be configured along with others to create a digital platform.

The Government of India used the Sunbird collection of building blocks to build DIKSHA (Digital Infrastructure for Knowledge Sharing).

The building blocks are designed in a generalised way, so they can be picked up by different users and configured to meet their needs. They have been used for diverse solutions such as a national teacher platform, an education leadership platform, a voice-enabled learning assistant, and a virtual programming academy.

Key definitions

Overview of key definitions — 1 of 3

The table below offers high-level definitions of the terms used when discussing digital platform building blocks. **For a detailed description of terms, with examples, see Annex A.**

Term	Definition
Digital platforms	An end-user-facing digital platform is an environment where a set of functionalities can be used by an end user. The end user could be a learner, teacher, coach, policy analyst etc.
Tech stack, development stack or solution stack	A list of all the technology services used to build and run one single application. LAMP (Linux, Apache, MySQL, PHP/Perl/Python) is the classic example of a web development stack.
Application Programming Interface (API)	An API is a communication interface that allows two applications to talk to each other. It lets a product or service communicate with other products and services without having to know how they're implemented or what language they were programmed in.
Backbone infrastructure	Backbone infrastructure refers to physical or abstract infrastructure that is needed to support a platform such as storage, global and local networks, fibre-optic cables, terminals, and software.
Digital backbone infrastructure	Digital backbone infrastructure refers to the information and communication technology (ICT) assets needed to operate digitally. This could be, for example, web hosting or cloud storage. A platform could pay for such services or locally maintain their platform.

Overview of key definitions — 2 of 3

Term	Definition
Microservices architecture	A microservice is a self-contained operation that can be seen as part of a business functionality, with a code interface making transparent how other platforms / applications / microservices etc. can interact with the operation.
Monolithic architecture	A monolithic architecture is the traditional unified model for the design of a software program. Monolithic, in this context, means composed in one piece. Monolithic software is designed to be self-contained; components of the program are interconnected and interdependent rather than loosely coupled as is the case with modular software programs.
Software frameworks	Frameworks refers to source code that is designed to be customisable, configurable, extendable, and integratable by software developers to meet different use cases.

Overview of key definitions — 3 of 3

Term	Definition
Extensibility	Extensibility refers to the the quality of being designed to allow the addition of new capabilities or functionality.
Modularity	Modularity refers to the concept of making multiple modules first and then linking and combining them to form a complete system. Modular programming is a software design technique where the functionality of a program is separated into independent, interchangeable modules, such that each contains everything necessary to execute only one aspect of the desired functionality.
Interoperability	Interoperability is the ability of different systems, devices, applications, or products to connect and communicate in a coordinated way. Functions of interoperable components include data access, data transmission and cross-organisational collaboration regardless of developer or origin.

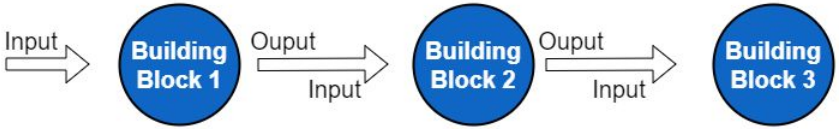
Possible ways of putting together building blocks

Building blocks can be configured to be used in different ways.

Stand-alone building blocks

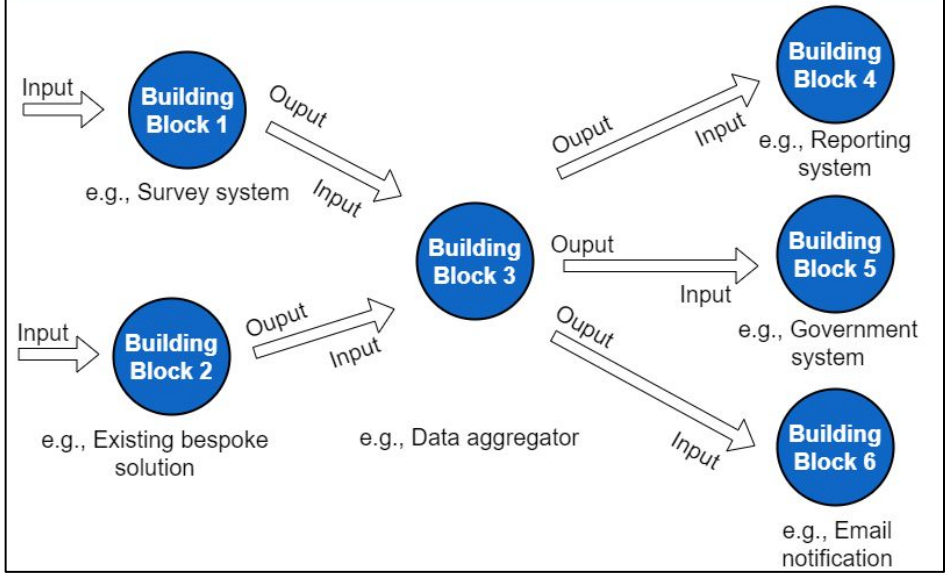
e.g., Reporting system which can be connected to a legacy system in order to display data in specific formats.

Linear structure building blocks



e.g., Survey system | e.g., Data agregator | e.g., Reporting system

Star structure building blocks



Source: Authors' own

Types and categories of building blocks

Types of platforms and tools

Below, we list types of platforms and tools that could be built using building blocks. In come cases, a platform includes multiple purposes and in others it has a single purpose.

Teaching and learning

- Content management systems (CMS)
- E-libraries
- Content creation, curation, and management platforms
- Learning management systems / Virtual learning environments for learners or teachers, including learning assessment tools
- Authoring platforms*
- Bulk messaging tools

Examples of building blocks include modules for quizzes, discussion boards, autograders, peer grading, chatbot, etc.

Education system management

- Education management information systems (EMIS)
- Student information systems (SIS)
- Annual Census
- Teacher attendance monitoring
- Student attendance monitoring
- Teacher reimbursement or promotion platforms
- Data collection tools

Examples of building blocks include modules for surveys, dashboards, reporting, analysers etc.

Building blocks and platforms that use them

We developed a long list of building blocks or platforms that are comprised of building blocks, to illustrate the type of building blocks available for countries to adapt and tailor according to their education system needs.

Teaching and learning

Sunbird
Sakai
OpenedX
Tsugi
Kolibri*
Moodle*

Education system management

OpenEMIS
DHIS2
Kobo Toolbox
RapidPro
Shiny
RapidSMS
Tangerine
ODK

>>Click here for a full mapping of these tools<<

Building block mapping categories — Technological

The long list of building blocks was mapped according to the following categories to unpack similarities and differences in types of building blocks. The table below outlines what we sought to investigate for each category.

Category	Explanation of mapping category
Openness	The code of the building block is available for download from a public server, in order to change, extend, or install the functionality. People are able to contribute in an open-source manner to extend the functionalities. The owner of the code is able to assign it an open-source license. Having this license is essential in order to be able to reuse the code and the type of license defines the level of reusability of the code.
API availability	The building block has an API that allows it to be integrated within a digital landscape.
Microservices architecture	The architecture is developed for microservices, allowing deployment in cloud and ease of scalability for more users, if needed.
Extensibility (marketplace, applications etc.)	The building block is extensible through some of the following options: 1) a marketplace with applications that are built for the building block, 2) with a list of plugins, which can be enabled based on need or other similar options.
Offline Support	The functionality of the building block or part of the functionality is available for use without an active internet connection.
Technology Stack	The list of technologies used in order to develop the building block.

Building block mapping categories — Technological

Category	Explanation of mapping category
Product support	A dedicated portal where users can get their questions answered related to the specific functionality of the building block.
Developer community	A community, which at most one month previous to the evaluation moment, has contributed to the building block with development.
Functional modularity	The BB is is able to enable / disable or substitute building blocks with others used within its creation.
Technical support	A dedicated portal where users can get answers to their technical questions relating to the specific functionality of the building blocks.
Interoperability	The blocks are built according to common communication standards (such as APIs), which allow for the exchange of information with other systems (building blocks or bespoke solutions).

Insights from mapping

During our mapping of the building blocks, we gathered the following interesting findings from a technical perspective:

- **Microservices vs monolithic architecture** There is a good balance between learning platforms that use microservices architecture and monolithic architecture, hence decision-makers can choose one or the other. The microservices architecture requires much more technical knowledge compared to the monolithic one. It is thus not always the most suitable option because more developer capacity and initial investment would be needed to maintain the platform.
- **Offline support** This is foreseen in most of the platforms, allowing its application in locations where internet connection is low or missing.
- **Software and source-code** Most platforms provide links to software downloads for users who want to jump straight into using the platform off the shelf, as well as source code links for those who want to spend more time adapting and customising the platform.
- **Product support vs developer community** Building blocks tend to lack product support because they are designed for repurposing rather than use-as-is. This can mean that a bigger investment is needed from the end users in order to understand the capabilities and limitations of the functionalities provided. Many platforms have strong developer communities to support each other at a coding level.
- **Sandbox** Some of the platforms offer a sandbox, which is an installation of the platform where users can test some of the functionalities but not all of them, thereby allowing a better understanding of the platform. These are useful as a quick test of a product's functionality and features.
- **Modularity types** Modularity is used differently in different platforms. In some cases, it refers to user-facing modules that have a specific user need (e.g., a quiz function), and sometimes it refers to a non-user-facing module that is for the developer to use at the coding level (e.g., biometrics authentication).

Deep dive into building block platforms

Overview of platforms reviewed

We reviewed three building block platforms. Each review outlines the platforms' technical and educational features and their use cases.

OpenEMIS

Education system management

Pioneered by UNESCO

Used, extended, and tailored across low- and middle-income countries

Case Studies:
Jordan
South Africa

DHIS2

Education system management

Pioneered by University of Oslo

Used, extended, and tailored across low- and middle-income countries

Case Studies:
Uganda
Tanzania

Sunbird

Teaching and learning

Pioneered by EkStep

Used, extended, and tailored in India

Case Studies:
Diksha
ShikshaLokam

OpenEMIS

OpenEMIS mapping — General

Category	Response
Sector	Education
Educational purpose	Education system management
Description on website	OpenEMIS is an Education Management Information System designed to manage education systems. OpenEMIS software is free and can be configured to fit local contexts.
Country implementations	Aruba, Bahamas, Barbados, Belize, Democratic Republic of Congo, Grenada, Guyana, Jordan, Kyrgyzstan, Lesotho, Malawi, Maldives, Namibia, Solomon Islands, South Africa, Sri Lanka, St. Kitts and Nevis, St. Vincent and the Grenadines, Turks and Caicos Island, Uzbekistan, Zambia (details can be found at: https://countries.openemis.org/)
Developer organisation	UNESCO
Type of developer organisation	Donor developed
Download / source code link	Software: https://www.openemis.org/downloads/ Demo: https://demo.openemis.org/core/Dashboard Source code available on request: https://github.com/OpenEMIS/coreNA
Functionality and features	Data collection and management
Academic community	No, but new strategic plans include development of academic community

OpenEMIS mapping — Technical details

Category	Response
Openness	GNU General Public License
API availability	Yes
Microservices architecture	No
Extensibility	Yes, besides the core, there are integration points for data gathering and data displaying. Each component offers API for integrability
Offline support	OpenEMIS Connect
Technology stack	Apache, HTML, CSS, Angular, PHP, MySQL, Linux
Product support	Yes, https://www.openemis.org/support/; https://support.openemis.org/core/en/home-en/
Developer community	No
Functional modularity	Yes (See Architecture Diagram)
Tech support	Yes, paid
Interoperability	Yes
Frameworks	Angular

