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# Using technology for questioning evidence in pre-service teacher education

Christian Bokhove<sup>1\*</sup> , Lucy Hoyes<sup>1</sup> and Ros Hyde<sup>1</sup>

\*Correspondence:  
C.Bokhove@soton.ac.uk

<sup>1</sup> Southampton Education School, University of Southampton, Southampton, UK

## Abstract

In recent years there have been more and more calls for the preparation of teachers to be increasingly evidence-informed. The assumption is that evidence-informed teaching practice improves the quality of teaching and subsequently student achievement will improve. Preparation for teaching using technology for student learning is well-established in pre-service teacher education programmes. However, the use of technologies to interrogate evidence by pre-service teachers is less well-researched. The work presented here offers insights as to how using technology can support and enhanced pre-service teachers in developing practices that are evidence-informed. Using a theoretical framework with elements of evidence-use mechanisms and Engeström's expansive learning cycle, a programme for training pre-service mathematics teachers in one European country was redesigned, with the programme leaning strongly on technology use to query evidence. Using a design-based research approach, this article describes the design iterations, and presents a case study with five in-depth interviews with pre-service teachers on evidence-use. From these cases, it is concluded that the use of technology can aid and support evidence-use. The paper concludes by presenting a new redesign of the programme with the use of generative AI, pointing towards future ways in which technology can support the development of teachers' evidence-use.

**Keywords:** Pre-service teacher education, Evidence-informed teaching, Expansive learning cycle, Technology, Digital literacy, Artificial intelligence (genAI)

## 1 Introduction

In pre-service teacher preparation, whether in Higher Education Institutions, or in alternative preparation programmes, recent calls to work in a more 'evidence-informed' way have dominated reforms in several European countries. For example, in England the 'Early Career Framework' describes an entitlement to training and "support for early career teachers linked to the best available research evidence" (Department for Education, 2019, p. 14), and in the Netherlands there are calls that PhD students who teach at universities should have a teaching qualification where teachers "learn to apply educational knowledge and recent evidence from the domain" (VSNU, 2018, p. 27). Such emphases on evidence in pre-service teacher preparation are in line with more general European developments as well. A key element the European Commission has

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formulated with regard to strengthening teacher education in the European Union (EU), is that “policies and actions should support student teachers and teachers to use and engage in research in their practice.” (European Commission, 2015, p. 35). In other words: research and practice go hand in hand when building evidence, and practitioners are expected to engage with research evidence. One approach is to consider research through different evidence-use lenses. In their review, Breckon and Dodson (2016) report on six categories of evidence-use mechanisms. An alternative approach is for teachers to use a so-called ‘expansive learning cycle’ (Engeström & Sannino, 2010) utilising action research and collaborative lesson research to innovate their teaching practice. Informed by results from educational and domain-specific research and scientific resources, this could encourage teachers to engage in the process of educational change. In such an approach, teachers set their own learning objectives and enquiries in interaction with the knowledge base of their discipline. Although researchers like Biesta (2007) challenge the notions of ‘what works’ evidence in education, research findings can make one’s problem-solving more intelligent. In a parallel development, the use of technology for a range of tasks relating to teaching and learning is well-embedded in teacher preparation programmes. However, less is known about how pre-service teachers utilise such technologies to support their own development as a teacher, especially how technologies of all kinds (including recently generative Artificial Intelligence, genAI) can help them develop practice that is evidence-based. This is particularly important given that genAI is a rapidly developing field and its use in teaching and learning is evolving quickly. Such rapid development also called for increased skills in making evidence-informed choices. This article focusses on this gap in the research, and presents work from one country in the Erasmus+ project ‘Research in Teacher Education’ (RiTE project). In this project, five research teams from four European countries collaborated through a case study approach aiming to promote and facilitate beginning teachers to develop evidence informed practice in STEM subjects. The case study described here follows the redesigning of a pre-service teacher education context in England based on principles from evidence-use mechanisms (Breckon & Dodson, 2016) and the expansive learning cycle with an emphasis on the crucial phase of ‘questioning’. A large part of the ‘questioning’ phase was designed with the support of technology, arguing that that for evidence to best take hold with practitioners, it should be subjected to questioning, scrutiny and reflection with the help of technology. The article first expands on the underpinning literature on evidence-use and technology use in pre-service teacher preparation, as well as our theoretical framework. Using a design-based research approach, the paper then describes the redesign of the programme, focussing on crucial elements for questioning with the aid of technology. The design iterations draw on five in-depth interviews with beginning teachers who experienced the redesign, focussing on technology elements from their interviews. Finally, the article looks at a further redesign of the programme for the future which uses generative AI.

