Department for Education

EdTech Quality Frameworks and Standards Review

DfE Quality Characteristics Project

(ref: PQFFSR)

December 2023

Authors: Dina Foster, Caitlin McLemore, Brandon Olszewski, Ali Chaudhry, Ekaterina Cooper, Laurie Forcier and Rose Luckin

Contents

List of Figures

Executive Summary

Primary aim

The primary aim of the Frameworks and Standards review is to document the strength of the evidence base against sector-led standards and frameworks for EdTech product quality and provide a single view of the evidence base to inform the design of a framework for the English system.

Background

Currently, in England, there is no universally agreed framework or standard that facilitates the evidenced-based judgement of what constitutes a high quality, effective EdTech product. In the absence of an evidence-based method to differentiate EdTech product quality, there is no clear guidance, grounded in pedagogical evidence, regarding desirable criteria or quality characteristics to look for when selecting EdTech products and tools. The Department for Education white paper, “Opportunities for all: strong schools with great teachers for your child”, published in March 2022, outlined the ambition to support innovation in schools and leverage the benefits of educational technology. A commitment to establishing a strong evidence base for the effective use of EdTech will allow schools to leverage the benefits of technology and inform decision-making.

Research methodology

The methodology adopted is a rapid exploratory review of existing frameworks and standards, drawing on the research consortium’s expertise in EdTech, academic research and education, to conduct a rigorous and thorough evaluation of quality components for effective design and pedagogical implementation of EdTech. This review seeks to establish a shared understanding of what constitutes “good quality” EdTech and “good quality” implementation. Expert panel feedback informed the development of relevant research questions around identifying successful components and characteristics of EdTech design and implementation as represented across existing frameworks. Academic literature and grey literature were searched to identify 74 frameworks for review. Frameworks were considered and evaluated in terms of quality characteristics, the (intended) role of the framework in the EdTech ecosystem, and features of the framework itself such as audience, motive, usability, and validity.

Overview of frameworks

Following the analysis, frameworks and standards were organised into six overarching themes: Strategic Implementation, Digital Pedagogy, Digital Competence, Evaluation Frameworks, EdTech Design and Quality of Evidence. The interrelatedness of the different themes within the implementation of EdTech explains significant overlap as many frameworks address more than one aspect of implementation and/or design. Educational technology is a rapidly advancing and evolving field, and the distribution of frameworks and standards by date shows the majority were either created in the last 8 years or have been updated within that period. Low levels of transparency and detail about research underpinning the creation and validation of frameworks make it difficult to ascertain the extent to which existing frameworks and standards are evidence-based. Consensus across the frameworks and standards identified some key components for quality design of EdTech products and the importance of strategic implementation of educational technology at a school level.

Quality components of EdTech design

Analysis of existing frameworks and standards identified some key characteristics, quality components, essential conditions and evaluation criteria for the design and implementation of EdTech. These were synthesised into four commonly agreed overarching quality characteristics of EdTech product design:

- EdTech products should meet the needs of its users
- EdTech products should enable and support digital pedagogy
- EdTech products should develop digital competence for learners and teachers
- EdTech products should adopt an evidence-informed approach

These key components of quality EdTech are represented in Figure 1 which also provides an overview of the sub-elements of each characteristic.

Quality EdTech products meet users' needs

EdTech developers should inform the design and development of EdTech products through a research-based approach and user-centred design. Quality EdTech product design should focus on understanding the existing educational ecosystem and real-life user needs. This is consistent with findings of a rapid literature review of quality characteristics of EdTech which highlighted how the careful consideration of EdTech product design can facilitate successful outcomes for learners and reduce teachers' workload. Other quality characteristics include enabling access and inclusion through

EdTech products, and using learning sciences research and pedagogical best practices to inform design and align learning activities with the curriculum and wider learning goals.

Quality EdTech products enable digital pedagogy

Quality components in this category highlighted the interconnectedness between pedagogical best practices and EdTech design. There was a consensus that EdTech is best designed by considering the ways in which it can extend and transform the teaching and learning experience to support traditional pedagogical methods. Many frameworks in this category also recommended new approaches to learning supported by EdTech products such as a shift to authentic, personalised and student-centred learning that engages and motivates learners. Interactivity, personalisation and improved learner engagement though the use of EdTech tools were identified in a rapid literature review of quality characteristics of EdTech as features that could enhance learner outcomes.

Quality EdTech products develop digital competences

Quality EdTech design considers how to support the development of learner competences such as digital literacy and helps to prepare learners for living, learning and working in a digital world. As well as designing for the achievement of specific learning goals, developers should consider how an EdTech product might develop and support a range of transferable digital skills. For example, specific skills and features of digital competence include digital creativity, which can be supported by providing learners with the opportunity to become digital creators. Learning activities that encourage problem definition, information curation, solution design, and collaborative interaction provide additional elements of digital pedagogy that can increase student digital literacy. Digital competence frameworks emphasise the importance of helping teachers to improve their expertise and knowledge by providing opportunities for professional development and facilitating use of EdTech-generated data and insights.

Quality EdTech products adopt an evidence-informed approach

The design of quality EdTech products should be driven by a research mindset with decisions and design processes underpinned by evidence and research. EdTech products that adopt an evidence-informed approach offer reassurance about the quality components of a potential EdTech solution and facilitate the evaluations undertaken by schools. By understanding the importance of evaluation and evidence for schools, EdTech developers can prepare for and respond to evaluative processes and share evidence that supports the existing or potential benefits of their EdTech product. Developers should iterate EdTech design using feedback, data and collaboration with users.

Evidence quality frameworks

Review of evidence quality frameworks revealed that standards that specifically address determining the quality of evidence in EdTech are limited. However, more generic evidence standards are also being applied to EdTech research to inform decision making. Evidence quality frameworks offer standards and criteria for categorising research from most to least rigorous as a proxy for highest to lowest quality, although the application of narrow criteria can exclude valuable research from consideration. Across evidence quality frameworks, there is consensus around what constitutes robust causal evidence, and hierarchies of evidence determined by characteristics of research study design and the extent to which impact and effect can be attributed to the intervention of an EdTech product.

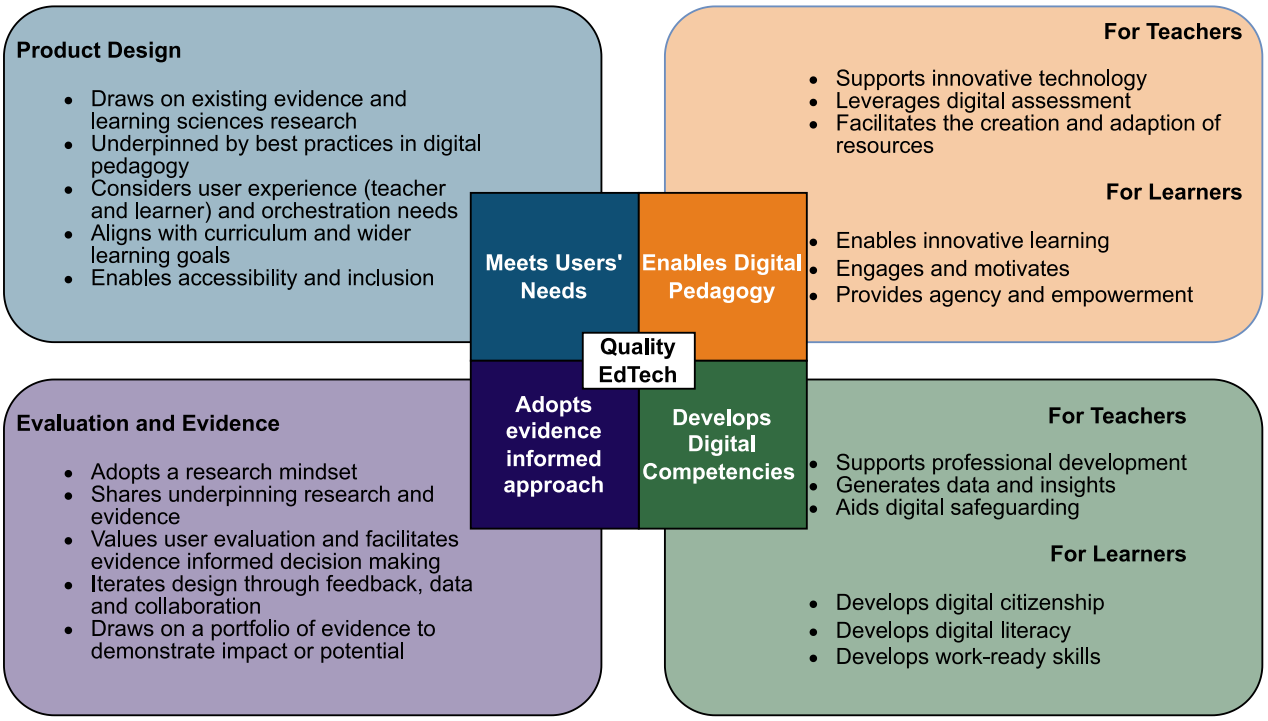
There is no consensus around the definition of highest-quality judgements as the differentiating factor between the top levels of evidence varies between frameworks, with some prioritising context over methodological considerations such as scalability or sample size.

Quality of Evidence recommendations

The paucity of frameworks that focus explicitly on educational technology with respect to evidence quality, combined with the lack of consensus around the markers of the highest levels of evidence, makes it difficult to recommend a single approach for determining quality of evidence. Adopting a more inclusive approach to gathering evidence allows for the inclusion of a variety of relevant and useful research to provide a coherent picture of the intervention or innovation. Evidence should be considered in relation to the question being asked of the research, not just "Does it work?", but "How and why does it work?" and "Will it work for us?".

Considering this, we recommend a focus on the extent to which EdTech product design is underpinned by research and evidence grounded in the learning sciences. There is value in the use of evidence portfolios that allow an accumulation of varying types of evidence, encouraging and enabling an individualised approach to evidence-informed practice and decision-making whilst still acknowledging established hierarchies of evidence when seeking evidence of causality. An EdTech product should build up an evidence portfolio as it progresses through the evidence quality spectrum beginning with a minimum requirement of research-informed design.

Figure 1 - Overview of quality components of EdTech product design



Overview

The work reported here is a project commissioned by the DfE: a Frameworks and Standards review (ref: PQFFSR) which is supported by a rapid literature review. The primary aim and objective of the Frameworks and Standards review is to document the strength of the evidence base against sector-led standards and frameworks for EdTech product quality relating to design and development and provide a single view of the evidence base to design a framework for the English system.

Expert Panel

To broaden and strengthen the expertise applied to this project, we recruited a panel of 6 experts from within the field of educational technology, who formed an expert advisory panel for this project (a list of panel members is in the appendices). The panel was involved in the critique and feedback upon the formation of research questions, definitions, and parameters of the research project in addition to making recommendations for resources for the inclusion in the frameworks and standards review. Furthermore, the majority of the panel participated in an adaptive comparative judgement activity to make judgements about the quality of evidence in selected papers regarding the literature review. These judgements informed the analysis undertaken of quality standards and frameworks reviewed in this project.

Transparency

The recruitment of an expert panel also helped to safeguard the impartiality of this report by providing additional scrutiny and challenge. In the interests of transparency, we would like to share the following declarations. Expert panel member Natalia Kucirkova (Associate Professor, University of Stavanger, Norway and Open University, UK) is the CEO of WiKIT which features in the report. Professor Rose Luckin (UCL) is the founder of EDUCATE Ventures Research which features in the report. The not-for profit organisation the International Society for Technology in Education (ISTE) created the Teacher Ready Framework, the ISTE standards, the ISTE essential conditions and the ISTE Seal of Alignment, all of which feature in the report.

Background

The Department for Education white paper, “Opportunities for all: strong schools with great teachers for your child”, published in March 2022, outlined the department’s ambition to support innovation in schools and leverage the benefits of educational technology. A commitment to establishing a strong evidence base for the effective use of EdTech will allow schools to leverage the benefits of technology and inform decision-

making. Currently in England there is no single framework or standard that facilitates the evidenced-based judgement of what constitutes a high quality, effective EdTech product. In the absence of an evidence-based method to differentiate EdTech product quality, there is no clear guidance, grounded in pedagogical evidence, regarding desirable criteria or quality characteristics to look for when selecting EdTech products and tools. Through the exploration of existing frameworks and standards, it is the aim of this review to identify commonly agreed quality components for the design and implementation of educational technology and indicate which frameworks, or parts of frameworks, are suitable for inclusion in a DfE approved framework for England.

Methodology

The methodology adopted and described below is a rapid exploratory review of existing frameworks and standards, drawing on the research consortium's expertise in EdTech, academic research and education, to conduct a rigorous and thorough evaluation of quality components for effective design and pedagogical implementation of educational technology. Whilst these two areas are undoubtedly linked, our extensive expertise across both of these fields tells us that existing frameworks are largely either school-facing or designed for EdTech companies and as such may contain different quality components accordingly. However, this review seeks to combine the two in a shared understanding of what constitutes "good quality" EdTech.

Brief outline of methodology workflow

1. Methodology, inclusion/exclusion criteria, definitions and research questions provided to expert panel for feedback.
2. Following a review of the methodology:
    a. Search and skim of journal articles for EdTech implementation frameworks & design standards.
    b. Hand searching of grey literature for Edtech implementation frameworks & design standards incl. panel recommendations.
    c. Snowballing research sources
3. Selection of existing frameworks/standards/guidance for EdTech design and EdTech implementation (in schools).
4. Analysis and synthesis of frameworks/standards & quality criteria to identify common features and role of evidence.
5. Using additional evidence from a rapid review
    a. Identification of common characteristics of existing frameworks.
    b. Identification of gaps and inconsistencies in existing frameworks.

   Mapping of existing frameworks landscape & evaluation of quality of frameworks/standards using quality evidence criteria

Research questions

1. What frameworks/standards and quality criteria exist for the design and development of EdTech products?
2. What evidence underpins the frameworks/standards?
3. What are the commonly agreed quality components of EdTech design within existing frameworks (in terms of both content and design)? And what are the gaps?

4. How has evidence informed the development of frameworks/standards?
5. What forms of evidence are used?
6. How is quality defined/represented?

Identification of frameworks

Existing frameworks were identified through a combination of searching approaches to enable a full and wide-ranging exploration of frameworks and standards on an international scale. Search approaches included scholarly sources using relevant search strings, hand searching of grey literature, and a snowballing approach to supplement.

