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SINE: strategic integration of navigated engagement - a design thinking framework for technology integration in secondary education

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Abstract: The integration of digital technologies in secondary education requires teachers to make principled decisions about when and how technological affordances serve learning. This paper introduces the SINE framework (Strategic Integration of Navigated Engagement), a design thinking scaffold that positions technology use as a pedagogical decision grounded in professional judgement, disciplinary epistemology, and learner need. The study examined approximately 80 learning design artefacts produced by preservice teachers across Mathematics, Science, English, HSIE, and Creative Arts (Drama) within an initial teacher education program. Qualitative content analysis examined how preservice teachers articulated pedagogical reasoning, positioned technology IN and OUT, interpreted technological affordances in relation to disciplinary purposes, and demonstrated developing teacher design thinking. Findings identified four themes: Pedagogical Reasoning During Design, Deliberate Positioning of Technology, Disciplinary Alignment of Technological Affordances, and Development of Teacher Design Thinking. The artefacts demonstrated varying levels of reasoning sophistication, with more developed responses explicitly connecting technology decisions to intended learning, disciplinary purposes, and anticipated effects on student understanding. Technology OUT decisions further demonstrated that purposeful integration can involve the deliberate exclusion of technology where other approaches better serve learning. Placement-situated artefacts from a subset of participants also provided evidence of the framework being applied within classroom-based planning contexts. The findings position SINE as a practical scaffold for making technology-related pedagogical reasoning visible and supporting context-responsive, discipline-aligned decision-making during learning design.

Keywords: digital pedagogy; preservice teachers; pedagogical reasoning; digital affordances; disciplinary epistemology; professional judgement; learning design

1. Introduction

In recent years, the rationale for integrating technology into teaching and learning has come under increasing scrutiny. The transformative potential attributed to educational apps and devices appears, in many respects, to have fallen short of initial expectations [1].

The challenge has shifted toward supporting teachers to make principled pedagogical decisions about how digital resources can be integrated into teaching and learning [2], [3]. What is needed is a structured means of reasoning through technology decisions that accounts for both the affordances of a specific technology or digital resource and the specific learning intention it is meant to serve. The SINE framework (Strategic Integration of Navigated Engagement) responds to this gap, offering teachers a decision-making process grounded in affordance theory and design thinking that supports deliberate, context-responsive choices about technology use,

rather than adoption driven by novelty or availability alone [4].

Teacher knowledge is central to the challenge of recognising and working with technology in practice where the technology supports and enables new learning experiences but does not detract from student focus. Affordances are not self-evident or discipline (subject) neutral. They require active interpretation, evaluation, and positioning aligned to the intended learning experience. This interpretive work is what allows teachers to align technology use with disciplinary purposes and support deeper forms of learning.

Existing frameworks, such as TPACK [5], SAMR [6], and iPAC [7], have made significant contributions by conceptualising the knowledge, levels, and learning dimensions associated with technology integration [8]. Building on these resources, the SINE framework provides a scaffold for teachers to critically evaluate and strategically position technology at the design thinking stage, ensuring that its use is pedagogically meaningful and disciplinarily purposeful. The SINE framework positions technology integration as a process of pedagogical decision-making, supporting teachers to align discipline intent with appropriate technologies [9]. In doing so, the SINE framework makes visible the decisions through which technology extends learning opportunities.

2. Background

The SINE framework rests on three theoretical pillars: affordance theory, design thinking scholarship and disciplinary epistemology. Each contributes a distinct and necessary dimension to the framework's design and together, they establish the theoretical conditions under which technology integration can be reconceptualised as an act of epistemically grounded pedagogical reasoning.

Affordance theory (AT), originating in Gibson's [10], [11] ecological psychology, conceptualises affordances as relational possibilities that emerge in the relationship between a tool's characteristics and the intentions and capabilities of the person using it. In educational technology research, this relational perspective has been taken up to describe the learning-relevant action possibilities that digital tools offer within specific pedagogical contexts [4], [12].

This relational conception has a significant implication for technology integration in teaching. The same technology may afford fundamentally different learning experiences depending on how a teacher interprets and enacts its possibilities within a disciplinary context. A spreadsheet, for instance, may afford numerical pattern recognition in Mathematics, data representation in science, or cost modelling in Business. These differences arise not because the technology changes, but from how its affordances are interpreted in relation to discipline knowledge. Affordances, therefore, can be understood as neither self-evident nor discipline-neutral, requiring active recognition, evaluation, and positioning to support deeper learning.

This positions teacher interpretation as the critical mediating act between a tool's potential and its realisation in the teaching and learning space. The SINE framework builds directly on this understanding, locating the work of technology integration not in tool selection but in the interpretive decisions teachers make when aligning affordances with disciplinary intent and learner cognition.

Teacher design thinking scholarship positions teachers as active designers of learning experiences whose professional knowledge equips them to balance multiple, often competing, factors when planning for diverse learners [13]. When designing learning experiences, teachers engage in problem framing, iterative reasoning,

and the production of artefacts that externalise and make visible their pedagogical thinking [13], [14]. Context, desired learning outcomes and student diversity impact on the decisions required for specific learning experiences. This emphasis on teacher decision-making also connects with the concept of digital agency. Knussen and Agnew [15] argued that teachers' engagement with digital technologies involves more than technological knowledge or competence, requiring professional agency to navigate contextual constraints and make decisions appropriate to particular learning environments. From this perspective, purposeful technology integration depends not only on what teachers know about technology, but on their capacity to exercise professional judgement about how, when, and whether technology should be used in response to pedagogical, disciplinary, and contextual needs. Translation of teacher professional knowledge into visible, actionable reasoning within the design process has been identified as a central challenge when integrating technology into the classroom [16]. Without structured scaffolding to guide decision making, technology integration can default toward tool selection and teacher-directed use rather than pedagogical positioning. This reflects not a lack of professional knowledge, but an absence of frameworks that explicitly externalise the design thinking process [17]. The SINE framework responds to this need by providing a decision architecture that makes pedagogical reasoning explicit, including the what, the why, and the anticipated impact of each design decision, particularly where technology is involved.

Disciplinary epistemology provides the third theoretical pillar, foregrounding the importance of grounding technology integration in the epistemic demands of specific subjects and learning contexts. Each discipline has its own ways of knowing, modes of inquiry, and forms of representation that shape what counts as learning and how understanding is developed and demonstrated. These disciplinary ways of knowing determine what kinds of activities, tools, and resources are appropriate at particular points in a learning sequence, and why. In teacher education and professional development, supporting the design of situated learning experiences where technology serves disciplinary intent is a productive and ongoing focus for both research and practice [18]. When technology becomes the key decision maker in the learning experience, integration decisions risk being driven by tool availability or novelty rather than by pedagogical purpose, and the intended learning impact may be overlooked [19]. The key is to carefully choose when, where, how, and why technology should be used as an integral component of the learning experience. When design decisions are grounded in disciplinary epistemology, technology becomes a positioned resource rather than a determining force [17].

The SINE framework is deliberately discipline-agnostic in its architecture, providing a structured reasoning process responsive to the epistemic demands of different disciplines. Demonstrated across Mathematics, Science, English, HSIE, and Creative Arts (Drama) in this study, SINE offers a practical approach to principled, discipline-sensitive technology integration that prioritises pedagogical purpose over tool selection. In doing so, it reframes technology integration from a question of tool use to a problem of epistemically grounded design.