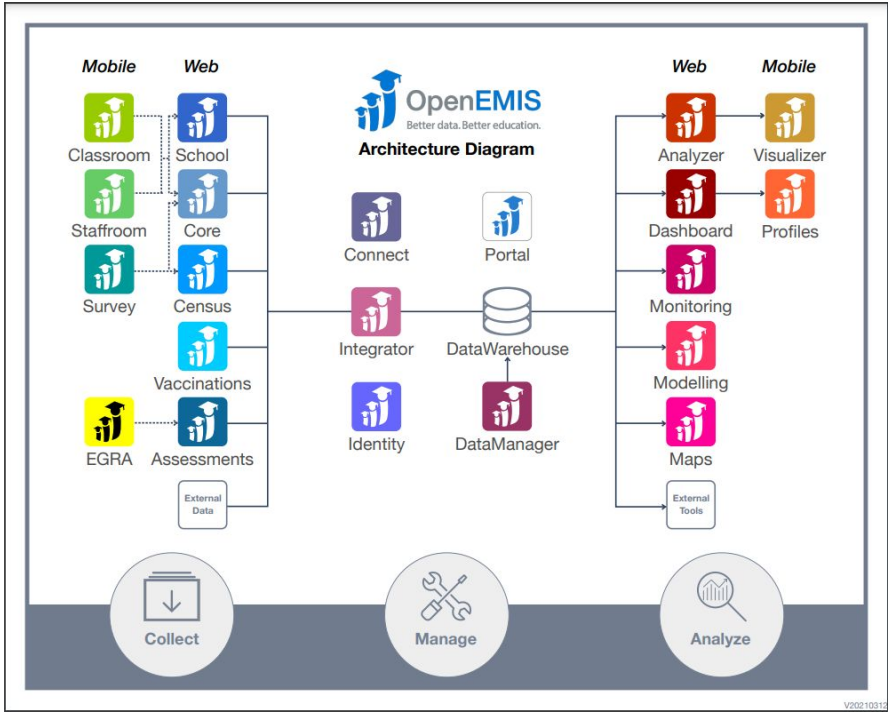
OpenEMIS — Overview

Description: OpenEMIS is an open-source education management information system, owned by UNESCO and often implemented by Community Systems Foundation (CSF).

It has a selection of functional modules that can be configured to meet local needs, and that can be integrated with existing legacy systems. The modules (see image on the right) can be configured for online or offline use, according to contextual needs.

The source code is open, so countries can adapt it to their needs and have local ownership of their source-code and platforms. The source code is maintained by UNESCO's own team, and the open-source community.

Funding: OpenEMIS receives funding from UNESCO. Funding for further development comes from implementation countries.



Source: :↑OpenEMIS (2020)

OpenEMIS — Design

Educational uses:

- Collect and report data on student attendance, behaviour, and learning progress
- Collect and manage data on teacher qualifications and attendance
- Manage data on educational institutions to optimise resources and services
- Monitor key performance indicators of national strategic plans to show progress
- Perform data analytics

Technology design:

- **Hosting** Countries can:
  - Download source code and install it onto their servers and structures;
  - Opt for a paid, cloud-hosting service offered by CSF, which hosts on Amazon Cloud Service. If they do this, the country does not have direct access to data, but can access it through an API.
- **Modularity** Some modules are dependent on the ‘core’, however, others are ‘standalone’ and can be used independently of the core. The modules have their own APIs, which can be used to connect them to other systems.

OpenEMIS in Jordan — a case study

- Jordan started implementing OpenEMIS in 2014; it was fully customised by 2017, replacing their former Eduwave system.
- OpenEMIS is more cost-effective than Eduwave. With Eduwave, MoE paid up to JD 400,000 per year in fees (licensing, maintenance, modifications, upgrades), whereas OpenEMIS is license- and royalty-free, and customisable.*
- Jordan hosts data domestically in multiple data centres, and has plans to shift towards cloud hosting.
- MoE has a preference to maintain OpenEMIS independently (i.e., not using support from international donors). However, due to a lack of capacity within the ministry, they contract a local firm to maintain the system.
- MoE receives training on managing OpenEMIS, however, gaps remain in their capacity to manage the system.
- OpenEMIS collects rich data, however, MoE lacks the capacity to leverage this data to inform policy. Therefore, data is collected, but does not achieve the goal of improving policymaking.
- MoE owns the hardware, software, and data. However, the lack of capacity to manage the system results in a lack of full ownership.
- Competing visions delayed OpenEMIS deployment and capacity-building.
- Low MoE salaries lead to high staff turnover. It is difficult to build capacity and retain trained employees.

Useful links: EMIS seminar and OpenEMIS Jordan evaluation.

Readiness considerations

Digital infrastructure maturity Jordan hosts OpenEMIS data domestically, and is conducting a cost-benefit analysis to explore cloud-hosting options.

Human capacity MoE has the capacity to manage some components of OpenEMIS independently, but not to autonomously sustain or further develop the system. Maintenance and development is mainly conducted by a contracted local technical firm.

Community support MoE procures developers to develop APIs to integrate OpenEMIS with other systems.

Funding MoE does not allocate sufficient operational or development budgets for OpenEMIS, resulting in a financial gap addressed through external funds. The upcoming EMIS Policy (under development) enforces EMIS budget lines for software and hardware service-level agreement support; software and hardware procurement, cloud-hosting fees, software development, and OpenEMIS helpdesk and training.

Political economy and policy There is currently no legal framework for EMIS, however, the EMIS Policy is in the final stages of development.

OpenEMIS — South Africa case study

- OpenEMIS is piloting a new co-creation model in South Africa, whereby the system is being co-developed by both MoE and Community Systems Foundation (UNESCO's implementing partner).
- OpenEMIS will replace the previous SA-SAMS — the South Africa School Administration and Management System.
- The co-creation models seeks to support local ownership, and to move away from country dependence on technical assistance.
- It is envisioned that South Africa will support the development of OpenEMIS modules, and to contribute these modules as global public goods.
- OpenEMIS was selected by MoE following a procurement process. A key selling point was that OpenEMIS is open source.
- MoE budget is minimal, but will cover initial training and support.
- CSF and UNESCO will provide user training and support MoE's IT team to manage the software.

Readiness considerations
Digital infrastructure maturity South Africa is considered a leader in digital infrastructure compared to its neighbours in Africa. However, there is significant inequality between the wealthiest segments of society who have reliable access to internet and connectivity, and the less wealthy, who largely do not have access.
Human capacity MoE has in-house capacity to develop and manage OpenEMIS, and to contribute source code for modular building blocks to the open-source community.
Community support MoE has in-house capacity to develop and manage OpenEMIS. They have plans to build a sub-regional community of practice around OpenEMIS, spanning southern African countries.
Funding MoE is paying UNESCO to develop OpenEMIS. The UNESCO funds are being used to sub-contract CSF as the technical partner. MoE also has budget allocated to developing OpenEMIS. However, operational budget cuts to fund PPE (personal protective equipment) during the Covid-19 pandemic ring-fenced the capacity to develop the system. UNESCO is also contributing resources to support this development.
Political economy and policy South Africa has strong data management (collection, protection, and sharing) policies.

OpenEMIS — Insights

Design insights

- OpenEMIS modules can be integrated with existing legacy systems, or used to develop new platforms.
- Contributors can develop APIs and plugins to connect OpenEMIS with other systems and database relation tools.
- OpenEMIS is funded through core UNESCO funding, as well as through funding from governments involved in implementing OpenEMIS.

Implementation insights

- The OpenEMIS team highlighted the following capabilities as essential to implementing their new, co-development model (being piloted in South Africa):
  - software development capabilities;
  - hardware infrastructure managers with enough knowledge on managing the relevant servers.
- UNESCO prefers to have a technical partner, who would ideally be a MoE. However, ministries often lack capacity.
- The recommended timeline for implementation technical assistance is three years, however, this differs from country to country.
- As the technology developed, UNESCO lacked the capacity to maintain OpenEMIS and support its implementation. As a result, they formed a long-term partnership with Community Systems Foundation (CSF), who now serves as the main implementing partner.
- During implementation, OpenEMIS and its implementers (such as UNESCO, CSF) do not fund hardware procurement; this is expected to be funded by ministries.
- Part of OpenEMIS implementation plans includes policy development, rollout plans, and capacity-building. The focus is on ‘people’ and ‘processes’, as much as it is on the technology.
- Prior to implementation, a needs analysis is conducted to understand the appropriate design and implementation mode of OpenEMIS in a given context.

DHIS2 for Education

DHIS2 mapping — General

Category	Response
Sector	Education
Educational purpose	Education system management
Description on website	District Health Information Software 2 (DHIS2) for Education is an open-source, stable, scalable, and customisable Education Management Information System (EMIS) solution.
Country implementations	DHIS2 is the world's largest Health Management Information System (HMIS) platform in use by 73 low- and middle-income countries. DHIS2 for education has education pilots in Eswatini, Mozambique, The Gambia, Togo and Uganda, Sri Lanka and Tanzania. The pilots were done in countries that already used DHIS2 for health.
Developer organisation	It is a global collaboration led by the University of Oslo.
Type of developer organisations	Academic institutions and International NGOs.
Download / source code link	Software: https://dhis2.org/downloads Source-code: https://github.com/dhis2
Functionality and features	Data collection and management
Academic community	The academic community is closely tied to the developer community.

DHIS2 mapping — Technical details

Category	Response
Openness	Global Public Good with BSD 3-clause License
API availability	Yes (See DHIS2 Core Web API)
Microservices architecture	No
Extensibility	Yes (Apps integrated in platform menu), Plugins, App Hub for optional applications
Offline support	Yes, See offline, online and hybrid deployment strategies
Technology stack	JavaScript, Python, PHP, Java, Apache HTTP Server, TypeScript, CSS 3, XML, PureBasic
Product support	Yes (See https://dhis2.org/support/)
Developer community	DHIS2 software development is a global collaboration managed by the Health Information Systems Program (HISP) at the University of Oslo (UiO). HISP is a global network comprised of 13 in-country and regional organizations, providing day-in, day-out direct support to ministries and local implementers of DHIS2.
Functional modularity	Uses a modular architecture (See https://dhis2.org/technology/)
Tech support	Yes (See https://dhis2.org/support/)
Interoperability	Yes (See Integration concepts documentation)

DHIS2 for health and education — Overview

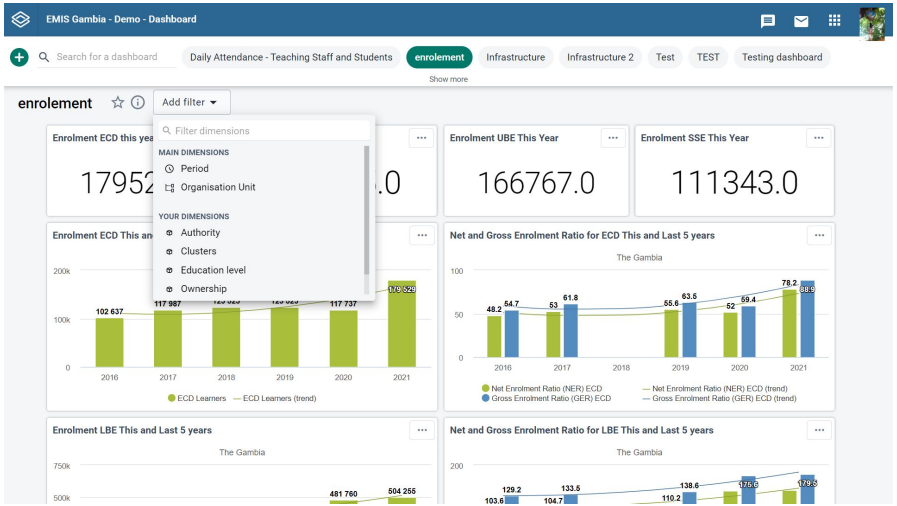
Description: DHIS2 for education is an open-source, stable, scalable, and customisable Education Management Information System (EMIS) solution. It builds on the decades-old DHIS software platform originally used in the health sector. It thus allows for cross-sector use (see school-based immunisation campaign undertaken in Uganda)

Over the last 5–6 years, the developers of DHIS2 shifted from viewing it as a system to seeing it as a scalable, modular, and layered platform. This led to a web-based core system with functionalities accessible through API. DHIS2 is intentionally designed for diverse technological contexts (e.g., offline support), integration and interoperability, capacity building, local ownership and product development.