The first stage was to search the literature to identify frameworks referenced in academic journals and conference proceedings. An initial string was run to gauge the number of relevant papers using this searching technique. The search string “EdTech” AND “frameworks” OR “standards” produced 171 results (115 were identified using UCL Discover and a supplementary search using Google Scholar identified a further 56 journal articles). Skimming for relevance resulted in the selection of 65 papers identified for further reading. Close reading selected 24 papers that discussed or proposed frameworks or standards for the implementation or design of educational technology.

The second stage of searching and selection was the hand searching of grey literature using the DfE Implementation of EdTech in schools and colleges (September 2022) as a starting point. Drawing upon the research team’s knowledge of the EdTech ecosystem and following up on expert panel recommendations, hand searching continued.

Finally, the research team employed a snowballing approach to supplement the frameworks and standards already identified. This allowed the research team to follow up on any relevant organisations, additional frameworks or evidence criteria discovered through the literature search and hand search sources. This ensured a wider and more exhaustive exploration of resources in the field.

Inclusion criteria

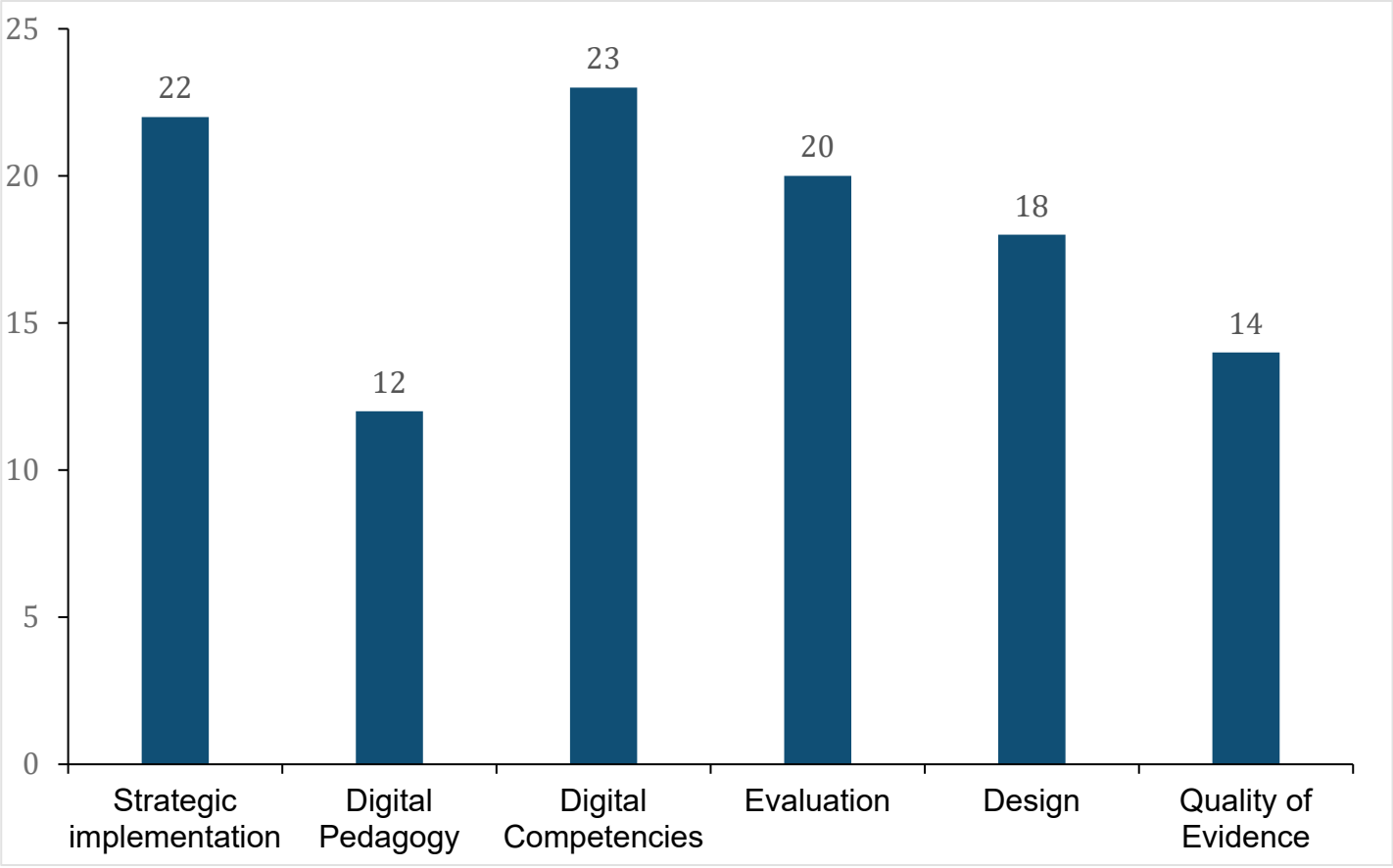
To narrow the scope of the search it was decided to select frameworks within the period 2000 to 2023 and available in English. Frameworks with an intended audience of either educators (including school leaders) or EdTech developers (including designers) were selected. To select frameworks from digitally mature countries, the OECD Education Innovation Index was used when selecting frameworks and standards to review. In particular the ICT innovation rating compared to OECD average was used. The

researchers acknowledged that the Index covers a period of ten years between 2006 - 2016 and undoubtedly much will have changed due to disruption of COVID-19, however, it is assumed that countries that were already advanced prior to the pandemic will have continued to develop and benefit from already having a greater developed infrastructure when faced with the challenges presented by COVID-19. The UK received a higher than OECD average score for computer availability (53 v 39), but only an average ICT innovation rating (33). Where appropriate, frameworks and standards selected for review were from countries with a similar or superior rating to the UK for its ICT innovation rating. Where there was doubt as to whether to select a framework, the decision was taken to prioritise frameworks from countries with education systems that most closely resemble the English school system.

Overview of frameworks

In total, 74 frameworks were selected for inclusion in the final review. Drawing on the work of Cherner & Mitchell (2021), during analysis, the research team framed consideration and evaluation of the frameworks in terms of features such as audience, usability, validity and motive. Other considerations included content-related quality characteristics, and the (intended) role of the framework in the EdTech ecosystem. The review of existing frameworks for the implementation and design of educational technology revealed many areas of focus, and there was a high level of consistency in their key components. The frameworks themselves varied in terms of the level of detail provided or the area of focus within a broad and ever evolving educational technology ecosystem. Thematic coding and analysis revealed key components and features of the frameworks and standards which were synthesised into six overarching themes: Strategic Implementation, Digital Pedagogy, Digital Competence, Evaluation Frameworks, EdTech Design and Quality of Evidence. Smaller frameworks or frameworks with a narrow focus tended to fall within one of the overarching themes whilst other larger, more ambitious frameworks addressed a wider scope of educational technology implementation and design and therefore a number of frameworks spanned two or more of the themes.

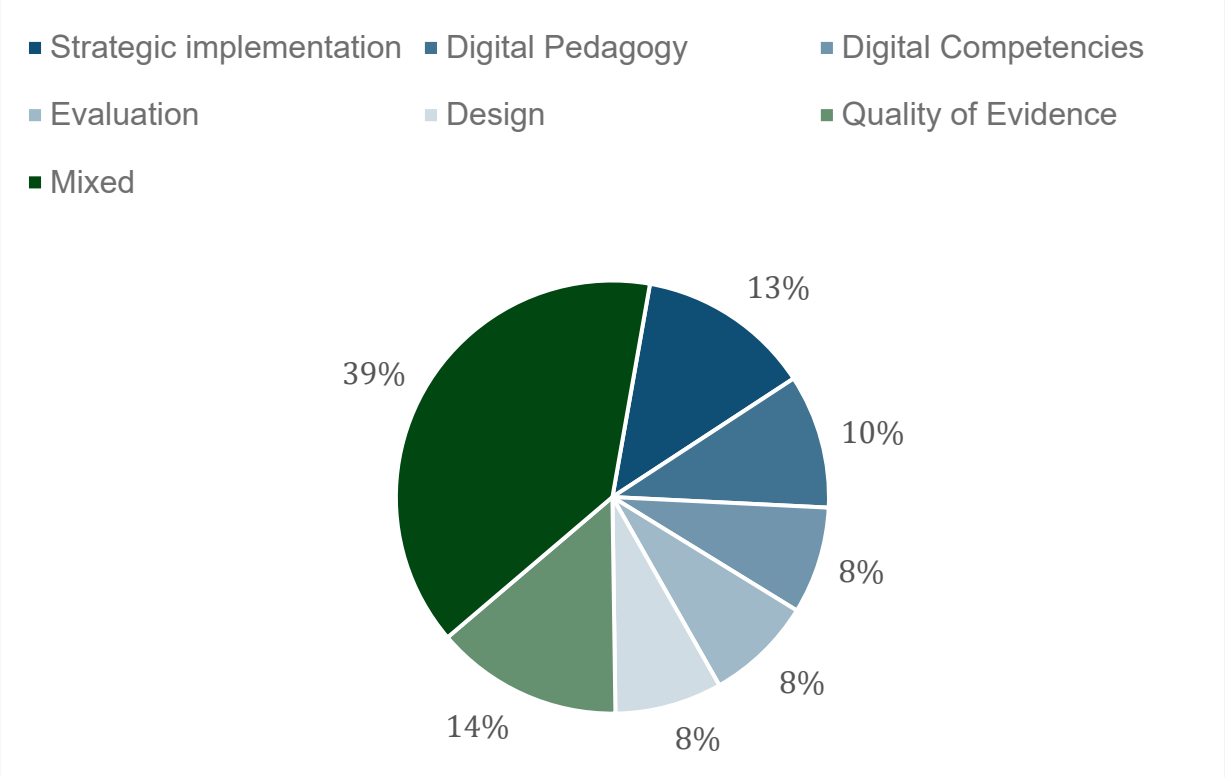
Figure 2 - Distribution of frameworks and standards by themes



The themes of strategic implementation and digital competence benefit from the most coverage across the frameworks and standards reviewed. Whilst the theme of evaluation features in many frameworks, it is often in the content of establishing the importance of evaluation as a strategic undertaking and less often as a practical framework to support the design of evaluative processes.

Figure 3 shows the distribution of the frameworks in terms of their focus on single or multiple themes. The interrelatedness of the different themes within the implementation of EdTech inevitably leads to significant overlap as many frameworks address more than one aspect of implementation and/or design.

Figure 3 - Frameworks and standards addressing singular themes



The distribution of frameworks and standards by date in Figure 4 shows the majority were either created in the last 8 years or have been updated within that period. Educational technology is a rapidly advancing and evolving field and as such recent frameworks are perhaps more applicable to current learning environments, particularly in the wake of the COVID-19 pandemic. That is not to say that older frameworks are not valuable. A small number of the frameworks and standards identified were later discovered to be legacy frameworks as the institutions and organisations that created them no longer existed or had been subsumed by other organisations. Whilst they might not be in active use, these frameworks still allowed us to identify common characteristics and components.

Figure 4 - Frameworks and standards distribution by date

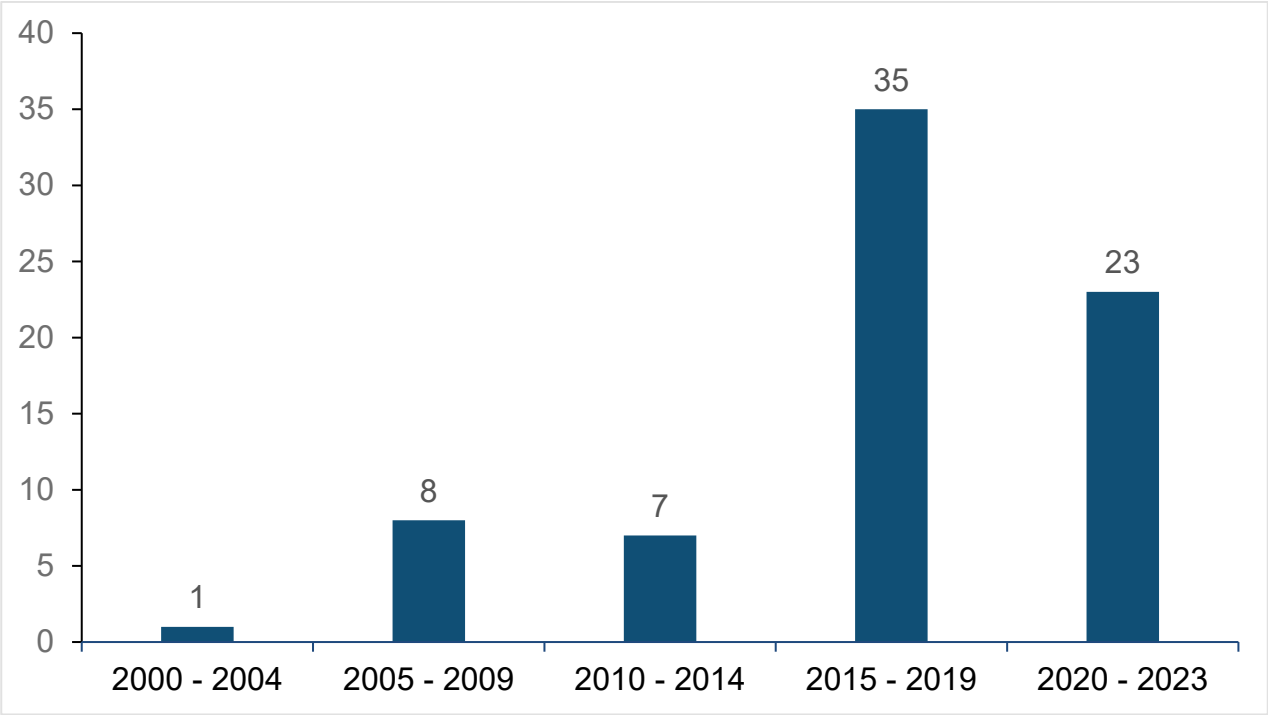
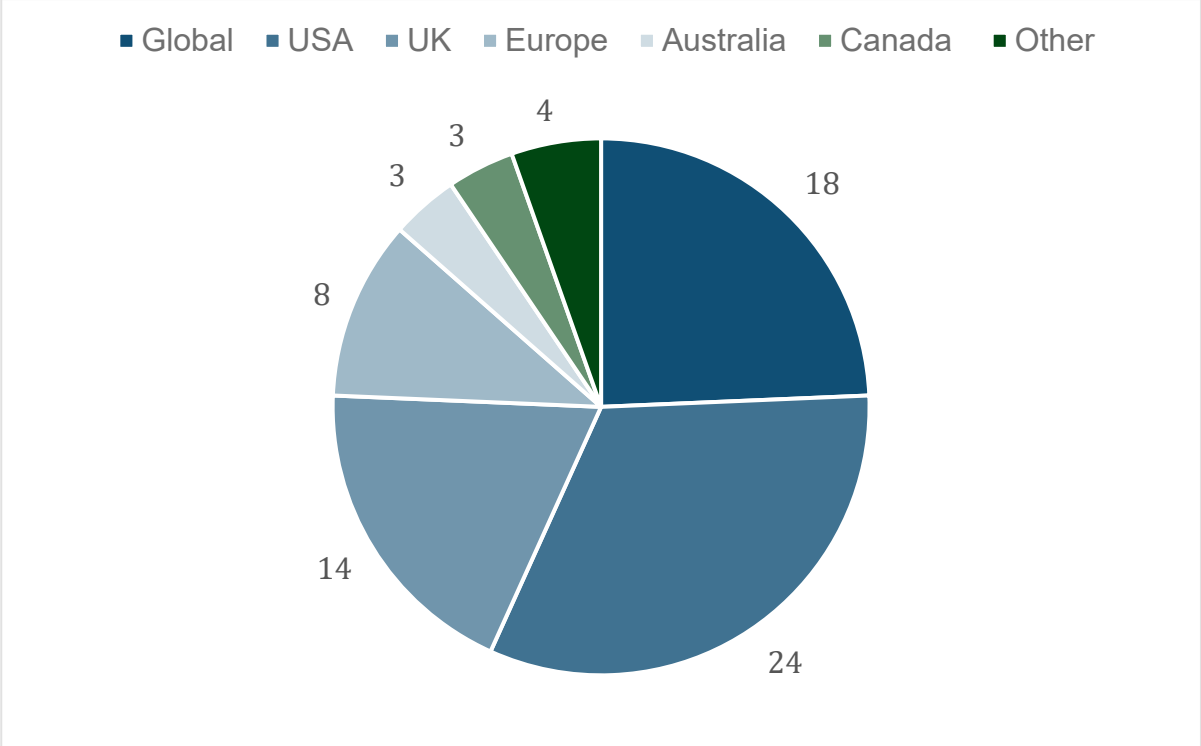