## **2 Literature background**

### **2.1 Evidence-informed practices for developing teachers**

Before proceeding with discussing evidence-informed practices, one needs to determine what is meant by ‘evidence’. The definition of evidence is discussed by many researchers,

not just in the domain of evidence-based practice (Kvernbekk & Pinto, 2011). ‘Evidence’ can be observed in several ways. One, for example, is with regard to the source of the evidence. According to Breckon and Dodson (2016), evidence can be generated through official research, which means in universities and other official research institutions. This normative adoption is expanded by the notion that research can also be conducted outside of official research institutions. There may also be a huge body of evidence within experts and practitioners in the relevant field. Another variable might be the format of the evidence (Gorard et al., 2020), for example whether it addresses a more general topic, or whether it focuses on one specific, specialised theme. The degree of interpretation can vary from the presentation of raw material to redrafted and highly interpreted materials. In this article, and in the wider RiTE project, evidence is defined as “the best available information regarding a particular topic, especially if it refers to results of various studies.” Regarding source, it is posited that “evidence can be gathered and interpreted by researchers and anybody else (e.g. practitioners, experts, ...) through intentional and systematic procedures.” Finally, the focus and format of evidence “can vary with regard to internal interests, values and purposes of the authors or the target group.” This definition still poses some challenging questions, for example what is the ‘best available information’ and also the extent to which it is known whether a study uses ‘intentional and systematic procedures.’ Nevertheless, it provides a starting point from which to work. However, even if there is agreement on what ‘evidence’ is, this does not necessarily tell us how to *use* evidence, while terms like ‘evidence-informed decision making’, or ‘evidence-use’ focus on the implementation of evidence in daily life. Breckon and Dodson (2016) conducted a meta-review of 36 systematic reviews including 91 interventions. All these interventions belong to the health sector, where much research on evidence-use has been done. In a second step they conducted a scoping review of other social sciences, such as media and psychology. The aim of their study was to have a deeper look into evidence-informed decision making in policy. Six evidence-use mechanisms were distilled from the existing literature:

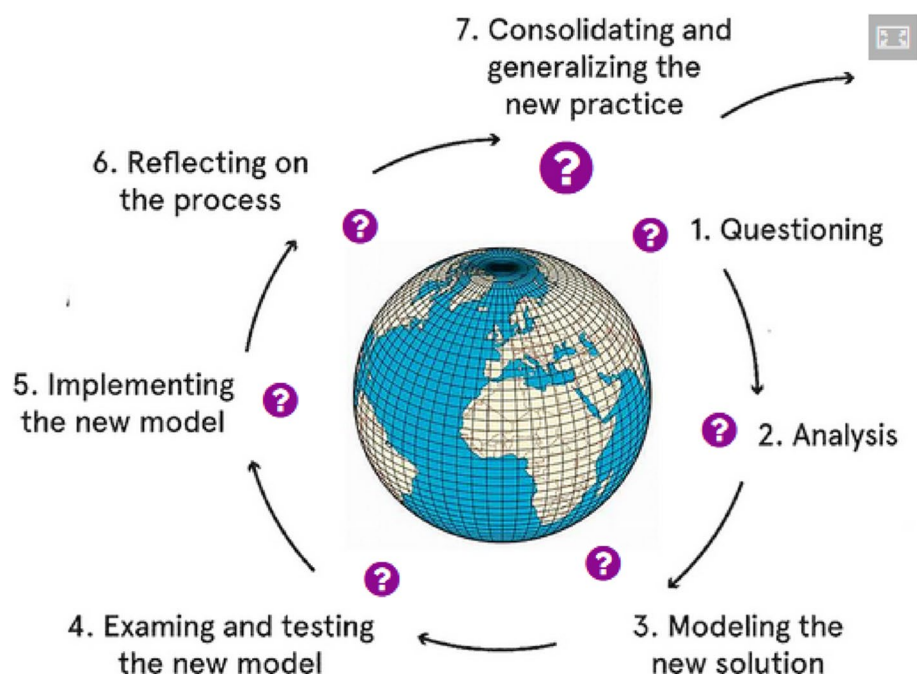
- Awareness – Building awareness and positive attitudes towards evidence use
- Agree – Building mutual understanding and agreement on policy-relevant questions and the kind of evidence needed to answer them
- Access and Communication – Providing communication of, and access to, evidence
- Interact – Facilitating interactions between decision-makers and researchers
- Skills – Supporting decision-makers to develop skills accessing and making sense of evidence
- Structure and Process – Influencing decision-making structures and processes (Breckon & Dodson, 2016, p. 6)

Gorard and colleagues (2020) focused on evidence-use in *education* and concluded that the majority of studies in the education domain “have not had positive results. This enables research users such as schools to make much more informed judgements about which interventions are likely to work in their context, and which will not” (p. 571). In this way, even negative results of studies can have a positive influence on decision processes in schools. With reference to the quality and subjectivity of evidence, it is

not always clear whether studies with a large influence in schools also are high-quality studies, and even if these studies have high quality, it is not clear how to implement the results in school, potentially leading to “wasted opportunities, and even harm, for the education system” (Gorard et al., 2020, p. 574). This is why it is relevant to look into the best mechanisms to nurture evidence-informed practices. Sjölund et al. (2022) reviewed the literature on research-practice partnerships and argue that “partnerships presenting opportunities for process use of research promote the highest degree of engagement with research by teachers” (p. 17) and highlight how teachers could “investigate questions relating to problems of practice” (p. 17). A fruitful research-partnership therefore seems to start with an investigation of relevant questions relating to teachers’ practices. The definition of ‘evidence’ used here is therefore broad in terms of source, focus and format and its use is seen through the use of a number of mechanisms with an emphasis on the ‘questioning’ phase in the expansive learning cycle.