Educational uses:

DHIS2 for education has the following components

- School Management
- Student Enrollment and Attendance
- Infrastructure Management
- Nutrition and Hygiene
- Resource Allocation
- Multi-Sectoral Analysis (Health, Education, Nutrition, Social Protection)



Source: ↑DHIS2 (2021)

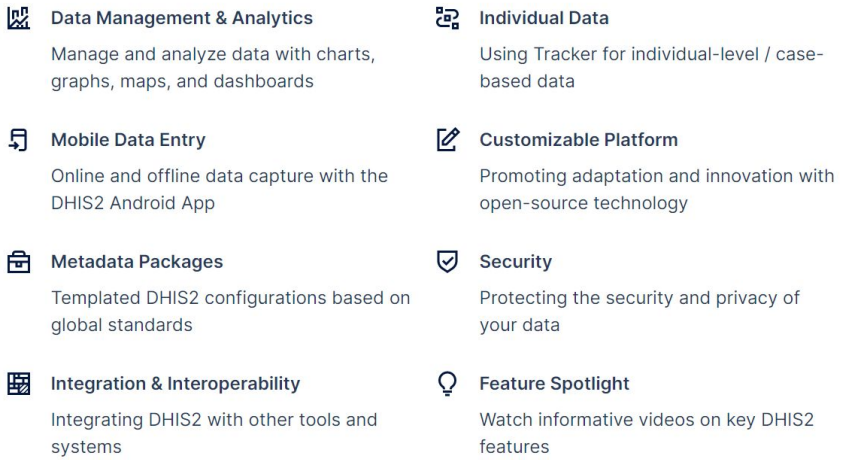
>>DHIS2 for Education Interactive Demo <<

Funding: The project was initially funded by the Norwegian Agency for Development Cooperation (Norad), the University of Oslo and the Research Council of Norway. Later partners include PEPFAR , The Global Fund to Fight AIDS, Tuberculosis, and Malaria, UNICEF, CDC, GAVI, The Vaccine Alliance and The Bill & Melinda Gates Foundation.

DHIS2 for health and education — Design

Functionalities and features: DHIS2 for education supports
- aggregate and individual-level data
- data entry on desktop and mobile devices
- the creation of custom web and Android apps
- and integration with other software platforms through open APIs.

The following software features allow for collection, validation, analysis, visualisation, and sharing of data.



Source: DHIS2 (2021)

Technology design:
- The platforms comprise:
  a. core components with low variability,
  b. complementary components with high variability,
  c. interfaces for modularity between core and complementary components.
- Because DHIS2 for Education is built on the core DHIS2 platform, it allows for seamless integration with Tracker and DHIS2 Apps, and uses DHIS2 sharing features to allow controlled access to data and analytics at all levels of the education system.
- DHIS2 release a new version every six months. Support and maintenance is provided for the three most recent versions.
- DHIS2 provides an App Hub, which provides links to additional web applications developed by the community (i.e., those in the HISP network and other international partners). These applications are designed to be fully compatible with the core software system.
- DHIS2 can be hosted locally on one's own servers or on the cloud using DHIS2 service providers.

DHIS2 for health and education — Uganda case study

DHIS2 for EMIS in Uganda

- The Ministry of Education and Sports (MoES) conducts an annual statistical census using statistical software tools such as MS Access and STATA. Feedback is done manually through post or email. The current process is costly, time consuming and limits data analysis capacities.
- Since March 2019, DHIS2 for EMIS has been piloted in two districts.
- These districts not only embraced the system for pre-primary and primary schools — using it to make strategic decisions about school infrastructure improvements and more — but hope to expand into secondary and tertiary education as well.
- The Mayuge district appreciated the new system as it reduced the paper burden allowing information to be accessed at a click.
- Head teachers requested feedback from data promptly and in an easily digestible way. Going forward, the pilot will focus more on how to improve dissemination strategies for information after it has been analysed.

Readiness considerations
Digital infrastructure maturity The pilot appeared to provide shared WiFi internet, which eased reporting, coordination, and communication with other departments.
Human capacity MoES Basic Education and Statistic teams underwent a series of training workshops on data entry, validation, and cleaning. MoES HQ was trained on data analysis, use, and presentation. Going forward, it was identified that more capacity building is needed at the school level.
Community support The teams visited a similar pilot in The Gambia and were able share experiences and lessons learnt. HISP Uganda hosted a learning event with the University of Oslo, HISP West Africa and Save the Children.
Funding Funders were not mentioned, however, districts were willing to continue using the system without funding, after the pilot. It thus needs to be properly budgeted for at the district planners office.
Political economy and policy Government buy-in was sought through a series of engagements. The pilot was welcomed in the two districts and thus had local government buy-in. Stakeholder engagement was undertaken with district leaders and schools to understand the reporting flow and data management from the school level to district and national level. Uganda still lacks an EMIS policy to enforce reporting and this is a major drawback.

DHIS2 for Health and Education — Tanzania case study

DHIS2 in Tanzania:

- Prior to 2021, the President's Office Regional Administration and Local Government (PO-RALG) used Statedu statistical software for the annual school census. Statedu was funded by UNESCO but they did not provide the source code to PO-RALG.
- DHIS2 has been used in the health sector since 2011.
  In 2021, PO-RALG used DHIS2 for education for the first time. Developers took the code from DHIS2 health platform and customised it in order to use it for the annual school census.
- Use of DHIS2 is likely to be discontinued after just one year of implementation. Initially, PO-RALG felt DHIS2 would suit their data collection needs (annual). However, when the Covid-19 pandemic began, they saw a need for more regular data collection, and DHIS2 could not fulfill this need. This is because the annual school census collects data once a year but another platform, the School Information System (SIS), collects data on a more regular basis. Additionally, SIS can already work fully offline and embed offline logic while DHIS2 would need extra development to incorporate these offline elements.
- PO-RALG's adaptations of DHIS2 were not made open source. This could be because they were tailored to particular needs and were deemed as not 'generic' enough to contribute to the open-source community. It would take time to make it generic, and this needs to be planned and resourced.

Readiness considerations
Digital infrastructure maturity Dar es Salaam is one of the most expensive cities for procuring international internet bandwidth. This has led to under-utilisation of bandwidth and low domestic usage. Offline capabilities are thus key to usage by teachers and other users.
Human capacity PO-RALG works in both the health and education sector thus there was knowledge sharing between the developers.
Community support DHIS2 for health has a strong HISP Tanzania network, however, it is unclear whether this community was contacted in the education implementation.
Funding Statedu was funded by UNESCO. It is not clear how DHIS2 or SIS is being funded.
Political economy and policy. The rapid development of platforms in the last two years is because the current government has prioritised technologisation.

DHIS2 for health and education — Insights

Design insights

- **Community Participatory Design (PD).** DHIS2 is developed using PD with the aim of empowering users. The idea has been to shift development away from a core developer team to a scenario where the users are the designers. This has been done successfully through in-country HISP networks comprising program implementers and academics.
- **Health vs education** The design of DHIS2 for education is not significantly different from DHIS2. This is because DHIS2 was not built in a way that is specific to health. The backbone routine of information systems are quite similar and the data needs to be coded so that it can be used for different purposes.
- **Funding DHIS2** As DHIS2 was created in an academic space, it was initially funded by research grants. Additionally, there are major donors that invest in such initiatives in the health sector. The education sector is not as advanced.

Implementation insights

- **Maturity path** A common problem in countries is isolated databases. While there is a tendency to strive for ultimate interoperability, DHIS2 implementers prioritise interoperability that is most useful. They first focus on getting the basics up, noting that there is a trade off between complexity, sophistication, scaling, robustness, and capacity.
- **Quality assurance** Open-source code allows for various product derivations. However, some of the spin-off versions are not coordinated centrally and are therefore not quality assured and may be incompatible with updates. Additionally, lack of funding means that few spin-offs are contributed back as GPGs.
- **Expanding in-country** Implementation problems more often lie at the organisational and political level than the technical level. Thus, it is often easier to expand DHIS2 for education in a country that already uses DHIS2 for health than to implement the education version in a new country. This is because trust in a product is important. DHIS2 has built a good reputation in the 20 years of being used in the health sector..
- **Donor endorsement** Having well-known donors supporting the project makes a significant difference in the perception of the product's quality.
- **Community** Building a strong developer community and academic community is key to sustainability; more so than the software itself.