Figure 5 - International distribution of frameworks and standards



Hand-searching identified a number of frameworks and standards that were not included in the review because they were not in English. This is a factor when considering the

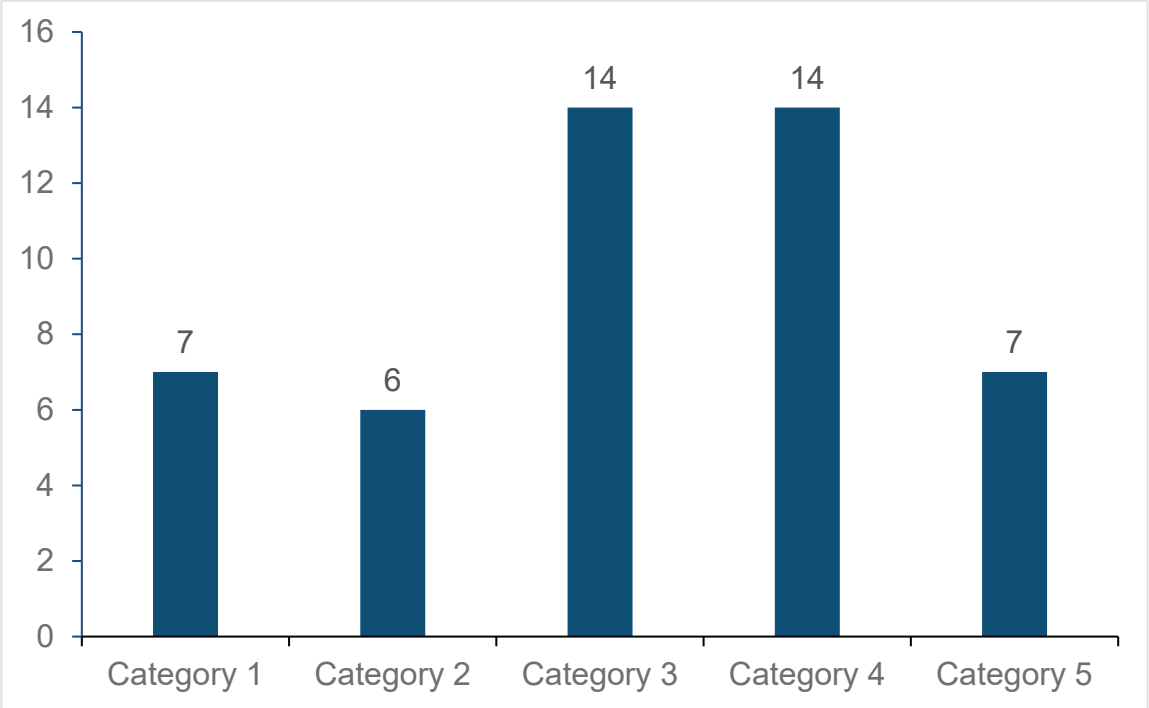
international distribution of the reviewed frameworks that form the basis of this report. eEducation Austria gives an in-English overview of a 3-pillar concept of digital competences, course development and organisation development to support digital education but the frameworks it provides are not available in English. The Netherlands and Croatia also have digitisation strategies and guidance that are excluded from this review for the same reason.

The role of evidence in framework development and validation

Identifying the evidence underpinning the frameworks selected for review was challenging as many frameworks did not share this information in any kind of detail or offered up generic statements claiming that that frameworks were created by experts and were evidence-based without providing supporting evidence for these claims. Some frameworks however provided more detail about the creation of the frameworks and broadly the role of evidence can be categorised as firstly; informing the design and development of a framework and secondly, in a small minority of cases; validating the usefulness of the framework. Several frameworks referenced other frameworks as fundamental to their development or built on the progress of existing frameworks. In a small number of cases, frameworks referred to accreditation and use of their frameworks by organisations as an endorsement or quality and credibility. Figure 6 shows the distribution of the frameworks according to the level of supporting evidence shared about the development and efficacy of the framework. Frameworks derived directly from academic studies have been excluded and so this shows the distribution of frameworks created by organisations drawing on research. Rather than making judgements about the quality of evidence underpinning the frameworks, the nature, detail and volume of evidence provided is taken into account.

- Category 1: Frameworks with no reference to underpinning evidence.
- Category 2: Frameworks that made claims of being 'based on research' or 'developed with educators' but offered no further detail.
- Category 3: Frameworks that included some detail about collaboration with named organisations or underpinning with existing research, frameworks, standards or certification.
- Category 4: Frameworks that provided some methodological detail about the evidence that underpins the development of the framework. For example, detail about sample size, 'rich and detailed discussions with 500 individuals from over 100 organisations', or specifying methods adopted or theoretical foundations.
- Category 5: Frameworks that were transparent and shared their methodology, such as data collection details, landscape analysis, and participant detail as well as underpinning principles framework design and undertaking pilot projects, and market validation of the framework.

Figure 6 - Distribution of supporting evidence underpinning organisational frameworks



There is an apparent effort to share the evidence underpinning EdTech implementation and design frameworks however Figure 6 shows that this is undertaken with varying degrees of detail. This distribution does not indicate the extent to which frameworks are underpinned by evidence but the extent to which that evidence is clearly shared with users.

Strategic implementation of EdTech

As documented in the Overview of Frameworks, many existing frameworks or standards relate to the strategic in-school implementation of EdTech. These frameworks are primarily aimed at school leaders and identify key conditions such as:

- Establishing a shared vision and goal-setting
- Creating a detailed and systematic implementation plan
- Evidence-based decision making processes
- Considerations for infrastructure (e.g. cost)
- Designing and implementing a cycle of evaluation
- Increasing equity and inclusion by involving stakeholders throughout the decision making process

Frameworks agree that a school's EdTech vision should be integrated into the overall school strategic plan with a focus on teaching and learning (rather than the tools used). Additionally, consideration of the existing ecosystem within a school setting is essential to successful EdTech implementation and integration. Conducting a self-evaluation can help schools better understand the role of EdTech in teaching and learning and how to leverage EdTech within their specific context. Recommendations for implementation plans include clear articulation of expected outcomes and uses, a project timeline with milestones, a cost analysis, anticipated infrastructure needs and a detailed evaluation plan.

Some strategic implementation frameworks also consider the use of EdTech to increase equity and inclusion. Specifically, frameworks recommend that school leaders involve stakeholders throughout the selection process to ensure equitable use of EdTech that is inclusive of diverse groups. Another common component of implementation frameworks is evidence-informed decision-making, which also features in the quality evidence section of this report. Further detail on implementation and strategic transformation characteristics can be found in the Appendices, along with a complete list of frameworks reviewed.

Analysis of Quality Components of EdTech design

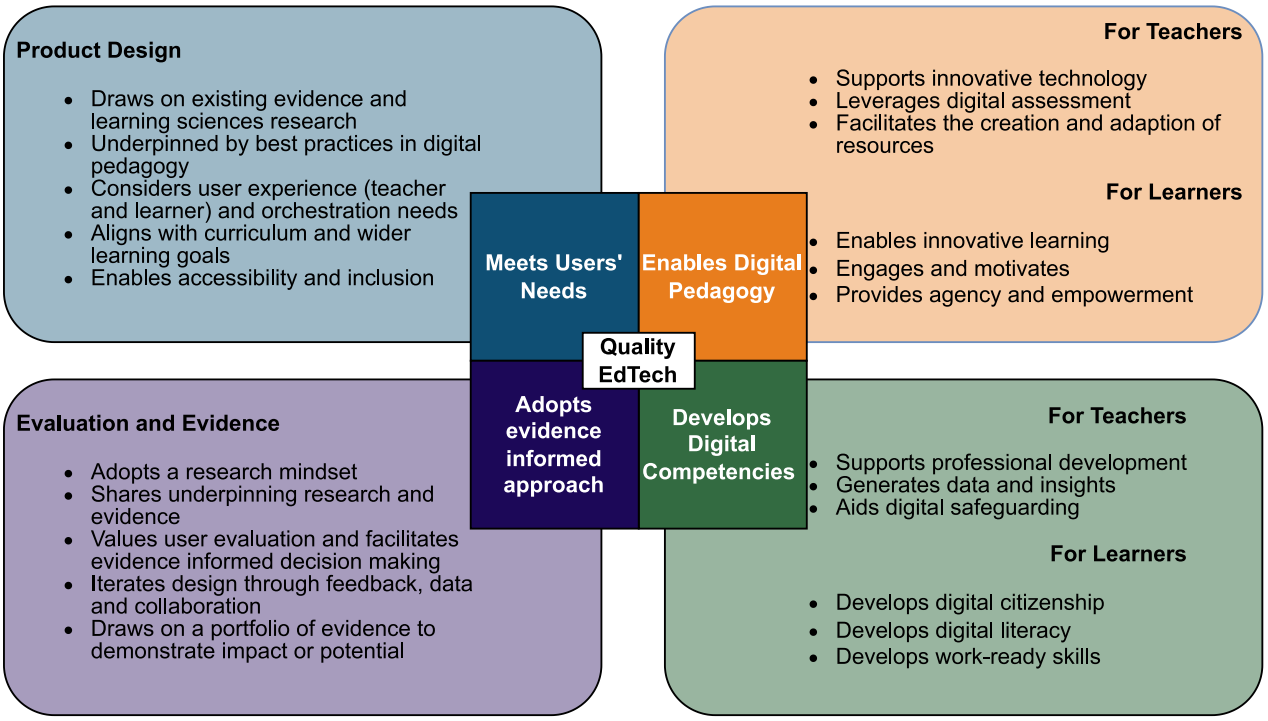
The design and implementation of EdTech is a complex domain with many desirable conditions and features. Analysis of existing frameworks and standards identified key characteristics, quality components, essential conditions and evaluation criteria for the design and implementation of EdTech. These were synthesised into four commonly agreed overarching quality characteristics of educational technologies.

1. EdTech products should meet the needs of its users
2. EdTech products should enable and support digital pedagogy
3. EdTech products should develop digital competences for both learners and teachers
4. EdTech products should adopt an evidence-informed approach

These key characteristics of EdTech are represented in Figure 7, which also provides an overview of the fundamental elements of each characteristic. The mapping out of these elements serves a dual purpose. It provides the foundation of a framework for the design of EdTech that encourages developers to embrace these characteristics, and identifies key characteristics for schools to look for when evaluating and choosing EdTech.

The research team has not found one all-encompassing framework that includes all the identified quality components but instead is able to highlight individual frameworks that address elements of each quality characteristic. Each of the four characteristics and accompanying elements are discussed in more detail in this report with the signposting of specific frameworks or standards that particularly support the development of each characteristic. These frameworks are recommended because they contain comprehensive detail and offer guidance and valuable resources to support the advancement and understanding of quality components in product design.

Figure 7 - Overview of quality components of EdTech product design



Meeting Users' Needs

Digital design frameworks focus on the design process for EdTech tools, providing guidance specifically to product designers and revealing consensus around quality design approaches. These principles include:

- Research-based product design
- Learning activities underpinned by learning sciences and best practices in digital pedagogy
- Understanding the education ecosystem to prioritise user experience
- Quality content that is well-aligned to curriculum and wider learning goals
- Ensuring accessibility and inclusion

Research-based product design

Digital design frameworks encourage EdTech developers to ensure that their product development is grounded in research by, for example, demonstrating a clear link between research and the learning approach that underpins an EdTech product. The use of research and evidence to inform and justify design approaches is a feature of quality EdTech design.

EdTech designers and developers should demonstrate that product design is situated within a research-supported theoretical framework and significant learning-design decisions are grounded in evidence informed by learning sciences research. Organisations such as ISTE, Digital Promise, EDUCATE Ventures Research, What Worked Education, and WiKIT offer guidance and support designed to help EdTech designers to understand why evidence is important and to help them navigate the rigours of research to bridge the gap between research and design. These companies act as evidence intermediaries (Williamson 2021) and work with EdTech developers to establish a research mind-set, logic model or theory of change. Some offer varying forms of accreditation to endorse and validate this evidence-led approach. Digital Promise, for example, offers a product certification if a product design meets the standards of its Research-Based Design certification.

Learning activities underpinned by learning sciences

A fundamental principle across many design frameworks is the need for developers to align learning activities in EdTech products to best practices in digital pedagogy and the learning sciences. To harness the potential of EdTech and enhance effective learning, the design of learning activities should draw on research to provide activities and necessary conditions for the learner such as opportunities for learner agency,

collaborative learning, valuation of previous knowledge, flexibility and relevant feedback (Vuorio et al, 2017). The design of content and learning activities should leverage opportunities for information provision, knowledge activation and knowledge application (Georgiouli et al 2008). Learning activities should be underpinned with proven pedagogical methods (including digital methods) taken from learning sciences such as chunking, sequencing, scaffolding, recall and reinforcement and addressing misconceptions.