3. The SINE framework

The SINE framework, Strategic Integration of Navigated Engagement, was developed from the theoretical foundations established above. The term navigated is deliberate, signalling that technology positioning is neither incidental nor assumed but the outcome of principled pedagogical decision making grounded in disciplinary

intent and learner need. It operates as a learning design scaffold that supports teachers to make deliberate, epistemically grounded decisions about when and how technology serves learning, and equally when other modes of learning are preferable.

The SINE framework does not begin with the assumption that technology should be present in the classroom. It provides a process through which teachers can make reasoned decision about whether technology has a pedagogically defensible role in the learning design for a particular activity or series of activities. The framework provides the foundation for selective, rather than ubiquitous, technology integration.

The framework begins with an anchoring stage in which the teacher establishes the enduring understanding for the topic, unit, or sequence of lessons, alongside the intended learning outcomes. This preliminary step is foundational. All subsequent design decisions are made in relation to the disciplinary knowledge and learning goals established here, ensuring that technology positioning is determined by pedagogical purpose rather than tool availability. This anchoring move is what positions SINE as a learning design framework rather than a technology selection tool.

The framework is built on three foundations – affordance theory, design thinking and discipline epistemology.

Affordance theory examines what the technology enables or makes possible for learners. The focus is on the relationship between the properties of the learning environment and the capabilities of the technology in that environment [11]. The affordance, therefore, depends on what the learner is being asked to do with the technology embedded within the discipline purpose and learning context. Significantly, within the SINE framework, affordance theory does not provide a rationale for technology use, but rather a theoretical basis for evaluating the efficacy and purpose of technology for a specific activity.

The design thinking component of the framework makes technology selection an iterative aspect of the design process rather than an addition in the activity. Selection is deliberate and considered, based on the affordances of the technology and how these affordances support the learning process. Teachers begin with the learners, context and the intended transferable knowledge from the activity [20]. Decisions within the design thinking process rely heavily on the teacher's technology expertise, theoretical understanding and practical skills relating to technology [16]. The SINE framework mitigates this dependence by providing teachers with conceptual lenses through which they can interrogate technology choices. Rather than requiring in depth working knowledge of an increasing range of digital tools, the framework directs attention towards the affordances required to support the intended activity. Essentially, the selection of technology becomes a reasoned design decision that can be tested, evaluated and reconsidered throughout the iterative design process, including whether technology is appropriate for the intended learning. The SINE framework does not seek to compensate for an absence of technological knowledge, but to scaffold the pedagogical reasoning through which that knowledge is applied.

From this foundation, the teacher works through each planned learning activity and makes a deliberate positioning decision: Technology IN or Technology OUT. Critically, both are active design choices. The decision to exclude technology from an activity is as principled and consequential as the decision to include it.

The third key foundation of the SINE framework focuses on design epistemology, inquiring if the technology supports the way knowledge is actually developed, represented, evaluated and communicated within the specific discipline.

Research supports the understanding that any one technology may have quite different pedagogical value across disciplines because the epistemic purposes for which it is used differ, and that technology selection should therefore reflect authentic disciplinary practices [7]. The SINE framework supports this process by prompting teachers to consider the relationship between technological affordances, disciplinary ways of knowing and working, and the intended learning.

All design decisions require the same pedagogical reasoning and carry the same accountability to learning outcomes. The technology in and out architecture of the SINE framework is the mechanism that foregrounds pedagogical purpose in learning design, positioning the teacher as the disciplinary expert and active designer of the learning experience. The distribution of technology in and out decisions across a sequence is not cyclical, hierarchical, or prescribed. The process is not intended to provide a “balance” of technology use but rather to strip back the design thinking of lesson planning to support teachers in all pedagogical decisions during the planning phase (see **Figure 1**). Each decision stands alone, determined by a single question: what does the learning require here, and how is that best supported?

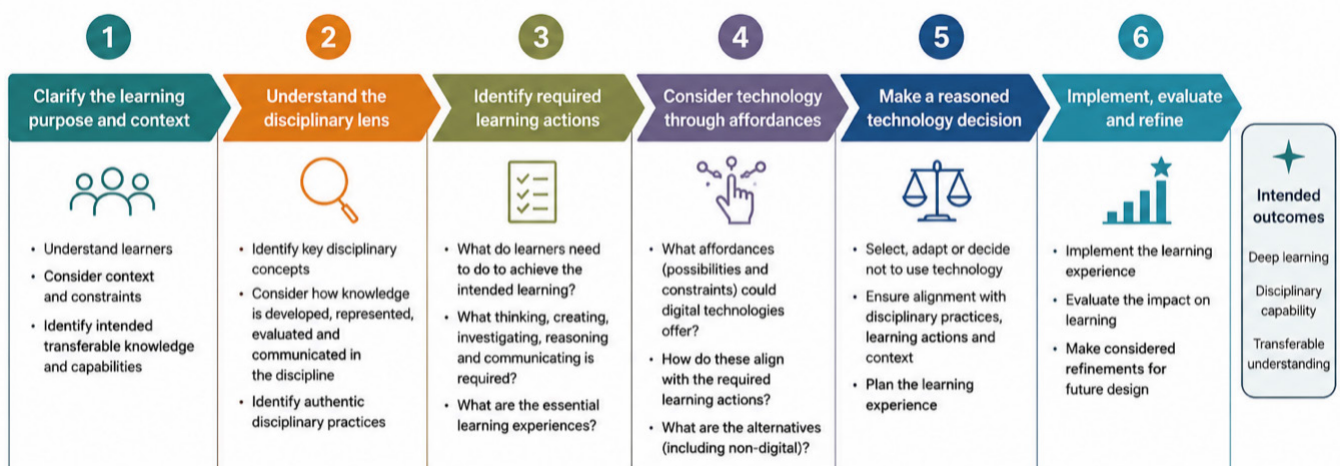


Figure 1. SINE Framework

Note: The SINE framework guides deliberate, contextually informed decisions about when technology supports learning and when other resources are more appropriate.

Following initial ideation and brainstorming of ideas for possible teaching and learning activities for any given unit of work or class lesson, the teacher begins the more refined design thinking process. For each selected learning activity, the teacher articulates three dimensions of design thinking reasoning. Initially, teachers identify what students will be doing in the activity and what they will be using (resources). Teachers would then explain why this activity, tool, or resource is appropriate for the learning, grounding the decision in disciplinary intent, learner need, and pedagogical context. The final component of each activity describes the intended effect or impact of the activity on student learning. Together, the SINE framework positions three prompts to externalise the reasoning that underpins design decisions, making professional judgement visible, revisable, and communicable. The prompts, what, why and effect/impact are depicted in **Figure 2**.