## 2.2 Expansive learning when beginning to teach

The approach in the RiTE project integrates Engeström’s expansive learning cycle as a methodology within the design of the study. The theory of expansive learning is intertwined with the broader theory of ‘activity theory’, which is not expanded on in this particular article. Three key dimensions can be considered in expansive learning theory. Firstly that it involves an active process, a transformation, and creation of culture of “communities as learners” (Engeström & Sannino, 2010, p. 2). Secondly, the theory is mainly interested in ‘horizontal movement’: to break (horizontal) borders of communities, cultures and activity systems, and ‘cross borders’. Such ‘boundary crossing’ contains learning potential (Akkerman & Bakker, 2011). Thirdly, expansive learning has the aim to form new theoretical knowledge and/or concepts, through empirical data. Figure 1



**Fig. 1** Expansive learning cycle as presented on the RiTE project website (<https://www.rite-project.eu/>)

presents the expansive learning cycle. The steps of Questioning and Analysis have the goal to identify the problem and inherent contradictions. The analysis therefore may include historical and actual-empirical analysis (Engeström, 2001). In the Modelling step, the new solution, or new activity, is designed.

Within the step of Modelling that follows, the activity under scrutiny obtains a new form and is transformed. The new activity attempts to avoid previously existing contradictions. When a new solution is accepted, it then is implemented in the Implementation step. After the Implementation, the whole process is reflected on in the Reflecting step. When this reflection is positive, the new activity will stabilise after a while, and the Consolidating step will generalise the new practice. At this point the expansive learning cycle is concluded. However, it might be possible, that after a while new contradictions arise with the 'new' activity, causing the process to start over again. As described, the expansive learning cycle provides a model for considering the learning of beginning teachers and further identifies the questioning step as the key entrance point for the consideration of evidence by them. This is further developed in the programme redesign, and Table 2.

### 2.3 Questioning when beginning to teach

Questioning and Analysing are the two learning actions that are most underpinned by the principles from developmental psychology and activity theory and distinguish the cycle of expansive learning from that of other participatory design processes. In the first Questioning step learners experience a critique or rejection of aspects of current practice. Engeström et al. (2013) identified three subcategories of questioning: challenging participants into questioning, criticising existing practice, and questioning the proposed development. Engeström and Sannino (2010) describe how expansive learning occurs through the first stage of questioning an aspect of existing knowledge and practice. In order to question, criticise or reject "some aspects of the accepted practice and existing wisdom" (p. 7) beginning teachers would need to have an awareness of the knowledge and practice that currently exists within the teaching contexts that they are learning to teach. This is potentially problematic because beginning teachers are usually designing lessons and teaching aspects of the curriculum for the first time. In order to have a critical awareness of existing teaching practices, teachers require insight into the activity of the departments that they work with and opportunities to interrogate the relationship between approaches to teaching and its relationship with students' learning. Enabling beginning teachers' early professional learning may depend on the beginning teacher disturbing their perception of how subject matter is taught and learned through insights that are based on the way that they were taught and learned the content themselves, as well as their early experiences of observing and sharing teaching spaces within their own school career. The 'questioning' that needs to lead to contradictions needs to be seen in this context. Although opportunities for contradictions that stimulate expansive learning are constrained by the beginning teacher's limited experience as well as their perceived responsibilities to their teaching institution, it is exactly the prevailing views of beginning teachers on entering their teacher preparation programme that need questioning. For instance, when it comes to the theme of 'evidence-use', a redesign of current practices would need to simultaneously teach evidence that supports the skills and

knowledge to become a good teacher, *and* instil a questioning attitude, something it is posited can be supported by technology use. The questioning step is therefore identified as the place where beginning teachers have the most appropriate opportunity to engage with evidence and to start developing evidence-based practice.

#### 2.4 Technology use in pre-service teacher preparation

The integration of digital technology into teacher preparation has transformed the landscape of how pre-service teachers are prepared for their roles in the classroom. Over time there has been a shift from traditional methods, which focused on basic computer literacy and the use of educational software for lesson planning and administrative tasks to approaches that emphasise the pedagogical use of digital technologies (EEF, 2019). Rapid changes in digital technologies means that there needs to be constant development in how early career teachers are prepared to confidently incorporate them in their own practice (Bothe, 2023). Recently, artificial intelligence (AI) has emerged as a particularly significant development within this field and educators are quickly realising the benefit of using genAI across a wide breadth of activity (Department for Education, 2024). Historically, digital technologies in education were considered in relatively distinct categories: administrative tools, presentational tools, subject-specific tools (e.g. those that "do the maths"), and pedagogical tools. However, in the current technological climate, genAI has disrupted traditional practices, and these historic classifications have become more blurred with the rise of genAI tools and embedded, web-based platforms (Kumar & Sharma, 2025). Future teachers must navigate a landscape where intelligent algorithms are invisibly integrated into everyday platforms like search engines and educational websites. This integration, often unnoticed by users, highlights the growing importance of critical digital literacy in the teaching profession, particularly in pre-service teacher preparation (Gousei et al., 2023; Millberg, 2025).

Mathematics education has long been at the forefront of technological innovation in teaching and learning. Decades before the formal inclusion of Information and Communication Technology (ICT) in school curricula, mathematics educators were exploring the pedagogical potential of digital tools. The development of LOGO programming introduced early visions of learner-centred, exploratory environments that leveraged computational power to deepen mathematical thinking (Hoyles et al., 1986). The introduction of dynamic geometry software—such as The Geometer's Sketchpad and Cabri—further transformed the landscape, allowing learners to manipulate and investigate mathematical structures dynamically and visually (Oldknow et al., 2010). Pre-service teacher preparation in mathematics has, accordingly, inherited and extended this legacy, often positioning its students as early adopters of emerging technologies. In doing so, it not only prepares future teachers to explore the possibilities of digital tools in their own classrooms but also influences the digital cultures of the schools in which they are placed and later employed. The quality of their technology experiences during teacher preparation significantly influences how they will use technology in their teaching careers (Mahon et al., 2018). Teacher educators play a crucial role in equipping pre-service teachers with the skills needed to enhance their confidence in using digital technology (Jenßen et al., 2021). Therefore, proactive engagement with digital technology will

support the development of early career teachers who are not only flexible and adaptable in response to technological change but are also equipped to think critically about and with technology. It is the application of technology for considering evidence that is the focus of this article.

