EdTech Hub

Clear evidence, better decisions, more learning.

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Systemic Mixed-Methods Research — A Conceptual Framework for EdTech Research at Scale

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Section 2.4.1 on agile service delivery paraphrases text from the UK Governments Agile Service Delivery manual (↑GOV.UK, no date), available under the Open Government Licence v3.0.

Reviewer

Aditi Bhutoria

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Abbreviations and acronyms

6Ps	People, practice(s), places, provision, products, policies
CoP	Community of Practice
EdTech	Educational technology
IDIA	International Development Innovation Alliance
LMICs	Low- and middle-income countries
MVP	Minimum viable product
RQ	Research question
SDG	Sustainable Development Goal
SMMR	Systemic mixed-methods research

Chapter 1. Introduction

When harnessed effectively, educational technology (EdTech) can accelerate progress toward the achievement of Sustainable Development Goal 4 (SDG4): *to ensure inclusive and equitable quality education for all.* The use of EdTech could level the playing field for marginalised groups—and contribute to the resolution of the learning crisis—by ensuring quality education for those who experience systemic exclusion in traditional schooling.[1]

The development of EdTech interventions has received huge investment over the past decade. Yet, a lack of systematic research has limited the potential impact of EdTech. In particular, the current evidence base lacks rigorous data on how EdTech can be used to support marginalised populations and to improve learning in low-income countries. As such, decision-makers struggle to identify what will—and will not—prove cost-effective at scale within their contexts. Together with political imperatives, this research gap often results in decisions and intervention designs that are not evidence-based.

The combination of large investments in EdTech and a limited evidence base demands rigorous research designs to investigate what works for different populations in specific contexts and why. This paper presents a guide to systemic mixed-methods research (SMMR) as an approach that offers a practical and rigorous way to address EdTech research challenges.

Chapter 1 provides background on the need for new thinking in EdTech research. The chapter identifies common challenges with EdTech interventions and offers a set of broad research questions in EdTech research. Chapter 2 outlines the concept of SMMR as a research design, while Chapter 3 describes the characteristics of this approach.

1.1. Seven challenges of EdTech interventions

The EdTech sector is plagued with an abundance of ideas and a limited evidence base. As such, decision-makers face several challenges when looking

[1] While the paper does not define marginalisation, it accounts for different types of marginalisation such as marginalisation due to location, gender, poverty, disability, and other societal circumstances.

to design and implement evidence-based EdTech interventions. Seven challenges are identified below.

Challenge 1. Many EdTech areas are under-researched

Limited evidence has been gathered on the impact of EdTech interventions in low-income countries. The majority of this research focuses on classroom-level interventions and overlooks other important areas of the national education system such as the use of geospatial data in education planning (↑Cristia et al., 2012). Even where research has focused on learners, it has not explored the value of using EdTech to support marginalised populations. For example, how do girls, children with disabilities, children in conflict-affected settings, and children in rural areas engage with EdTech interventions?

Challenge 2. An incomplete understanding of what works and what does not work in a given setting

A better understanding of the potential of using EdTech — and education interventions more broadly — can support more impactful, cost-effective, and sustainable education service delivery (↑Joyce & Cartwright, 2020; ↑Banerjee et al., 2020). Decision-makers can use such an understanding to identify whether an intervention may lead to learning gains (↑Banerjee et al., 2020). Here, an important consideration is the extent to which EdTech interventions can address specific education system needs at scale in resource-constrained environments.

Challenge 3: Intervention designs are neither evidence-based nor rigorous

The design of EdTech interventions often has a weak relationship with rigorous, user-centred evidence. The 'EdTech innovator' culture often feeds off confident optimism and hype rather than empirical evidence (↑Selwyn, 2016). Many EdTech pilots are not evaluated or researched with the aim of refining the next iteration of programme delivery.

Where pilot evaluations exist, the results are often not explicitly tied to routes to scale. Instead, designers adopt a mentality that a pilot will scale automatically if a study proves something works. This approach fails to acknowledge the fact that pilot studies tend to be too short to provide a valid assessment of the

impact of EdTech use on learning and of wider considerations of cost-effectiveness (↑Angrist et al., 2020).

Challenge 4: Policy decisions are not necessarily evidence-based

There is a striking gap between the EdTech evidence that is available and the degree to which policymakers utilise EdTech evidence. Overall, some areas are more evidence-based than others; we contend that EdTech in low- and middle-income countries (LMICs) and teacher professional development in LMICs (↑Allier-Gagneur et al., 2020; ↑Popova et al., 2018) are two areas that are particularly struggling from the lack of application of available evidence. Often the challenge is with the questions being asked and expectations of the policymakers regarding EdTech. Even where vested interests do not get in the way, the lack of the application of evidence — reflecting perhaps a general lack of understanding of EdTech — is a particular issue.

More widely, vested interests play an important role. In general, 'politics' and policymaking are inextricably linked; around the world, many policies are made to reflect political allegiances and interests rather than what is in the population's best interest. This is true for both party politics as well as for the 'politics' of other areas, such as what donors are willing to fund. Perhaps, it is particularly where interventions have reached district or national scale, that such issues come into play.

When the emphasis is merely on 'how to introduce EdTech' rather than on 'improving learning outcomes', then the most impactful interventions are often not the ones that are implemented. This may be due to a prevalent view that EdTech is a silver bullet.

Challenge 5: Stakeholders are disconnected

EdTech interventions may be more prone to failure than others because of the cross-cutting and multi-stakeholder nature of these programmes. Even where decision-makers have the right evidence, they may not be empowered to act on the available data due to an absence of appropriate institutional structures. For example, a policymaker from a 'teacher training department' may need a decision to be made in a 'technology department'. EdTech developments can be led by the technology industry / private sector, where technology-first approaches are employed. Evidence for learning is often not relied upon.

Furthermore, approaches may be based on a 'trickle-down from rich to poor' approach rather than designing with the most marginalised in mind.

There is scope for increased dialogue and collaboration among EdTech industries and users. An impressive number of global, regional, and country platforms exist, but interactions between these networks are rare. A global and inclusive community of practice could unite decision-makers from governments across low-income countries, the private sector, academia and donor communities.

Challenge 6: EdTech evidence is not readily accessible

The issue of access to evidence is a complex one. We note that access to academic resources, such as conferences and journal publications, is costly at a surface level. Clearly, this limits the sharing of academic evidence. However, the issue of evidence availability is far deeper than the narrow view of evidence as being 'academic evidence' would suggest.

For example, there is no established website or web-based library that makes EdTech evidence readily available to interested parties, such as policymakers and civil society organisations. This need for stakeholders to invest great effort into even accessing EdTech evidence contributes substantially to the failure of effective EdTech implementation. EdTech Hub has established an evidence library (https://docs.edtechhub.org) to address this (cf. also ↑Haßler et al., 2021q).

Challenge 7. Robust research is expensive

There is no universal 'what works', no one-size-fits-all 'best practice in education'. Insights and practices are contextual, and we therefore focus on 'effective practices' — in a given set of circumstances, what classroom practices typically enable successful student learning? Likewise, there is no 'best practice' in EdTech, which is further exacerbated by the rapid evolution of technology. Very few actors in the sector have embraced rigorous research designs capable of addressing the central challenge of interest: which EdTech-enabled interventions are scalable, iterative, and cost-effective?

Addressing such problems requires robust research. However, robust research is expensive. Even research that might be considered rigorous by academic standards has flaws (cf. ↑Kerwin & Thornton, 2020). Rather than suggesting that this 'cost of research' can be fixed by 'brute force' (i.e., more funding) — or, at the

very least, can *only* be fixed by more funding — we also need to look for new approaches.

There is a need for rigorous, multi-faceted, agile, and adaptive research that systematically uncovers 'what works' in specific contexts (and 'why'). These findings must then be built into actionable evidence that decision-makers can utilise as they decide whether and how to scale any given EdTech intervention.

1.2. Eight guiding questions

Any masters' programme in research methods would emphasize the primary role of the research questions; the research design is subordinate to the research questions. Therefore, before outlining SMMR as a new research design, we need to consider the types of research questions that SMMR seeks to answer. Figure 1 below identifies eight overarching research questions. We have identified these questions based on the need within the education sector in LMICs, and based on the need within the EdTech sector. We propose that SMMR is useful for EdTech researchers addressing similar types of research challenges.

RQ1 and RQ2 are core questions concerning evidence on the education outcomes of EdTech programmes. RQ3 draws out factors, incentives, and constraints that shape whether decision-makers adopt and scale EdTech interventions — perhaps like an Education Endowment Foundation toolkit[2] for EdTech. Research on RQ1–RQ3 is only fully answerable if research designs can be innovated (RQ4).