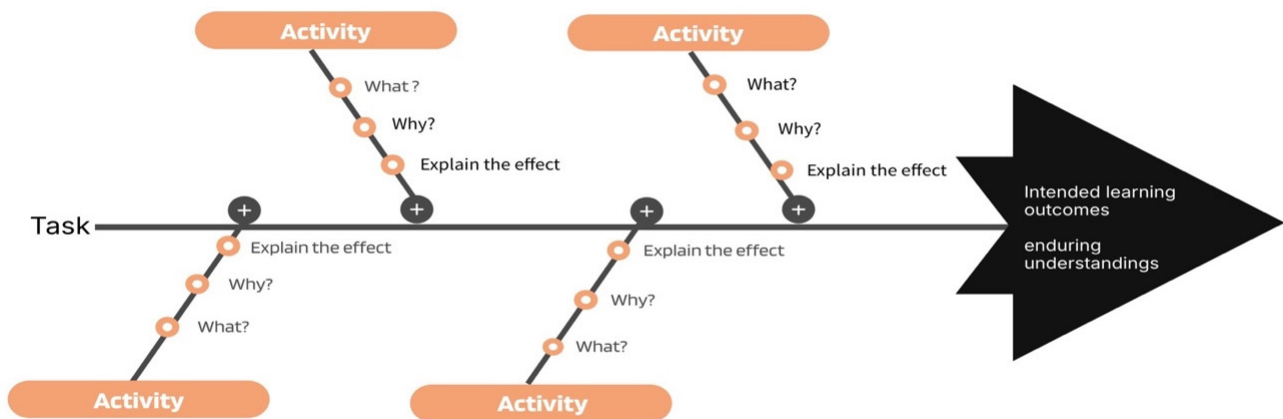


Figure 2. SINE Framework diagram

Note: The diagram illustrates the deliberate positioning of design decisions across a learning sequence, anchored by the intended learning outcomes or enduring understandings and articulated through the what, why, and effect (or impact) of each decision.

Structured as a directional flow with learning outcomes or enduring understandings anchored at one end, activities are repositioned and mapped above and below the central axis. Technology OUT decisions appear above the axis and Technology IN decisions below the axis, each maintaining annotations depicting the what, why, and effect of design decisions (**Figure 3**).

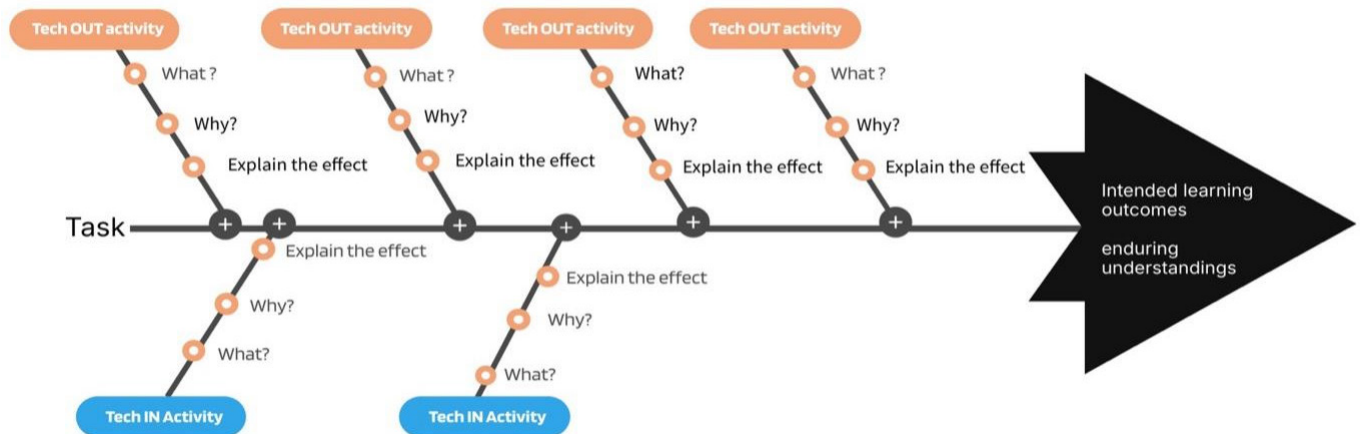


Figure 3. SINE Framework showing Technology IN and Technology OUT colour coding and positioning

Note: The SINE framework diagram illustrating positioning of technology IN and technology OUT design thinking decisions across a learning sequence in preparation for evaluation

This visual architecture makes the patterning of technology across a sequence of learning immediately legible, supporting both the design process and the communication of intent. For visual flow, the teacher can connect the sequence of activities with a line, observing the transition between In and OUT activities.

Following the mapping process, selected technologies should be tested as per the intended use for the activity and evaluated against purpose, accessibility, policy

and availability, using the SINE framework Technology in Action Evaluation form (Appendix A). The evaluation form supports the development of a rationale for technology selection, while also developing the pedagogical reasoning necessary for purposeful technology selection and integration.

The SINE table extends the initial design reasoning in a more expanded form. Where the diagram provides an overview of the design sequence, the table provides structured space for teachers to elaborate the reasoning behind each decision, including how technological affordances align with disciplinary intent, what representational demands are at stake, and what evidence of learning impact is anticipated. Together, the diagram and the table constitute a two-stage design architecture, with the diagram functioning as a generative reasoning tool, while the expanded table provides a structure for detailed pedagogical justification (**Table 1**).

Table 1. SINE Framework expanded table

Activity	What	Why	Effect
Planned teaching and learning activity/experience	<i>What</i> technology/tool would be suitable? <i>What's</i> the need? <i>What's</i> the evidence to support the use of this technology/tool?	<i>Why</i> this technology? <i>Why</i> now? <i>Why</i> this approach?	What is the <i>effect</i> or impact of using this technology on student learning? <i>How</i> does this activity/technology extend or deepen understanding? <i>What</i> would evidence of learning look like?

Note: The SINE framework table extends the reasoning of the SINE diagram, providing structured space for teachers to articulate how technological affordances align with disciplinary intent, learner need, and anticipated learning impact across each activity in the sequence.

Additional columns can be added to the table to align the activity with specific elements of other frameworks such as iPAC and SAMR or with specific teacher standards such as the Australian Professional Standards for Teachers [21] (**Table 2**).

Table 2. SINE Framework table showing Australian Professional Standards for Teachers (APST) alignment

Activity	What	Why	Effect	APST Alignment
Planned teaching and learning activity/experience	<i>What</i> technology/tool would be suitable? <i>What's</i> the need? <i>What's</i> the evidence to support the use of this technology/tool?	<i>Why</i> this technology? <i>Why</i> now? <i>Why</i> this approach?	What is the <i>effect</i> of using this technology on student learning? <i>How</i> does this activity/technology extend or deepen understanding? <i>What</i> would evidence of learning look like?	eg., Standard 2.6 Information and Communication Technology (ICT) eg., Standard 3.4 Select and use resources (including ICT, to engage students in their learning).

Note: The SINE framework table can include alignment to other framework elements (eg., iPAC or SAMR) or to teacher standards such as the Australian Professional Standards for Teachers

Acting as a metacognitive scaffold, the SINE framework externalises the design thinking process during planning, at the point where decisions are made,

and before they are enacted in the classroom. In doing so, the framework supports teachers to articulate the pedagogical reasoning that connects technological choices to disciplinary learning in ways that are both purposeful and accountable.

A subsequent refinement of the SINE framework extends the evaluation of what, why, and effect by asking teachers to consider how an activity might proceed if the selected technology were unavailable or disrupted, for example through loss of power or internet connectivity. This additional prompt is intended to deepen consideration of the pedagogical value and necessity of the technology within the learning process. This refinement was not part of the framework implementation examined in the present study.

4. Methodology

This study employed a qualitative content analysis of learning design artefacts produced by preservice teachers enrolled in a digital technologies subject within an initial teacher education program at the University of Technology Sydney. Qualitative content analysis provides a systematic means of examining documentary data and can incorporate both theoretically informed and inductively developed categories [22], [23].

One hundred students participated in the subject, the majority in the final year of their program, with a smaller number completing the subject at an earlier stage in their coursework. Students were drawn from five secondary Key Learning Areas: Mathematics, Science, English, Human Society and Its Environment (HSIE – History, Commerce, Business Studies and Economics) and Creative Arts (Drama), reflecting the cross-disciplinary composition of the cohort.