### 3 Methodology

This study uses ‘Educational Design Research’ (EDR) to frame the activities (Plomp, 2013). EDR is characterised by focusing on developing research-based solutions for complex educational problems in real-world settings. In this case, it concerns a focus on a technological contribution to the critical use of evidence in a teacher training context. EDR is interventionist in that the ideas are concretely tried out in a real-world setting. The EDR process is iterative, involving continuous cycles of analysis, design, evaluation and revision. In this project, there was one complete iteration, as shown in Table 1.

EDR is process-oriented, and more interested in how interventions work, not just whether work, something which can be gauged through the active involvement of practitioners. This work addresses the research question:

*What are the characteristics of a technology-supported intervention for critical evidence-use by secondary mathematics pre-service teachers?*

The design process followed the layers of formative evaluation (Tessmer, 2013) starting out by designing and revising the programme through self-evaluation in the design team, the authors of this article. The design was then subjected to expert review within the wider RiTE project. Finally, the programme was then used with a cohort of 23 secondary mathematics pre-service teachers in 2020-21, with the second and third author of this article as the main tutors. The first author conducted a one-hour interview with each of three pre-service teachers (2 females, 1 male) in July 2021 on a voluntary basis to gather views on evidence-use. Although this article specifically focuses on technology use, the core objective of the intervention was critical evidence-use, with technology being a means, a tool, to an end. Such is also apparent in the fact that the interview schedule focussed on evidence, including the follow questions:

- 1) What do you understand by evidence?
- 2) Where do you think evidence plays a major role in our daily life?

**Table 1** Research process stages

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• Identification of research question
• Self-evaluation of existing programme against research question by tutor team
• Redesign of relevant programme elements
• Expert review from the wider project team
• Programme used with cohort in 2020–21
• Interviews with three pre-service teachers
• Analysis of interview data
• Revisions to programme for 2021–22
• Programme used with cohort in 2021–22
• Interviews with two pre-service teachers
• Analysis of interview data
• Proof-of-concept with genAI
• .....

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- 3) When do you use evidence in your daily life and what does this evidence look like?
- 4) What role does evidence play in your teaching profession?
- 5) How do you consider the role of evidence for school?
- 6) How well has your training prepared you to deal with evidence in your teaching profession?

After some small revisions, the same programme was used in 2021-22 with another cohort of around 21 pre-service teachers, with the second and third author of this article again the main tutors. The first author conducted a one-hour interview with each of two pre-service teachers (2 females) in July 2022 on a voluntary basis to gather views on evidence-use. The analysis focussed on the design iterations involving technology, and the mechanisms reported in the interviews. For the purposes of the technology focus, only observations and results from the interviews that pertain to technology are included in this article. After recording the interviews on the Microsoft Teams platform, the five interviews were transcribed and coded the transcripts through thematic analysis (Braun & Clarke, 2006), focussing only on technology contexts. The analysis was informed by reflections at each stage from the tutors teaching the programme. The first-named author acted as a critical friend for the two tutors and meetings of the wider project team provided opportunities for interrogation of emerging findings within and across the Anonymised Project country-level case studies. For a wider report on the Anonymised Project, as well as all the materials for the intervention, to the public use report is available on the project website at anonymous link. Ethics approval was sought and given by the university's ethics board under number 61371. This article now first reports on the redesign of the teacher preparation programme.

#### **4 Redesign of pre-service teacher preparation programme**

At the University of Southampton, United Kingdom, the post-graduate programme to become a secondary mathematics teacher (PGCE) contains three Master level assignments, two of which are mathematics education specific. In the RiTE project the support for these two assignments A1 and A2 was redesigned. A1 is a critical evaluation of one out of two mathematics education topics: mathematical resilience or mathematical (mis-)conceptions. A2 then asks pre-service teachers to design a small research project on the topic of A1, collect some empirical data, analyse it and then draw some conclusions on the basis of these data. Regarding the evidence-use mechanisms by Breckon and Dodson (2016), the focus is on awareness and skills i.e. building self-awareness of pre-service teachers' evidence-use and the skills to evaluate evidence. The set of activities to complete both assignments has been mapped to the Engeström cycle shown in Fig. 1, as presented in Table 2, with a specific focus on the use of technology in each of the phases.