Sunbird

Sunbird mapping — General

Category	Response
Sector	Education
Educational purpose	Teaching and learning solutions
Description on website	Sunbird is designed to support multiple languages and multiple teaching and learning solutions by providing the building blocks for the development of platforms and learning solutions to suit various use cases, contexts ,and needs.
Country implementations	India
Developer organisation	EkStep Foundation
Type of developer organisation	Philanthropic initiative
Download / source code link	https://github.com/project-sunbird
Functionality and features	Content and Learning, Interaction and Collaboration, Taxonomy and Tagging, Practice / Sending and Assessment, Telemetry and Data Analytics, Credentialing and Badging.
Academic community	No academic community

Sunbird mapping- Technical details

Category	Response
Openness	MIT license
API availability	Yes (see API Reference Documentation)
Microservices architecture	Yes (see API Reference Documentation)
Extensibility	Yes (through Plugins)
Offline support	Yes (through Sunbird Mobile App
Technology stack	Angular, node.js, elastic search, apache, kafka & kibana, akka, Android
Product support	No
Developer community	To meet the complex and diverse needs of learning services, over a period of time multiple organisations have come together to contribute towards Sunbird infrastructure software and make it available as a digital public good. These like-minded organisations with a common objective are collaborating together to co-build and co-maintain Sunbird infrastructure software in a unified, well-architected and production -eady manner.
Functional modularity	Yes (see http://docs.sunbird.org/2.10.0/architecture/overview/)
Tech support	Yes (see https://github.com/project-sunbird/sunbird-community/discussions)
Interoperability	Yes (see http://docs.sunbird.org/2.10.0/architecture/overview/)

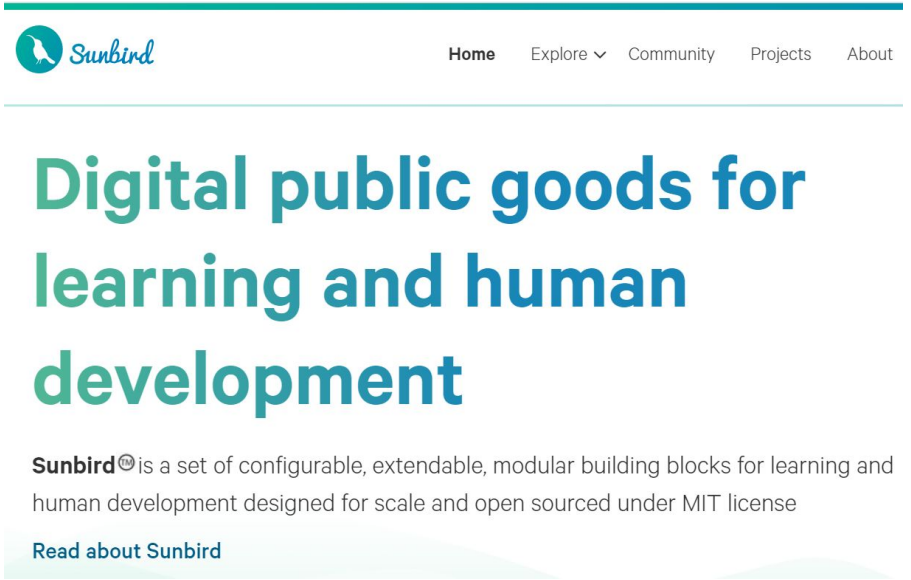
Sunbird

Description Sunbird is designed to support multiple languages and multiple teaching and learning solutions by providing the building blocks for the development of platforms and learning solutions to suit various use cases, contexts, and needs.

It can be used by any organisation, be it government, non-profit, or private.
Sunbird also comes with reference solutions built by the community, which can be readily used. The architecture of Sunbird has been deliberately designed in a generalised and externalised manner; it can be configured and extended by any organisation to run a platform that enables solutions in its context and domain. Sunbird is designed for diversity and scale so that it caters to multiple domain needs and the scale and diversity of India.

Countries implemented: India

Funding: Philanthropic funding



Source: Sunbird (2021)

Sunbird

Educational uses:

- Content creation
- Review procedures
- Publishing content and consumption
- Facilitates collaboration and partnership
- Creating communities for discussions
- Extensive resource library
- Credentialing and badging functionality
- Contribution and curation functionality
- Telemetry and data analytics functionality

Software links (sandbox):

https://www.sunbird.org/explore/explore-sunbird

Technology design:

- **Hosting.**Countries can:
  - Download source code and install it onto their servers and structures using Kubernetes;
  - Opt for a paid, cloud-hosting service such as Azure, Amazon etc.
- **Modularity** It is built with a core functionality and specific features are integrated through building blocks such as cAdvisor, ELK stack, Prometheus and their plugin ecosystem, Grafana, Elastic Search, Play Framework etc. This is also possible because Sunbird's API can be used and integrated into other systems.

Sunbird implementation — DIKSHA case study

- DIKSHA is India's national teacher platform (Digital Infrastructure for Knowledge Sharing).
- It is an initiative of the Ministry of Human Resources Development, Government of India.
- The platform has eight solution verticals that address school education in India including teacher professional development, access to teaching and learning content, and school leadership among others.
- The government of India initiated VidyaDaan, a national program for content sourcing and contribution using DIKSHA infrastructure.
- One of the major functionalities integrated in DIKSHA was QR Codes scanned from textbooks, which led to easier access of learning materials on the platform that were related to the topics described on the pages of the textbooks.

Readiness considerations
Digital infrastructure maturity Each of the 36 States and Union Territories in India have their own virtual space on DIKSHA, as tenants with the autonomy to select the solutions relevant to them.
Human capacity Development is undertaken through subcontracted technical companies. EkStep has no technical know-how in house. Since it is also open source, it allows contributions that are not initiated by EkStep.
Community support The technical community was developed in five years. The steps included building the core, publishing it, and then involving consulting firms who experimented with it and then developed the platform further. Actively encouraging partners like PWC and EY to support with technology and consulting.
Funding DIKSHA is owned and funded by the Government of India.
Political economy and policy The Indian government has an open-source policy that enabled them to choose Sunbird, an open-source platform.

Sunbird implementation — ShikshaLokam case study

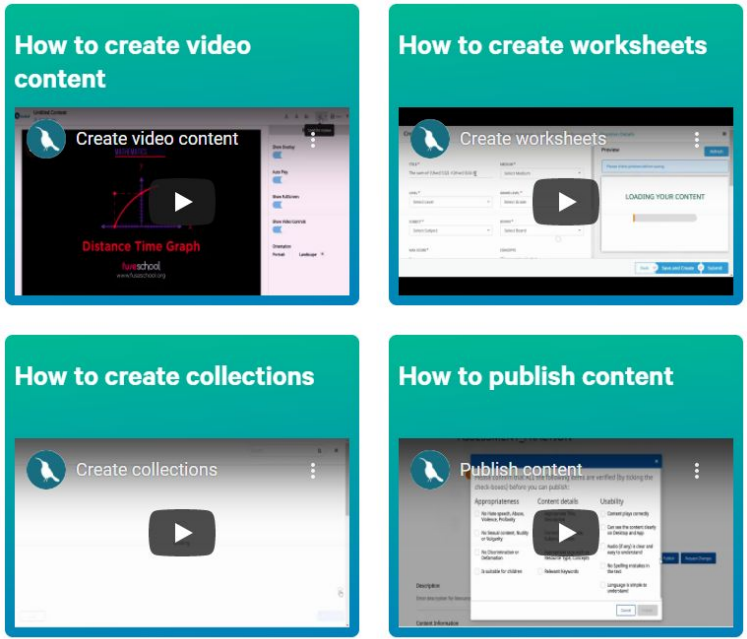
- ShikshaLokam is an education leadership platform. It is a manifestation of Societal Platform thinking, a systematic method to resolve complex societal challenges with speed, at scale, and sustainably.
- ShikshaLokam offers open-source technology capabilities and resources to a variety of ecosystem players, including Individuals, NGOs, and government.
- The ecosystem has four components: Bodh (Learn to improve), Samiksha (Assess to improve), Unnati (Plan to improve), Dhiti (Analyse to improve).
- The Samiksha software solution equips users to create their own framework to assess education institutions such as schools and Anganwadis (rural childcare centres), as well as assess individuals of the system such as headteachers, teachers and other officials. You can generate reports, analyse data and draw insights.
- The Unnati software solution enables users to undertake a set of action projects with a specific objective in a specified period of time. Education leaders can use Unnati to create projects, invite other people such as collaborators, assign timelines, execute and monitor progress.

Readiness considerations
Digital infrastructure maturity The architecture of Sunbird was the enabler for delivering learning solutions to the ecosystem. The Sunbird architecture allows for Samiksha and Unnati services to be stand-alone applications as well as integrated services within the ShikshaLokam platform.
Human capacity Currently ShikshaLokam has about 20 team members, from learning experiences designers to members managing the programme and partnership.
Community support The functionalities are being used by about 12 million teachers in 1.5 million schools, in 100 departments, offering product insights. In addition, having Sunbird at the base of their development, they are able to contribute to Sunbird development but also benefit from the advancement of Sunbird.
Funding ShikshaLokam is an Education Leadership Platform under the aegis of the Shibulal Family Philanthropic Initiative.
Political economy and policy ShikshaLokam acts as an orchestrator in the education leadership space, helping adapt solutions used in one context for use in another one.

Sunbird — Insights

- **Problem-first approach** The Sunbird team first focuses on the problems / challenges / needs that should be addressed within the education system and then considers how can technology can be leveraged to resolve these aspects.
- **Microservices** Sunbird uses a microservice architecture, which allows it to scale and easily integrate new building blocks in order to offer advanced functionality and user experience to the end users.
- **Funding** Sunbird is actively developed by EkStep with the funding they have at hand, but also through the different locations in which Sunbird has been implemented.
- **Government use** Sunbird is being used by the government of India in the DIKSHA implementation.
- **Community** Sunbird has a community that was developed over about five years.
- **Support** Sunbird offers both product support (e.g., through its 'How to' videos) and developer support (e.g., through its community forum).

How to Videos



Source: Sunbird (2021)

Deep dive into country case studies

Countries interviewed or mentioned in our interviews

The following countries were either interviewed or mentioned in interviews with platform developers.

Direct interviews on digital platforms

- Kenya
- Sierra Leone
- Tanzania
- South Sudan
- South Africa

DHIS2 for education pilots implemented

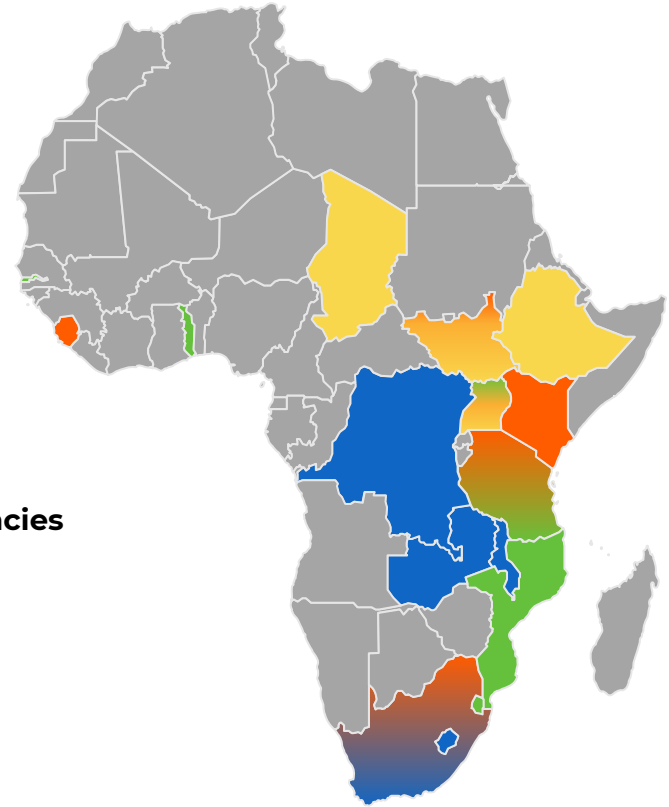
- Eswatini
- Mozambique
- The Gambia
- Togo
- Uganda
- Tanzania*

OpenEMIS implemented

- DRC
- Lesotho
- Malawi
- South Africa
- Zambia

UNESCO Education in Emergencies Data Case studies in SSA

- Chad
- Ethiopia
- Uganda
- South Sudan



*Tanzania is not listed on the DHIS2 for education website but PO-RALG in Tanzania have reported using it

Image created using https://www.pptmaps.com

Country deep dives on digital platforms used

Through our country interviews, we sought to investigate what education platforms exist in the country , how they were developed, and the factors to consider in platform development. We mapped all the platforms we came across, whether bespoke, building blocks or off-the-shelf. We provide early insights as to whether building blocks would address a need and whether there would be a demand for them

Sierra Leone

Low resource context

Deep dive: Education management platforms

Tanzania

Low- to middle-income context

Deep dive: Education management platforms

Kenya

Low- to middle-income context

Deep dive: Teaching and learning platforms

South Sudan

Emergency context

Deep dive: Education management platforms

N.B. The information presented is not exhaustive of the digital platform landscapes in these countries. It presents what we have gathered through interviews and desktop research at an initial exploratory stage.