However, the existence of new methods is not sufficient in and of itself. Our focus on societal change necessitates a greater understanding of the way in which research and intervention methods can become established among researchers and widely used across the sector (RQ5). Related to this, it is vital to understand how a change in the research environment can affect the sector more widely and translate into a change in education programme implementation (RQ6). Finally, to be agile and adaptive, EdTech researchers themselves need to be reflective EdTech practitioners. Accordingly, we ourselves continuously monitor, evaluate, learn and adapt, understanding the role of the researcher (and research programmes) within the wider EdTech ecosystem (RQ7).

[2] ↑Teaching and Learning Toolkit England: Education Endowment Foundation, ↑Early Years Toolkit, Higgins et al. (2013).

Figure 1. *Eight overarching research questions.*

RQ1. From a systems perspective, what interventions accelerate, spread, and scale EdTech initiatives to deliver better learning outcomes for all children, including the most marginalised, in low-income countries?

RQ2. From a systems perspective, which EdTech interventions present the greatest value for money and social return on investment?

RQ3. What are the characteristics of EdTech interventions (systems perspective) that are effective, and in particular are able to reach 'at-scale' use? What are the barriers and enabling factors?

RQ4. What are the most rigorous, scalable, inclusive research designs and methodologies for answering research questions 1, 2 and 3?

RQ5: What steps can EdTech researchers take to better utilise and build upon better research designs? How can a global Community of Practice (CoP) effectively promote these research designs?

RQ6: How can evidence-based insights about EdTech (including those generated under RQ1–3 and RQ4–5) be used by a wide range of implementers and decision-makers, leading to better learning outcomes for all?

RQ7: From a systems perspective, what is the most effective role of a research programme and of a cross-sector, global CoP in answering RQ1–RQ6 and in securing long-term impact across the sector?

RQ8. What are the evidence gaps that decision-makers face when using EdTech to deliver quality education, focusing on the most marginalised?

Chapter 2. What is systemic mixed-methods research?

A multifaceted approach to EdTech research is required given the challenges that EdTech interventions face, as outlined in Chapter 1. This chapter outlines such an approach in the form of a new type of research design called Systemic Mixed-Methods Research (SMMR).

2.1. Initial definition of SMMR

Systemic Mixed-Methods Research is a type of mixed-methods research that focuses on researching systems with a view to improving equitable learning outcomes.

The word 'systemic' means relating to a system — a set of components that interconnect and work together as a unified whole — as opposed to a singular part. Systems can be thought of as 'complex' or 'dynamical' (↑Arnold & Wade, 2015, ↑Chen, 1975, ↑Meadows, 2008), reflecting the idea of 'aid on the edge of chaos' (↑Ramalingam, 2013). SMMR seeks to capture the complexity of systems without oversimplification, recognising recent research that demonstrates the sensitivity of outcomes to implementation choices (↑Kerwin & Thornton, 2018; ↑Kerwin & Thornton, 2020). Importantly, researchers need to explicitly define the system under investigation.

The system in question could be the national education system of a particular country. For example, DFID's 2018 Education Policy ('Get Children Learning') calls for national education systems that address "the full span of education provision across both public and non-state sectors. It is made up of inputs, processes, people and politics, which together determine whether children are learning" (↑DFID, 2018: 19).

Can SMMR be used to research a national education system? This is, of course, a matter of definition. While SMMR could be used to research national education systems, these systems are large and multifunctional, with components that are not equally relevant for specific problems. Moreover, there may be components outside of national education systems that are relevant for a systemic approach.

Given the ambiguity of the word ‘system’, we propose introducing specific terms to clarify this concept for our approach. To distinguish more general sẏstems to be researched using SMMR from national education systems, we write ‘system’ with an ‘ṡ’ (reminiscent of the change of quantities over time in classical mechanics / dynamical systems) to refer to general sẏstems:

sẏstem

Otherwise, we explicitly use the term ‘national education system’ to refer to what normally comes under the way a state regulates its education system.

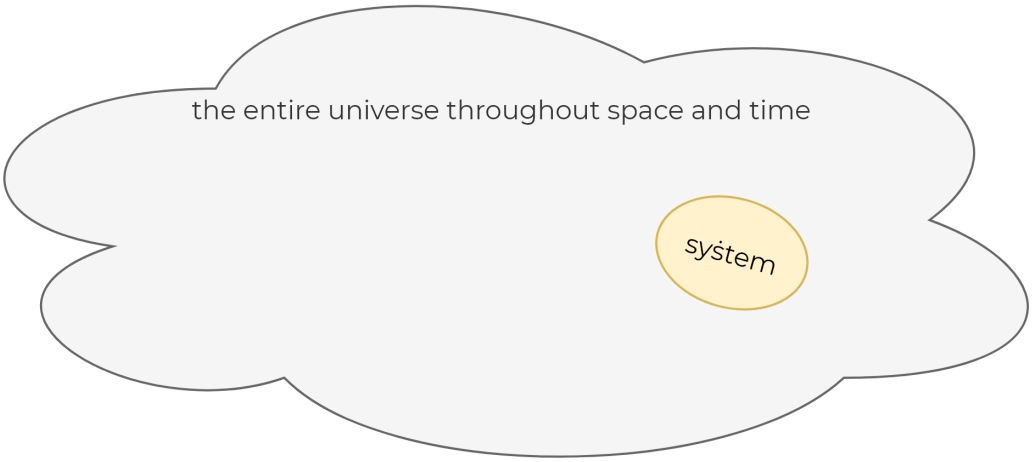
With this distinction, we will now consider how to identify what comprises a sẏstem.

2.2. What sẏstem are you researching?

When given a research question, SMMR first considers the sẏstem components with relevance to the issue at hand rather than immediately identifying the methods that may be used to answer the question.

Every system necessarily has a boundary and always constitutes a ‘sub-sẏstem of the universe’ as illustrated in Figure 2.

Figure 2. *A sẏstem and the universe. The diagram shows a sẏstem within the universe. The sẏstem has a boundary that separates it from the rest of the universe.*



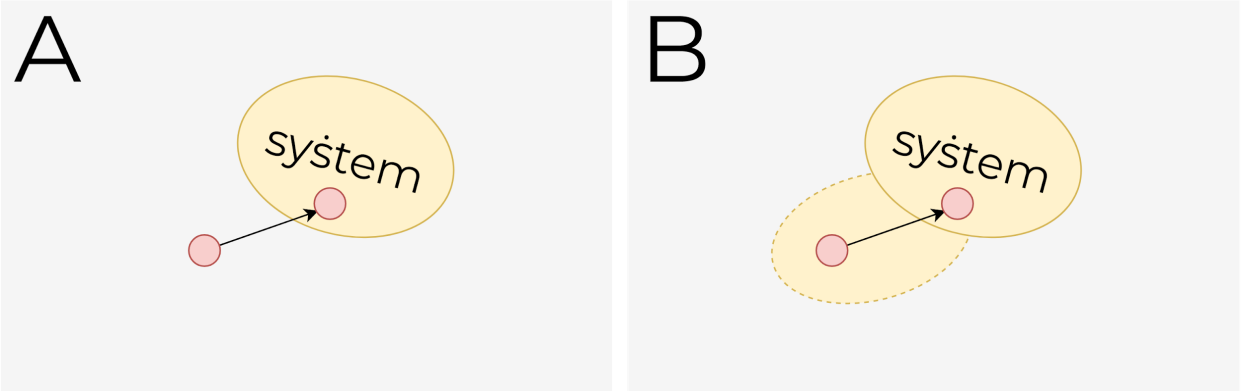
Importantly, the boundary has to be chosen so that the influence across the boundary can be controlled or quantified. If there are external processes that strongly influence a system, the system needs to be redefined to account for these processes (see Figure 3).

For example, suppose we are interested in education data in Sierra Leone. Let's consider the system in terms of people and policies (cf. Section 2.3.5). In terms of people, the system comprises the ministry- and district-level officials as core users. In terms of policies, the system comprises the

- Education Sector Plan as the overarching policy framework;
- Annual School Census as the principal data collection product.

However, the new Radical Inclusion policy identifies the collection of data on girls and students with special educational needs as a priority (↑Ministry of Basic and Senior Secondary Education, 2021). In doing so, the new policy will likely influence the original system, which is therefore expanded to include that policy.

Figure 3. *Redefining the boundary of the system. The left side (A) shows a process that has an important influence on a process within the system. It is, therefore, necessary to redefine the system boundary to account for that influence (B).*



The above definition of a system boundary is perhaps a trivial observation but in reality it is a complex process.

2.3. Identifying relevant system components

This section first outlines two preliminary considerations that inform the selection of system components for SMMR:

- levels within the national education system
- student demographics.

The following subsections then outline four frameworks for identifying components of a system to consider in research:

- Causal loop diagrams
- Principles for digital development in education
- 6Ps framework
- Structured pedagogy.