The questioning phase is a crucial element of the redesign, and this is where the affordances of technology use were exploited. The cycle of activities first had to make sure that there was a comparable evidence-base for all pre-service teachers. This was done by constructing a literature list for the two topics mentioned earlier: 'attitudes to mathematics and resilience' and 'conceptions and misconceptions in mathematics'. These lists had numerous seminal works from the field. Technology support was then added to the

**Table 2** Phases of the expansive learning cycle mapped to the intervention, technology use highlighted in bold

Phase from the Expansive Learning Cycle	Description
Questioning	In the 'Questioning' phase students are offered a range of literature on the two topics 'attitudes to mathematics and resilience' and 'conceptions and misconceptions' in mathematics education. We want them to be open-minded but also critical. We teach trainees to unpick research articles on these topics with instruction, activities and instructional videos. <b>Technology: The videos discuss the underpinning articles in a screencast format (Fig. 2)</b>
Analysis	In the 'Analysis' phase we ask them to analyse the literature more deeply, with some articles being studied in larger detail. For both topics this involves 'critiques' of the prevailing ideas about the topics. The phase should lead to critical insight about the topic at hand. The topic is related to trainees' experiences in the school they are learning to teach. The analysis feeds into an essay for 'assignment 2', which is a critical review of the literature of one of the two topics mentioned. 'Academic writing support' is provided in skill building sessions. <b>Technology: search skills to find additional literature from sources of evidence</b>
Modeling the new solution	The combined result of the analysis and linking it to trainees' own classroom practice, leads to a plan to study the topic within their own teaching context i.e. 'Modelling the new solution'. In other words, they make a plan for some empirical data collection that applies the insight gained from the literature to their own classroom practice. <b>Technology: data collection methods include using technology for the data collection tools</b>
Examining and testing the new model	The plan (see modelling) is submitted (i.e. will be examined and provided feedback by the tutors) and then 'tested' in the placement school. In our view of the Engeström cycle, we have interpreted this as the execution of the plans. <b>Technology: use depends on the specific research questions of the pre-service teachers</b>
Implementing the new model	However, in our view it's the reflection on the results that actually forms the 'implementation' phase. After all, it is that step that really brings together the prior literature and the data collected by trainees' own classroom experiences (i.e. genuine 'evidence-informed practice'. The phase is accompanied by 'data analysis' (depending on the research question, this can be both quantitative and qualitative) skill building sessions. <b>Technology: data analysis is supported by technology, including statistical packages and general use software (spreadsheets, word processors)</b>
Reflecting on the process	Finally, we envisage that a 'Reflection' on the whole process instils a habit of 'evidence-informed practice' in the trainees. <b>Technology: the interviews at the end of the course represent the reflection phase – although they are more generally about 'evidence-use', this article focuses on the technology use aspect</b>
Consolidating and generalizing the new practice	We hope this habit (see reflecting) then will be 'consolidated' in future years, especially in the first year after qualification as 'Newly Qualified Teacher' (NQT) <b>Technology: although this article focuses on the year-long teacher preparation programme, follow-up research could see whether evidence-use and technological support for this is consolidated</b>

presentation of the two topics. For two of the articles for each topic in-depth annotated PDF versions were created, with critical evaluation of numerous conceptual and methodological aspects of the articles. Pre-service teachers were asked to study and watch

these, thus providing a 'baseline' of existing knowledge for the two themes. After that, about a month later, tutors set out to challenge that evidence-base. They did that by explicitly using two articles that each challenged the 'existing wisdom' from the initial set of sources. For example, for the theme of 'attitudes to mathematics and resilience' a psychological article was chosen (Burgoyne et al., 2020) which explicitly argues that the claims about the foundations of 'Mindset Theory', one of the terms often associated with resilience, appear stronger than the evidence. The paper was discussed in an annotated PDF and a screencast, as depicted in Fig. 2.

The same thing was done for the theme of misconceptions. While one body of knowledge around this topic argues that it is best to not include misconceptions and errors in instruction, as they might teach students the wrong things, other studies argue that explicitly including errors and misconceptions would help. It is this tension we aimed to exploit in line with Engeström and Sannino (2010, p.7): "questioning criticizing or rejecting some aspects of the accepted practice and existing wisdom". Not only do we posit that Engeström's approach is adopted, but it also fits well in the Typical Performance Indicators used at the institution for Master level credits. After this phase, technology was also used to broaden the literature base of the pre-service teachers, teaching them how to search for research articles. The design of an empirical project was supported with data collection methods that often used technology in some way. After this, data was analysed, often with technology tools, for example statistical packages and general use software like spreadsheets and word processors.

## **5 Technology use through the eyes of the pre-service teachers**

Interviews more generally focussed on evidence-use, but this analysis specifically looked at the role technology plays in our redesign. The five interviews represent accounts of pre-service teachers at the end of the redesigned programmes at two different time-points, allowing exploration as to whether the intentions of the design were met, at least for these pre-service teachers. Three themes were distinguished in the interviews.

### **5.1 Theme 1: technology platforms as source for evidence**

Interviewees frequently referred to news websites and platforms like BBC News and other news channels as primary sources for information and evidence about current events. Pre-service teacher A mentioned her reliance on BBC News as a trusted source for absorbing evidence, as well as reading magazines and research for her assignment. Pre-service teacher B highlights how he consults specific newspapers or websites for news and refers to articles he has read as part of the programme. Several times, interviewees recognised a need to consult multiple sources, for example pre-service teacher C mentioned it was important to do this to get "a picture of the potential truth," especially when reports "say slightly different things" or "don't reference their sources". These considerations come to the heart of what are considered trustworthy sources of evidence or not. Interviewees also talked about sources they would not trust, with several in the realm of technology platforms, for example social media. Pre-service teacher D expressed her view of social media as a platform for potentially harmful misinformation that needs to be critically challenged. Pre-service teacher B acknowledged social media as transformative for the teaching profession, but also highlighted the need for