Tanzania — Deep dive

Tanzania: Context

63% of primary schools had access to some kind of **power source**, while 22% were connected to the national grid and 15% had no access to electricity (in 2016).

82% of people had a mobile **cellular subscription** (2019). Meanwhile, 4% of households had access to a computer (in 2016).

25% of the population used the **internet** (2018), while 1.8% of people have a fixed broadband subscription (in 2019).

Item	Figure
Students	21,473,330
Teachers	315,425
Schools	44,087
Regions	25

Source: Country-Level Research Review: EdTech in Tanzania (↑Jordan et al., 2021)

The above statistics were taken from *Country-Level Research Review: EdTech in Tanzania* (↑Jordan et al., 2021)

Tanzania: Overview of digital platforms for education

The President's Office Regional Administration and Local Government offices (PO-RALG) developed approximately 24 platforms between 2019–2020 across the health and education sectors. Much of this development was through funding from the UK Foreign, Commonwealth and Development Office as part of the Education Programme for Results (EPforR) in Tanzania. Education platforms in Tanzania include:

Student and teacher placement	Data management	Services	Promotion
Student placement system for Forms 1 and 5	Annual school census (previously on Statedu and DHIS2)	Claims and debt management information system	Teacher promotion and incentives system
Teacher deployment system	Basic education statistics Tanzania (BEST)		
	Basic education management information system (BEMIS)		

Tanzania: School Information System (SIS)

SIS is a bespoke platform funded by FCDO that PO-RALG is iteratively developing.

Tanzania's m360 SIS School Information System is a daily school reporting mobile information system, that enables instant data collection for school characteristics, daily classroom attendance, evaluation and behavior, teacher and staff distribution, and initial enrollment and generates an identification code for each student, which is valid even when the student transfers to a different school. Data is input by principals, teachers, or other staff. The most important technical characteristic of the application is its ability to instantly transmit data to sub-national and national levels. To comply with this goal, internet and / or SMS must be available. The application determines if one of both is available and transmits the data accordingly, without user intervention.

SIS has four modules:

- **Baseline** Maintains timely updated database of teachers, staff, and students (enrollment process).
- **Daily classroom** Daily attendance, evaluation (by grade and subject), and behavior are the core of the application.
- **Finance** Allows the school to keep a detailed record of deposits and expenditure.
- **Reports** Reports are generated at school level, providing key information for the head teacher.

EdTech Hub provided technical support to PO-RALG on how to rapidly develop and improve the SIS. User research was conducted in four schools.

Source: ↑PORALG (2021)

Tanzania: Overview of digital platforms for education

Data storage

- All apps are hosted in a data centre owned by PO-RALG.
- Before 2019, everything was running on Windows-based servers. In 2019, PO-RALG started to use Linux servers.
- Moving to cloud-based storage is something PO-RALG would be willing to do, but initially, it would mean changing too much too quickly. However, this seems to be the next logical step.

Interoperability

- There is not much focus on interoperability between PO-RALG's 24 platforms (spanning health and education).
- This is partially due to time pressure, linked to available funding.
- These platforms more or less have the same users and rely on the same data, so it doesn't make sense for them to all be separate.
- The platforms use a common set of languages, because they are the languages the IT team is familiar with.

Tanzania — Readiness considerations

Readiness considerations
Digital infrastructure maturity Limited infrastructure and currently no content distribution networks from main content providers, however, there are multiple data centres in Dar es Salaam. Dar es Salaam is one of the most expensive cities for procuring international internet bandwidth. This has led to under-utilisation of bandwidth and low domestic usage. Offline capabilities are thus key to usage by teachers and other users.
Human capacity Low capacity within PO-RALG, however, they contract technical consultants and embed them within PO-RALG IT teams.
Community support Platforms developed are mostly bespoke, there is therefore no developer community support.
Funding The funding for developing digital platforms has largely been through the UK Foreign Commonwealth and Development Office's Education Programme for Results in Tanzania.
Political economy and policy The rapid development of platforms in the last two years is because the current government has prioritised technologisation. Currently no data protection laws.

Useful links: DE4A summary and EPforR lessons learned.

Tanzania — Need and demand

What types of platforms are needed in the education system?

There is a need to merge the large number of existing platforms into unified platforms.

What is the decision-making process for platform development?

- **Tech stacks** Priority is given to using tech stacks that people are comfortable with, so that if new developers need to be hired this can be done quite easily. Tech stacks used include:
  - PostgreSQL
  - SQL
  - Java
  - PHP
- **Ownership** Because they already have their own School Information System (SIS), it would be difficult to convince the government to move away from that towards an open-source solution, even if another platform was found to be more cost-effective. The political context surrounding access and use of data affects decision-making processes in relation to platform development.

What interest and demand is there for using platform building blocks going forward?

PO-RALG could be willing to adopt building blocks if the advantages and disadvantages were well-presented to them (i.e., 'educating demand'). Examples of benefits that would be appealing to PO-RALG include:

- building stronger systems in shorter times;
- reducing the duplication of coding done for similar functions;
- leveraging what has already been built;
- deploying systems faster.

It would be useful to look at specific areas where there is a need for building blocks (e.g., building forms), and to integrate those within the SIS rather than using building blocks to build something from scratch.

Tanzania — Key insights

- **Embedded consultants** PO-RALG embeds technical consultants within their technical team, to work on code alongside the ministry team. This mitigates issues they had previously faced, e.g., with consultants owning the code or the data.
    - Before 2020, PO-RALG used to outsource coding but faced issues with maintenance, as well as consultants not supplying source code or documentation, and obstacles to further development.
- **Proliferation of platforms** PO-RALG has approximately 24 platforms spanning the health and education sectors, which could likely be reduced to 3–7 platforms.
- **Platform development linked to donor funding** Development of digital platforms is strongly linked to donor funding, and associated disbursement-linked indicators (DLIs). The use of building blocks in Tanzania would likely benefit from being linked to DLIs on relevant government programmes.
    - Given the embeddedness of digital platform development within donor programmes, a larger number of key stakeholders are at play, including technical assistants (typically international consulting firms), donors, and governments.
- **Scoping processes often limit the capacity for platform development** Platform development is often delineated and restricted by the preparatory processes involved. For example, an initial Terms of Reference (ToR) for platform development is drafted to contract technical consultants and project funding. However, the Terms of Reference are often drafted by non-technical personnel within the government. As such, they may lack awareness on the time needed to develop digital platforms, and may underestimate the time input required. As a result, the available time and funds for platform development are limited.
    - One notable exception to this was the development of SIS. While the initial project scoping was drafted by non-technical personnel, developers were involved in reviewing the requirement analysis. Thus, developers had oversight of the project scoping from the outset.

Sierra Leone — Deep dive

Sierra Leone: Context

93% of households have access to a **mobile phone**. Meanwhile, 55% have access to radio, 20% to television, and 11% to a computer (in 2020).

55% of senior secondary schools have access to **electricity**. Meanwhile, 36% of junior secondary schools and 14% of primary schools have access (in 2021).

14% of senior secondary schools have **computers** for teaching and learning. Meanwhile, 8% of junior secondary schools and 2% of primary schools have computers (in 2021).

7% of senior secondary schools have **internet access** for teaching and learning. Meanwhile, 4% of junior secondary schools and 1% of primary schools have internet access (in 2021).

Item	Figure
Students	2,695,590
Teachers	82,779
Schools	11,034
Local councils	22

Source: 2020 Annual School Census Report (↑Ministry of Basic and Senior Secondary Education, 2021)

Reference: 2020 Annual School Census Report (↑Ministry of Basic and Senior Secondary Education, 2021) and Demographic and Health Survey Report. (↑Statistics Sierra Leone, 2020)

Sierra Leone: Overview of digital platforms for education

Sierra Leone uses a selection of digital platforms in education, some of which use building blocks.

Platform	Owner	Insights
Annual School Census (ASC)	Ministry of Basic and Senior Secondary Education (MBSSE).	Annual school-level data collection. Funded by the World Bank. The system uses SurveyCTO, a proprietary platform.
Education Data Hub	MBSSE and Directorate of Science, Technology, and Innovation (DSTI)	Public education data repository. Built using MySQL. An EdTech Hub report suggests usability of the platform is low.
Vatebra Joint Education Sector Dashboard	MBSSE and Ministry of Tertiary and Higher Education (MTHE)	EMIS. Funded by the European Union (EU).
Teacher Records Management System	Teaching Service Commission (TSC)	Manages teacher records. Developed by Charlie Goldsmiths Associates. Data is managed centrally, and is accessible by TSC and MBSSE.
UNICEF EduTrac	MBSSE and Unicef	School-level data collection. EduTrac is powered by RapidSMS, a free and open-source framework of building blocks for building interactive SMS applications.

Sierra Leone: Overview of digital platforms for education

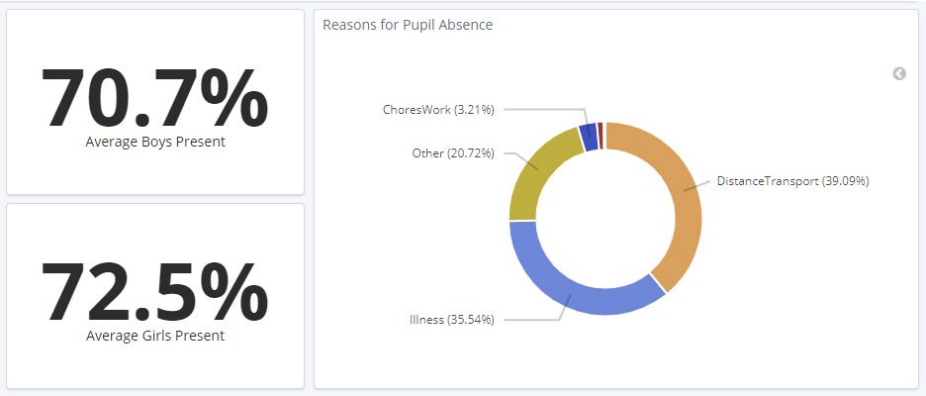
Sierra Leone uses a selection of digital platforms in education, some of which use building blocks.

Platform	Owned by	Insights
Sierra Leone Education Attendance Monitoring System Dashboard (SLEAMS)	TSC	Tablet-based teacher monitoring. Piloted by Charlie Goldsmiths Associates. SLEAMS customises the open-source Open Data Kit.
Leh Wi Lan's separate dashboards for principals, district supervisors, and ministry-level staff	MBSSE	School-level data collection. Funded by the FCDO. Leh Wi Lan's data collection and coaching tools are built on Tangerine. It is open source, can be standalone, and is customisable.
GoSL Integrated GIS Portal	DSTI	Cross-sectoral dashboard for geospatial data, including education data.
Education Innovation Challenge Dashboard	DSTI	Data on foundational literacy and numeracy. Funded by the Education Outcomes Fund.
MBSSE PubPub	MBSSE	Policy development and review platform. Use PubPub, an open-source publishing platform.
Learning Passport	MBSSE, DSTI, and Unicef are developing plans to roll this out	Yet to be deployed.