2.3.1. Levels within the national education system

Prior to identifying specific system components for SMMR, researchers should consider whether the proposed analysis will span the various levels of the education system. ↑Hennessy et al. (2020), with reference to ↑Bronfenbrenner (1979) and ↑Hammond (2019), point out that to

> *"fully understand the factors that either facilitate or obstruct the take-up and effective use of EdTech, researchers need to attend to multiple (macro-, meso-, and micro-) levels of the [national] educational system (e.g., politics, policy, governance and accountabilities, community, school, teacher, family, child), as proponents of an ecological framework have argued"* (↑Hennessy et al., 2020: 19).

Common levels in the national education system include:

- Intergovernmental bodies (e.g., the African Union and UN organisations);
- National administration (e.g., national ministries);
- Regional administration (e.g., district offices);
- Groups of schools (e.g., grouped in wards or clusters);

- Community organisations, faith-based organisations, and other NGOs;
- Schools;
- Non-teaching aspects of school (e.g., parent-teacher committees);
- Teachers in classrooms;
- Students in and outside of classrooms.

2.3.2. Student demographics

Researchers must consider aspects of student demographics such as:

- deep-rural, peri-urban, urban;
- out of school, partially in school, fully in school;
- gender;
- language;
- Special educational needs and disabilities (SEND);
- conflict and crisis settings;
- local human development index.

Moreover, the field of political economy offers a range of different perspectives. For example, ↑Kingdon et al. (2014) note that

> *"Unfavourable political economy blocks educational reform. This review confirms that education reform takes place under circumstances that in many cases are politically driven, and shaped by the interests and incentives facing different stakeholders, as well as by formal and informal institutions. Insights from the literature urge consideration of the interests, actions and choices of a wide range of actors, working in a wide range of institutions across a number of interacting stages, in the process of education policy reform — from agenda-setting, to programme design, to adoption, to implementation to institutionalisation and sustainability."* (↑Kingdon et al., 2014:48)

Furthermore, the authors note that

> *"The review found that the theoretical themes of the literature focus on the effects of regime type (e.g., democracy), degree of openness, the role of competing parties, and concentration of resources. In addition, we discovered a growing literature on the role played by vested interest groups, such as teachers' unions, which has been crucial in furthering our*

> *understanding of how power is exercised by different players.*" (↑Kingdon et al., 2014:48)

2.3.3. Causal loop diagrams

The system dynamics approach has not been extensively used in education (↑Barends, 2019). This system dynamics approach involves the development of conceptual models such as causal loop and actor diagrams to evaluate policies or predict future outcomes (↑Assidmi, 2015; ↑Grobbelaar & Buys, 2005; ↑Groff, 2013; ↑Johnson et al., 2018; ↑Murphy, 2016; ↑Sanchez et al., 2009).

Figure 4 provides an example of a basic causal loop diagram on teacher professional development and learning outcomes. The diagram shows that head teachers who promote professional development positively influence whether professional development takes place. The diagram also illustrates that government-led performance-related pay can have a similar positive influence.

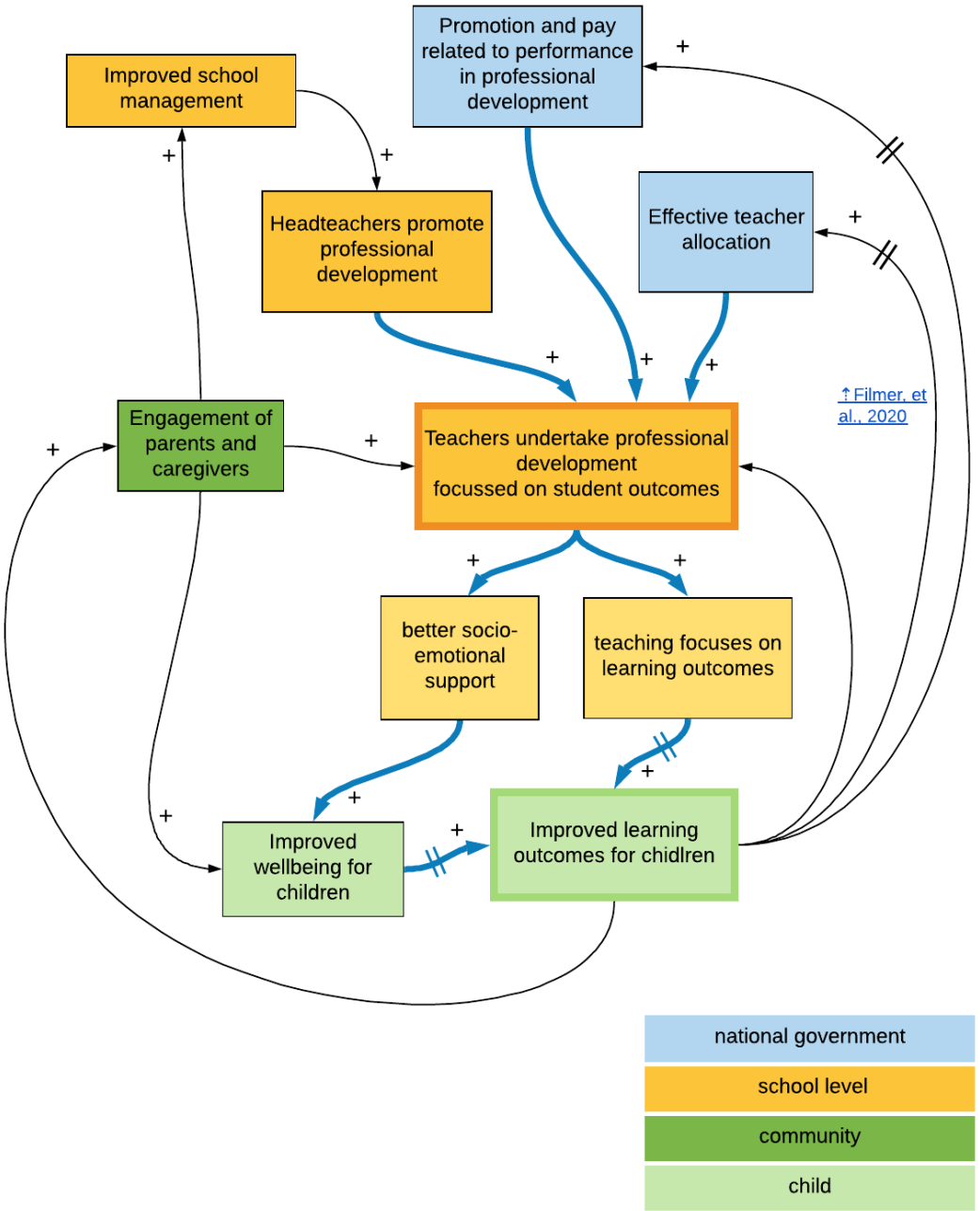
Teacher professional development focusing on learning outcomes for students will lead to better learning outcomes (↑Allier-Gagneur et al., 2020), albeit with a delay. Newer teaching practices take time to take hold; during that transition phase, learning outcomes may even temporarily decrease. The importance of socio-emotional support is also recognised, and better socio-emotional support for children can be stimulated through teacher professional development. One would expect this to have a relatively quick impact on student well-being, which in turn will lead to better learning outcomes. Community engagement is also likely to be important. For example, the engagement of parents and caregivers will have a positive impact on school management (accountability) as well as on children, who will have better support and encouragement at home. Finally, improved learning outcomes for children will have an impact on education systems governance (evidence-based practices) as well as on the community. Clearly, it would be possible to extend the diagram much further.

Once an initial diagram has been developed, the links in the diagram can then be discussed regarding the available evidence. To keep the diagram below simple, we have only illustrated this with one link (↑Tanzania: Filmer et al., 2020, on teacher performance-based incentives).

An important question is how we know whether such a causal loop diagram has captured the most important influences. Ultimately, it is of course a matter of research; over the course of a research programme, the various links are evaluated and reworked. However, what guidance can be provided to ensure that the initial diagram has captured as many relevant connections as possible?

The following two sections consider two frameworks that are helpful in this regard.

Figure 4. *Basic causal loop diagram on teacher professional development and student learning outcomes. The lines indicate influences ("+" being a positive influence; the diagram has been formulated so that influences are all positive). The double bar "||" indicates a delayed effect. Thicker blue lines indicate likely dominant effects. For illustrative purposes, a single reference has been added to show how the influences would be backed up through research.*



2.3.4. The Principles for Digital Development in Education

The Principles for Digital Development in Education constitute a variation of the ↑Principles for Digital Development that have been tailored to the education sector (↑Haßler, 2020). The principles are a useful tool to chart a course through causal loop diagrams, offering several dimensions for consideration. The Principles for Digital Development in Education include:

- **Design with the User** — User-centred design starts with getting to know the people you are designing for — through conversation, observation, and co-creation.
- **Understand the Existing Ecosystem** — Well-designed initiatives and digital tools consider the particular structures and needs that exist in each country, region, and community.
- **Design for Scale** — Achieving scale requires adoption beyond an initiative's pilot population, and often necessitates securing funding or partners that take the initiative to new communities or regions.
- **Build for Sustainability** — Building sustainable programmes, platforms, and digital tools is essential to maintain user and stakeholder support, as well as to maximise long-term impact.
- **Be Data-Driven** — When an initiative is data-driven, quality information is available to the right people when they need it, and they are using this data to take action.
- **Use Open (Standards, Open Data, Open Source, Content, Access and Innovation** — An open approach to digital development can help to increase collaboration in the digital development community and avoid duplicating work that has already been done.
- **Reuse and Improve** — Reusing and improving is about taking the work of the global development community further than any organisation or programme can do alone.
- **Address Privacy and Security** — Addressing privacy and security in digital development involves careful consideration of which data is collected and how data is acquired, used, stored, and shared.
- **Be Collaborative** — Being collaborative means sharing information, insights, strategies, and resources across projects, organisations and sectors, leading to increased efficiency and impact.