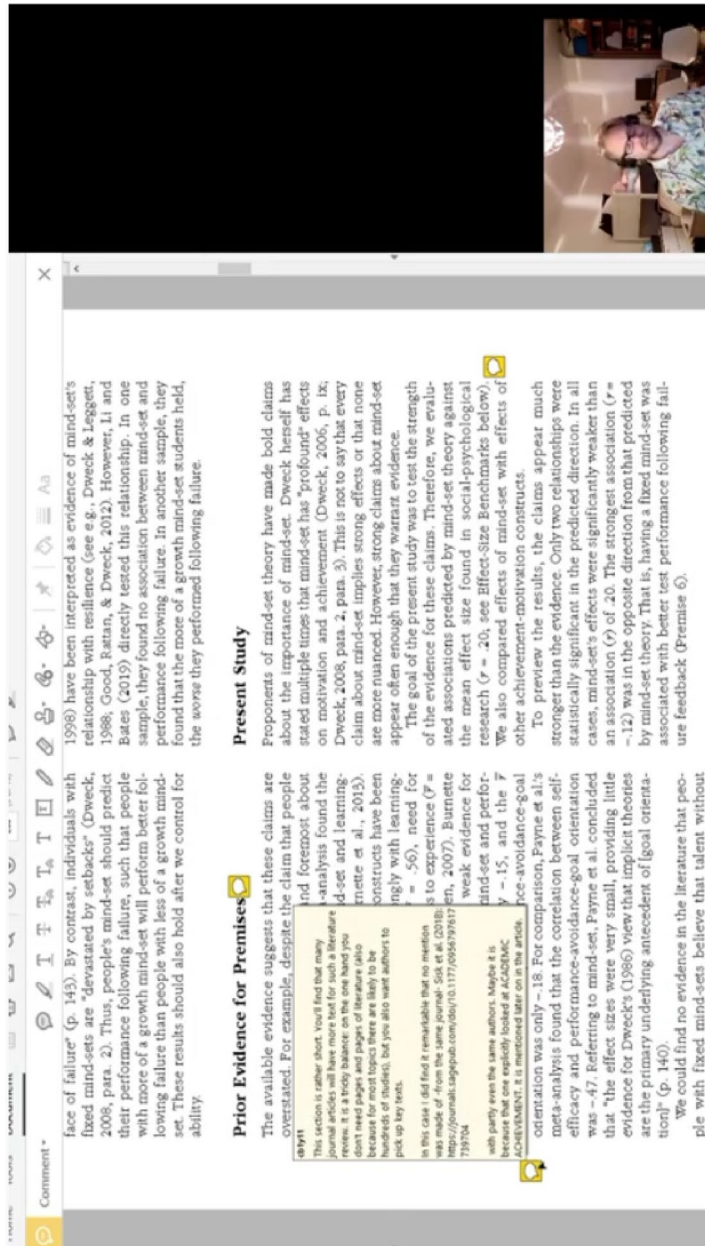


Fig. 2 Screenshot video presentation by the first author of an annotated research article critical of 'growth mindset'

critical engagement with information obtained from these platforms, especially in educational settings. Pre-service teacher A explicitly mentioned social media as a channel she would not trust for evidence, stating "I wouldn't trust things like I don't know social media, Facebook, anything that comes up on there. I'm not really I wouldn't really trust that as being evidence". Pre-service teacher C also reflected on how ubiquitous and often unreliable information on the news, also via social media, has made it difficult to discern truth. She stated, "I take everything on the news now with a pinch of salt because I'm like I just don't know if I you see like just the way things are going they'll say one thing and then the next day it turns around and it's something different.". It is clear from this theme that the programme aimed at evidence-use, incorporates extensive reflections on the relationship between what constitutes evidence in an era of technology use.

## 5.2 Theme 2: challenging evidence

As has become clear from the first theme, there is a significant challenge in discerning truth from the vast amount of conflicting information available digitally, leading to feelings of being "uninformed and"... "unable to make that judgment call" (pre-service teacher C). There seems to be temporal element in this as well, with recent developments in video editing, a "video can be tampered with" (pre-service teacher C), further complicating trust in digital evidence. Interviewees expressed a preference for documented or "hard" evidence (e.g., emails over conversations, quantitative data over anecdotes) due to its tangibility and concrete nature (pre-service teacher E). However, there was also an acknowledgment that not everything quantifiable can be captured, and qualitative data, like student opinions or feelings, also holds value, even if "it's more difficult" (pre-service teacher C) to measure comparatively. Although interviewees seemed to be well aware of the need to critically engage with evidence, part of the Masters level modules, there also were practical objections. While technology facilitates data collection (e.g., questionnaires), the practicality of using complex research methods (like large-scale surveys) for daily teaching was questioned, suggesting that some academic evidence collection may not translate directly to classroom practice. For example, although pre-service teacher E stated how before her critical evaluation of evidence, which included screencasts, she "didn't know anything about mathematical anxiety or resilience when I started assignment one and actually feel that that's one of the things from the whole year that I've taken out". A priori, she was more positive about the more practical assignment two with empirical data collection, but stated "I think will probably stay with me a little bit less. because it's not something I will use kind of so often on a daily basis teaching". This contradicts other pre-service teachers, for example, pre-service teacher B, who valued the experience of collecting his own evidence through small-scale projects and interventions, stating that this has been "really interesting" and helps teachers "back up what I'm doing" against external directives. It should be noted, though, that much depends on time constraints in a busy teaching profession. This limits the ability to "read everything" or engage in extensive personal "proper research" to verify information, leading teachers to prioritise efficient information gathering, as expressed by some pre-service teachers. The increasing ubiquity of digital information channels has created both opportunities for evidence collection and significant challenges in evaluating

its quality and trustworthiness, pushing individuals to develop more critical assessment skills, something that was an aim of the revised programme.