As part of a formal assessment task, students were required to apply the SINE framework to a learning sequence relevant to their teaching discipline. Each student produced a SINE diagram and accompanying table, articulating the what, why, and effect of each technology positioning decision across a planned sequence of learning activities. These artefacts were completed under standard assessment conditions and submitted for grading in the ordinary course of the subject.

The decision to analyse the artefacts as research data was made after the conclusion of the semester, following assessment marking and grade distribution. This sequencing was deliberate and methodologically significant. Students had no prior knowledge that their work would subsequently be used as research data, reducing the potential for responses to be shaped by research awareness. Prior to analysis, all artefacts were deidentified. Ethics approval was obtained for post-assessment data collection and analysis of student work (UTS HREC ETH25-11597).

Eighty artefacts met the inclusion criteria and were included in the analysis. Artefacts were eligible for inclusion where both the SINE diagram and accompanying table were complete. Artefacts containing an incomplete diagram and/or table were excluded from analysis. Analysis combined theoretically informed and iterative qualitative coding. Initial coding categories were derived from the conceptual architecture of the SINE framework, including the what, why and effect prompts, technology IN and technology OUT positioning, technology affordances, disciplinary alignment, learner context and evidence of design reasoning. These categories were progressively refined through repeated examination of the artefacts as patterns and distinctions became apparent within the dataset.

NVivo was used to organise and code the artefacts and to support system comparison within and across disciplinary contexts. Analysis examined the

quality and specificity of pedagogical reasoning communicated, the distribution and justification of Technology IN and OUT decisions, the relationship between technological affordances and disciplinary purposes and evidence of developing teacher design thinking. Cross case comparison was then undertaken, to examine emerging patterns, variations in reasoning and differences in how technological affordances were interpreted. The four themes presented in the findings were developed through this process.

Illustrative exemplars were selected to demonstrate identified patterns and variation across the developmental range, from emerging engagement with the framework to more sophisticated, disciplinarily grounded design thinking. These examples are used in the findings to illustrate patterns across the broader dataset rather than as the sole basis for analytical claims.

A subset of preservice teachers included reflections within their submissions describing how they had applied the SINE framework during professional experience placements. Because these reflections had been produced as part of the original coursework rather than in response to the subsequent research study, they were treated as supplementary, naturally occurring accounts of how participants reported applying the framework within authentic classroom contexts.

To support traceability across the findings while maintaining deidentification, artefacts are referenced using a discipline-based coding system. Each artefact is assigned a prefix denoting its Key Learning Area, with M indicating Mathematics, S Science, E English, H HSIE, and D Creative Arts (Drama), followed by a numeral distinguishing individual artefact within each discipline (e.g., M1, M2, S1). These codes are used consistently across all artefacts used in the findings and discussion.

5. Findings

The artefacts analysed in this study demonstrated that the SINE framework supported preservice teachers to engage in principled pedagogical reasoning. Variation in depth, specificity, and disciplinary alignment across the artefacts provides insight into the developmental range of engagement with the framework.

The findings draw on diagrams, accompanying tables, and reflective commentary produced by preservice teachers across secondary Key Learning Areas, including Mathematics, Science, English, HSIE, and Creative Arts (Drama), and are organised into four interrelated themes. Together, these themes illustrate how the framework operates as a scaffold for translating pedagogical intent into structured design decisions in the development of teaching and learning activities.

- Pedagogical Reasoning During Design
- Deliberate Positioning of Technology
- Disciplinary Alignment of Technological Affordances
- Development of Teacher Design Thinking

5.1 Pedagogical reasoning during design

Across the artefacts, preservice teachers demonstrated varying levels of pedagogical reasoning enacted during the design of learning sequences. The structure of the SINE framework requires consideration of the what, why, and effect of each planned activity, framing pedagogical reasoning as part of the design process rather than as retrospective reflection (**Table 3**).

Table 3. Examples of design thinking and pedagogical reasoning

Discipline	Example of technology use	Pedagogical Reasoning
Mathematics	Graphing software to visualise relationships between variables	Development of pattern recognition and visual explanation
Science	Simulation to manipulate ecosystem variables	Observing causal relationships not easily replicated physically
English	Collaborative annotation platform for shared text analysis	Comparison of interpretations and dialogic engagement
HSIE	Spreadsheet or modelling tool used to evaluate scenarios	Applied analysis and real-world decision-making
Creative Arts (Drama)	Digital media platform to create and refine artefacts	Iterative creation and multimodal expression

Note: Table provides representative examples drawn from preservice teachers' SINE diagrams and accompanying tables across Key Learning Areas. The descriptions reflect pedagogical reasoning articulated during the design of learning sequences, with variation in depth and specificity across artefacts.

In less developed artefacts, pedagogical reasoning during design was often limited to descriptions of intended activity or tool use. The what component was typically completed with clarity, outlining what students would do, while the why and effect were more generalised or closely tied to the features of the selected technology. For example, one preservice teacher noted:

“Students will use a digital quiz to review key terms. This helps keep them engaged and makes learning more interactive.”

In this case, the reasoning is embedded within the planning process but remains focused on engagement and tool functionality, with limited elaboration of how the activity supports disciplinary understanding.

In more developed artefacts, preservice teachers articulated clearer connections between the inclusion of technology and the intended learning processes at the point of design. The why component was used to explain why a particular technology was positioned within a specific activity, and the effect described the anticipated impact on student learning. For example, in a science sequence, one preservice teacher wrote:

“Students use a simulation to manipulate variables within a virtual ecosystem. This allows them to observe cause and effect relationships that are not easily replicated in a classroom setting.”

Similarly, in an English sequence, a preservice teacher described:

“Students annotate the text collaboratively to identify themes and language patterns. The shared space allows them to compare interpretations and respond to each other’s ideas.”

In these examples, the reasoning is articulated during planning and is oriented toward how the activity is expected to support particular forms of thinking within the discipline.

5.2 Deliberate positioning of technology

The notion of considering Technology IN and Technology OUT for teaching and learning activities provides a foundation for principled decision-making about when and why to use technology in the design of teaching and learning activities. There is no prescribed pattern to these decisions and they are not designed to be iterative. Each decision stands alone, determined by what the learning requires at that point in the

sequence.

In the artefacts examined, preservice teachers provided a rationale for their decision to either use or not use technology for each planned teaching and learning activity. The overview of design and positioning was captured in the SINE diagram, with the rationale and intended effect elaborated in the accompanying table. Preservice teachers were directed to apply the same decision-making considerations to all activities regardless of whether technology was included or excluded, focusing primarily on the intended outcomes and how each activity would develop student capability toward the enduring understanding established at the outset of the design process.

Across the artefacts, the quality of reasoning applied to Technology OUT decisions varied considerably, and this variation is itself instructive. In less developed artefacts, OUT decisions tended to be justified in terms that could apply to any subject at any point in a sequence. A Business Studies preservice teacher (H1) positioned a paired and whole-class discussion following a video analysis with the rationale that dialogue deepens student understanding of marketing strategies by hearing different perspectives from peers. While the activity is purposeful, the reasoning does not engage with why the removal of technology serves the learning at that particular moment, nor what the discussion was designed to produce that the preceding technology-enabled activity could not.