Understanding the education ecosystem to prioritise user experience

It is widely agreed across digital design frameworks that understanding the existing ecosystem, how it is structured, its pain-points and needs, will aid product design. Embedding teacher and learner needs within product quality criteria is a fundamental principle of developing effective EdTech tools. Co-design provides developers the opportunity to fully appreciate the mindset of the user and to probe the user experience to ensure an EdTech product is easy to navigate, intuitive and solves a problem. Adopting a collaborative approach acknowledges the interconnected and interdependent relationship between educators and developers (Luckin & Cukurova, 2019) and allows EdTech design to address real-world issues within the education ecosystem.

A key component of meeting users' needs is the problem-solving capability of an EdTech product. The EdTech developer’s guide from the U.S. Office of Educational Technology identified ten areas in which EdTech developers had the opportunity to support teaching and learning priorities. They included mastery of academic skills, promoting life-long learning, designing effective assessment, making learning accessible to all learners and closing achievement and opportunity gaps.

Usability is another essential component of quality EdTech design as meeting real-life orchestration needs is crucial for the successful implementation of an EdTech product. Classroom usability should be a priority and product design should consider the intuitiveness of the user interface. Quality criteria outlined in the ISTE Seal of Alignment Framework such as the discoverability of features, the ease of navigation and the filtering of content offer a helpful assessment of the "teacher readiness" of an EdTech product.

Quality content that is well-aligned to curriculum and wider learning goals

There is consensus that quality EdTech content should be accurate with clear presentation of ideas, emphasis on key points and an appropriate level of detail. Content quality features also include elements such as comprehensibility and content adjacence to aid understanding and clarity of the information presented. An EdTech product should be underpinned by national learning standards and all content, learning, practice and assessment activities should be aligned to learning outcomes. Teachers and learners can achieve learning goals through well-designed content and activities clearly aligned to learning objectives that are regularly and clearly displayed. Furthermore, frameworks emphasise the importance of being able to reuse content in a broad range of learning contexts and promote the adaptation of content to make it suitable for many types and levels of learners. In addition, content design can provide opportunities to support the development of wider social skills such as empathy building and constructive communication.

Accessibility and inclusion

An accessible EdTech tool includes controls and presentation formats that are designed to meet the needs of all user groups, including learners with physical, learning, cognitive or other disabilities, as defined by accessibility standards such as the Web Content Accessibility Guidelines (WCAG). The design and quality of the interface should enable a straightforward login process and easy navigation of the product. The interface design should not be cluttered but clear and engaging with meaningful headings and illustrations. A desirable component is the ability for the teacher to easily see exactly what the learner sees on screen to understand the learners' perspective. Assistive features such as video captioning, audio file transcriptions and descriptive tags for images should be easy to find and activate. EdTech products should be compliant with relevant international standards of (inter)operability and provide user support as well as ensuring that metadata is available to users.

The importance of accessibility features and adherence to accessibility guidelines is common across many frameworks, however, inclusivity principles are less prevalent. To promote inclusion, content should reflect inclusivity principles and represent a variety of ethnic and cultural groups to support learner motivation and agency. In addition, the ISTE Seal of Alignment looks to see if EdTech products allow learners to build their awareness of equity and inclusivity issues such as the dynamics of power, privilege and oppression.

Frameworks and standards that address product design:

- Research-Based Design Certification, Digital Promise
- Seal of Alignment Framework, ISTE[1]
- Learning Object Review Instrument, Leacock et al 2007
- EdTech Tulna Standards, EdTech Tulna
- Design Implementation Framework, McCarthy et al. (2018)
- EdTech Developer's Guide, U.S. Office of Educational Technology
- EdTech Standards of Evidence, What Worked Education
- Evidence-Informed Learning Technology Framework, Moeini (2020)

[1] TO NOTE: Since reviewing materials for this report, the nomenclature of the ISTE Seal of Alignment has changed. The ISTE Seal of Alignment framework is now published on the ISTE website as the "Teacher Ready EdTech Product Evaluation Guide". The ISTE Seal (formerly known as the Seal of Alignment) is a product certification for edtech products that is based on the Evaluation Guide, as well as the ISTE Standards.

Enabling Digital Pedagogy

The frameworks revealed a range of features regarding digital pedagogy. There was widespread consensus that the educational significance of an EdTech product was best exploited with specific and informed digital pedagogy rather than relying on traditional pedagogies.

The role of educational technologies is significant as pedagogical practices shift from traditional teacher-centred instruction to student-centred learning. Many frameworks seek to conceptualise the role of technology in teaching and learning; overwhelmingly the consensus is to not simply digitise existing practices but to use EdTech to innovate through digital pedagogy. By considering the ways in which educational technology can achieve what traditional teaching methods cannot, educators are encouraged to exploit the affordances of the EdTech product at their disposal.

Common characteristics of enabling digital pedagogy include:

- Enabling innovative pedagogy
- Leveraging digital assessment and use of data
- Facilitating creation and adaptation of resources
- Enabling innovative learning including adaptive and personalised learning
- Engaging and motivating learners
- Offering learner agency and empowerment

Enabling innovative pedagogy

The concept of enhancing teaching (to an extent that would not be possible without technology) is at the core of digital pedagogy and the ever-developing affordances of educational technology provide educators with the opportunity to exploit an EdTech tool for its pedagogical flexibility and agility. Quality EdTech products should facilitate new approaches to pedagogy as educational technologies offer up the opportunity to enhance or even transform existing practices.

EdTech products need to enable teachers to apply evolving teaching strategies and manage the learning process effectively using digital tools and digital environments. Product design should incorporate an understanding of the flexibility required to respond to the changing demands and challenges of teaching with educational technology. Teachers are encouraged to be critical about the use of EdTech and consider carefully how a product might impact teaching and learning. A quality component of an EdTech product is the way in which it might support the orchestration of digital strategies and help the teacher to critically consider the following questions from the triple E Framework:

- Engagement, “Does the technology allow students to focus on the task of the assignment or activity with less distraction?”
- Enhancement, “Does the technology create paths for students to demonstrate their understanding of the learning goals in a way that they could not do with traditional tools?"
- Extension, “Does the technology create opportunities for students to learn outside of their typical school day?”

Leveraging digital assessment and use of data

Advantageous features of EdTech products include facilitating the manipulation of a range of assessment mechanisms, the ability to use automated metrics to track learner progress and the capacity to provide timely, detailed and actionable feedback to learners. There is consensus in digital pedagogy frameworks that teachers should use data to inform and drive their teaching and support students in achieving their learning goals. Formative assessment data and the provision of learner analytics should be readily available to inform teachers about learners' progress and help to identify any knowledge gaps.

Digital assessment strategies leverage educational technology to vary assessment activities and tasks for both formative and summative assessment leading to a richer and more diverse assessment experience for learners with varying needs. EdTech products should support the setting of personal learning goals and provide learners with opportunities to reflect on their progress. Quality assessment activities should be designed in a variety of formats whilst remaining appropriate for the content and learners' needs. Learners would benefit from demonstrating their learning in multiple ways and tracking their performance against clear success criteria. Not only should assessment data be well-placed to benchmark progress, but it should be easily communicated with students, parents and education stakeholders.

Facilitating creation and adaptation of resources

A customizable interface is considered an important quality component of EdTech products. Enabling teachers to customise controls and settings as well as content supports the development of innovative pedagogical practices and allows teachers, where necessary, to tailor content and activities to the needs of individuals and specific student groups. Many frameworks, including the ISTE Standards for Educators, the European Framework for Digital Competence of Educators and the Education and Training Foundation’s Digital Teaching Professional Framework, direct teachers to consider how they might leverage educational technology to better accommodate learner variability and personalise learning for their students. Quality EdTech products offer

educators the opportunity to create or adapt learning activities with ease, to accommodate individual learners' needs or provide greater differentiation.

Enabling innovative learning including adaptive and personalised learning

Many frameworks agree that through quality EdTech products, teachers can apply evolving digital pedagogies to bring about new learning experiences for learners. Digital pedagogy frameworks encourage educators to consider what learning experience they want to design for their learners and EdTech products can facilitate this process.

The Technology Integration Matrix (TIM), for example, demonstrates how successful integration of technology can result in collaborative, constructive and goal-directed learning as teachers leverage the flexibility of educational technology to provide innovative learning opportunities. EdTech products should equip teachers with the tools and features to activate learning processes, present and cue content effectively and contextualise instruction. EdTech design should facilitate a constructivist approach, providing learners with the chance to construct meaning and make their own connections. Educational technologies provide opportunities for learning through new models of learning such as open learning, distributed learning, learning communities and knowledge building communities. (Aparacio et al, 2016). Educational technologies should facilitate learning on an individual level, permitting learners to work at an individual pace and level as well as following an individualised pathway determined by their own assessment data.

Engaging and motivating learners

A quality component of EdTech is the way in which it leverages technology to create authentic learning activities that maximise active, deep learning and develop complex learning and thinking skills rather than positioning learners as passive recipients of information. Digital pedagogy frameworks universally recommend that digital resources be used to motivate and engage learners. EdTech products can help to motivate and engage learners through varied learning activities offering authentic problems and applied examples to prompt innovative learning experiences. Situating learning in real-life contexts, personalising learning and allowing learners to track their progress all contribute to learners' levels of engagement.

Offering learner agency and empowerment

Learners can develop and exercise a greater degree of autonomy and control their learning through the use of educational technology. The European Framework for Digital Competence of Educators makes particular reference to the use of educational technology to empower learners as they benefit from creative engagement with content

and exposure to new, real-world contexts, hands-on activities and complex problem solving. EdTech products that facilitate learning activities, that invite deeper thinking and engagement with complex yet compelling subject matter and challenges help to put learners in the driving seat. Transparency around assessment data, assessment criteria and learner progress fosters student independence and self-direction, encouraging learners to reflect on their learning and set their own learning goals.

Frameworks and standards that address enabling digital pedagogy:

- Digital Teaching Professional Framework, Education and Training Foundation
- European Framework for Digital Competence of Educators, European Commission
- Standards for Educators, ISTE
- Standards for School Leaders, ISTE
- Standards for Students, ISTE
- The Triple E Framework, Kolb (2011)
- PICRAT Technology Integration Model, Kimmons (2020)
- TPACK: Technological Pedagogical Content Knowledge Framework (Context informed), Mishra (2019)
- SAMR (Substitution, Augmentation, Modification, Redefinition) Model, Puentedura (2010)

Developing Digital Competences

Digital competences were identified by many existing frameworks as essential to the successful implementation of EdTech and cover the extent to which teachers must acquire and use a multitude of digital competences, capabilities and skills across the EdTech ecosystem. Although primarily concerned with educator professional competences and standards, many frameworks also included learner competences such as learners' digital literacy and digital citizenship. As a companion to the successful implementation of EdTech products, facilitating the development of digital competences is a desirable characteristic of EdTech products and a lack of digital competency can act as a barrier to progress and innovation.

Common characteristics of developing digital competences include:

- Supporting professional development including the development of digital skills
- Generating data and insights
- Supporting digital safeguarding
- Developing digital citizenship
- Developing digital literacy
- Developing work-ready skills

Supporting professional development

A common feature of teacher competence, as shown by many of the frameworks, is the need to stay up to date with technology tools, developments and digital pedagogy techniques. Teachers are expected to keep abreast with theories and methods relating to how to transform learning with technology and applying evolving pedagogical strategies. The UNESCO competency Framework for Teachers identifies the "Teacher as Innovator" as an element of professional learning. EdTech products should enable teachers to curate, create and evaluate complex, interactive digital resources to support their teaching objectives. For this reason, professional personal development is a key feature of digital competence frameworks and there is consensus around the need for development of digital pedagogy as well as improving technical expertise and knowledge. It is desirable for EdTech products to facilitate this development by considering these needs at the design stage of product development.

There is consensus across frameworks that teachers should be involved in the identification, assessment and selection of digital tools. As part of this process, teachers are encouraged to consider specific learning objectives, learner groups, pedagogical approach and context when choosing EdTech tools and resources. They should also take into consideration not only the importance of evaluating the extent to which an

EdTech tool meets a specified need but also to assess any cultural, physical, technical or economic accessibility constraints. An awareness of this, and transparency about relevant design decisions, would allow EdTech products to support teachers in their role as critical evaluators.

Networking and sharing of good practice are popular elements of the teachers' competence frameworks. Teachers are advised to dedicate planning time to collaborate with colleagues to create authentic learning experiences that leverage technology to best effect. Facilitating the sharing of learning experiences with colleagues through educational technology could have significant benefits to learners, teachers and EdTech product developers. EdTech product design could encourage teachers to use technology for their own professional progression, modelling practice for colleagues in the identification, experimentation, evaluation and adoption of new digital resources.

Generating data and insights

A quality component of EdTech product design is the generation of data that is relevant, comprehensive and enables the teacher to leverage the benefits of digital assessment and make transformative use of data.

As discussed in the Enabling Digital Pedagogy section, teachers are expected to use data to gain insights into learners' progress. Learner activity data generated by EdTech tools can be analysed and interpreted to inform teaching and also leveraged to support innovative practices such dynamic assessment, comparative judgement and cognitive tutoring.

Supporting digital safeguarding

Teachers are identified through digital competence frameworks as a guardian and promoter of the ethical and responsible use of technology, data and social media. They must ensure they assess the validity, credibility and reliability of different digital sources, including social media and web-based material. As described by the ISTE Standards for Educators, “Educators inspire students to positively contribute to and responsibly participate in the digital world”.

The critical evaluation of digital forms of information is a key component of using technology effectively and responsibly and is an example of how teachers model digital citizenship for learners. EdTech developers should be mindful of this responsibility and consider how product design could facilitate responsible and ethical use of technology.

Teachers are also advocates of equitable access to educational technology, and quality EdTech products should address inclusion issues and promote equity and diversity. The management and organisation of digital content should also protect sensitive digital

content and respect and correctly apply and uphold legal conditions and requirements such as copyright, licence, data and privacy regulations.

Developing digital citizenship

Without exception, the competence frameworks emphasise the fundamental importance of digital citizenship. Teachers and learners must understand ethical implications of use of technology and have an awareness of the global impact of technology. They should also be well-informed about the potential negative impact of technology on well-being, and the importance of protecting one's own personal data.