In conjunction with a causal loop diagram, researchers can use these principles to interrogate the system. For example, a researcher could ask: who are the key users of an intervention? What factors are most important for sustainability? Can I draw on influences from open innovation or open practices?

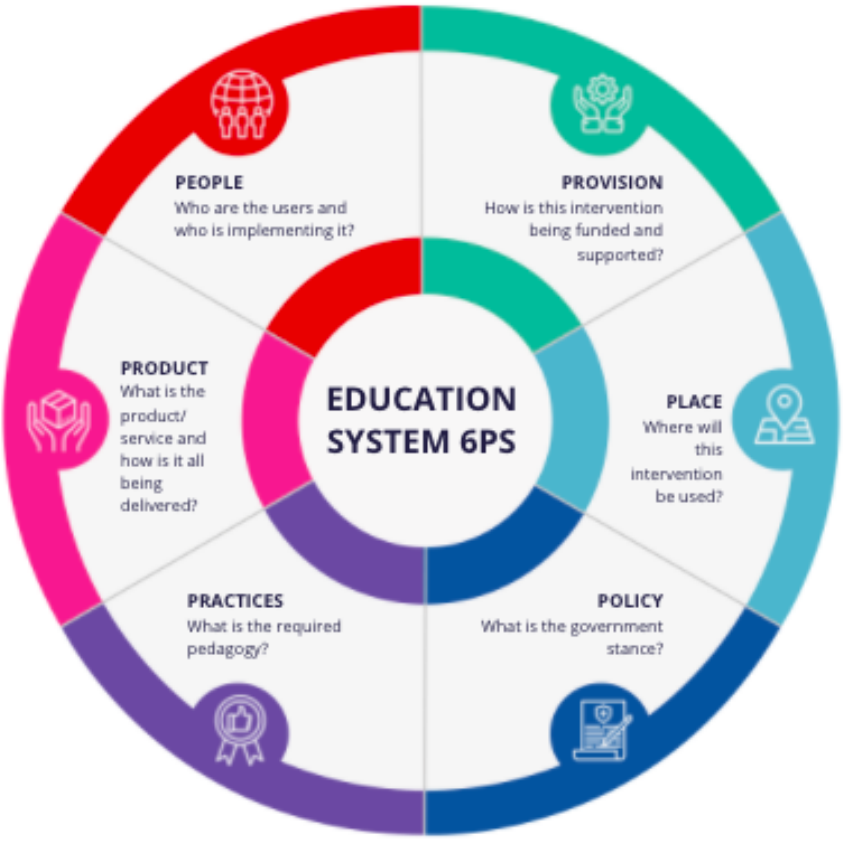
2.3.5. 6Ps framework

The '6Ps' ('six Ps', ↑Rahman & Carter, 2020) are a helpful framework for identifying components to include in the system that you are going to research using SMMR (see Figure 5). The '6Ps' are listed below:

- **People.** All those involved in education. This includes children and young people (including learners, the out-of-school and those who are marginalised within the national education system), their parents, their educators, innovators, researchers, and those working towards improved provision of education on a global level.
- **Practices.** The practice(s) of those people, including teaching and learning behaviours, pedagogy, and research methodology and design.
- **Places of learning (formal, non-formal and informal).** This includes learning contexts for children, educators, researchers, and policymakers such as educational authorities, non-governmental organisations (NGOs), and international donors.
- **Provision of human and material resources.** Provision of human and material resources including educator allocations, supply chains, and infrastructures such as connectivity and power.
- **Products and resources.** Products and resources to aid teaching and learning: textbooks, educational materials, equipment, and technology devices.
- **Policies.** Official agreements, including sector plans, legislation, national and sub-national regulations, and global frameworks and conventions.

Alongside the Principles for Digital Development in Education, the 6Ps framework can highlight system components to include in a causal loop diagram. ↑Rahman & Carter (2020) provides resources for conducting a 6Ps audit, which helps to ensures that the team focuses on all elements of the education system that are needed to make the intervention successful, and do not avoid the difficult parts.

Figure 5. *The 6Ps Framework. This framework codifies system components into 6Ps of people, provision, product, practices, policy, and place. The circular diagram symbolises how each of these components interconnect as part of a single system.*



2.3.4. Structured Pedagogy

The notion of 'Structured Pedagogy' provides a framework that identifies eight components that can enable effective classroom practice (↑Adam et al., 2021). These components include:

- **Leadership development**. Support to government and school leaders to improve the management and sustainability of the education initiatives.
- **Lesson guides**. Lesson plans and scripted lessons to help teachers deliver the curriculum.
- **Teaching materials**. Teacher guides, 'Big Books' or other teaching aids used by teachers to help deliver lessons or support instruction

- **Learning materials**. Resources for students including textbooks, workbooks, worksheets, student readers, and maths manipulatives that are closely aligned to the lesson guides.
- **Teacher training**. Training delivered to teachers to help them teach effectively, utilise the teaching and learning materials, and improve instruction over time.
- **Ongoing teacher support**. Personalised support provided to teachers, including: coaching, participation in communities of practice, and technology-enabled teacher support.
- **Assessment**. Tools and processes to measure progress against targeted learning outcomes through formative and summative assessment.
- **System management**. Integration of data and feedback from various system actors / components of the initiative to build accountability and transparency.

As with the Principles for Digital Development in Education and the '6Ps framework', these components can inform what may be missing from a causal loop diagram.

2.4. Agile service design and the IDIA scale

In the final section of this chapter, we introduce the idea of agile service design and the International Development Innovation Alliance (IDIA) scale. Like the other concepts mentioned above, the IDIA scale can also help us understand systems. However, this section focuses on how systems might change or scale over time. To understand how systems scale, we introduce three different frameworks for scaling: Agile service delivery, the IDIA scale and finally an agile framework for education. For orientation, the table in Figure 6 provides a comparison of the three and illustrates how the scales are broadly compatible.

We note that in this section we initially speak about education programming to illustrate the meaning of the different scales. However, in the penultimate subsection (3.8) we return to these concepts and apply them to research and SMMR.

Figure 6. *The IDIA scale, classic agile and extended agile frameworks compared.*

IDIA	Agile service delivery[3]	Agile in education interventions
—	Discovery	Discovery
Stage 1. Ideation		
Stage 2. Research and development	Alpha(s)	Alpha(s)
Stage 3. Proof of concept		
Stage 4. Transition to scale	Beta(s)	Beta(s)
Stage 5. Scaling		Scaling
Stage 6. Sustainable scale	Live	Live

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2.4.1. Agile service delivery

The UK Government's Agile Service Delivery manual (↑GOV.UK, no date) draws on a specific approach consisting of several phases. The approach is for service delivery across the UK government, not specific to education, and is defined as follows.

Discovery phase

The discovery phase focuses on understanding the problem that needs to be solved, learning about the service users and what they are trying to achieve. It means understanding any constraints that you may face, the underlying policy intent and opportunities to make improvements across different agencies or teams.

[3] UK Government's Agile Service Delivery manual (↑GOV.UK, no date).

Alpha phase

The alpha phase focuses on trying out different solutions to the problems you learnt about during discovery. Practically, this means that you build prototypes and test different ideas. It is also an opportunity to challenge existing processes. The alpha phase is selective, focussing on the areas you think will be most challenging. Importantly, by the end of alpha, you should be in a position to decide which of the ideas that you've tested are worth taking forward to beta.

Beta phase

The beta phase focuses on taking the best idea from alpha and starting to build it. It involves thinking about how your service will integrate with (or start to replace) existing services, and preparing for the transition to the live phase.

The beta needs to be structured so that you can roll out the service to actual users—while minimising risk and maximising the potential to learn and iterate the service. The UK Government's Agile Service Delivery Manual (↑GOV.UK, no date) envisages undertaking a 'private beta' first, involving a limited number of invited users of your service in order to obtain feedback and improve the service. The 'public beta' follows the 'private beta' . An important aspect of the public beta is preparation for the live phase.