Sierra Leone — Leh Wi Lan dashboards

- Leh Wi Lan has separate dashboards for:
  - principals
  - district supervisors
  - ministry-level staff.
- The dashboards are funded by FCDO.
- Leh Wi Lan have used Tangerine to observe and coach teachers in government and government-assisted secondary schools.
- More recently, they have shifted their focus to adapting the Tangerine software for data collection.
- The dashboards collect data on a range of indicators, including attendance, teacher registration, time in class, learning resources, and classroom visits.
- Leh Wi Lan have plans to use Tangerine for classroom observations and coaching going forward.
- Leh Wi Lan has plans to merge their data collection efforts, and financial backing, with the One Tablet Per School data collection programme.
- Leh Wi Lan team is in the process of creating digital scorecards for each school.

- Tangerine is a collection of building blocks used for data collection and education system management.
- Tangerine is open source, and has a GNU General Public License.
- Tangerine was developed by RTI International.



Source: June 2021 data from Leh Wi Lan's principal dashboard (↑Leh Wi Lan, 2021)

Sierra Leone — Readiness considerations

Readiness considerations
Digital infrastructure maturity Infrastructural constraints such as low levels of electricity and internet access constrain the development and use of digital platforms. The TSC uses Amazon Web Services for cloud storage as they cannot host platforms themselves because it is very expensive, there are electricity issues, and they don't have servers. The government has partnered with telecommunications providers to reduce mobile data charges for education platforms and to increase the number of schools with internet access.
Human capacity Limited capacity. There is a need to build the capacities of IT staff within the TSC. Both MBSSE and DSTI have staff who can actively implement, use, and maintain digital platforms; develop software packages; and collect, process, and analyse data as needed. Capacity exists among employees, however, more support is needed in terms of the number of employees.
Community support Platforms are generally segmented and bespoke, and many platforms remain relatively unknown and unused (↑Freiermuth et al., 2020). Community support is thus limited.
Funding Generally, donor funding is not coordinated. Multiple donors fund the development of digital platform pilots without coordination among donors, leading to a proliferation of unsustained pilot platforms. Furthermore, funding is not sustained, and this poses a challenge to the maintenance of software. After a project's funding expires, the project dies naturally.
Political economy and policy The government is generally open to the use of open-source platforms and building blocks.

Sierra Leone - Need and demand

What types of platforms are needed in Sierra Leone in the education system?
While the government has multiple digital platforms that perform similar data management functions, few of these are operable and used at scale. In this context, the government needs to rationalise the choice of data management platforms for use at a national-level and to develop a consolidated education data warehouse to extract, store, and disseminate information from existing sources as required.

What is the decision-making process for platform development?
The decision-making process is driven by local needs, available resources, and sustainability. There is an awareness that there is a high turnover with donor-funded platforms. A cost-benefit analysis is conducted within specific government units to determine different pathways to platform development to meet particular needs. However, lack of coordination among different government units and donors leads to competition and duplication of efforts at the expense of local needs. At a macro-level, the decision-making process is fragmented. Donor organisations work with government units and agencies to design and develop platforms in silos. The lack of coordination in the decision-making process for competing platforms reduces the potential to effectively address local needs.

What interest and demand is there for using platform building blocks going forward?
- Sierra Leone would be interested in using building blocks, but it depends on the technology used - they would have to use technology that people are comfortable with.
    - Building blocks would be preferred over building from scratch, because they would save money. They would also empower government to do their own thing without pressure from donors.
- Sierra Leone is interested in open source. However, it is perceived as being less secure and private, partly because it is cheaper.

Sierra Leone — Key insights

- **Procurement of tech support** The MBSSE and TSC procure tech support through a standard tendering tendering process. Charlie Goldsmith Associates and Vatebra have previously won contracts.
    - TSC makes it clear from the outset that source code and data would be owned by TSC, not the consultant.
    - TSC's own developers did not further develop the source code or adapt it.
- **Capacity-building** If building blocks are used, it would be useful to have an academy to train developers to use, adapt, and develop the building blocks.
- **Funding and sustainability** It would be more useful for donors to pay for longer-term hosting and maintenance fees, for example, over five years. This would give the government enough time to generate funds to cover hosting and maintenance, or to create better hosting plans. Instead, the donors usually pay for one year, and when they leave, the government does not have the capacity to continue paying.
- **Digital infrastructure** The digital infrastructure in Sierra Leone is limited, with intermittent electricity supply and many households and offices operating without power for several hours every day (at best). Having this infrastructure in place is important before discussing building blocks.
- **High turnover** Resource constraints have forced the ministry to constantly move between providers who offer 'free' or low-cost services before subscription hikes.
- **Lack of locally driven solutions** At times platforms have been pushed and developed by donors, despite the MoE expressing a lack of need for them. This results in resources being spent and the platforms going unused. There is a need to align development with local needs, rather than donor needs.

Kenya — Deep dive

Kenya — Infrastructural context

82.6% of primary schools have electricity (↑UNESCO Institute for Statistics, 2018).

52% of people are connected to mobile services (GSMA, 2020), while the country has 98% mobile penetration (↑DataReportal, 2020).

43% of the population use the **internet** (↑DataReportal, 2020).

The above statistics were taken from *EdTech in Kenya* (↑Otieno & Taddese, 2020).

Item	Figure
Students	13,334,991
Teachers	404,442
Schools	42,831
Counties	47

Source: Kenya Approved Basic Education Statistical Booklet 2019. (↑Ministry of Education, 2019)

Disparities in access to ICT across urban and rural regions are highest for internet and lowest for radio.

Kenya — Overview of digital platforms for education

In our research, we came across the following education-related digital platforms in Kenya. None of the platforms made use of building blocks (neither in their design, nor their content) and they were primarily bespoke platforms.

Kenya Education Cloud (KEC) (kec.ac.ke)

KEC is a one-stop destination where one can access quality content for learning. Content creators, content owners and publishers can also submit interactive digital content for curation (quality assurance).

Deep dive to follow

National EMIS (NEMIS) (nemis.education.go.ke/)

NEMIS is a web-based data management solution that collects data and information from education institutions; processes and reports the status of designed indicators; and provides the sector a solid ground for effective management to ensure that every Learner counts.

Currently undergoing development — needs further investigation as a possible user of building blocks

Kenya National Examination Council (KNEC) (knec.ac.ke/our-portals/)

The KNEC portal page links to various portals for students and teachers to register for examinations and well as receive certification.

Kenya — Kenya Education Cloud (KEC)

KEC is an online platform that was first initiated in 2018. It is developed and maintained by the Kenya Institute of Content Development. KEC has interactive digital and on-demand radio content, textbooks for teachers and students, teacher training on curriculum implementation and ICT in learning. The KEC comprises several platforms, some of which are developed while others are planned. Some are interdependent, while others are stand-alone (↑Groeneveld et al. 2021).

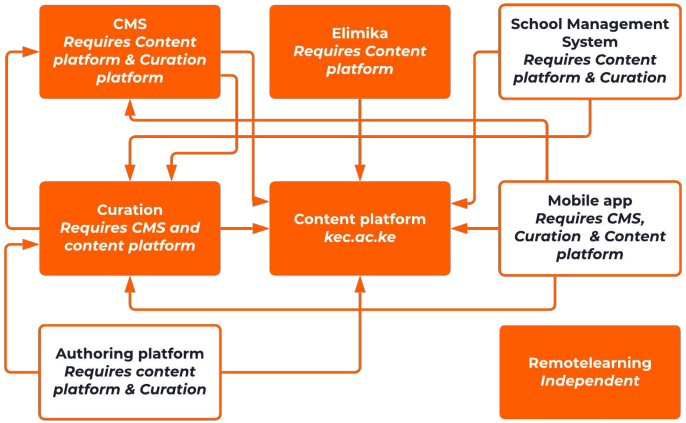


Figure: Interrelatedness of different platforms (*Source*: ↑Groeneveld et al. (2021), CC BY 4.0).

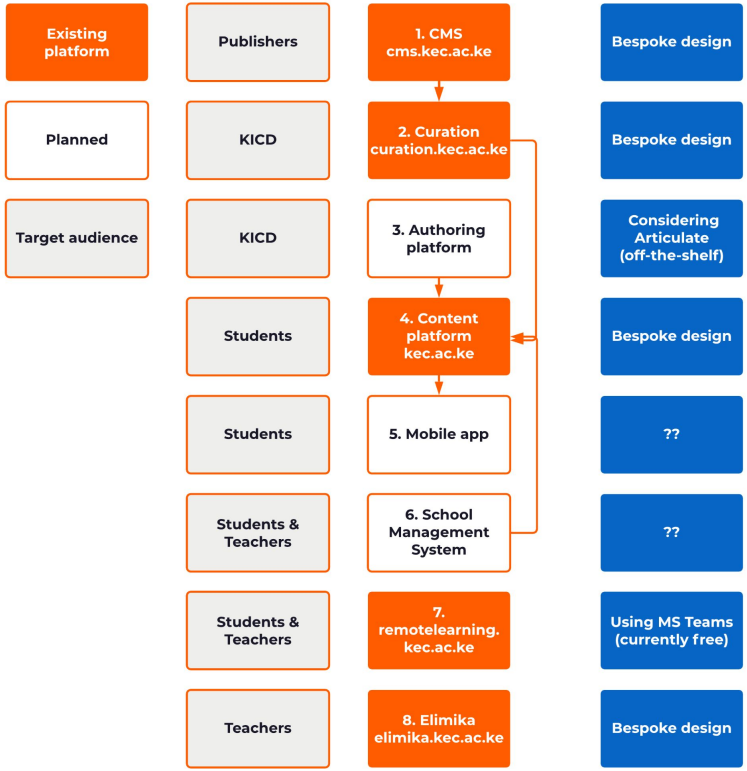


Figure: Existing and planned KEC platforms and their intended audiences. (*Source*: ↑Groeneveld et al. (2021), CC BY 4.0).

Kenya — Readiness considerations

Readiness considerations
Digital infrastructure maturity The government is striving to get all schools connected to the internet. Alongside this is the concept of community halls where ICT infrastructure is provided at a community centre. There are many ongoing initiatives to get schools connected to the internet.
Human capacity Development of software is normally tendered externally to consultants / firms. In the past these have more likely been international but local capacity is increasing.
Community support Within the education space, local publishers have a strong voice in shaping policy on education content production. This helps to produce content that is locally developed.
Funding Local publishers are paid for the content they produce. The content they produce is quality assured by KICD and made accessible on portals for a fee. Thus, students need to pay for content from publishers although content created by KICD is free (i.e., a freemium model). While this does not support the move towards Open Educational Resources, it provides a sustainable business model for local content creation.
Political economy and policy It is not clear whether KEC complies with legal frameworks on storing user data.

Kenya — Need and demand

The following insights were gathered from interviews.

Why is most of KEC built from scratch?
KICD prefers to have its own platform(s) as it has a large mandate and needs to cater to diverse populations with diverse needs. For this reason, a customised platform was needed. A specific need of theirs was a platform to curate content. This was seen as an activity that requires a high level of integrity in relation to Kenya's national curriculum; if an open-source platform was used, this could pose security and integrity issues.

What is the decision-making process for platform development?
Within KICD's mandate, platforms are developed as the need arises. While these platforms are created to respond to urgent, locally-identified needs, a long-term strategic plan that takes an integrated rather than siloed approach will lead to platforms that are more beneficial to teaching and learning (↑Groeneveld et al. 2021).