Whilst learners' digital citizenship falls under the digital guardianship of educators, EdTech products should consider how to support the acquisition of digital competencies and skills necessary for digital citizenship. Similarly to their teachers, learners are expected to develop an awareness and understanding of risks related to technology use and develop the ability to use technology safely and responsibly. In addition, learners should gain independence through their use of digital tools and have opportunities to develop their digital identity and citizenship.

Developing digital literacy

Developing digital skills and supporting digital literacy are key characteristics of quality EdTech product design. As well as designing for the achievement of specific learning goals, developers should consider how an EdTech product might develop and support broad and transferable digital skills. Specific skills and features of digital literacy include digital creativity and providing learners with the opportunity to become digital creators. For example, the Digital Intelligence Global Standard on digital literacy, literacy skills and readiness specifies that learners need to be able to conceptualise, create, adapt, modify, organise and share digital content.

Through the use of EdTech products, teachers should create opportunities for learners to develop these competences and use them with increasing independence. Learning activities that encourage problem definition, information curation, solution design and collaborative interaction are additional elements of digital pedagogy that could contribute to high levels of digital literacy.

Developing work-ready skills

The development of competences such as collaboration and communication are often categorised under skills to ready learners for the workplace. Many frameworks reference potential employability as a driver for the development of particular digital skills such as troubleshooting, effective communication or collaborative problem solving. Whilst many of these skills are also necessary for sound digital citizenship, engaging in practices that

develop these digital capabilities and skills are popular recommendations in digital competence frameworks. EdTech products are well positioned to offer learners the opportunity to participate in reflective practices using technology in preparation for future employment or use technology to practise industry or employment-related skills, such as time management, where appropriate.

Frameworks and standards that address developing digital competence:

- European Framework for the Digital Competency of Educators (Digi-Comp) including the SELFIE tool, European Commission
- Digital Teaching Professional Framework including the ENHANCE professional development platform, Education and Training Foundation
- Quebec Digital Competency Framework, Ministry of Education Quebec
- Standards for Educators, ISTE

Adopting an evidence-informed approach

Many teacher-facing frameworks stress the importance of the selection of high-quality EdTech tools and resources; however, few frameworks provide specific guidance for the evaluation and selection of EdTech products. Schools are encouraged to consider evidence and evaluation of EdTech solutions in two different ways. Firstly, a school should design and undertake their own evaluation of educational technology already in use at the school and identify to what extent predefined goals are being met. This forms a valuable and integral part of the feedback loop to continue to inform evidence-based decision making. Secondly, a school should evaluate the quality of an educational technology as part of a selection process before adoption and implementation. EdTech products that adopt an evidence-informed approach offer reassurance about the quality components of a potential EdTech solution and facilitate the evaluations undertaken by schools in both scenarios. By understanding the importance of evaluation and evidence for schools, EdTech developers can prepare for and respond to evaluative processes.

Common characteristics of adopting an evidence-informed approach:

- Adopting a research mindset
- Sharing evidence of efficacy and underpinning research and design principles
- Understanding the importance of user evaluation
- Iterating design through feedback, data and collaboration
- Constructing a portfolio of evidence

Adopting a research mind-set

Evidence frameworks suggest that teachers undertaking critical evaluation of digital sources should use rigorous and research-informed criteria when making judgements and decisions about the suitability of an EdTech product. It is recommended that they evaluate the accuracy, perspective, credibility and relevance of information offered up as supporting evidence for a particular tool or product. Developing a research mind-set from the outset provides EdTech developers the opportunity to demonstrate the link between research and the design and development of an EdTech product at each stage of innovation. Incorporating learning sciences principles into EdTech design translates research findings into Edtech products that use proven strategies to support learners. Developers with a research mindset embrace this concept and adopt evidence-informed approaches and resources. The Digital Promise Learner Variability Navigator, for example, maps out relevant strategies related to learner variability and highlights its potential for the design of EdTech numeracy and literacy products.

Sharing evidence of efficacy and underpinning research and design principles

Transparency for schools and users is a key element of adopting an evidence-based approach to EdTech design. By sharing the research underpinning design principles and decisions, developers allow users to understand and compare EdTech products to evaluate and select the tools that are designed to best meet their needs, priorities and context. Sharing underpinning research and design principles highlights alignment of an EdTech product with key quality features such as use of pedagogical principles and standards, quality of content, quality of activities, quality of assessment and feedback, interaction, usability, accessibility and compliance with interoperability standards. Using research and gathering evidence to demonstrate the effectiveness of an EdTech product is a complex concept that will be discussed further in the quality evidence section.

Understanding the importance of user evaluation

The importance of cyclical and continuous evaluation is supported by many frameworks for effective tech use in schools. Effective evaluation processes include iterative review cycles, feedback loops and rapid-cycle evaluations to capture detail about the use of EdTech products, measure outcomes and compare them to the intentions and strategic objectives held when the tools were introduced. In the EdTech Evidence Toolkit, the U.S. Office for Educational Technology appeals to EdTech developers to create tools to assist schools in their endeavours to gather evidence so that it might be analysed and incorporated into their decision making and adoption processes. It would be desirable for EdTech products to facilitate their own evaluation and help schools to consider their own user experience, map out their expected learning outcomes, examine their implementation in context and finally, consider if there is evidence of efficacy and impact.

Iterating design through feedback, data and collaboration

A recent report into the state of evidence in EdTech in the UK (BESA and EDUCATE Ventures Research, 2023) identified the growing need for evidence within the EdTech ecosystem to assess effectiveness of EdTech tools, to inform adoption and implementation decision-making in schools, to build trust between educators and developers, to build successful businesses and to evaluate the impact of educational technologies on teaching and learning. The design process should not stop with the adoption of an EdTech product instead developers should seek feedback and gather evidence from the perspective of different stakeholders to gain valuable insights and inform iterative design and development of the EdTech product. Collaborative approaches and practices such as co-design allow design to be informed by evidence and real-life context and help the developer to meet the evolving needs of the user as schools demand more from EdTech products.

Constructing a portfolio of evidence

The UNESCO Global Education Monitoring (GEM) Report Concept Note acknowledges “technology has multiple education benefits that are not easily measured empirically, given technology’s ubiquity, complexity, utility and heterogeneity. But absence of evidence of benefits does not mean that there are no benefits". The nature of technology therefore means that care needs to be taken when applying evidence quality framework to educational technology that has not been designed expressly for this purpose and that the benefit of technology is not easily demonstrated. The challenge of how to demonstrate the impact of an EdTech product will be discussed in the evidence quality section of this report; however, quality evidence frameworks consider a spectrum of evidence and acknowledge the validity of different types of evidence for different purposes.

Frameworks and standards that address evaluation of EdTech:

- Digital Promise Pilot Framework, Digital Promise
- Learning Object Review Instrument, Leacock et al. (2007)
- Seal of Alignment Framework, ISTE
- Evaluation Taxonomy, Learning Assembly
- EdSurge Product Index & Decision Guide, EdSurge
- EdTech Tulna Standards, EdTech Tulna

Evidence Quality Frameworks

The BESA 2020 EdTech in English Maintained Schools report showed that, while school leaders are basing their selection of EdTech solutions on colleague recommendation, internet searches, and education websites, a significant number are also turning to research. However, there is scant guidance for educators when faced with the challenge of evaluating the quality of evidence presented to them. The research team found few frameworks designed specifically for determining the quality of evidence in educational technology research; however, more generic evidence standards are also being applied to EdTech research to inform decision making. It is essential to recognise however, that the complex, ubiquitous and evolving nature of technology signals a note of caution when applying evidence quality frameworks to educational technology that have not been designed expressly for this purpose.

Evidence Quality frameworks (not specific to EdTech)

- The Education Endowment Foundation (EEF) 'padlock' rating
- Evidence4Impact (E4I) Evidence rating system
- Queensland Standards of Evidence
- ESSA Tiers of Evidence
- What Works Clearinghouse (WWC) Standards
- Australian Education Research Organisation (AERO) Standards of Evidence
- NESTA Standards of Evidence

Evidence Quality frameworks (specific to EdTech)

- WhatWorked EdTech Standards of Evidence
- A Framework for Quality in Educational Technology Programs (Confrey et al. 2002)

For a detailed overview of the characteristics of each of these Evidence Quality Frameworks, please see the appendices.

Analysis of Evidence Quality Frameworks

The overarching purpose of evidence quality frameworks is to provide a basis for determining which interventions are likely to produce certain outcomes, in which contexts and for which learners based on the research undertaken into the particular intervention. Evidence quality frameworks offer standards and criteria for categorising research from most to least rigorous as a proxy for highest to lowest quality.

It is helpful to note, with respect to consistency, that the results of the adaptive comparative judgement (ACJ) activity, conducted as part of a literature review that supports this framework analysis, revealed consensus across the judges when judging the quality of research sources that were specific to educational technology. Common features of research judged as highest quality included the explicit recognition of the limitations of the research that was being reported, the clarity of research questions directly linked to their findings and the rigorous justification for the adopted methodology. For meta-reviews, the judging panel also identified the diversity of included studies as an indicator of quality.

Our analysis of the existing quality evidence frameworks shows that there is consensus around certain criteria and standards of evidence pertaining to hierarchies of evidence and quality characteristics of different tiers of evidence. There are also significant differences between some evidence quality frameworks such as the use of inclusion criteria, the importance of context, and flexibility of evidence quality judgements. Furthermore, there was a lack of consensus around the criteria for the highest-quality judgements.

Inclusion criteria

Inclusion criteria or screening standards can have a significant impact on the quality judgement of evidence as it serves as a gatekeeper, excluding some research from consideration. Whilst some frameworks are broadly inclusive, others prescribe rigid study design criteria such as number of teachers in treatment groups, minimum duration of studies, sample size as minimum requirements for assessment. Not all frameworks impose stringent inclusion and exclusion criteria. The NESTA Standards of Evidence, for example, are not associated with specific data types or research methods and so does not identify explicit criteria that evidence must meet. The What Works Clearinghouse (WWC) standards demonstrate flexibility by allowing for the inclusion of studies that meet quality standards with reservations rather than excluding non-experimental studies from consideration.

Hierarchy of evidence

Evidence quality criteria guide educators in their appraisal of evidence supporting an intervention. Almost all of the Evidence Quality Frameworks reviewed categorise and rank research into tiers of evidence that graduate through a quality criteria spectrum, often (but not always) moving from the lowest quality evidence to strongest evidence, providing the best indication that an intervention will achieve the expected outcomes. Generally, only studies that meet the standards of the higher evidence tiers are deemed to offer strong or moderate evidence that an intervention "works". These higher tiers are accessible to rigorous experimental or quasi-experimental studies that demonstrate a

causal link between the intervention and at least one nominated outcome. This characteristic is common across all evidence quality frameworks. Research studies and evidence that demonstrate a correlation between an intervention and a desired outcome are given lower quality ratings (or excluded) as the studies cannot make the explicit causal link needed to attribute the outcome to the intervention alone. Lower ranking evidence is described as demonstrating a clear rationale.

Characteristics of highest-quality evidence

- Independently evaluated or validated
- Well-designed experimental study with control groups
- Large number of participants
- Randomly assigned participants
- High levels of confidence to attribute causality
- Evidence is scalable

Characteristics of high-quality evidence

- Well-designed experimental study
- Random assignment of participants may not have been possible
- Possible to isolate and attribute impact to an intervention

Characteristics of moderate-quality evidence

- Correlation study that explores the relationship between an intervention and a relevant outcome
- Demonstrable link between an intervention and a positive outcome

Characteristics of promising or low-quality evidence

- Demonstrates a rationale or a clearly defined logic model based on rigorous research
- Draws on existing research to give a logical and coherent account of potential impact
- Well-designed plan to undertake research into effects of an intervention
- Low confidence that an intervention causes positive effects

Lack of consensus around the highest quality judgements

There is no consensus around the highest quality judgements as the differentiating factor between the top levels of evidence varies between frameworks. ESSA (via the WWC standards) prioritises randomised selection of participants, whilst the EEF padlock system differs from other frameworks as it looks at the size of the body of evidence to support an intervention as a proxy for quality of evidence. For NESTA, replicability and scalability is the deciding factor and the differential between the top two tiers for the AERO standards of evidence is the extent to which the intervention may have a positive effect in the users' context. In this case, the degree of confidence between high and very high is determined by the individual.

Context

The value and importance placed upon the context is variable across different evidence quality frameworks. Similarity of context, transparency of context and implementation details are used as an indicator of quality of evidence and provide potential users with valuable insights into whether an intervention might have a similar effect in their own context. Whilst it does not feature as a characteristic of quality evidence, the E4I database also indicates if an intervention has been evaluated and adds a Union Jack flag on the ratings page of an intervention to indicate increased confidence that an intervention is likely to be effective if implemented within UK schools. This is a unique characteristic amongst the quality evidence frameworks reviewed.

Flexibility

There is limited scope for flexibility within the evidence quality judgements but the Queensland Standards of Evidence offers the opportunity to make different quality judgements across four separate dimensions for consideration: attribution; impact; scalability and investment. Whilst there is likely to be some degree of uniformity across the ratings for each dimension, the guidance does allow for differing levels of strength of evidence citing, for example, that an initiative may have very high (level five) evidence of impact but the scalability may be unknown (level one). This framework is less prescriptive in terms of what constitutes a well-designed study or how impact is determined other than it must be measurable. The Framework for Quality in Educational Technology Programs refrains from ranking evidence in hierarchical tiers but instead offers a number of desirable characteristics to inform individual judgements.

Recommendations for Evidence Quality frameworks

Educational Technology requires an inclusive approach to evidence

A key challenge when evaluating the quality of evidence is achieving the balance between applying rigorous academic standards and supporting the continued development of services and products as discussed in the NESTA Standards of Evidence. This is particularly pertinent when considering research in the field of educational technology as EdTech innovation and development continues at a pace, in stark contrast to the much slower pace of rigorous research. When considering the topic of evidence quality, NESTA, as part of its practical guide to using research evidence, shares hierarchies of evidence as a means of thinking about evidence using prioritisation but not exclusion (Breckon, 2016).