Live phase

The live phase is about supporting the service in a sustainable way at scale and continuing to iterate and make improvements. In particular, the live phase:

- continues to address any constraints you identified at beta;
- continues to develop the service and work with other organisations providing services that are part of the same journey, so that you're iterating towards solving a whole problem for users;
- transitions to or integrates any existing transactions that meet a similar need in to the new service.

Retirement

The final phase is retirement. The service may eventually need to be retired, for example, if policies change or if there is evidence that user needs have changed.

When retiring a service, it is important to consider user needs in the same way you did when you first built the service.

2.4.2. Agile education service delivery

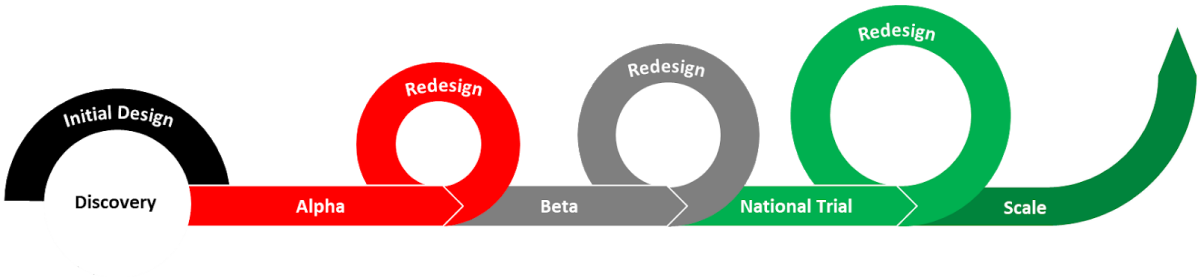
The next framework we introduce is a variation of the UK Government's Agile Service Delivery Manual (↑GOV.UK, no date). For education programmes, the discovery and alpha stages make immediate sense and are transferable. Discovery maps neatly onto considering prior evidence and how that evidence is validated through user-testing (Section 3.8). The alpha phase is easily related to utilising cycles of design-based research / design-based implementation research (↑Bakker, 2018; ↑Barab, 2014; ↑Fishman et al., 2013; ↑Getenet, 2019), which are iterative.

In education programming, the beta phase is also fairly straightforward. A specific amendment is considered for the specific scale of the beta. With a focus on learning outcomes and potentially whole-school intervention, you should consider the sample sizes necessary for such assessments. For a clustered (quasi-)experimental design, a typical scale (for reasonably secure outcomes, with a reasonable minimum detectable effect size) might be a sample size of 50 schools in the treatment group and the same in the control group. We may therefore say that for agile education service delivery, a beta might include 50 or so schools per group. Broadly speaking, this might mean that the beta takes place in one district of around 100 schools.

For education programming, you then need to consider how to transition from beta to live. For a digital service in the UK, this would be quite straightforward. However, for an education service, the transition to scale requires a separate ‘scaling’ phase, during which the initiative is extended from one district to cover all districts in a country.

These changes have been incorporated in the agile model of the Activating EdTech programme and are illustrated in Figure 7.

Figure 7. *Discovery, alpha, beta, national trial, live.*



2.4.3. The IDIA scale

The next framework we introduce is the IDIA scale. In 2017, the International Development Innovation Alliance published the report 'Insights on scaling innovation' (↑IDIA, 2017), which synthesises existing terms in relation to the phases required to successfully develop and implement innovations from ideas to working at-scale. The six-stage IDIA framework is outlined in Figure 8.

SMMR is suitable for researching innovations at all stages of the IDIA scale, but also offers scope for the research to grow alongside the interventions. The approach of the IDIA scale is compared to agile service delivery in Figure 6 above.

Figure 8. *The IDIA scale.*

Stage 1. Ideation

Defining and analysing the development problem and generating potential solutions through scanning of existing and new ideas ('horizon scanning').

Stage 2. Research and development

Further, developing specific innovations that have the potential to address the problem.

Stage 3. Proof of concept

When the intellectual concept behind innovation is field-tested to gain an early, 'real-world' assessment of its potential.

Stage 4. Transition to scale

When innovations that have demonstrated small-scale success, develop their model and attract partners to help fill gaps in their capacity to scale.

Stage 5. Scaling

The process of replicating and/or adapting an innovation across large geographies and populations for transformational impact.

Stage 6. Sustainable scale

The wide-scale adoption or operation of innovation at the desired level of scale/exponential growth, sustained by an ecosystem of actors.

2.5. The challenges and research questions

Finally, we note that the six challenges and eight research questions were designed to span a range of different components of the system. Considering the challenges and research questions is therefore also helpful in determining what needs to be included in the system.

Having discussed systems and how they can be defined, we will now look at SMMR in more detail.

Chapter 3. Characteristics of systemic mixed-methods research

Building on the initial broad definition of SMMR in Section 2.1, we will now further define the notion of SMMR. The most important aspects of the characteristics of SMMR are:

1. **SMMR is systems research.** A system is explicitly the object of research in SMMR. SMMR research initially defines the system under investigation and amends the scope of the system under investigation as needed.
2. **SMMR is 'second generation' mixed-methods research.** SMMR encompasses traditional educational mixed-methods research (the mixing of qualitative and quantitative approaches), but embraces additional research approaches, such as design-based research.
3. **SMMR is reflexive.** SMMR considers the research programme (including all programme activities) to be subject to (reflexive) systemic mixed-methods research at the research-programme level. It considers the research programme itself as an integral part of the wider system research, typically employing design-based methods.

These characteristics are the most significant characteristics, setting SMMR apart from other types of research. We will discuss these in turn in the following three sections (3.1, 3.2, 3.3), followed by a number of additional characteristics that are important with regard to research on EdTech in lower-income countries.

3.1. SMMR is systems research

As we have noted above, the first innovation of SMMR is to consider SMMR as systems research. Further, this means that SMMR needs to have a clear idea of the system being researched. If the system definition is not appropriate, it can be amended explicitly.

↑Hennessy et al. (2020) note that systems thinking offers powerful approaches for addressing complex problems; such thinking challenges well-established

linear planning and measurement approaches, which favour the certainty of results and neat narratives or theories of change.

3.2. SMMR is 'second-generation' mixed-methods research

The second innovation for SMMR is the integration of 'traditional' mixed-methods research (e.g., ↑Bamberger, 2012;↑Creswell, 2013; ↑Johnson & Onwuegbuzie, 2004; ↑Tashakkori & Teddlie, 1998) with methods that fall outside the scope of traditional mixed-methods research.

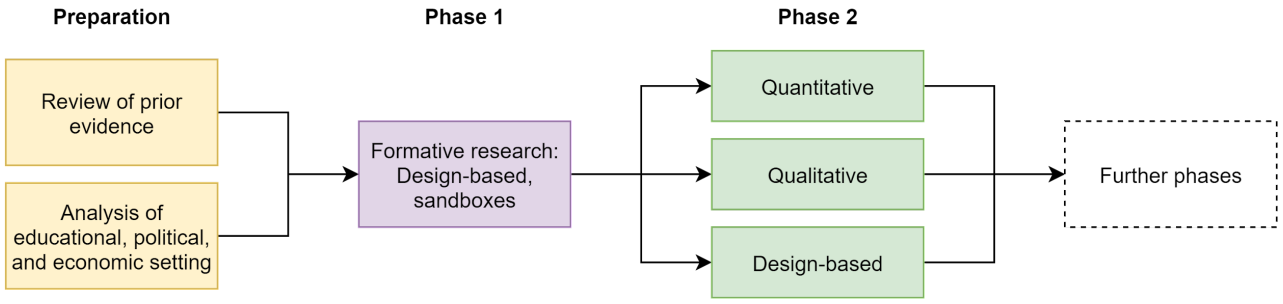
SMMR acknowledges the value of combining quantitative and qualitative approaches in order to appreciate both the scale of effects and understand the reasons behind observed phenomena. We use the phrase 'quantitative and qualitative approaches', rather than 'quantitative and qualitative data'. Combining different types of data is a limited view of mixed methods. Since qualitative data can be analysed both qualitatively and quantitatively in the same study, there is an argument that mixed-methods research does not necessarily require the raw data collected to be one type or the other, but instead able to be transformed into different types and analysed using both quantitative and qualitative approaches (↑Symonds & Gorard, 2010).

SMMR also acknowledges the value of design-based and lean approaches and integrates these into our mixed-methods approach. Therefore, it includes other approaches that are not traditionally included in mixed methods. In particular, specific classes of design-based and divergent approaches are incorporated, such as 'nimble' randomised control trials, case controls, political ethnography, intersectionality-based policy analysis, sandboxing, and cost assessments. In other words, SMMR proposes state-of-the-art mixed-methods research designs, which integrate quantitative and qualitative data with participatory and iterative approaches, as well as agile and lean approaches to research originated in the startup sector (↑Chang, 2018). Such approaches include:

- Theory of Change (↑Vogel, 2012);
- Outcome harvesting (↑Wilson-Grau, 2018);
- Network analysis (↑Wasserman & Faust, 1994);
- Techniques associated with adaptive management (↑Pasanen & Barnett, 2019);
- computationally-intensive approaches (such as geoinformation systems).