What interest and demand is there for using platform building blocks going forward?
KICD felt that it was not a simple case of saying yes or no to building blocks. These products would need to be critically analysed according to a cost-benefit analysis. If using them adds value to what they do and if it increases access then they would definitely consider it. KICD would want to analyse the benefits, cost implications, sustainability, and the need for extra technical people for support etc.

What interest and demand is there for developing platform building blocks going forward?
While the developer community is growing and capable, developers would still need guidance on what platforms are needed and who the users are. Therefore, more stakeholders are necessary for problem analysis, ideation, and user needs research if they are to develop building blocks. Developing building blocks thus requires input from the entire ecosystem.

Kenya — Key insights

- **Lack of an overarching strategy** To ensure alignment of and integration between the platforms, ↑Groeneveld et al. (2021) noted the need for an overarching strategy. For example, there are plans to integrate KEC (managed by KICD) with NEMIS (managed by the MoE) thus coordination is needed.
- **Procurement processes** When a platform needs to be developed, it is advertised and goes through a competitive tender process. A local or international consultant or firm can be contracted to complete the work. The local company can also sub-contract an international consultant. The terms of reference make clear that KICD still owns the code and reserves all rights.
- **e-Commerce platform** Commercial publishers raised the issue of KICD being both a regulator and competitor of content creation. The e-commerce platform was launched with a profit-sharing model. However, it has not yielded revenue and is currently not operational (↑Groeneveld et al. 2021). Alternative models that do not pass the cost to students need to be developed.
- **Temporarily free platforms** MS teams was offered free of charge to KICD due to the Covid-19 pandemic. KICD is unsure how long they will be able to use it free of charge. If they are asked to pay for it at a later stage, they will review their available financial resources as well as look into alternative options. Such temporarily free models end up locking users in as users become dependent on the platform.
- **Need for incremental and agile platform development** A number of platforms are being designed simultaneously with little user feedback. The platforms would benefit from incremental design that takes into consideration low connectivity settings, for example.
- **Educating demand** Since the SWOT analysis done by ↑Groeneveld et al. (2021) that outlined how the KICD could make better use of mature and widely used off-the-shelf platforms, KICD has been considering Articulate360 as its authoring tool. This outlines the importance of sharing effective practices with decision-makers in order to improve decision-making.

South Sudan — Deep dive

South Sudan — Context

Prolonged conflict, economic factors, natural hazards and years of underinvestment in education have converged to put stress on the delivery of quality education for South Sudanese children.

2.2 million

children are estimated to be out of school, with 3.1 million needing targeted interventions to access education.

51%

of the population live below the poverty line (2008), and this is likely to have increased due to conflict.

28.2%

of the country has access to electricity

33%

of the population has access to mobile phones / mobile networks.

Source: Strengthening Education Management Information Systems (EMIS) and Data for Increased Resilience to Crisis: country case study: South Sudan (↑Mwaniki(2021))

South Sudan — Overview of digital platforms for education

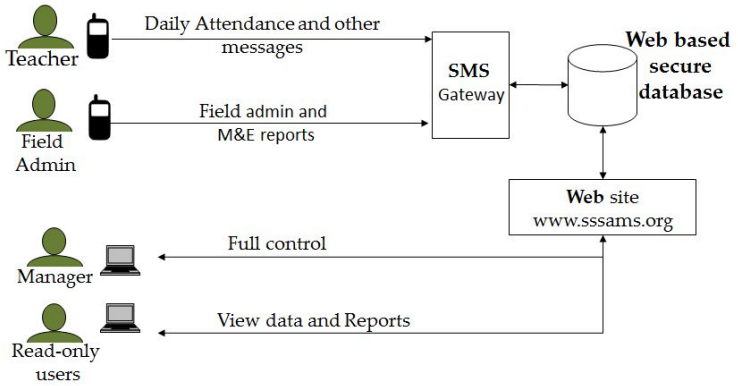
EMIS Annual Education Census (AEC)	The AEC is the main data exercise conducted by Ministry of General Education and Instruction (MoGEI) directly through its staff. It is funded through the Global Partnership for Education (GPE) and UNICEF. It covers key indicators in pre-primary, primary and secondary education, non-formal education, and technical and vocational education (TVET). Data collection is paper-based.
EMIS	EMIS is built on MS Access and is thus not online. The EMIS unit intends to gradually decentralise data collection activities to the state level, while the national level would retain an overseeing role (↑Mwaniki, 2021).
South Sudan Schools' Attendance Monitoring System (SSAMS)	SSAMS was developed as part of the Girls Education programme. Developed by Charlie Goldsmiths Associates and other consortia partners. The platform is hosted on Amazon and TSO in Europe. It runs on PHP and MySQL. It is the most promising platform to develop further.
Human Resource Information System (HRIS)	Developed and managed by Charlie Goldsmiths Associates, managed by Mott MacDonald and funded by the EU IMPACT project (↑Mwaniki, 2021). HRIS is designed for teacher management, e.g., for teacher incentives or to provide cash transfers for girls.
Refugee EMIS (REMIS)	REMIS is managed by UNHCR. All refugee data is collected through a biometric system at the point of registration that is overseen by UNHCR. Since the Djibouti Declaration on integrating refugee education into national education systems, REMIS is likely to be integrated into EMIS.
World Food Programme (WFP)	This is a simple platform that is used to monitor school feeding in South Sudan.

South Sudan — SSAMS

SSAMS is a bespoke solution funded by the FCDO and the Government of Canada.

- 'Ana Fii Inni' — 'I am here!' is the name given to the South Sudan Schools' Attendance Monitoring System (SSAMS), developed as part of the six-year Girls' Education South Sudan (GESS) programme.
- SSAMS uses mobile technology to collect and manage real-time, fully disaggregate data on pupil enrollment and attendance.
- It offers password-protected access to individual student data.
- Attendance data is reported by SMS and automatically parsed and presented in real-time.

The system uses text based reporting into an online database, allowing users at school, state and national level to see instant reports



Scalable: The system is designed to be rolled out to every school in the country: over 4000 schools.

Source: ↑SSAMS (2021)

SSAMS is being handed over to MoGEI by Charlie Goldsmith Associates (CGA), who were managing the system as part of GESS 1. GESS 2 is managed by BMB Mott MacDonald with additional pro-bono support from CGA (Mwaniki, 2021).

South Sudan — Readiness considerations

Readiness considerations
Digital infrastructure maturity In South Sudan, basic infrastructure is the priority. Basic infrastructure like roads are severely underdeveloped and this complicates service delivery. Approximately, 70% of classrooms are either open-air, in tents, roof-only, or semi-permanent. In addition, 42% of primary and secondary schools and classrooms are either partially or completely damaged(↑Mwaniki, 2021).
Human capacity The MoGEi relies on external and international partners for technical support and development of the system. A consulting firm, FHI360, ran EMIS staff training through UNICEF but it was basic in that it did not develop local skills. Altai consulting, another consulting firm, also ran training and it was much more impactful. They trained staff on data analysis, data management, and quality control. Staff still require long-term training on computer programming and networking as this is an area of expertise that is lacking. Refresher training is also needed due to fast-changing technology.
Community support No community support was mentioned.
Funding The country is largely dependent on donor support. There is lack of funding for adequate salaries that can sustain people with technical skills. Sometimes, staff who manage EMIS go without pay for months (↑Mwaniki, 2021). They are always losing talented staff that go to other jobs where they can get better pay. In response to this, they are urging the government to look into financial support for staff who have been trained and are managing this system. Currently, they are engaging with UNICEF through Global Partnership for Education (GPE) funding but more financial assistance is needed if they are to develop an integrated system.
Political economy and policy South Sudan is led by the funding initiatives of donors. Many of these efforts lack coordination.

South Sudan — Need and demand

The following insights were gathered from interviews.

What types of platforms are needed for the education system in South Sudan?

The problem faced by South Sudan is that different agencies separately collect data according to their own interests. Data is fragmented and managed separately. When the MoGEI is approached for data, they do not have it as it is decentralised. They are looking for an integrated system that is simple and easy to use, that can streamline data collection, aggregate data from different sources and systems, and display it to the MoGEI website in a user-friendly way. They want a system that is easy to control, cost-efficient, and sustainable such that it can be maintained when donor support ends.

What is the decision-making process for platform development?

Decision-making on what platforms are needed is largely led by donor funding.

What interest and demand is there for using platform building blocks going forward?

MoGEI are not interested in having yet another data platform in the country but are very interested in a platform that can centralise all the data. If an interoperable platform using building blocks could do this, it would address their current problem. Some of the questions they could ask are: Can it accommodate all other datasets currently sitting at different environments? Can it be expanded to include other datasets?

What interest and demand is there for developing platform building blocks going forward?

Given the lack of capacity to maintain platforms and retain trained staff, it is unlikely that South Sudan would be able to invest in creating building blocks.

South Sudan — Key insights

- **Lack of coordination between donors** South Sudan has multiple partners who have data, e.g., UNHCR, Save the Children, WFP, as well as different departments in the MoE. When the data is analysed separately and triangulated, there are sometimes contradictions in findings. This confuses planners who use the data for decision-making.
- **Centralised information and system management** Instead of donors each investing in separate initiatives, the MoE urges them to invest in having one source that is easy to supervise and monitor and that will be cheaper to maintain. Analysis will improve as data will be in one place.
- **Further development of SSAMS** At present, SSAMS is the most likely system that could be built on to become the central system. It has student data, school information, covers the whole country and has teacher data. They still need to investigate whether modules can be added to it but this should be possible. Currently, the system accepts data inputs ranging from SMS to online. The question is: Is it worth improving SSAM or or coming up with a new platform? Which is more efficient? Benefits to staying with SSAMS is that it already has data, is already implemented, and has been used for a few years.
- **Funding opportunity cost** While it is important to invest in monitoring and evaluation to ascertain whether interventions are working, there are a great number of projects and donors in the monitoring and evaluation (M&E) space. When funding pots are limited there is an opportunity cost between funding to address basic needs and funding to support M&E (including building blocks for this).

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Annex A — Detailed definitions and examples

Digital platforms

Definition	Examples in education
An end-user-facing **digital platform** is an environment where a set of functionalities can be used by an end user. The end user could be a learner, teacher, coach, policy analyst etc. Digital platforms are built using a 'tech stack' (see Slide 15, Slide 36 and Slide 108). *Note: The platform can be (a) built from scratch; (b) built from building blocks (existing software and tools) tailored to the needs of the platform's purpose; (c) purchased from a supplier*	The Coursera platform was built from scratch for its specific purpose (proprietary software) The EdX platform is built from OpenEdX (open-source platform software) Diksha was built from Sunbird (open-source platform software). The https://edtechhub.org website is a webservice that was built using Wordpress (open-source webservice software).