In more developed artefacts, the reasoning became activity-specific and, in the strongest cases, disciplinary. A Mathematics preservice teacher (M1) designing a sequence on non-linear equations positioned hand-graphing from a table of values as a deliberate OUT activity, justified on the grounds of fluency and exam preparation, noting that while digital graphing tools allow immediate manipulation of variables, physically graphing provides another representation that builds the procedural understanding students need independently of technology. The OUT decision here is not a rest from digital tools but a recognition that what hand-graphing demands of students is different from, and complementary to, what Desmos affords. A second Mathematics artefact (M2) extended this reasoning further, framing paper-based hypothesis writing and consolidation activities as deliberate OUT decisions on either side of the technology-enabled modelling phase. The first of these was placed to clarify schema and reduce cognitive load before engaging with digital tools, the second to support transfer of understanding beyond the technology itself. Technology IN and OUT were sequenced as a coherent cognitive architecture, not as a pattern of alternating activities.

In Science, a preservice teacher (S1) designing a sequence on lunar phases positioned a physical lamp model as a Technology OUT activity following a 3D simulation, reasoning that students needed to physically model the orbital mechanics they had previously explored digitally in order to reinforce the spatial reasoning the content demands. The OUT decision is explicitly relational, situated in response to what the simulation provided and justified by what embodied, non-digital engagement offers that extends and deepens the learning the simulation began. Similarly, a preservice teacher designing a sequence on electrostatics (S2) positioned a Technology OUT Predict-Observe-Explain experiment as the investigative core of the lesson rather than a supporting activity, on the grounds that students build understanding of charge behaviour through hands-on experience in ways that a video introduction cannot replicate.

The most disciplinarily grounded OUT reasoning in the artefacts examined

appeared in two examples from distinct KLAs. In an English sequence (E1) designed around textual perspective, a guided discussion comparing two texts was positioned as Technology OUT at the point where students were required to notice a composer's use of mode, tenor, and field, and to consider how those choices shaped perspective and meaning. The absence of technology here was purposeful, creating the conditions under which interpretive, dialogic thinking was designed to occur. A Drama preservice teacher (D1) designing a unit on Hamlet Act 5 demonstrated comparable disciplinary logic across multiple OUT decisions. Emotive expressions practice and lines recital were both positioned as Technology OUT activities with the explicit rationale that students needed to engage physically and vocally with performance skills, developing facial expression, gesture, and delivery through embodied, peer-critiqued practice that no digital tool could replicate. The final performance itself was Technology OUT by design, the culmination of a sequence in which digital tools had served the preparation but could not substitute for live enactment.

Beyond individual OUT decisions, a number of artefacts demonstrated an understanding of deliberate positioning that extended across the design as a whole, where the integration of IN and OUT decisions reflected considered thinking about how learning should move through a topic rather than where technology could be inserted into it. One preservice teacher (M2) articulated this orientation explicitly, reframing the design question from what digital tools can do to what students' need at each moment of learning and when technology is the best means of providing it. Another (S3) made the same point from a different angle, noting that technology is not used for the sake of technology but strategically integrated at points where it will extend and transform the learning experience. In these artefacts, the SINE framework appears to have functioned as intended. Rather than operating as a checklist for technology inclusion, it served as a scaffold for thinking about when and why each activity, with or without technology, serves the learning it is designed to support.

The variation across these artefacts reflects the developmental challenge the OUT-decision poses for many preservice teachers. Selecting and justifying a digital tool is a familiar task. Articulating why its absence serves learning requires a different and less practised form of pedagogical reasoning. That the framework prompted this reasoning, even at varying levels of depth and disciplinary specificity, is evidence of its capacity to reorient design thinking away from tool selection and toward the learning requirements of each activity.

5.3 Disciplinary alignment of technological affordances

The SINE framework makes no discipline-specific prescriptions about which technologies should be used or when. Its architecture is deliberately agnostic, applying the same diagram structure, the same what, why, and effect prompts, and the same IN and OUT positioning logic regardless of KLA. Across the artefacts, preservice teachers interpreted technological affordances through the epistemic demands of their subject, frequently using the same tools to do fundamentally different things depending on what the discipline requires students to do in the learning activity.

This pattern is most clearly visible when the same technology appears across multiple KLAs. Canva is one of the most frequently used tools in the artefacts, but the reasoning offered for its inclusion varies significantly by discipline. In a science sequence on cell biology (S3), Canva was used as a means of multimodal scientific communication, with students collaboratively designing visual representations of organelles in ways that mirror how scientists communicate findings. The affordance

being activated here is co-creation and visual synthesis of conceptual knowledge. In a Stage 6 Business Studies sequence (H1), the same tool was deployed to serve an entirely different epistemic purpose, with students producing a professional marketing campaign that simulates real industry communication, where the affordance is creative professional production and the demonstration of applied marketing understanding. In a history sequence on WWI testimonies (H2), Canva timelines were offered as one mode of multimodal historical synthesis, intended to support empathetic interpretation of primary sources through creative expression. The tool is identical across all three contexts; what changes is the disciplinary framing that determines which of its affordances are activated and why.

Simulation tools show a comparable pattern. PhET Interactive Simulations appear across both Science and Mathematics artefacts, but the reasoning for their inclusion differs in ways that reflect genuine disciplinary epistemology. In Science sequences, PhET was consistently used to make invisible or inaccessible phenomena observable. In an electrostatics sequence (S2), it was used to visualise charge interactions that cannot be safely replicated physically; in a natural selection sequence (S4), it was used to model population change across generations that no classroom investigation could produce in real time. The affordance being drawn on is the simulation of disciplinary reality, standing in for what scientists investigate when laboratory conditions are unavailable. In Mathematics sequences, the same simulation environment was deployed differently, to make abstract algebraic relationships manipulable and visually immediate, allowing students to observe how changes to coefficients produce different graphical representations and to develop intuitive understanding of mathematical structure before engaging with formal procedures (M1, M3). The epistemic work being done is not the same. In Science, simulation stands in for inaccessible reality. In Mathematics, it externalises abstract structure. The SINE framework's what, why, and effect prompts surfaced this distinction, requiring preservice teachers to articulate not just what the simulation did but why it was appropriate for this learning at this point, and that question produced disciplinary answers.

Google Docs offers a third illustration of the same principle. Across the artefacts it functions as a persistent shared text environment, but what it is used to do varies by discipline. In an English sequence (E1) focused on textual perspective, Google Docs was used to maintain digital logs of students' voice-typed first responses to texts alongside their later written analytical responses, with a readability tool used to make visible the differences between spoken and written mode. Here the affordance is the tracking of the writing process itself, with Google Docs serving as a record of how thinking and language develop over time, which is a distinctively English disciplinary concern. In a Science sequence (S5), the same tool functioned as a scientific report scaffold, with the teacher providing real-time feedback on students' data interpretation and written communication of findings. The affordance being drawn on is structured individual writing with formative feedback, serving the discipline's requirement for evidence-based written communication. In a Commerce sequence (H3), Google Docs functioned as a collaborative planning space where student groups brainstormed and organised ideas together, with the teacher monitoring contributions in real time. The same tool, activated through three different disciplinary lenses, produces three meaningfully different learning experiences.

The most explicitly epistemological reasoning in the artefacts appeared in an English sequence (E2) that addressed the disciplinary traditions of the KLA

directly. The preservice teacher argued that technology in English must be positioned against the subject's established analytical traditions, beginning the sequence with a Technology OUT close reading task precisely because students need direct engagement with language and meaning before digital mediation is introduced. The Technology IN activity that followed, in which students used digital tools to reimagine a Shakespearean text through adaptation, was positioned not as a replacement for that textual engagement but as an extension of it, enabled by the foundation the OUT activity had established.