**5.3 Theme 3: technology for data collection**

Interviewees also described technology in a more instrumental way, namely as a suite of digital tools and systems to collect and manage evidence related to student assessment and progress. For example, pre-service teacher B mentions including spreadsheets for visualising quantitative data or surveys and polls to gather student feedback and check for understanding. As some data are often routinely collected in schools anyway, pre-service teacher A noted that school-side information systems already include a comprehensive range of data, including student marks, behaviour incidents, effort, homework, and tracking against target grades. Finally, pre-service teachers noted that data collection also takes place in a context of professional standards and accountability. For example, pre-service teachers C and E referred to technology in the form of electronic copies of reflections, lesson plans, and observation notes as "evidence that you did something". The use of technology is an ubiquitous element of the teaching profession.

**6 Futher redesign**

The design-based approach focussed on several iterations of a redesigned teacher preparation programme based on principles of evidence-use and expansive learning. This article highlights the important role of technology in all phases of the programme. Especially, elements of the ‘Questioning’ phase could be supported with such technology. However, despite these affordances of current technologies, the role of the two programme tutors, authors two and three of this article, cannot be understated. Their decades-long experience of the teaching profession, as well as their extensive knowledge of the mathematics education research literature is embedded throughout the programme, and provides an essential ingredient of pre-service teachers’ critical evaluation of evidence. In an ideal world, every teacher would have such a ‘knowledgeable other’ throughout their career, and available at any time. However, in practical terms this is not realistic, and therefore great opportunities are seen in the affordances of genAI, as reported by, among others, Mishra et al. (2025), Panday-Shukla (2025), and Sowa et al. (2025). Especially much is seen in integrating the critical questions tutors would typically teach pre-service teachers when engaging with research literature. Take as an example,

**Table 3** Example evidence grid for evaluating journal articles (from Masters level courses)

Aim/purpose	What are the main aims/arguments? What are the research questions? Is there a rationale for the research?
Methodology/research design	What paradigm is the research located in? What methods were employed? Are they appropriate to collect the relevant data? (reliability/validity?)
Data analysis, results/key findings	What are the main findings? Are they presented clearly? Are they convincing? (reliability validity)
Conclusions	Are these well developed and based upon the data presented?
Evaluations/Limitations: strengths/weaknesses	What are the main strengths of the research? What are the main limitations of the research? What are the main assumptions made regarding the underlying principles/theories of research?

an evidence grid used for a Masters level module in the general Masters programme at the institution. The grid asks pertinent questions as presented in Table 3. These have loosely been used as a basis for the screencasts in the redesigned programme that forms the basis of this article.

The questions can be applied one by one or even the whole list of questions can be applied in one go. Of course, this might incentivise an un-thinking, uncritical attitude as well. As a proof-of-concept, these questions were taken and fed into the package NotebookLM (<https://notebooklm.google.com/>) which uses the Large Language Model (LLM) Gemini, together with the same mindset article as in Fig. 2 (Burgoyne et al., 2020). The proof-of-concept demonstrates that NotebookLM can help with understanding the research article in a much more interactive way than most other instructional media. Critically evaluating a research article becomes a critical *dialogue* between a pre-service teacher and an genAI agent, where the pre-service teacher can ask any questions they have. For example, Fig. 3 shows the interface of NotebookLM for the article in question. In the left panel a short summary of the sources is pasted in a notebook, in this case just the one article. Key topics and open badges are presented as well. On the right hand side, there is a chat agent. The agent was asked to provide the rationale for the study. This was a lengthy answer, and so the screenshot also shows how the agent is asked to shorten the answer to 50 words. Provided answers can be saved as notes, copied for use in other software programs, and voted up or down to give a judgement of the quality of the answer. This information is used to further train the LLM.

In this example, NotebookLM is also asked what the biggest limitation of the article is, with the LLM replying that results mainly apply to university students. NotebookLM has more features including the option to customise a short or long audio podcast about the article, a study guide with questions about the article for study purposes, a briefing document with a summary of the article, and other summary options. There are many more LLMs, like Co-Pilot, ChatGPT, Claude, Perplexity and others, but even just mentioning these here is likely to be prone to being dated very quickly. Whilst we do not yet have data regarding the use of genAI in this way, the above proof-of-concept demonstrates the potential for genAI to support pre-service teachers in understanding evidence. All in all, genAI has the potential to support pre-service teachers in becoming critical consumers of research, especially as they can include elements of Socratic dialogue (Le, 2019).