A particularly important aspect of the inclusion of design-based research is that small-scale formative work is used initially before progressing to larger-scale research. Looking ahead to Section 3.7 below on prior evidence, we may say that SMMR designs are always sequential mixed-methods designs overall (see Figure 9).

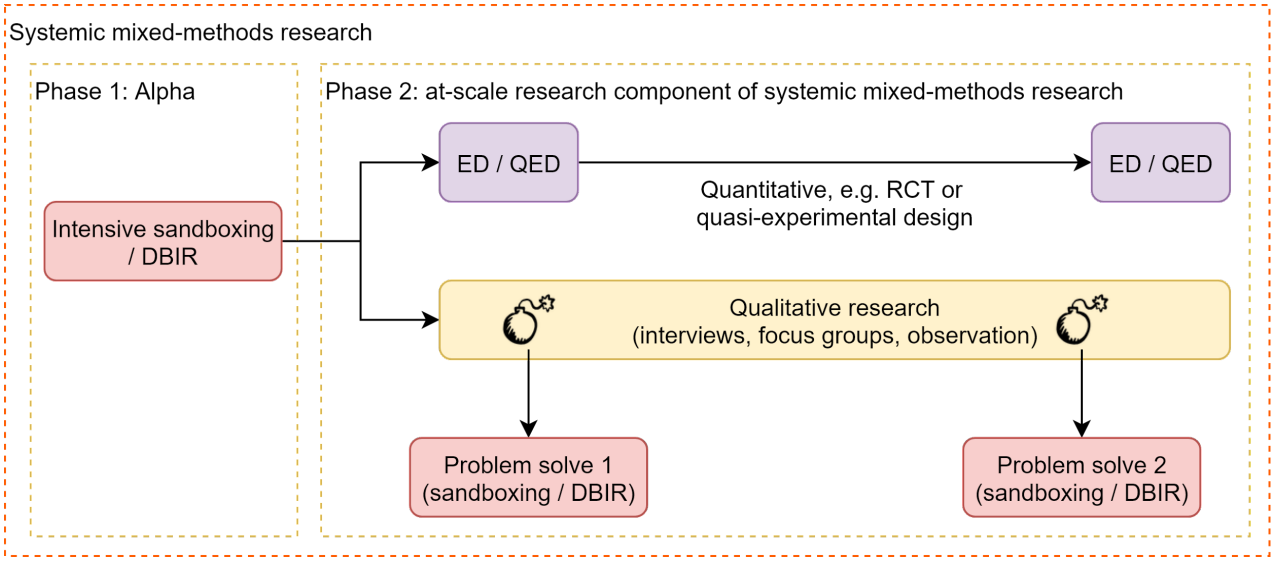
Figure 9. *First example of a simple sequential SMMR research design.*



Following an evidence review (Section 3.7) and depositing the initial draft of the research design into an archive (Section 3.9), the work progresses to Phase 1 (formative research), before other parallel or sequential approaches are used (Phase 2).

Figure 10 shows a further example of a simple sequential SMMR research design. A preparatory phase (not shown) and Phase 1 are identical to Figure 10. However, for Phase 2, additional detail has been added.

Figure 10. *Second example of a simple sequential SMMR research design, with reference to 'sandboxes' and design-based implementation research (DBIR).*

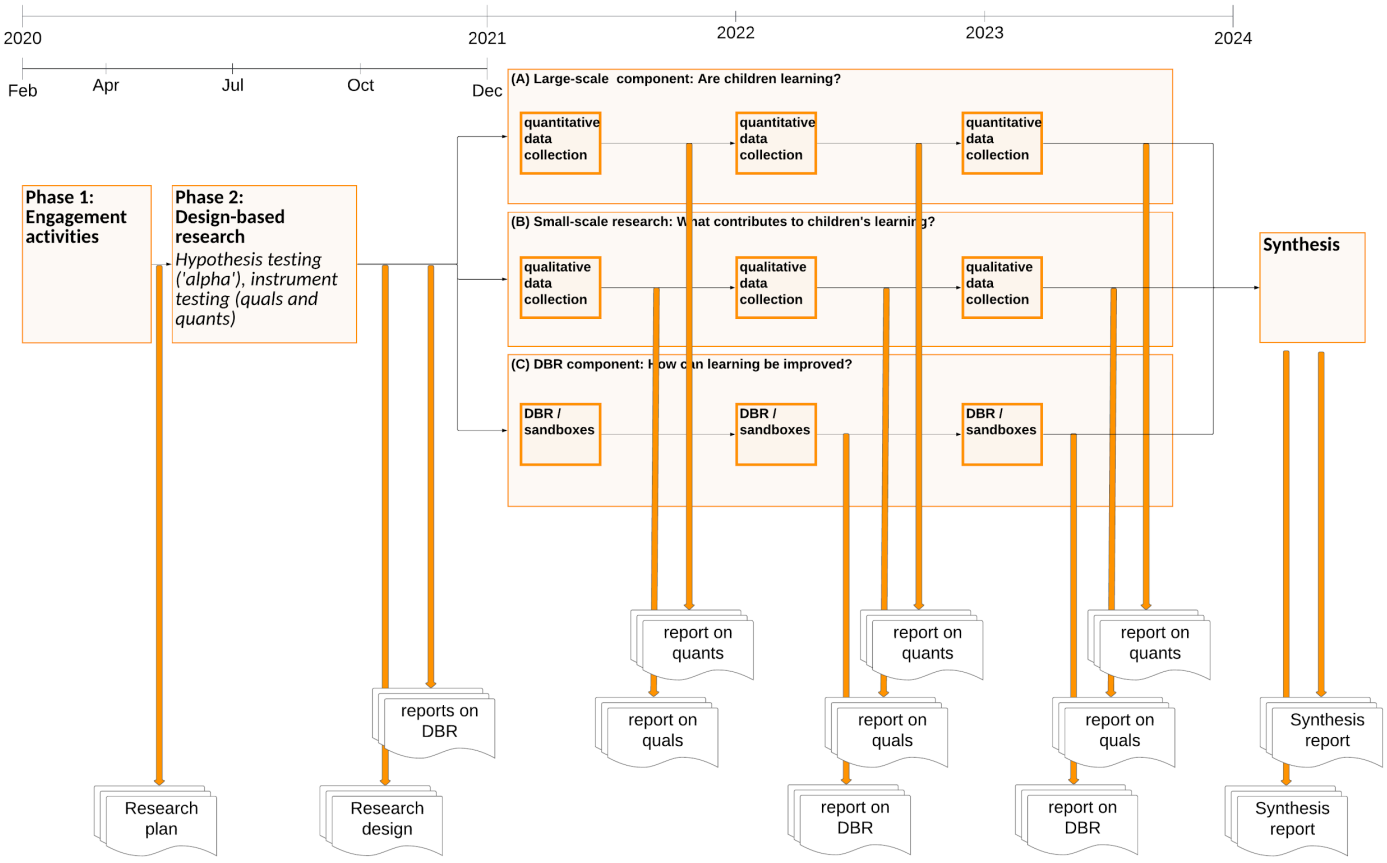


In Phase 2, a quantitative experimental design (e.g., an RCT) or a quasi-experimental design (QED) assesses learning outcomes (baseline, endline). The experimental design takes place in parallel with qualitative research (interviews, focus groups, observation, artefact analysis, etc). Sandboxes are used to troubleshoot issues that arise during Phase 2.

A more complex research design is illustrated in Figure 11. An initial Phase of engagement activities ('Discovery', see 3.8) is followed by Phase 2 of design-based research. This is followed by a multi-year, parallel, mixed-methods design. In Figure 11 we also show the outputs that could be expected from the design at various stages (cf. Section 3.9).

Finally, we note that there are important developments in mixed methods that have to be taken into account (e.g., ↑Gorard, 2007; ↑Symonds & Gorard, 2010), particularly with regard to understanding complexity (↑Poth, 2018).

Figure 11. *An exemplar SMMR research design, designed across four phases of increasing research scale (adapted from Haßler, 2018).*



3.3. SMMR is reflexive

Research designs are never entirely static. For example, 'instrument trialling' is usually part of implementing a particular design, and while it does not change the overall design or methods, it still affects details of the research implementation. Similarly, we sometimes speak of 'reflective researchers' — researchers who proceed with caution and consideration, rather than executing a rigid research design. Such ideas — already inherent in many research designs — are made explicit in the third conceptual advancement, namely the realisation that the 'system' includes the observer, i.e., the researcher.