Taken together, these examples demonstrate that the SINE framework supported preservice teachers to engage with technology as a disciplinary resource rather than a generic utility. The framework's requirement to articulate why a tool is positioned at a particular point in the sequence, and what effect its inclusion is expected to have on disciplinary learning, created the conditions under which affordance interpretation became an act of disciplinary reasoning. What is significant for the framework's credibility is that disciplinary alignment was evidenced across all KLAs represented in the study, demonstrating that SINE's architecture is responsive to disciplinary epistemology without prescribing it.

5.4 Development of teacher design thinking

The SINE framework frames technology integration as a design problem rather than a selection task. In doing so, it functions as a metacognitive scaffold that externalises the reasoning teachers engage in when planning learning sequences. Across the artefacts, evidence of this scaffolding effect appeared in three related ways: in the explicit integration of design thinking processes alongside the SINE diagram, in the transfer of the framework's decision architecture into authentic placement contexts, and in preservice teachers' reflective articulation of how the framework changed their orientation toward planning.

A number of artefacts demonstrated that preservice teachers were engaging in design thinking as a deliberate precursor to the SINE diagram itself. Several included handwritten or diagrammatic evidence of the empathise, define, ideate, prototype, and test stages mapped onto their learning sequence before the formal artefact was produced. A Science preservice teacher (S5) included process notes documenting the empathy stage as the identification of a specific learner challenge for students who were curious but not yet connecting the content to real-world contexts. This framing of the problem directly shaped the subsequent technology positioning decisions, with digital simulation identified as the means of bridging that gap. The sequence was not designed around the tool, but rather, the tool was selected in response to a clearly defined learner need. An English preservice teacher (E2) applied the same logic, explicitly framing the recognition of declining creative engagement in English as the empathy stage that drove all subsequent design decisions in the sequence. The decision to begin with a Technology OUT close reading task was grounded in a defined understanding of what English students needed before digital mediation could extend rather than bypass their disciplinary thinking. A Commerce preservice teacher (H6) similarly documented the design thinking stages within the artefact, mapping empathise through prototype onto a sequence in which students moved from analysing authentic advertising examples to creating their own promotional materials. In each of these artefacts, the SINE framework and the design thinking process were operating together, with the what, why, and effect prompts providing the structured space in which the outcomes of design thinking were made visible and accountable.

The most substantive evidence of the framework's practical usability appeared

in artefacts produced in response to, or in anticipation of, professional experience placements. A Science preservice teacher (S6) described the learning sequence as designed directly from placement experience with a specific class, noting the learner profile in detail including EAL/D students, students with ADHD, gifted learners, and students with lower ability levels, and explaining that technology decisions were made in direct response to those known learner needs. The preservice teacher stated explicitly that the intention was to integrate technology not for the sake of it but to enhance engagement, ensure equitability, and achieve enduring understanding. This framing reflects the SINE framework's anchoring logic, with the enduring understanding and learner context established first, and technology deployed in service of both. A Mathematics preservice teacher (M11) described a lesson that was implemented during placement at an independent school with a specific Stage 5 class, noting that the design was reviewed by both the supervising teacher and the student teacher and amended following their feedback. This iterative refinement of the design in response to real classroom conditions and professional feedback represents a qualitatively different engagement with the framework than a hypothetical design task and is evidence of the framework functioning effectively within the conditions of authentic teaching practice.

A third dimension of design thinking development was visible in preservice teachers' metacognitive reflections on the planning process itself. Several artefacts included commentary, in the Technology in Action evaluation responses or in the Part B written reports, that described how engaging with the framework had shifted the questions they asked during planning. One preservice teacher (S8) articulated this directly, describing a move from asking what technology can do to asking what students need at each moment of learning and when technology is the best means of providing it. Another (S3) noted that the deliberate alternation between Technology IN and OUT had ensured that technology enhanced rather than replaced the cognitive and social dimensions of learning, reflecting an awareness of the framework's purpose that extended beyond compliance with its structure. These reflections were not prompted by the assessment task directly; they emerged from preservice teachers' engagement with the design process itself, suggesting that the framework had functioned as intended as a tool for making pedagogical reasoning explicit, revisable, and communicable.

Taken together, these three dimensions indicate that the SINE framework supported the development of design thinking capacity in ways that extended beyond the immediate task of planning a learning sequence. Preservice teachers who engaged most deeply with the framework demonstrated an understanding of technology integration as a principled design problem requiring empathy with learners, definition of disciplinary intent, and deliberate positioning of each activity in relation to both. The variation in depth across the artefacts is consistent with the findings of the preceding themes. What is significant is that the framework created the conditions under which this development was possible, providing a structured yet flexible architecture that preservice teachers could engage with at varying levels of sophistication and carry into authentic classroom practice.

6. Discussion

The four themes identified in the findings, Pedagogical Reasoning During Design, Deliberate Positioning of Technology, Disciplinary Alignment of Technological Affordances, and Development of Teacher Design Thinking,

collectively demonstrate how the SINE framework functions as a scaffold for teacher design thinking. Across these themes, what emerged was not simply evidence that preservice teachers used the framework for planning, but that engaging with its decision architecture shaped the questions they asked during the design phase. Preservice teachers were prompted to consider why technologies would be used, when they were or were not appropriate, how their affordances aligned with disciplinary purposes, and what effect each activity was intended to have on learning. The findings therefore extend scholarship positioning teachers as designers of learning experiences by demonstrating how a structured design scaffold can externalise pedagogical reasoning during planning [13], [16].

6.1 Pedagogical reasoning during design

TPACK, SAMR, and iPAC have each made significant contributions to how technology integration is understood and evaluated in educational contexts [24], and a number of artefacts in this study drew on those frameworks alongside the SINE framework. Each offers a different lens: TPACK foregrounds the knowledge teachers need, SAMR provides a way of evaluating the degree of transformation technology affords, and iPAC identifies the pedagogical drivers that make mobile learning meaningful (Kearney et al., 2022). What the SINE framework adds to this landscape is a design architecture that underpins the planning process, requiring teachers to articulate in writing the reasoning that connects each activity to disciplinary intent and anticipated learning impact. Research has continued to refine how TPACK is understood and applied in practice, with recent work foregrounding context as a critical dimension of technology integration [25], and recognising that distinguishing between knowledge domains in the moment of planning remains a productive area for scaffolding support [26].

The SINE framework does not resolve these challenges so much as provide a structure through which preservice teachers can work with them during planning. Rather than asking teachers simply to identify an appropriate technology, the framework requires each activity to be considered in relation to the intended learning, the disciplinary purpose it serves, and the anticipated effect on student understanding. The what, why, and effect prompts make this reasoning explicit, while the Technology IN and OUT decisions require preservice teachers to consider whether technology is the most appropriate means of supporting the learning at that particular point in the sequence. In this sense, SINE operates as a generative rather than evaluative framework. It scaffolds the reasoning through which a learning design is developed, rather than providing a means of judging technology integration after the design has been produced. This distinction is particularly relevant in initial teacher education, where preservice teachers are still developing the capacity to translate pedagogical, disciplinary, and technological knowledge into reasoned design decisions [13], [16].