## 7 Conclusion and discussion

This article reports on the role technology played in a redesign of a teacher preparation programme at a research-intensive university in the south of England, addressing the research question:

*What are the characteristics of a technology-supported intervention for critical evidence-use by secondary mathematics pre-service teachers?*

The programme was redesigned along the lines of evidence-use principles (Breckon & Dodson, 2016) and Engeström's (2001) expansive learning cycle. Whilst the sample size is very small, and the data comes from a single country limiting generalisability, the findings are in line with the larger RiTE project involving five teams in four European countries. Technology supported most of the phases of the cycle, but interviews with

The screenshot displays the Google NotebookLM interface. At the top, the title reads "Mind-Set Theory: Strong Claims, Weak Evidence". Below this, the "Sources" section lists a document: "burgoyne-et-al-2020-how-firm-are-the-foundations-of-mind-set-the...". A "Source guide" is visible, containing a summary and key topics: "Mind-set The...", "Evidence Stren...", "Performance G...", "Growth Mind-s...", and "Fixed Mind-s...". The main chat area contains a question: "In 50 words?". The AI response states: "The study's rationale was to empirically test mind-set theory's six key premises 1 2. Proponents made bold, profound claims 2 3 that needed equally strong evidence. 2 4. Researchers evaluated predicted associations against a social-psychological effect-size benchmark (r=.20) and compared mind-set's effects to other achievement-motivation constructs 4 5." Below the response are options to "Save to note" and "Mention the biggest limitation". A second question asks: "The biggest limitation identified in the sources is that the study's findings regarding the strength of evidence for mind-set theory's claims are applicable - at least for university students - 1." The AI response is "Start typing...". At the bottom, there are input fields for "Who are the authors of this study?", "What is the purpose of mind-set theory?", and "What is growth mind-set?".

Fig. 3 Screenshot of Google's NotebookLM for the article Burgoyne et al. (2020)

pre-service teachers showed that it was particularly helpful for sourcing evidence, challenging evidence, and collecting evidence. The findings showed that even with current technology teachers' 'questioning' can be supported. With the rapid developments in genAI it is expected that this will become even more fruitful and important. In doing so, there are several important issues to be mindful of.

Firstly, one needs to realise that pre-service teachers are still *novices* in teaching, and they are still learning how to teach. This mindset is not always conducive for exploring the often different directions in evidence-use. A pre-service programme would want to instil some form of *automaticity* in teaching, as automaticity can be beneficial and critical to the effective functioning of a teacher in the classroom. Feldon (2007) argues that automaticity "reduces the overall level of cognitive load necessary to process multiple complex interactions, which allows the allocation of working memory to careful assessments of the needs of individual students" (p. 132). However, automaticity can also negatively affect the quality of classroom instruction, as it can lead pre-service teachers to form biased assessments and revert to unintended teacher behaviours when load levels are too high. It would be very easy for a pre-service teaching programme to remove elements of critical thinking at Masters level and focus solely on habit formation. Unfortunately, habit formation can also limit growth in teacher effectiveness (Hobbiss et al., 2020). Therefore, in the long run, it is desirable to try and mitigate the downsides of automaticity. Given the limited duration of pre-service teacher programmes, pre-service teachers' critical thinking about evidence-use should be on the radar throughout the complete career trajectory. Although this article focuses on the year-long pre-service teaching programme, follow-up research could see whether evidence-use and technological support for this is consolidated after the programme as well, especially in the long-term. After all, the profession as a whole would benefit from such evidence-use. Research on this should be extended to recently qualified teachers.

This aspect also brings up a second crucial point in this study: the focus on the *design* of our programme. In the view of the authors, the design of interventions does not always receive the attention it deserves. This design addressed five characteristics in EDR approaches (Van den Akker et al., 2006, p.5). The redesign is *interventionist*, in that it aimed to design an intervention in a real world setting. the redesign also went through several *iterations*, analysing the current situation and then incrementally changing and improving the redesign. This approach is *process-oriented*, with a focus on understanding and improving the redesign. This is exemplified by the actual design in Table 2, the input of tutors in this work (second and third authors of this article), but also by soliciting views of pre-service teachers throughout the process. As the redesign was concretely used within one university, and was not just designed for research purposes, the redesign is *utility-oriented*, and thus practical for users in real contexts. The redesign also was very much *theory-oriented*, with evidence-use mechanisms (Breckon & Dodson, 2016) and Engeström's (2001) expansive learning cycle. Any redesign should be tailored to the specific context of an institution. For example, the articles we used for screen-casts were about mathematics education, but for other subjects other journal articles should be chosen. There also might be differences in the way in which pre-service training is organised in a country, making a different structure necessary. Given the extended time invested in the design in this project, interviews with pre-service teachers were the

most that could be achieved evaluation-wise. Proper evaluations should be part of future research, though. These should include field experiments where critical evidence-use is measured before and after an intervention based on the ideas set out in this case study, contrasted with 'business-as-usual'. Follow-up interviews with pre-service teachers could reveal more about the qualitative aspects of evidence-use as well.

Finally, technology use in pre-service teaching should not be seen as a 'silver bullet'. For decades, technology use has shown 'perennial promise', but whether it is effective, depends on many contextual factors, and this is also true for the pre-service teaching context. If this would only lead to disappointment, that would be bearable, but in some cases technology use can also backfire, especially with recent developments. For example, technology use can also lead to less critical thinking due to cognitively offloading, especially in a new age of genAI (Gerlich, 2025). Like all innovations, it should not be dismissed out-of-hand, but considered using its strengths and limitations.

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#### Authors' contributions

CB wrote the first draft of the manuscript, co-designed the redesign, held the interviews, analysed the data, and revised the manuscript. LH and RH co-designed and implemented the redesigned pre-service teacher programme, and revised the manuscript.

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#### Data availability

The materials for the redesigned programme are available on [www.rite-project.eu](http://www.rite-project.eu). The interviewees in this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

#### Declarations

##### Ethics approval and consent to participate

Ethics approval was sought and given by the university's ethics board under number 61371.

##### Consent for publication

Not applicable.

##### Competing interests

The authors declare that they have no competing interests.

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