Tech stacks, development stacks, solutions stacks

Definition	Examples in education
A **technology stack**, also called a **development stack** or **solutions stack**, is a list of all the technology services used to build and run one single application. More narrowly, it refers to the set of technology services that is used to build and run an application / platform. LAMP (Linux, Apache, MySQL, PHP/Perl/Python) is the classic example of a web development stack. It has four open-source components: the Linux operating system, the Apache HTTP Server, the MySQL relational database management system (RDBMS), and the PHP programming language. The technology stack is chosen based on the size of the platform build, in order to support an appropriate software architecture, which has impact on scalability, extensibility, and performance of the platform. Also the technology stack can be dependent on the chosen hosting / running infrastructure.	WordPress typically uses the LAMP stack. OpenEdx indicates that it is built with this tech stack: Ubuntu, Docker, Django, and React. Coursera lists a large tech stack on stack share. Sunbird's tech stack includes AngularJS, Java Play, Apache Cassandra, ElasticSearch and Docker

Application Programming Interface (API)

Definition	Examples
An **API** is a communication interface that allows two applications to talk to each other. It lets a product or service communicate with other products and services without having to know how they are implemented, usually the API does not consider the language user in building the platform. A platform that offers an API is usually used as an extensibility* (enhancement) point to integrate or to be integrated with other platforms, offering a broader functionality and enhanced user experience to the end user. In addition, some platforms offer APIs in order to isolate the platform logic from the user interface, hence allowing the entity to create their own customised user interface but with an already existing built-in functionality.	Indiastack offers open APIs with the scope of integrating data into the digital solution provided, with the scope of eliminating paper-based documents. PayPal are famous for their ability to integrate into other applications through their API in order to provide payment solutions. SurveyMonkey is a survey creation and management application. It has an API that allows it to be integrated into other applications, hence providing the applications where it is integrated with the possibility of launching surveys.

Digital (backbone) infrastructure

Definition	Examples in education
Backbone infrastructure generally refers to physical or abstract infrastructure that is needed to support a platform such as storage, global and local networks, fibre-optic cables, terminals and software. Digital backbone infrastructure refers to the information and communication technology (ICT) assets needed to operate digitally. This could be, for example, web hosting or cloud storage. A platform could pay for such services or locally maintain their platform. In the case of Ekstep, a community focused on digitising school systems, the term 'Digital infrastructure' is used in the sense of both the physical infrastructure *and* the digital landscape (the complete list of applications used in an environment, or several environments that relate to one another).	Web services and digital platforms run on a variety of digital backbone infrastructures, such as Amazon Web Services, Google Cloud, Microsoft Azure, Openstack or 'on-prem' (i.e., on-premise infrastructure that is self-maintained). Cloud storage and computing services (e.g., Amazon Web Services) Web hosting (e.g., Bluehost or Gandi)

Microservices architecture

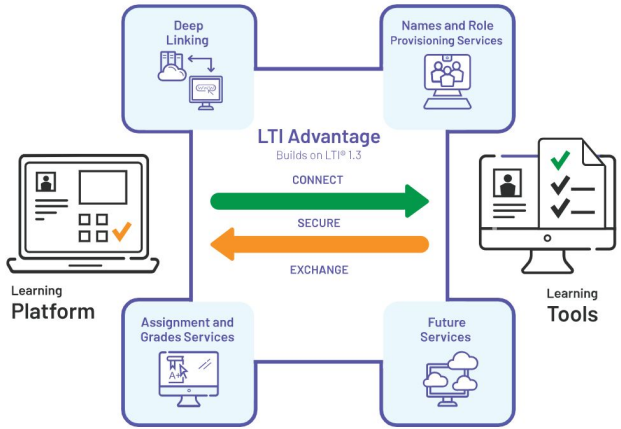
Definition	Examples
A **microservice** is a self-contained operation that can be seen as part of a business functionality, with a code interface making transparent how other platforms, applications, or microservices etc., can interact with the operation. The specifics of microservices is that they are loosely coupled, testable, independently deployable, and organised around business capabilities. The microservices architecture is used for systems that have a fluctuating demand from end users or when it is expected that their demand will grow into the future. It allows for easy scalability to adjust to the number of requests. The microservices can be hosted on machines that do not scale in resources (processor, RAM, etc.) at the same pace as the number of requests. This results in lower costs of microservice architecture compared to the alternative offered by monolithic architecture (all in one piece; not modular).	Netflix, which is a popular video streaming service, responsible for 30% of internet traffic, uses microservices architecture as part of a video streaming API. Rather than everything being part of a single piece of software, Netflix is made up of multiple, loosely-coupled elements. This reduces the risk of the entire infrastructure having a single point of failure. Sunbird uses microservices to expose (make available) their functionality, hence allowing the scalability of their functionality as the digitisation initiative is adopted in every school and every institution.

Software frameworks

Definition	Examples
Frameworks refer to source code that is designed to be customisable, configurable, extendable, and integratable by software developers to meet different use cases. A framework can in itself contain other frameworks. Usually this piece of software cannot be used as a stand-alone; its purpose is to be integrated in another piece of software. A framework can be a building block to create a digital platform. The extensibility can be created by enhancing or overwriting a specific logic from a certain module or entirely replacing a module (less common). The advantage of using frameworks is the speed of development, functional stability, and standardisation, since they are usually built on best practices specific to programming principles and the programming language used.	UserFrosting, is an open-source identity management framework, which can be integrated in PHP-based applications to provide the user management functionalities (user creation, permissions etc.). The developers are able to provide this functionality without developing it on their own, but by integrating UserFrosting. Primefaces, is an open-source user interface framework, providing java-based interface elements, which developers can use to build their own user interface.

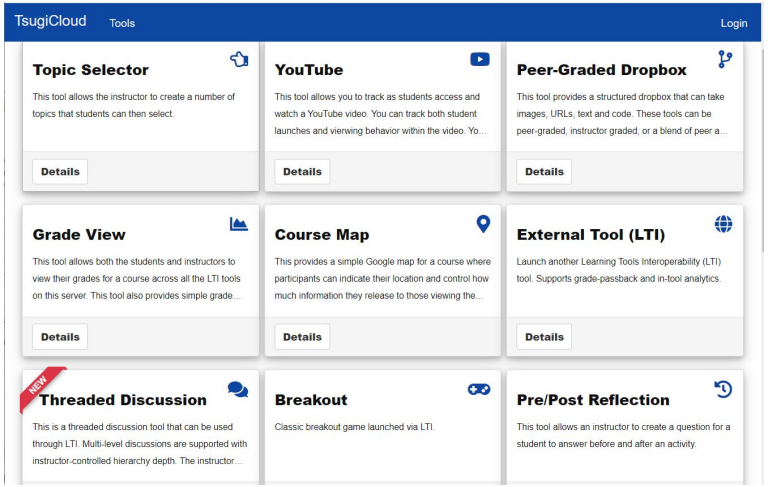
Example — Learning Tools Interoperability

Learning Tools Interoperability® (**LTI**) is an education technology standard developed by the IMS Global Learning Consortium. The standard aims to deliver a single framework for integrating any Learning Management System (LMS) product with any learning application, allowing for a combination of applications to be used. The use of LTI allows for LMS vendors to make proprietary extension frameworks that make it possible to 'plug-in' external applications. For example, an institution with an existing LMS can use LTI to integrate an existing assessment tool into their LMS, without the need to programme the integration.



Source: IMS Global (2021)

TsugiCloud hosts open-source Tsugi Tools that can be seamlessly integrated into any LMS that supports LTI.



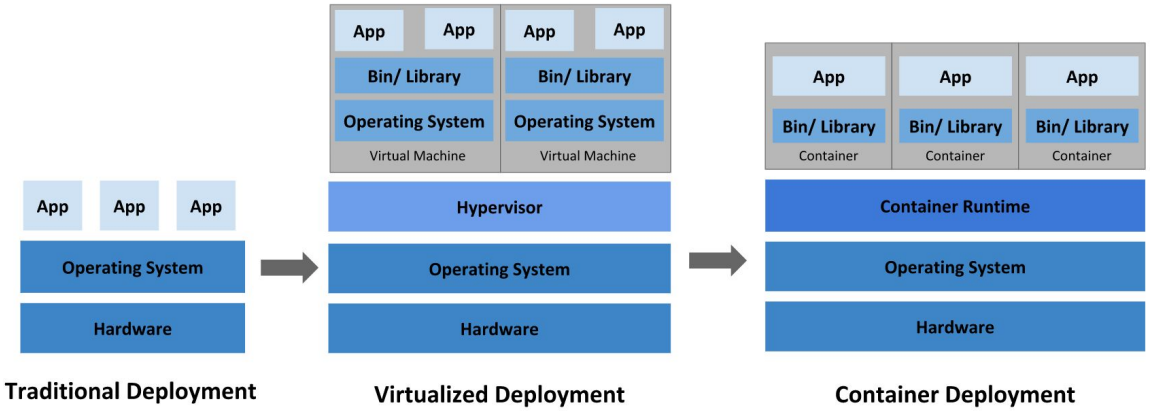
Source: Tsugi (2021)

LTI is not a building block in itself but a standard that allows for applications to integrate with each other. LTI does not require applications to be open source. It is included in this study as it is a very popular and successful way of improving the extensibility of Learning Management Systems.

Example — Kubernetes

Kubernetes is a portable, extensible, open-source platform for managing containerised workloads and services that facilitates both declarative configuration and automation. It has a large, rapidly growing ecosystem. Kubernetes services, support, and tools are widely available.

Sunbird uses Kubernetes to containerise its code*. The installation script uses the Kubernetes orchestration engine to run the Sunbird docker images. Kubernetes consists of manager and agent nodes. The pods run on the agent nodes and the manager nodes manage the pods' lifecycle. Services like Portal, LMS Backend, API Gateway and Proxies etc., are run as Kubernetes pods.



Source: ↑Kubernetes (2021)

* A container is a discrete environment set up within an operating system in which one or more applications may be run, typically assigned only those resources necessary for the application to function correctly

Annex B — Methodology

Research questions

This study set out to explore the following research questions.

1. What are they key **terms** used to describe digital platform building blocks, and how do we define them?

2. What are the **current and potential use cases** of digital platform building blocks by ministries of education in sub-Saharan Africa (SSA)?
   a. What use cases of digital platform building blocks **exist in SSA**? How are they used, extended, or tailored?
   b. What use cases of digital platform building blocks **exist elsewhere** — such as in India — that could provide insights for SSA?
   c. What are the **enabling factors and conditions** that lead to the successful use of digital platform building blocks in SSA?

3. To what extent is there a **need** and **demand** from governments in sub-Saharan Africa for digital platform building blocks as global public goods?
   a. What platforms are governments currently using? What was the **pathway to current use**?
   b. To what extent would education systems in sub-Saharan Africa **benefit** from digital platform building blocks as global public goods?

4. What early insights can we share on the **potential catalytic impact** of open-source digital platform building blocks to enable education systems, and what are the **potential risks** of provision?

Methodology

We explored the existing and potential use cases of digital platform building blocks through a **qualitative, primary research approach.**

Continuous desktop research, including documentation review, platform review, website review, and review of countries' digital infrastructures.

Semi-structured interviews with key informants through snowballing, including:

- 7 country interviews
- 3 platform interviews2 donor interviews.

The building block mapping process

We aimed to develop a long list of building blocks that are either developed or used in SSA. To do this, we followed a mapping process.

We undertook desktop research to identify the **types of platforms and tools** used in education systems.

We conducted interviews with donors, ministry officials, and product developers to **gather a long list** of platforms and tools that are used.

We reviewed a long list of platforms and tools and used them to **develop the criteria** of what building blocks are, what they are not, and what are grey areas.

We developed a **mapping rubric** to categorise the long list of platforms and tools.