6.2 Deliberate positioning of technology

The requirement to apply the same reasoning to Technology OUT decisions as to Technology IN decisions is where the SINE framework makes its most distinctive contribution to design thinking in initial teacher education. The decision not to use technology is rarely treated as a principled design act in planning frameworks or in professional practice [27], [28], yet the findings demonstrate that when teachers are required to justify it with the same rigour as a technology inclusion decision, genuinely disciplinary reasoning emerges. What the artefacts show is that the absence of technology is not a neutral default but a pedagogical position, and that articulating

why is precisely the kind of thinking the framework is designed to develop. The Drama sequence on Hamlet illustrates this most clearly. The Technology OUT decisions there are not pauses between digital activities but the disciplinary core of the unit. Performance learning requires the body, the voice, and live enactment. That this reasoning was produced within the SINE framework, by a preservice teacher still in the early stages of professional formation, points to the framework's capacity to surface the disciplinary knowledge that teachers hold but do not always make explicit in their planning [24]

6.3 Disciplinary alignment of technological affordances

The third theme, Disciplinary Alignment of Technological Affordances, demonstrate that affordance interpretation is most productive when understood as a disciplinary skill rather than a generic one. Maulet et al. (2024) found that teachers' perceived affordances for using technology in teaching are shaped significantly by subject-specific knowledge and context, and Starkey et al. (2023) argued explicitly that each discipline is different in how it positions digital tools within its epistemological traditions. The evidence in this study supports both claims. The same tool produced fundamentally different pedagogical reasoning across KLAs, not because preservice teachers were applying different frameworks but because the SINE framework's what, why, and effect prompts required them to think through the disciplinary purpose of each activity. In this sense, the SINE framework is generative, structuring pedagogical reasoning while design decisions are being made rather than evaluating those decisions retrospectively. Where technology, pedagogy, and disciplinary context are seen as inseparably interwoven [4], a framework that supports teachers consider that relationship at the activity level makes a productive contribution to design thinking in initial teacher education.

The variation in depth and specificity across the artefacts has direct implications for how the SINE framework is introduced and supported in initial teacher education. The findings suggest that Technology OUT reasoning develops more slowly than Technology IN reasoning, which is consistent with Lee and Zhai's (2024) observation that preservice teachers' lesson planning with technology tends to default toward inclusion rather than deliberate positioning.

6.4 Development of teacher design thinking

The fourth theme, Development of Teacher Design Thinking, extends these findings beyond individual technology positioning decisions. Evidence from the artefacts suggested that some preservice teachers were beginning to use the framework as a broader way of reasoning about learning design, particularly where SINE was used alongside design thinking processes or applied during professional experience. In the placement-situated artefacts, decisions were more explicitly connected to known learners, disciplinary constraints, classroom conditions, and professional feedback. Importantly, these artefacts provide evidence that preservice teachers applied the SINE decision architecture within authentic classroom planning contexts rather than only within hypothetical university-based design tasks. While the data cannot establish whether this use was sustained beyond professional experience or resulted in changes to teaching practice, it demonstrates the applicability of the framework within the more complex conditions of classroom-based planning contexts. This form of context-responsive decision making also connects with the development of teachers' digital agency. Knussen and Agnew [15] argued that digital agency involves more than technological knowledge or competence, requiring

teachers to exercise professional judgement in navigating contextual constraints and determining how technology can appropriately support learning. While digital agency was not examined directly in the present study, the capacity to make and justify decisions about when, why, and whether technology should be used is consistent with this broader conception of teacher agency. This is also consistent with Lozano Cabezas et al. [29], who found that the teaching models preservice teachers enact during professional experience are shaped by the pedagogical scaffolds they bring into placement contexts. For initial teacher education, this suggests value in using SINE across multiple design contexts rather than as a single planning exercise, allowing preservice teachers to revisit and refine these reasoning processes as their pedagogical and disciplinary knowledge develops.

7. Limitations

Several limitations should be considered when interpreting the findings. First, the primary data comprised learning design artefacts produced by preservice teachers as part of a formal assessment task within an initial teacher education program. Although the decision to analyse the artefacts was made only after assessment and grade distribution, reducing the potential for responses to be shaped by research awareness, the findings represent the pedagogical reasoning preservice teachers were able to articulate within the conditions of a university-based design task. They do not establish how consistently that reasoning was enacted in classroom practice.

Second, evidence of application during professional experience was available only for a subset of preservice teachers and was derived from reflections included within their existing submissions. These accounts provide evidence that the SINE framework was applied within authentic classroom planning contexts, including in response to known learners, disciplinary requirements, classroom conditions, and professional feedback. However, they do not establish sustained use of the framework beyond professional experience or its longer-term influence on teaching practice.

Finally, the cross-sectional nature of the study does not allow conclusions to be drawn about whether engagement with the SINE framework leads to the development of design expertise over time, nor whether learning sequences designed using the framework produce stronger student learning outcomes. These questions are particularly important given evidence that the quality of technology integration is associated with student engagement and the development of digital competencies [3]

Future research should therefore examine the framework longitudinally and across different stages of teacher expertise. Tracking preservice teachers into their early years of teaching would enable investigation of whether the reasoning processes scaffolded through SINE are sustained, adapted, or further developed through professional practice. Research with experienced teachers would provide a complementary perspective, examining how the framework operates when applied by practitioners with more established pedagogical and disciplinary expertise. Further research examining the implementation of SINE-designed learning sequences and associated student outcomes would also provide evidence of the relationship between principled technology positioning during planning and its effects in classroom practice.

8. Conclusion

The SINE framework was developed to provide a foundational understanding and articulation for how technology integration is enacted as an integral part of

teacher design thinking, rather than as a separate decision about tool selection. The findings demonstrate that preservice teachers were able to use its design architecture to make pedagogical reasoning visible, deliberately positioning technology IN and OUT across learning sequences, and interpret technological affordances in relation to disciplinary purpose and intended learning. Variation across the artefacts also revealed different levels of sophistication in this reasoning, reinforcing the value of the SINE framework as a scaffold through which developing expertise can be articulated and examined. Evidence across Mathematics, Science, English, HSIE, and Creative Arts (Drama), indicates that this architecture can accommodate different disciplinary ways of knowing without prescribing particular technologies or patterns of technology use. Application of SINE by a subset of preservice teachers during professional experience, further demonstrates the framework's applicability within the classroom-based planning context, while further research is needed to establish sustained use and impact on practice and student learning, as a practical design tool across the breadth of secondary education.

At a time when the educational value of widespread technology integration is increasingly being questioned, the contribution of the SINE framework lies in shifting attention from the presence of technology to the quality of the pedagogical reasoning that determines its use. Technology does not improve learning by virtue of its inclusion. Rather than assuming that technology should be present, the framework requires teachers to determine what each activity is intended to achieve, what disciplinary and learner needs are present, and whether particular technological affordances provide the most appropriate means of supporting that learning. Importantly, the same reasoning applies when technology does not offer sufficient pedagogical value and a Technology OUT decision is made. In this way, SINE provides a structured approach to determining the pedagogical value of technology during the design of teaching and learning, rather than assuming that value in advance. It begins with a more productive question: not which technology to use, but what the learning requires. When technology is positioned in response to that question, its integration becomes a reasoned component of teacher design thinking rather than an end in itself.

Data Availability Statement: The data supporting the findings of this study are not publicly available due to ethical and privacy considerations associated with the use of student assessment artefacts.

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Informed consent statement: The requirement for informed consent was waived because the study involved the retrospective analysis of existing, deidentified student

assessment artefacts collected prior to the commencement of the research. No participants were recruited for the study, and no additional data were collected from students for research purposes.

Conflicts of interest: The authors declare no conflict of interest.