Consider a programme — Programme A — focusing on the implementation of an intervention. Such a programme would not undertake research, but would have a 'monitoring and evaluation' component. Moreover, quite likely, a value-for-money assessment would be undertaken. Now consider the research programme B. The programme undertakes research, and the outcome of this programme is (ideally impactful) research. However, the research programme itself may not necessarily be evaluated. Now change perspective again and consider programme A —What if the intervention implemented by the programme was a piece of research? This precisely is the thinking behind SMMR — Undertake the research with a rigorous approach to evaluating how the research programme is performing. However, this evaluation should not be separate or inferior; instead, the functioning of the research programme becomes a reflexive research question (i.e., RQ7 above). We note that a related concept is multi-loop learning: The first loop being the research outcomes themselves, the second loop being what is learnt about the programme itself.

This reflexive research question is addressed through selected SMMR methods, e.g., employing design-based methods. Such thinking fully aligns with contemporary thinking about adaptive programme management. In the same way that adaptive programme management seeks to make programmes more efficient and effective, the reflexive element of SMMR seeks to increase effectiveness and efficiency — reducing costs and making research more rigorous, significant, and original.

The effect of adaptive management is to be able to 'pivot' the programme if necessary. The same is true for a research programme. SMMR acknowledges the changeability of relevance across systems. In doing so, SMMR constantly re-assesses design, implementation, and effectiveness in practice.

3.4. SMMR designs are driven by societally-relevant research questions

Having outlined three innovative aspects of SMMR in the above sections, we will now turn to a number of characteristics that are less innovative but equally relevant for research technology in education.

Characteristic 4 is that designs are driven by societally-relevant research questions. This means SMMR focuses on what *needs* to be researched, rather than what is *easily* (or feasibly) researched. Given the focus on EdTech in low-income countries, this means foregrounding equity, gender, and inclusion, always assessing the costs of interventions, engaging with the perspectives of multiple stakeholders and ensuring all designs are founded on a reasonable systemic perspective (written down in causal loop diagrams).

An interesting example of research that specifically targets marginalised populations is CONSORT-Equity in the health sector (↑Morgan et al., 2016; ↑Welch et al., 2017). Targeting marginalised populations in the context of research means considering effects on different population subgroups at risk of marginalisation (including, but not limited to, the following dimensions of marginalisation: disability, gender, poverty and conflict-affected). Simply conducting sub-group analysis by such dimensions of difference is not sufficient, and studies should incorporate equity considerations in their analytical frameworks, research questions, data collection, and analysis.

3.5. SMMR teams are inclusive and equitable

The fifth characteristic is that SMMR teams are inclusive and equitable. This is not just out of ethical considerations, but also because such teams will be better able to cope with the multiple challenges faced by the research team in executing high-quality research. SMMR teams value interdisciplinarity and have a broad range of members; they can include educators, school and district leaders, community members and government and particularly children and young adults. That is to say, children and young adults are not just research subjects but also participating stakeholders where appropriate, i.e., they participate in the research process (↑Lansdown, 2005; ↑Lansdown, 2009; ↑World Vision, 2014).

Teams operate as equitably as possible because SMMR is concerned with developing the capacity for sustaining change in systems. Often research teams have a 'high / low-income country' divide. In SMMR we stipulate that research teams are built with consideration for gender, anti-racism, and diversity and that they embrace difference and divergence for societal norms.

With the team, tasks are equally distributed; for example, all researchers participate in data collection and all researchers participate in data analysis. Similarly, credit for research outputs is distributed fairly. We note that it is important to not just aspire to inclusion and equity but to apply specific frameworks and metrics that make inclusion / equity measurable and verifiable (cf. Section 3.3 on reflexivity). For example, ↑Hankivsky's intersectionality-based policy analysis framework could be applied to advance equity within research programmes and research programming (↑Hankivsky, 2012; ↑Hankivsky et al., 2014; ↑Hankivsky & Kapilashrami, 2020).

3.6. SMMR is ethical

The sixth characteristic of SMMR is that it is ethical research. If SMMR is driven by societally relevant research questions (3.4), then it has to be ethical too. The rights and dignity of research participants, sponsors, the community of education researchers and the wider sector are taken into consideration. Legal and ethical research registration and application processes of the relevant country should be followed, with pre-registration of research outcomes and trials wherever possible. Adverse effects of the research on participants are safeguarded against, and also child-/participant-friendly reporting, and open access is mandated for all research output.

As outlined in Section 3.5, we need to be reflexive. Ethical risk assessment cannot only take place at the start of the programme, but needs to be a continuous process. Showing a clear awareness of the explicit risks associated with the research programme in question and how they are safeguarded against is critical. Risks need to be acknowledged, and concrete steps regarding efforts taken to counteract their impact are essential.

3.7. SMMR builds on prior evidence

The seventh characteristic of SMMR is that it avoids duplication of effort by building rigorously on prior evidence. This raises the question of what is

included in prior 'evidence'. Here, we include research that is considered rigorous by high-income country standards. However, no research evidence can be taken at face value, and even research that is regarded as rigorous needs to be critically evaluated. 'Prior' evidence does not just include evidence from primary research, but also from narrative reviews and meta-analysis.

However, many researchers consider that there is a significant gap between what the formal research literature reports and what can be found in the less formal /grey literature (↑Haßler & Adam, 2021, and references therein). SMMR, therefore, recognises a broad range of prior evidence, including informal reports. During the early phases of an SMMR programme (Discovery), the evidence needs to be validated through interviews and focus groups.

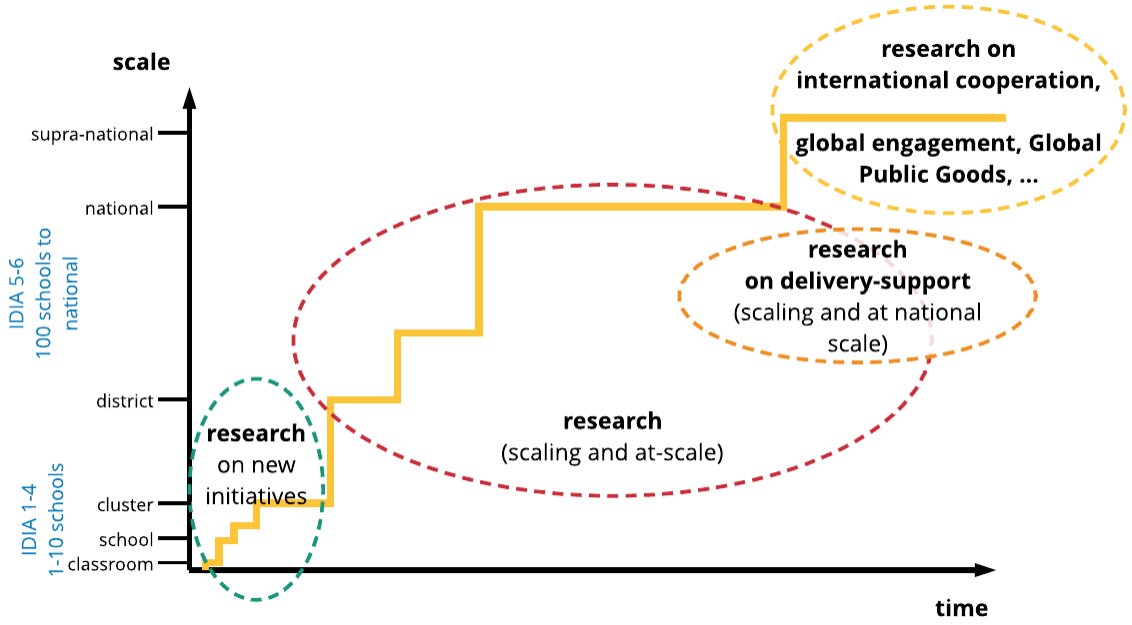
3.8. SMMR is dynamically iterative and uses agile service design

The eighth characteristic of SMMR is that it is iterative and employs an agile service-design approach ('discovery-alpha-beta-live'), which makes SMMR robust and flexible, ranging from small-scale pilot studies to engagement with full educational systems at the national or global regional levels.

Figure 12 below illustrates different scales at which EdTech implementation programmes operate. This has important consequences for how research is organised. Initially, at smaller scales (IDIA Scale 1–3; a few classrooms or a few schools), certain types of research (such as design-based research or design-based implementation research) are the most appropriate, as they help initiatives refine their approach and scale.

The initiative then scales (IDIA Scale 4–5; district level, 100 schools). Importantly, from an education research perspective, these scales open up the possibility for (quasi-)experimental approaches, for example in the form of cluster-randomised control trials. However, even at a national scale, there are a range of opportunities, including research on delivery support, research on international cooperation, political economy, etc (Figure 12).

Figure 12. *Approximate scales of time and national education systems at which different phases of SMMR can operate.*



The approaches above have been introduced as scales for interventions and they are commonly used as such. However, they are significant in SMMR, for a number of reasons. First, in undertaking SMMR, we need to be clear at which scale we are operating and draw on appropriate methods. Second, we can easily see how SMMR would scale alongside interventions (see Figure 12). However, even where an intervention is at scale already, SMMR still needs to secure the initial stages, particularly if prior evidence may not represent a full picture (3.7).