For educators trying to adopt an evidence-based approach to their EdTech selection and implementation, exclusive application of rigorous quality criteria reduces the research field significantly. The restrictive nature of discounting other studies in favour of controlled experiments is illustrated in the Universal Evidence Report developed by LearnPlatform, Inc. The report seeks to share and simplify evidence sources by cataloguing studies to establish an overview of context specific insights into EdTech tools. Of the 117 studies listed, only 27 have been validated with an ESSA rating and of those 19 are rated Tier 4, demonstrating a rationale. When applying the criteria for Tier 1 evidence, only 6 of 117 studies are considered to display strong evidence. Applying only the most rigorous criteria when considering evidence can be problematic within the EdTech ecosystem as traditional efficacy and effectiveness studies are not always available for all types of Ed Tech intervention. Evidence standards provide a framework for determining which interventions work, in which contexts and for which learners, based on the research undertaken into the intervention. A multi-faceted, holistic approach to evaluation could offer the decision-maker multiple sources of evidence depending upon what they are looking for when considering EdTech products. The demand for strong causal evidence is well-met by the characteristics of experimental studies however case studies and evaluations can provide valuable insights into how a product was implemented and used in varying contexts.

Towards a portfolio of evidence

Whilst experimental research is well-suited to generating high-quality evidence that an intervention works, other research approaches can provide other, valuable insights. Schools and developers could embrace the concept that different types of evidence serve different purposes and use a portfolio of evidence supporting an EdTech product rather than limiting themselves only to research that demonstrates causality (Kucirkova, 2022). For example:

- “Does it work?” - Judgements about effectiveness require a clear causal link between an EdTech product and a specific outcome. Rigorous experimental or quasi experimental research can address this.
- “How or why does it work?” - Understanding details about process, implementation and the user experience are better served through qualitative research that explores practitioner experience such as case studies and evaluations.
- “Will it work for us?” - Stakeholder perspectives and sharing detail informs perspectives users about the context of existing research and enables them to make a judgement about the likelihood of a similar effect depending upon the similarities or difference of their own context.

Building an evidence or efficacy portfolio (Carolan & Zielezinski, 2019), adopts a more inclusive approach to gathering evidence and would allow for the inclusion of a variety of relevant and useful research to provide a coherent picture of the intervention or innovation (U.S. Office of Educational Technology, 2013). This also allows smaller, newer EdTech developers to demonstrate the potential of their product. A recent report on the Global perspective of EdTech test beds (a controlled environment that allows educators and developers to design and test out new EdTech tools) highlights some of the methodologies employed in test beds to "support the evaluation of EdTech implementations” included action research, rapid evaluation cycles and design-based research methods.

The potential benefits of innovation in technology require innovation in the way in which evidence is evaluated. A portfolio of evidence would be underpinned by a hierarchy of evidence that mirrors the spectrum of evidence quality for EdTech products found in the evidence quality frameworks. An EdTech product would gradually build up its quality evidence portfolio as it progresses through the spectrum, beginning with a minimum requirement of research-informed design. By shifting focus from outcomes to the principles underlying the design of educational technology, the quality of evidence process begins with the importance of research-based design (Van Nostrand et al., 2022).

A portfolio of evidence of a good quality EdTech product would begin by:

- Sharing a well-defined theory of change
- Articulating how product design is underpinned by learning-sciences research
- Demonstrating how it is designed to meet users’ needs

Placing an emphasis on evidence-informed design and the existence of appropriate processes and organisational structures to ensure the continual production of good quality evidence provide a timely, transparent and inclusive way to begin to address quality of evidence through an approach that is accessible to all EdTech developers.

Acknowledgements

The research teach would like to thank the members of the expert panel for their time, expertise, questions, feedback and valuable insights.

Appendix

Expert Panel members

Chris Dede (Senior Research Fellow, Harvard Graduate School of Education)

Natalia Kucirkova (Professor, University of Stavanger, Norway and The Open University, UK)

Alison Clarke-Wilson (Professorial Research Fellow, University College London)

Angela McFarlane (Professor Emeritus, University of Bristol and trustee at the Education Development Trust)

Jen Helmshaw (Department for Education)

Isabel Kempner (Education Endowment Foundation)

List of Frameworks reviewed

Framework	Author	Year
A Framework for Evaluating Appropriateness Of Educational Technology Use In Global Development Programs	MIT, & IIM	2016
Learning Object Review Instrument (LORI) Framework	Nesbit, Belfer & Leacock	2009
A Framework for Quality in Educational Technology Programs	Jere Confrey, Nora Sabelli and Karen Sheingold	2002
Achieve OER rubrics as part of the OER Evaluation tool	Achieve	2011
AERO Standards of Evidence	Australian Education Research Organisation (AERO)	2021
Assistive and Educational Technology Standards and Teacher Competencies in Relation to Evidence-based Practice:	Dalton & Roush	2010
BIRD-E Blueprint for inclusive research and development in education	InnovateEDU	2019

Framework	Author	Year
Considering contextual knowledge: The TPACK Diagram gets an Upgrade	Mishra	2019
Developing evaluation tools for assessing the educational potential of apps for preschool children in the UK	Kolak et al	2020
Developing instructional technology standards for educators: A design-based research study	Crompton & Skykora	2021
Digital Competence Framework	Welsh Government	2020
Digital Promise Pilot Framework	Digital Promise	2016
Digital Teaching Professional Framework	Education and Training Foundation (ETF) in collaboration with Jisc	2018
Dimensions of personalisation in technology-enhanced learning: A framework and implications for design	Fitzgerald et al	2018
DQ (Digital Intelligence) Global Standard on digital literacy, digital skills and digital readiness	DQ Institute	2020
E-learning stakeholders responsibility matrix	Wagner et al	2008
EdSurge Product Index & Decision Guide	EdSurge	2012
EdTech Context Framework within the EdTech genome project	EdTech Evidence Exchange	2021
EdTech Developer's Guide	Office of Educational Technology	2015
EdTech Evidence Toolkit	Office of Educational Technology	2023
EdTech Readiness Index	World Bank	2021
EdTech Standards of Evidence	What Worked Education	2022
EdTech Tulna Standards	EdTech Tulna	2021
EEF Padlock rating in Toolkit Guide	EEF	2023
Efficacy Framework: A Practical Approach To Improving Learner Outcomes	Pearson	2013
Enhancing user value of educational technology by three layer assessment	Vuorio et al	2017

Framework	Author	Year
ESSA Tiers of Evidence	US Gov	2015
Essential conditions for tech use in schools	ISTE	2009
ETF (European Training Foundation) READY model	ETF	2022
European Framework for the digital competence of Educators - DigCompEdu	Joint Research Centre (JRC) - European Commission's	2017
Evaluation Taxonomy	Learning Assembly	2017
Evidence rating system	Evidence 4 Impact (now part of EE)	2017
Framework for adopting LMs	Georgiou et al	2008
Framework for Stakeholder Inclusion in the technology planning process	CoAction Learning Lab (Penn State)	2019
From digital literacy to digital competence: the teacher digital competency (TDC) framework	Falloon	2020
ICT for education: a conceptual framework for the sustainable adoption of technology-enhanced learning environments in schools	Rodriguez et al	2012
ICT Framework - a structure approach to ICT in Curriculum and Assessment: revised framework	National Council For Curriculum and Assessment	2007
ICT In Education Toolkit	UNESCO	2005
INESCO ICT Competency Framework for Teachers	UNESCO	2018
International Computer Driving Licence - ICT in Education module	International Computer Driving Licence	2019
ISTE Seal of alignment framework	ISTE	2023
ISTE Standards for educators, students, school leaders and coaches	ISTE	2018
K12 Digital Capability Framework	Holon IQ	2023
Level Of Teaching Innovation (LOTI) Framework	LoTi Connection	2010
Microsoft K-12 Education Transformation Framework	Microsoft	2015
NAACE Self-Review Framework	NAACE	2020
NESTA Standards of Evidence	Puttick & Ludlow	2013

Framework	Author	Year
Observation Protocol for Technology Integration in the Classroom (OPTIC)	NorthWest Educational Technology Consortium	2009
PICRAT	Kimmons	2020
PISA 2021 ICT Framework	PISA	2019
Principles for Digital Development	Digital Principles	2016
Professional Development Framework for Digital Learning	Department of Basic Education, South Africa	2019
Professional Digital Competence Framework for Teachers	Norwegian Centre for ICT in education	2017
Putting evidence to work - A school's guide to implementation	EEF	2019
Quebec Digital Competency Framework	Ministry of Education Quebec	2019
Queensland Standards of Evidence	Queensland department of education	2023
RAT	Hughes et al.	2006
Research-Based Design certification	Digital Promise	2019
SABER-ICT Framework Paper for Policy Analysis	Trucano (World Bank Education)	2016
SAMR	Puentedura	2010
Scaling Access and Impact: Realizing the Power of EdTech	Omidyar Network - philanthropic investment firm	2019
SELFIE (Self-reflection on Effective Learning by Fostering Innovation through Educational Technology,) and SELFIE PTK (pedagogical innovation assistant toolkit)	European Commission	2018
SMART EdTech Assessment Tool	SMART Tech	2018
Teacher Ready Framework	ISTE	2023
The Design Implementation Framework	McCarthy et al. building on the work of Stone et al.	2018
The Evidence-Informed Learning Technology Enterprise Framework	Moeini	2020

Framework	Author	Year
The MASTER framework	EdTeh Hub	2022
The T3 Framework for Innovation in Education	Magana	2017
The technology integration matrix	Florida Centre for Instructional Technology	2019
Towards Systemic EdTech Testbeds: A Global Perspective Effectiveness, Efficacy, and Learning Outcomes	Vanbecelaere et al	2023
Understanding Technology Literacy: An e-Learning Theoretical Framework	Aparacio, Bacao & Oliviera	2016
Using Digital Technology to improve learning	Education Endowment Foundation (EEF)	2019
Using Research Evidence - a practical guide	NESTA	2016

Strategic implementation of EdTech

Strategic implementation frameworks such as the ISTE Essential Conditions, the International Computer Driving Licence, the NAACE Self-Review Framework and the UNESCO ICT Competency Framework for Teachers amongst others, outline several key components and commonly agreed features for the effective and strategic implementation of EdTech within a school environment. These frameworks are largely aimed at school leaders and explore key conditions to indicate a readiness for successful EdTech interventions and leverage educational technology to have a positive impact on teaching and learning. The frameworks tend to be overarching and contain within them key strategic priorities for consideration when planning the adoption of an educational technology. They are concerned with the successful integration of technology and identify essential conditions, standards and systems that need to be considered when planning for EdTech implementation. There is consensus across these frameworks about core features of the strategic implementation of educational technology, namely a shared vision with clear goals, detailed implementation planning, systematic evaluation processes, infrastructure provision and ensuring equality and inclusion at a strategic level. Each of these elements is an expected component of successful educational technology implementation.

Vision and goal-setting

The importance of a shared vision of educational technology is evident across the existing frameworks. A common feature of digital strategy framework components is that EdTech vision must not stand alone but instead be woven into the strategic planning for the school as a whole using digital solutions to help achieve wider reaching objectives. The NAACE Framework describes developing EdTech strategy as enabling the school to improve through a flexible, innovative and creative vision with challenging targets" (Leadership and Management p. 3). Vision for change features heavily in the Microsoft K-12 Education Transformation Framework, encouraging a growth-mindset to bring about change and a culture of continuous improvement. There is consensus around the importance of schools identifying concrete, measurable, clearly defined goals that are aligned with the wider school priorities. Once a need is identified and clearly defined, schools are better placed to make evidence-informed decisions about how educational technology might best address the issue. The Education Endowment Foundation (EEF) recommends using a robust process to identify the area for improvement and self-evaluation frameworks. The NAACE Self-review Framework, the SMART EdTech Assessment Tool, Microsoft K-12- Education Transformation Framework and the European Commission's SELFIE tool all offer a framework within which schools can audit their status, benchmark their progress and develop and implement an action plan accordingly.

A limited number of frameworks offer a note of caution with regards to goal setting. Schools are reminded that although educational technology can be used effectively, the appropriateness of any tool and its use is a priority when making decisions. Expected outcomes and defined priorities should drive the goal-setting process rather than a desire to use a particular technology or tool.

A vision for educational technology should be underpinned by an understanding of how technology can be leveraged to improve teaching and learning. There is consensus across many existing frameworks that vision and goal setting should be supported by evidence. This is reinforced by the EEF report into using digital technology to improve learning which prompts leaders to consider the pedagogical rationale for how technology will improve learning. The ISTE Standards for Education Leaders recommends the development of a vision specifically informed by the learning sciences in order to improve student success. While many implementation frameworks guide schools to underpin their goal-setting with a sound understanding of the benefits of educational technology, the acknowledgement of barriers to successful implementation are less common. Understanding current educational technology policy and standards also feature in some implementation frameworks and schools are encouraged to translate the wider affordances of educational technology to their local school context. Through the self-evaluation process undertaken as part of the goal-setting, schools can identify the current

and desired levels of technology integration and leverage technology to achieve meaningful learning environments with students engaged in active, collaborative, constructive, authentic and goal-directed learning as identified in the Technology Integration Matrix from the Florida Centre of Instructional Technology.

Implementation planning & Infrastructure

Detailed implementation plans should outline the systematic approach being adopted, clearly articulating how educational technology will be used, monitored and evaluated. Overwhelmingly, existing implementation frameworks call for a detailed evaluation plan for determining the success and impact of adopted technology. Expected outcomes must be well-defined in advance, specifying how they will be regularly measured in an actionable and realistic way. As part of implementation planning, schools must have clear expectations and milestones about project timing, anticipated training needs, resourcing, additional support and a detailed cost-analysis. Infrastructure is a popular component of existing implementation frameworks and alongside cost implications, schools are recommended to have robust plans in place regarding capacity, connectivity, devices, and training needs. Without successful integration of EdTech tools and solutions within the existing ecosystem of a school, the aims and purposes of EdTech implementation are drastically undermined. Infrastructure and operations are one of the 10 context variables singled out by the EdTech Context Framework (within the EdTech Genome Project) produced by the EdTech Evidence Exchange. Connectivity, compatibility of devices, system specifications and other operational considerations are “enabling conditions that lower barriers for implementation, facilitate uptake and support scaling and sustaining new educational technologies" (p. 66). Detailed information regarding technical implementation and infrastructure standards are beyond the scope of this report, but further information can be found in the DfE Meeting digital and technology standards in schools and colleges resources.

A common component of implementation frameworks is the practice of making evidence-informed decisions when selecting educational tools for adoption. Only one framework took a different approach, the Digital Promise Pilot Framework offers a step-by-step guide to schools or districts who are looking to run an educational technology pilot scheme. An involved, costly and complex process, this is perhaps not best suited to many schools although it may appeal to large multi-academy trusts.

Evaluation systems

The evaluation process will be explored in more detail later in this report; however, they have a key role as part of the strategic implementation of any educational technology. The cycle of evaluation is important not only to determine whether an educational

technology tool or intervention is working but to also feedback into the continuing evolution and development of the schools' vision for educational technology. Feedback loops inform continual evaluation of the effectiveness of educational technology, the cost-benefit analysis and help to meet future demand, ensuring that technology is being used to meet changing priorities within the school community.

Equality & Inclusion

The importance of using educational technology to increase equity and inclusion was a significant feature of strategic frameworks. School leaders can ensure the inclusive selection of technology by involving stakeholders in vision-building, agenda setting and selection processes. Stakeholder involvement featured heavily in the reviewed frameworks and identified the importance of acknowledging that different user groups of technology will have varying needs and, crucially, may have different success criteria. The Framework for Stakeholder Inclusion in the Technology Planning Process from the CoAction Lab describes the importance of prioritising the user experience and considering what successful educational technology implementation might look like from the perspective of different stakeholders within the school community. The Framework provides a detailed guide to ensure an inclusive approach to developing digital strategy and implementation. Although designed for Higher Education institutions, questions within the framework such as "Are different members of a stakeholder group impacted differently? In what ways? How does this inform our understanding of the problem, need, or technology?" are applicable to any educational context. The framework structures the process of defining an initiative and investigating solutions to adopting a solution and reviewing and suggests methods for connecting with stakeholders as well as sharing sample questions and exemplars drawn from other institutions to support stakeholder inclusion in EdTech decision making. Schools must ensure that digital safeguarding is an essential part of digital strategy and there should be (what the SABER-ICT Framework describes as) a prioritisation of "pro-equity" provision using technology to increase equity, inclusion and digital citizenship. Although many frameworks referred to the importance of equity and inclusion, only the ISTE frameworks made additional mention of the value of culturally inclusive learning materials that reflect diversity without perpetuating stereotypes.

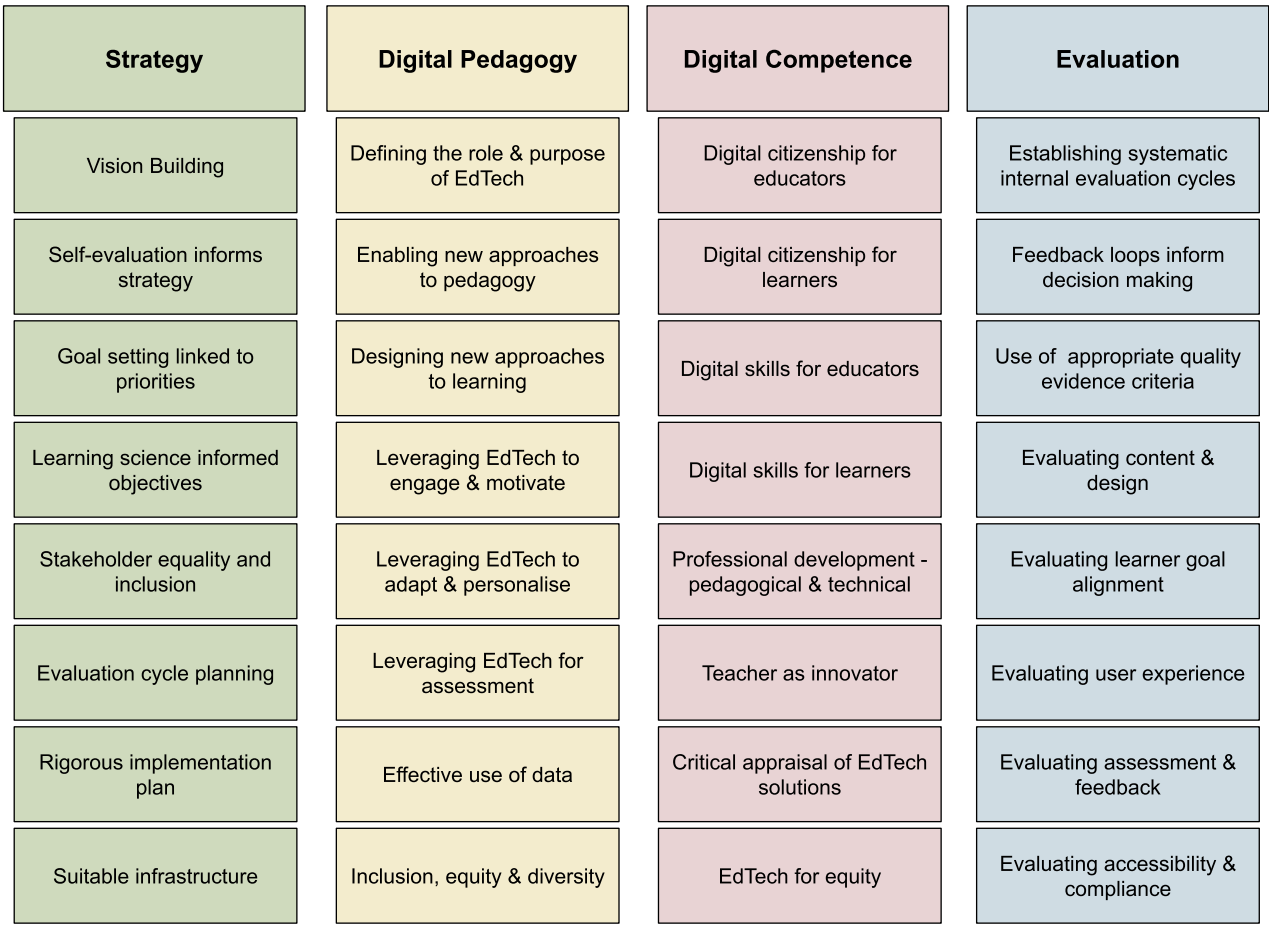
In addition to ensuring equitable access and experience, schools should, at a strategic level, consider the culture of the school community in relation to educational technology. By understanding the comfort, openness and competence of its stakeholders, schools can create an environment where stakeholders are empowered to use technology in teaching and learning. An element of this empowerment which featured significantly in strategic frameworks is the concept of teacher agency. The idea of empowerment through educational technology extends to the consideration of how teachers can engage

with the agenda setting process and are given resources such as training opportunities in order to control their own professional development.

Quality Components Matrix

The key components for implementation and design as supported by consensus across a variety of educational technology frameworks are extensive and offer a detailed description of successful EdTech implementation and design. To represent the fundamental areas of EdTech implementation and demonstrate how they inter-relate and depend upon one another, we have designed a Quality Components Matrix. The Matrix can be used to understand how the different components feature within a school as implementation flows from strategy to evaluation through the essential supporting components of developing digital pedagogy and digital competences. School leaders, educators, learners and other stakeholders begin with strategy and progress through the different stages of implementation, applying digital pedagogies and developing digital competence before evaluating the EdTech and iterating the process. EdTech developers are informed by schools' strategy, and design tools that help schools to meet their goals. Digital pedagogy principles being adopted by schools are embedded into EdTech and products that help to address digital competence and meet minimum evaluative standards and expectations of the users.

Figure 8 - Quality Components Matrix - key components of implementation flow in schools informs design of EdTech products



Strategic implementation requires school leaders and stakeholders to build a holistic vision and set priority-linked goals, underpinned by self-evaluation and informed by learning-sciences research. Strategic planning around evaluation systems, infrastructural needs and capacity set the trajectory for implementation. The Strategy of implementation must be supported by the development of suitable digital pedagogy to successfully realise the strategic vision. By defining the intended role and purpose of educational technology to enhance, or transform, certain aspects of teaching and learning and fully exploiting the potential for EdTech to meet the priority-driven goals, a clear and detailed road-map is set for how educational technology will be used within the school. The next stage in the implementation flow focusses on enacting that digital pedagogy through the acquisition and development of digital competence for both teachers and learners. Personal and professional competences are necessary for educators to fulfil and engage with effective digital pedagogy as they develop and employ digital skills in order to design and create innovative teaching and learning opportunities. The final stage in the implementation flow of EdTech is the evaluation of the impact of educational technology. Internal evaluation processes measure progress towards desired and planned outcomes and feedback into the vision and priority-setting process. Systematic evaluation of

EdTech features empower educators to make informed decisions about product selection and portfolios of evidence are used to support the continued development and evolution of EdTech implementation strategy.

The design of educational technology can be informed by the implementation flow as an encapsulation of the many needs and essential conditions that must be met for successful EdTech implementation. The key components of each stage feed into the design of suitable EdTech tools and products. Strategy defines the overarching user needs, digital pedagogy and competence indicate how educational technology that is underpinned by learning sciences can be used to address those needs. Systematic evaluation provides valuable insight into what successful implementation looks like as well as feeding back into evolving needs and encouraging a research mind-set as schools demand more from educational technologies.

Evidence Quality Frameworks

The BESA 2020 EdTech in English Maintained Schools report showed that, while school leaders are basing their selection of EdTech solutions on colleague recommendation, internet searches, and education websites, a significant number are also turning to research. However, there is scant guidance for educators when faced with the challenge of evaluating the quality of evidence presented to them. The research team found few frameworks designed specifically for determining the quality of evidence in educational technology research; however, more generic evidence standards are also being applied to EdTech research in order to inform decision making.

It essential to recognise however that as The UNESCO Global Education Monitoring (GEM) Report Concept Note acknowledge “technology has multiple education benefits that are not easily measured empirically, given technology’s ubiquity, complexity, utility and heterogeneity. But absence of evidence of benefits does not mean that there are no benefits". The nature of technology therefore means that care needs to be taken when applying evidence quality framework to educational technology that have not been designed expressly for this purpose.

Quality Frameworks that are not specific to Educational Technology

Determining "What Works"

Evidence standards provide a framework for determining which interventions work, in which contexts and for which learners, based on research undertaken into the intervention. Quality of evidence frameworks offer standards and criteria for categorising types of research from most to least rigorous as a proxy for highest to lowest quality. As this review of existing quality frameworks demonstrates, there is consensus around the ranking of types of research; however, some of the quality criteria for determining a rating

differs from one framework to another. The highest standards of evidence that a product is effective are achieved through rigorous experimental or quasi-experimental studies that demonstrate a clear causal link between the intervention and at least one nominated outcome. This standard is common across all quality evidence frameworks and supports schools to select EdTech interventions that have been rigorously studied and shown to improve learner outcomes. Evidence that demonstrates a correlation between an intervention and a desired outcome are given lower quality ratings (or excluded) as the research studies, through approach, design or implementation, cannot make the explicit causal link needed to attribute the outcome to the intervention alone.

The Education Endowment Foundation (EEF) rating system

Padlock rating for research trials

The padlock rating presents a classification system and accompanying procedure for judging the security of findings from EEF evaluations. The rating also makes recommendations around the design and analysis of evaluations that should be considered for these studies. The ratings have been designed specifically to differentiate between EEF evaluations, most of which are set up as randomised controlled trials (RCTs). The ratings are from 5 padlocks, the most robust evidence that could be expected from a single study, to 0 padlocks which denotes a study that adds little to the evidence base. The ratings take no account of whether the intervention itself was successful.

The padlock ratings largely refer to the internal rather than external validity of the findings. There needs to be some judgement on the part of the audience as to whether the finding might be generalisable to their context. The system is only to be used to classify the security of findings for EEF evaluations where the primary purpose is to determine impact, not where the primary purpose is formative or to establish feasibility.

The security rating is determined by four criteria:

1. Design: The quality of the design used to create a comparison group of pupils with which to determine an unbiased measure of the impact on attainment. Higher padlocks are given for designs better suited to deal with confounding.
2. MDES: The minimum detectable effect (MDES) that the trial was powered to achieve at randomisation, which is heavily influenced by sample size.
3. Attrition: The level of overall drop-out from the evaluation treatment and control groups, measured at the pupil level regardless of the level of randomisation.
4. Threats to internal validity: A series of markers that explain whether the results could be explained by anything other than the intervention.

Padlock rating for the Teaching and Learning Toolkit

As part of the Toolkit, the EEF provides educators with a systematic summary of evidence relating to a particular learning approach or intervention. The EEF provides a number of indicators to help educators understand the likely impact, cost and effectiveness of a given intervention. Impact is rated in 12 tiers, each representing the number of additional months' progress gained as determined by effect size. Interventions are allocated a padlock rating (1 = very limited evidence through to 5 = very extensive evidence) according to the strength of evidence as shown in the systematic review of research studies that meet the inclusion criteria. Interventions with fewer than 11 research studies that meet the inclusion criteria are given a zero-padlock rating. As the number of studies increases so do the number of padlocks, for example an intervention would need between 45 and 60 studies that meet the toolkit inclusion criteria to receive a three-padlock rating of moderate evidence. This framework for quality evidence differs from others as it looks at the size of the body of evidence to support an intervention as a proxy for quality of evidence. Further metrics of quality include the capping of padlock ratings if many of the studies were not independently evaluated or there is considerable unexplained variation in the results across the studies. Furthermore, if only a small proportion of the studies were undertaken recently or in real-life contexts then additional padlocks can be lost. Significantly, if there is an insufficient proportion of randomised controlled trial studies within the collection of studies, the rating is also compromised due to the potential influence of other factors on the results of the study such as the inability to reliable attribute causality.

Evidence4Impact (E4I) Evidence Rating System

The Evidence 4 Impact website provides educators with easy access to information about educational interventions that have been shown to be effective. Originally developed by the Institute for Effective Education and now hosted as a legacy site by the Education Endowment Foundation (EEF), the E4I searchable database of interventions uses an evidence rating system to indicate whether an intervention's effectiveness has been proven. Only studies that meet the minimum standards of rigour (as determined by inclusion criteria) are evaluated and featured in the database. Eligible studies are of sound methodological quality and relevance of study design, consisting of at least two teachers in each treatment group. Interventions must be compared to control groups and participants randomly assigned, be conducted in real world settings and of a duration of at least 12 weeks. Once selected, studies are rigorously evaluated and allocated one of five Level of Evidence Ratings; Strong, Moderate, Limited, No Impact and Not Evaluated. As the inclusion criteria conducted an initial screening of eligible studies, all studies are randomised or matched studies and the level of evidence rating is determined primarily by sample size (500 for students for Strong, 150 students for Limited) and sample-size-weighted effect (Moderate at least +0.10 and No Impact less than +0.05). Whilst it does not feature as a characteristic of quality evidence, the E4I database also indicates if an intervention has been evaluated and adds a Union Jack flag on the ratings page of an

intervention to indicate increased confidence that an intervention is likely to be effective if implemented within UK schools. This is a unique characteristic amongst the quality evidence frameworks reviewed.