3.9. SMMR is open and transparent

There is significant evidence that open access research reduces costs (↑Manyika et al., 2013) and that open data contributes to economic wealth (↑Lateral Economics, 2016). It could also be said that other sectors (such as the humanitarian sector) are ahead of the education sector in adopting open data (↑The Humanitarian Data Exchange).[4] For example, geospatial data—as well as data sharing and collaboration—is well established in the humanitarian sector,

[4] https://humdata.org

but despite a number of programmes in this area, it remains on the fringe of education planning and associated research (↑Humanitarian OpenStreetMap Team).[5]

The ninth characteristic of SMMR is that all outputs of SMMR are Global Public Goods.

3.9.1. Global Public Goods: The three freedoms

In the definition of Global Public Goods, we follow the concepts of the three freedoms (↑Haßler & Mays, 2014).

Legal freedom. SMMR outputs are openly licensed. For reports (and other copyrightable works) SMMR uses Creative Commons licenses (Creative Commons Attribution). Similarly, all data is open data (Open Data Commons licenses), unless this is not possible due to privacy or security concerns.

Technological freedom. The second freedom is technological freedom, which enables users to exercise legal freedom. This means that, for instance,

- Outputs follow accessibility standards;
- Outputs are formatted so that they can be easily accessed and downloaded;
- Programme websites are low-bandwidth so that they are accessible by all stakeholders and the general public (cf. Section 3.5);
- Outputs are identifiable and discoverable, for example through the inclusion of Digital Object Identifiers (DOIs) as well as hosting documents with appropriate metadata to improve discoverability.

For further details on technological freedom in relation to the publishing of documents, see ↑Haßler (2018).

Freedom to collaborate. The third freedom is the freedom to collaborate. This means forming equitable and inclusive teams (cf. Section @3.5). It also means that information about the research programme is transparently available from day one so that others can make informed decisions and eliminate duplication. This means that research designs need to be pre-registered. For example, it would be unacceptable for randomised control trials in health to not be

[5] https://www.hotosm.org/

pre-registered. However, in education, typically large-scale (quasi-)experiments (including randomised control trials and other evaluations) are not registered.

3.9.2. Research outputs

The three freedoms broadly apply to programme outputs, which raises the question: what constitutes a 'programme output'? We normally associate outputs with formal publications or reports. However, outputs also include primary data. For example, the ↑DFID Ethics Principles for Research and Evaluation (2011; Principle 8, Publication and Communication, p. 2) states that, "Where possible, and respecting confidentiality requirements, primary data should be made public to allow secondary analyses."

Naturally, personal data and otherwise sensitive data is protected: It is not disclosed in research unless respondents have given specific consent. Such data needs to be anonymised by removing direct and indirect identifiers, reducing the precision or textual meaning of a variable, and removing relational and geo-referenced data.

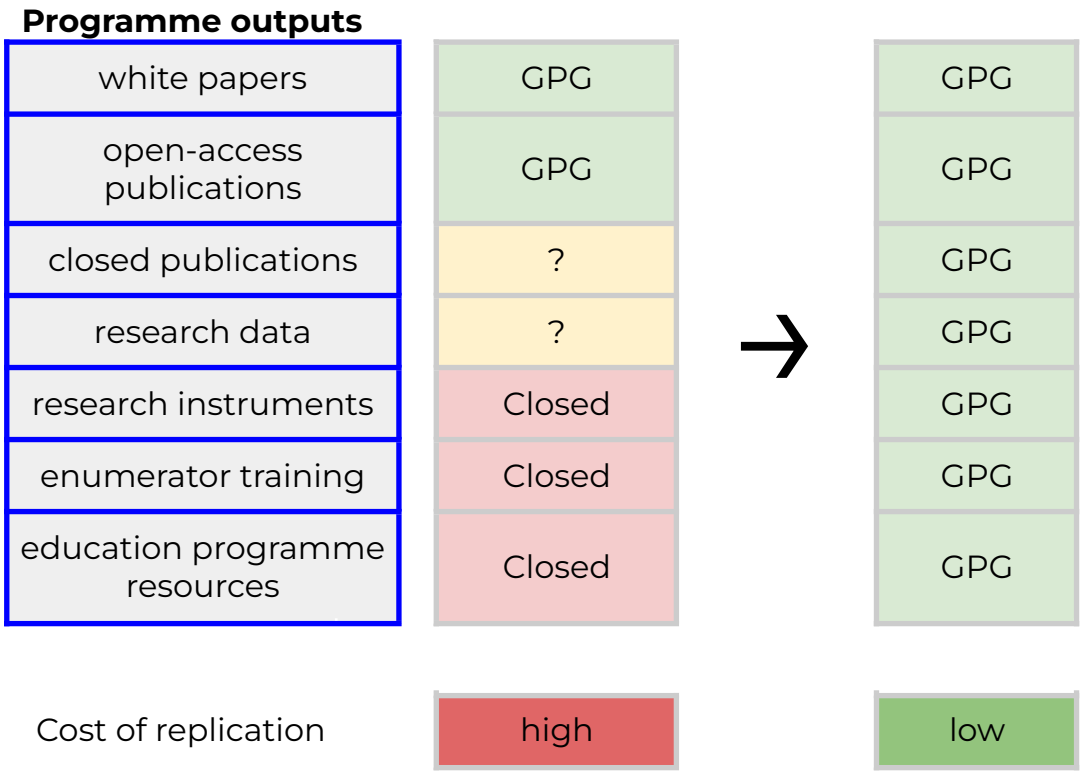
The ↑DFID Research Open and Enhanced Access — Implementation Guide (2013) guide takes a broad view as to what constitutes valuable and useful outputs; the policy employs "*a broad conception of useful outputs [based on the] value and use to others.*"

The 'open research' narrative of the ↑Research on Open Educational Resources for Development (ROER4D)[6] programme may provide further inspiration in formulating open access policies.

In SMMR, such outputs that are useful to others are deemed to include research instruments, process documents, economic details of implementing specific research methods, training materials for enumerators and accounts of any challenges encountered, as well as risk management documents. Making such outputs enables full or partial replication and follow-up studies. It also allows for an independent assessment of how research can be made more effective and efficient. Figure 13 compares research outputs that may be open in usual research programmes with the outputs that are open in SMMR.

[6] https://zenodo.org/communities/roer4d

Figure 13. *Global Public Goods (GPGs) associated with research programmes.*



3.9.3. Openness in practice

An open and transparent approach also means that all trials are pre-registered. This is common practice in other fields, such as health, for example, in the effort of '↑All Trials Registered. All Results Reported'[7] and the ↑Cochrane Reviews (↑Higgins et al., 2020).[8] However, in education, or indeed EdTech, this is often not the case.

In systemic mixed-methods research, all trials are pre-registered.

We also noted that all data should be made available publicly. Likewise, the resulting publications should be made publicly available for public, peer, and community review. Reports and papers are published as publicly accessible preprints, as soon as they are available. We note the importance of failure (of research methods and EdTech interventions) and the importance of negative

[7] http://www.alltrials.net/
[8] http://www.cochranelibrary.com/

outcomes for sector advancement. Multi-year programmes publish interim findings.

Publicised documents also include methodology frameworks—such as the systemic mixed-methods research framework—and the reflexive feedback on lessons learned by researchers. It should, of course, be acknowledged that this is far from a simple process for national education systems to achieve. However, a large part of the success of SMMR relies on this.

Open data policies and regulations for large-scale capturing and use of school data in this manner should be discussed, critiqued, refined, and implemented. There is a dual relationship. On the one hand, it is important to have a robust data policy and rules and regulations to ensure the SMMR approach can be undertaken in the first place. On the other hand, SMMR informs data management protocols to make them more flexible over time. This dual relationship needs to be acknowledged, and there is scope for future research to connect SMMR and global data management practices.

Finally, we need to acknowledge that there may be a tension between early open access and the requirement of top quality journals to be exclusive. Researchers may want to retain ownership of datasets for their own future exploitation. While a stepwise release of datasets would be natural, it is important that release of data and publications are not delayed.

We have already noted the important societal contributions open data makes (↑Manyika et al., 2013; ↑Lateral Economics, 2016) and noted open access policies in the sector (↑DFID, 2013). For systemic mixed-methods research, the generation of high-quality Global Public Goods is the primary goal. We also note that, e.g., in the UK ↑REF, the notion of 'high quality' does **not** rely on journals and impact factors:

> *"No sub-panel will use journal impact factors or any hierarchy of journals in their assessment of outputs. No output will be privileged or disadvantaged on the basis of the publisher, where it is published or the medium of its publication* (↑REF, 2019, p.42)."

Therefore, we contend that the practices of open access are not in conflict with (at least some) academic practices, while open access brings significant gains for international development. We will revisit these issues in ↑Haßler et al. (2021q).

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This bibliography is available digitally in our evidence library at https://docs.edtechhub.org/lib/TD2ASC4G

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