Queensland Standards of Evidence

There is a clear difference in the Queensland Standards of Evidence as it breaks down the assessment of research areas into four separate dimensions for consideration: attribution; impact; scalability and investment. The dimensions are rated on a scale of 1 (lowest) to 5 (highest) according to the quality of evidence supporting each dimension. Whilst there is likely to be some degree of uniformity across the ratings for each dimension the guidance does allow for differing levels of strength of evidence citing, for example, that an initiative may have very high (level five) evidence of impact but the scalability may be unknown (level one). This framework is less prescriptive in terms of what constitutes a well-designed study or how impact is determined other than it must be measurable. There is a clear distinction, however, in categorising studies where reasonable explanation supports the attribution of measurable change to an intervention and instances where change can be attributed to the intervention.

ESSA Tiers of Evidence

The ESSA tiers of evidence are supported by the What Works Clearinghouse (WWC) standards as means of determining which studies meet the quality criteria for study design (see WWC Standards). The non-statutory guidance accompanying ESSA makes explicit the aim of strengthening investment in educational technology by identifying local needs and selecting relevant interventions that are supported by evidence. The tiers of evidence graduate through a quality criteria spectrum, moving from the lowest quality evidence, Tier 4 - Demonstrates a Rationale, to Tier 3 - Promising Evidence, to Tier 2 - Moderate evidence before arriving at Tier 1 - Strong Evidence, indicating that it will achieve the expected outcomes.

Features of Tier 1 are a well-designed and implemented experimental study (i.e. meets WWC Standards without reservations). At least 350 randomly assigned participants, from more than one school or district, were involved in the study in either a control or intervention group. The study showed a statistically significant positive impact on participant outcomes and no strong negative findings. Tier 2 fulfils all the same conditions as Tier 1 with the exception of meeting WWC standards. Tier 2 studies meet the WWC standards with reservations, which reflects a less well-designed study that, for example, was unable to randomly select or assign participants. Tier 3 - indicates promising evidence and consists of a well-designed correlational study that explores the relationship between two variables and is statistically controlled for bias with a statistically positive effect on a relevant outcome. Tier 4 - demonstrates a rationale through a well-

defined logic model based on rigorous research with an effort to study the effects of the intervention already underway or at least planned.

What Works Clearinghouse (WWC) Standards

Research is evaluated using screening standards and quality standards to categorise studies as either meeting WWC Standards without reservations or meeting WWC Standards with reservations. Screening standards include elements such as relevance of timeframe, intervention, sampling and reporting of at least one outcome relevant to the WWC review. The study must reliably measure a relevant outcome that the study design intended to measure and reporting must be adequate to allow for calculating the effect size for at least one outcome measurement. Quality standards dictate that it must be a randomised controlled trial or a quasi-experiment. To meet the standard without reservation, there must also be randomisation of participant placement. In addition, the study should be without high levels of attrition, intervention contamination or teacher-intervention confound (when only one teacher is assigned to each condition) to remain without reservations.

Australian Education Research Organisation (AERO) Standards of Evidence

In common with the ESSA Tiers of Evidence and the E4I Evidence Ratings System, the AERO standards attribute ratings to research according to the quality of evidence supporting the causal relationship between the intervention and outcome. AERO Standards attribute four levels of confidence, although the ranking is inversed in comparison to other frameworks and Level 4 research is considered the highest quality and Level 1 demonstrates low confidence that an intervention causes positive effects.

The highest AERO standards (Level 4 and Level 3) can only be attributed to rigorous experiments with control groups however, similarly to the ESSA Tier 3 (Promising Evidence) but unlike the E41 Evidence Rating System, the AERO Tier 2 (Medium Confidence) relates to a demonstrable correlation between the intervention and positive effects on outcomes. Unlike the ESSA standards, this tier does not need to have statistically controlled for selection bias which signifies that research could take the form of a case-study or cross-national survey and could be designed using qualitative, quantitative or mixed-methods approaches. The differential between the top two tiers for the AERO standards of evidence is the extent to which the intervention may have a positive effect in the users' context. Differences in individual contexts when compared to the context of the study results in a lower confidence of a positive impact whereas a Tier 4 study will have been conducted in a very similar context to the intended user. Ultimately, the degree of confidence between high and very high is determined by the individual.

NESTA Standards of Evidence

The NESTA Standards of Evidence are not associated with specific data types or research methods and so does not identify explicit criteria that evidence must meet (e.g. sample size or length of study). Instead, the NESTA standards outline expectations of evidence at the different levels and describe how evidence of impact might be generated for each of the standards, prioritising high quality, robust, appropriate and scalable evidence.

The standards of evidence consist of five levels of evidence ranging from the lowest (Level 1) to Level 5 (highest). Progression through the levels begins with drawing on existing data and research to give a logical, coherent and convincing account of potential impact (Level 1). Level 2 builds on this by introducing data that indicates a positive correlation, as we have seen in the and AERO frameworks. Demonstrating causality is a requirement of Level 3 as data is used to isolate and attribute impact to the intervention. This is achieved using a control or comparison group however there is no criteria regarding participant selection or allocation. Once causality has been established, the next level of quality, Level 4, requires independent, external validation, replicating and confirming the research. Level 5 extends the evidence quality standards from replicability to scalability as an intervention maintains a strong impact at multiple locations. Evidence of an intervention's positive impact in different contexts is a key quality component that features in other frameworks however, level 5 of the NESTA standards is particularly ambitious although, it is perhaps significant that it is a framework for evaluating the quality of evidence of any innovation, not limited to educational interventions and research.

Educational Technology Quality Frameworks

What Worked EdTech Standards of Evidence

The What Worked EdTech Standards of Evidence are intended to help developers underpin their product development with research and assist educators in their appraisal of the effectiveness of educational technology. The standards apply a rating of strong, moderate, weak or very limited evidence to research studies. As with other quality frameworks, studies which fail to show a causal relationship between an intervention and outcome are rated as demonstrating weak evidence. As with some other frameworks, an increasing sample size is specified for each standard although this framework has a criterion of more than 1000 participants across multiple sites to demonstrate scalability. Transparency of context and implementation details are specifically mentioned and used as criteria to judge overall quality of evidence whilst is unusual across other quality frameworks although contextual information is essential for replicability.

A Framework for Quality in Educational Technology Programs (Confrey et al. 2002)

This framework pre-dates the Every Student Succeeds Act and the accompanying ESSA Tiers of Evidence to judge the quality of evidence supporting an intervention however it was constructed specifically for the application to educational technology. Commissioned by the U.S. Office of Educational Research and Improvement and informed by an expert panel, the Framework for Quality in Educational Technology Programs consists of four key areas of focus: Quality of Program, Educational Significance, Evidence of Effectiveness & Usefulness to others. The Evidence of Effectiveness section offered some evidence quality criteria to guide educators in their appraisal of evidence supporting an intervention. Unlike other quality evidence frameworks, this does not categorise evidence in different levels according to quality but recommends a set of quality characteristics. Studies should be rigorous, include comparison groups, adopt clear methods with appropriate sample sizes and include a quantified, externally validated demonstration of positive change as a result of the intervention. Although the framework specifies quantitative studies, it also recommends in-depth qualitative analysis of the change among participants.

References

Aparicio, M., Bacao, F. and Oliveira, T. (2016) An e-learning theoretical framework. *Journal of Educational Technology and Society,* 19(1), pp. 292-307.

BESA (2020) EdTech in English Maintained Schools https://www.besa.org.uk/insights/edtech-in-english-maintained-schools/ (log-in required)

BESA and EDUCATE Ventures Research (2023) The state of evidence in EdTech 2023. Available at: https://www.besa.org.uk/wp-content/uploads/2023/03/230327-The-State-of-Evidence-in-EdTech-2023.pdf (Accessed 31 March 2023)

Bond, M., and Bedenlier, S. (2019) Facilitating student engagement through educational technology: towards a conceptual framework. *Journal of Interactive Media in Education* 2019.1

Breckon, J. (2016) Using research evidence: a practice guide, NESTA https://www.nesta.org.uk/toolkit/using-research-evidence-practice-guide/

Castañeda, L., and Williamson, B. (2021) Assembling New Toolboxes of Methods and Theories for Innovative Critical Research on Educational Technology. *Journal of new approaches in educational research* 10(1) 1–14.

Cherner, T. and Mitchell, C. (2020). Deconstructing EdTech frameworks based on their creators, features, and usefulness. *Learning, Media and Technology*, pp.1–26. doi:10.1080/17439884.2020.1773852

Confrey, J., Sabelli, N., and Sheingold, K. (2002) A framework for quality in educational technology programs. *Educational Technology* 42(3,) pp. 7-20.

Crompton, H. (2021). Developing Instructional Technology Standards for Educators: A Design-Based Research Study. *Computers and Education* Open. 2. 100044. 10.1016/j.caeo.2021.100044.

Dalton, E. M., and Roush, S. E. (2010). Assistive and Educational Technology Standards and Teacher Competencies in Relation to Evidence-Based Practice: Identification and Classification of the Literature. *Journal of Special Education Technology*, 25(2), 13–30. https://doi.org/10.1177/016264341002500202

Department for Education (2022), Opportunity for all: strong schools with great teachers for your child https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063602/Opportunity_for_all_strong_schools_with_great_teachers_for_your_child__print_version_.pdf (Accessed 26 May 2023)

Digital Promise Evaluating studies of EdTech Products Available at: https://digitalpromise.org/wp-content/uploads/2016/04/DP_EvaluatingTheResults.pdf (Accessed 31 March 2023)

Digital Promise Learner Variability Navigator https://lvp.digitalpromiseglobal.org (Access 26 May 2023)

EdSurge. Product Index Decision Guide Available at: https://index.edsurge.com/decision/ (Accessed 31 March 2023)

Carolan, J and Zielezinski, M. (2019) Debunking the 'Gold Standard' Myths in EdTech Efficacy EdSurge https://www.edsurge.com/news/2019-05-21-debunking-the-gold-standard-myths-in-edtech-efficacy

EdTech Evidence Exchange (2021) The EdTech Genome Project Report Available at: https://edtechevidence.org/wp-content/uploads/2021/10/EdTechGenomeProject-FinalReport_10-1-21.pdf (Accessed 31 March 2023)

Falloon, G. (2020), From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development* 68 pp. 2449-2472.

FitzGerald, E, Kucirkova, N., Jones, A., Cross, S., Ferguson, R., Herodotou, C., Hillaire, G. and Scanlon, E. (2018) Dimensions of personalisation in technology-enhanced learning: A framework and implications for design. *British Journal of Educational Technology* 49(1), pp.165-181.

Georgouli, K et al. A Framework for Adopting LMS to Introduce E-Learning in a Traditional Course. *Journal of Educational Technology & Society*, vol. 11, no. 2, 2008, pp. 227–40.

Haßler, B., et al. (2021) Syṡtemic Mixed-Methods Research—A conceptual framework for scalable EdTech research (Working Paper No. 9) https://doi.org/10.53832/edtechhub.0001.

Instructure. (2023) 2023 EdTech Evidence Mid-Year Report. Available at: https://learnplatform.com/report/evidence-report (Accessed 31 March 2023)

King, M et al. (2016), Bridging the edtech evidence gap: A realist evaluation framework refined for complex technology initiatives, *Journal of Systems and Information Technology,* Vol. 18 No. 1, pp. 18-40. https://doi.org/10.1108/JSIT-06-2015-0059

Koehler, M. J., Mishra, P., Kereluik, K., Seob Shin, T. and Graham, C. R. (2014), The technological pedagogical content knowledge framework. in Spector, J.M et al (eds)

Handbook of research on educational communications and technology. Springer Science and Business Media, New York 101-111.

Leacock, T. L., and Nesbit, J.C. (2007) A framework for evaluating the quality of multimedia learning resources. *Journal of Educational Technology & Society,* 10(2), pp.44-59.

Learn Platform, Inc. (2023) Universal Evidence Reports https://www.evidencereports.com

Luckin, R. and Cukurova, M. (2019), Designing educational technologies in the age of AI: A learning sciences-driven approach. *British Journal of Educational Technology*, 50: 2824-2838. https://doi.org/10.1111/bjet.12861

McCarthy, K., Watanabe, M. & McNamara, D The Design Implementation Framework: Guiding Principles for the Redesign of a Reading Comprehension Intelligent Tutoring System in M. Schmidt, A. A. Tawfik, I. Jahnke, & Y. Earnshaw (Eds.), Learner and User Experience Research: An Introduction for the Field of Learning Design & Technology. EdTech Books. https://edtechbooks.org/ux/9_the_design_impleme

Mishra, P., Koehler, M. J., & Henriksen, D. (2011). The seven trans-disciplinary habits of mind: Extending the TPACK framework towards 21st century learning. *Educational Technology*, 51 (2), 22-28.

Price, S. and Oliver, M. (2007) A framework for conceptualising the impact of technology on teaching and learning. *Journal of Educational Technology & Society*, 10(1), pp.16-27.

Sonnenberg, L. K., Onan, A. and Archibald, D. (2021), Educational Technology Competency Framework: Defining a Community of Practice across Canada. *Canadian Journal of Learning and Technology*, 47(1) pp.1.

Sosa-Díaz, MJ., Sierra-Daza, MC., Arriazu-Muñoz, R., Llamas-Salguero, F.and Durán-Rodríguez N (2022), EdTech Integration Framework in Schools: Systematic Review of the Literature. Frontiers Education. Doi: 10.3389/feduc.2022.895042

UNESCO Global Education Monitoring (GEM) Report Concept Note (2023). Available at: https://unesdoc.unesco.org/ark:/48223/pf0000378950 Accessed 31 Mar. 2023.

U.S Department of Education, Office of Education Technology (2013), Expanding Evidence Approaches for Learning in a Digital World https://files.eric.ed.gov/fulltext/ED566873.pdf

Van Nostrand, P., Noakes, S., Shah, Z., and Luke Luna C. (2022). An overlooked indicator of edtech quality: The use of learning sciences research. Digital Promise. https://doi.org/10.51388/20.500.12265/150

Vincent-Lancrin, S., et al. (2019), Measuring Innovation in Education 2019: What Has Changed in the Classroom?, *Educational Research and Innovation*, OECD Publishing, Paris, https://doi.org/10.1787/9789264311671-en.

Vuorio, J., Okkonen, J. and Viteli, J. (2017). Enhancing user value of educational technology by three layer assessment. *Proceedings of the 21st International Academic Mindtrek Conference*. doi:https://doi.org/10.1145/3131085.3131105.

Williamson, B. (2021) Meta-edtech*. Learning, Media and Technology* 46.1 (2021): 1-5.

Department for Education

Reference: RR1398

ISBN: 978-1-83870-526-8

For any enquiries regarding this publication, contact us at: Edtech.team@education.gov.uk or www.education.gov.uk/contactus

This document is available for download at www.gov.uk/government/publications