References

- [1] S. Forsström, M. Njå, E. Munthe, J.-L. Álvarez-Galván, and L. Houldsworth, “The impact of digital technologies on students’ learning: Results from a literature review,” OECD Education Working Papers, Sep. 2025. doi: 10.1787/9997e7b3-en.
- [2] C. N. Blundell, “Using design thinking to embrace the complexities of teacher learning-practice with digital technologies,” *Professional Development in Education*, vol. 51, no. 3, pp. 386–404, May 2025, doi: 10.1080/19415257.2024.2422063.
- [3] T. Consoli, M.-L. Schmitz, C. Antonietti, P. Gonon, A. Cattaneo, and D. Petko, “Quality of technology integration matters: Positive associations with students’ behavioral engagement and digital competencies for learning,” *Educ Inf Technol*, vol. 30, no. 6, pp. 7719–7752, Apr. 2025, doi: 10.1007/s10639-024-13118-8.
- [4] T. Fawns, “An Entangled Pedagogy: Looking Beyond the Pedagogy—Technology Dichotomy,” *Postdigit Sci Educ*, vol. 4, no. 3, pp. 711–728, Oct. 2022, doi: 10.1007/s42438-022-00302-7.
- [5] P. Mishra and M. J. Koehler, “Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge,” *Teachers College Record: The Voice of Scholarship in Education*, vol. 108, no. 6, pp. 1017–1054, Jun. 2006, doi: 10.1111/j.1467-9620.2006.00684.x.
- [6] R. Puentedura, “SAMR: Moving from enhancement to transformation,” Transformation, technology and education. [Online]. Available: https://www.hippasus.com/rrpweblog/archives/2006_11.html
- [7] M. Kearney, P. F. Burke, and S. Schuck, “The iPAC Scale: A Survey to Measure Distinctive Mobile Pedagogies,” *TechTrends*, vol. 63, no. 6, pp. 751–764, Nov. 2019, doi: 10.1007/s11528-019-00414-1.
- [8] W. Shiu, “Conceptualising the Pedagogical Purposes of Technologies by Technological, Pedagogical Content Knowledge and Substitution, Augmentation, Modification and Redefinition in English as a Second Language Classrooms,” *Education Sciences*, vol. 15, no. 4, p. 411, Mar. 2025, doi: 10.3390/educsci15040411.
- [9] G.-G. Lee and X. Zhai, “Using ChatGPT for Science Learning: A Study on Pre-service Teachers’ Lesson Planning,” *IEEE Trans. Learning Technol.*, vol. 17, pp. 1643–1660, 2024, doi: 10.1109/TLT.2024.3401457.
- [10] J. Gibson, *The ecological approach to visual perception*. Houghton Mifflin, 1979.
- [11] J. J. Gibson, *The Ecological Approach to Visual Perception: Classic Edition*, 1st ed. Psychology Press, 2014. doi: 10.4324/9781315740218.
- [12] A. Maulet, W. Admiraal, N. Algozhaeva, and N. Balta, “School teachers’ perceived knowledge and affordances for using technology in teaching,” *CONTED TECHNOLOGY*, vol. 16, no. 3, p. ep515, Jul. 2024, doi: 10.30935/cedtech/14713.
- [13] N. Bosch, T. Härkki, and P. Seitamaa-Hakkarainen, “Teachers as reflective learning experience designers: Bringing design thinking into school-based design and maker education,” *International Journal of Child-Computer Interaction*, vol. 43, p. 100695, Mar. 2025, doi: 10.1016/j.ijcci.2024.100695.
- [14] J. P. Donaldson and B. K. Smith, “Design Thinking, Designerly Ways of Knowing, and Engaged Learning,” in *Learning, Design, and Technology*, J. M. Spector, B. B. Lockee, and M. D. Childress, Eds., Cham: Springer International Publishing, 2023, pp. 837–860. doi: 10.1007/978-3-319-17461-7_73.
- [15] L. Knussen and A. Agnew, “Supporting early career teachers’ digital agency: a role for mentorship?,” *Irish Educational Studies*, vol. 41, no. 1, pp. 201–211, Jan. 2022, doi: 10.1080/03323315.2021.2022524.
- [16] L. Lockyer, S. Agostinho, S. Bennett, L. Knussen, and M. Plumb, “Designing for Teaching with Digital Technology,” in *Teacher Design Thinking and Practice*, Singapore: Springer Nature Singapore, 2025, pp. 145–161. doi: 10.1007/978-981-95-1950-7_8.
- [17] M. Kearney, S. Schuck, and K. Burden, “Digital pedagogies for future school education: promoting inclusion,” *Irish Educational Studies*, vol. 41, no. 1, pp. 117–133, Jan. 2022, doi: 10.1080/03323315.2021.2024446.
- [18] L. Starkey *et al.*, “Each discipline is different: teacher capabilities for future-focussed digitally infused undergraduate programmes,” *Education Tech Research Dev*, vol. 71, no. 1, pp. 117–136, Feb. 2023, doi: 10.1007/s11423-023-10196-2.
- [19] J. Ross and N. Alsayegh, “Technocentrism,” *edtechnica*, 2023, doi: 10.59668/371.12180.
- [20] J. McTighe and G. Wiggins, *Understanding by Design*, Expanded 2nd. Association for Supervision & Curriculum

Development, 2005.

- [21] Australian Institute for Teaching and School Leadership, “Australian Professional Standards for teachers.” [Online]. Available: <https://www.aitsl.edu.au/standards>
- [22] G. A. Bowen, “Document Analysis as a Qualitative Research Method,” *Qualitative Research Journal*, vol. 9, no. 2, pp. 27–40, Aug. 2009, doi: 10.3316/QRJ0902027.
- [23] U. Kuckartz and S. Rädiker, *Qualitative content analysis: methods, practice and software*, Second edition. Los Angeles: SAGE, 2023.
- [24] M. Warr and P. Mishra, “Integrating the discourse on teachers and design: An analysis of ten years of scholarship,” *Teaching and Teacher Education*, vol. 99, p. 103274, Mar. 2021, doi: 10.1016/j.tate.2020.103274.
- [25] D. Petko, P. Mishra, and M. J. Koehler, “TPACK in context: An updated model,” *Computers and Education Open*, vol. 8, p. 100244, Jun. 2025, doi: 10.1016/j.caeo.2025.100244.
- [26] F. Tschönhens, I. Backfisch, T. Fütterer, and A. Lachner, “TPACK in action: Contextual effects of pre-service and in-service teachers’ knowledge structures for technology integration,” *Computers and Education Open*, vol. 7, p. 100219, Dec. 2024, doi: 10.1016/j.caeo.2024.100219.
- [27] G. Dunne, “Resisting Edutainment: How Reward Deficiency Syndrome Fuels the Student Attention Crisis,” *Stud Philos Educ*, vol. 45, no. 2, pp. 147–173, Apr. 2026, doi: 10.1007/s11217-025-10022-7.
- [28] M. Bower, “Technology-mediated learning theory,” *Brit J Educational Tech*, vol. 50, no. 3, pp. 1035–1048, May 2019, doi: 10.1111/bjet.12771.
- [29] I. Lozano Cabezas, M. J. Iglesias Martínez, S. Arroyo Salgueira, M. D. M. Camús Ferri, and A. Giner Gomis, “What teaching models do Pre-Service teachers learn during placements?,” *Cogent Education*, vol. 9, no. 1, p. 2034393, Dec. 2022, doi: 10.1080/2331186X.2022.2034393.

Appendix A

1. Technology in Action Evaluation

Link to evaluation form



2. Questions

4. Name of technology *

5. Is the technology free, or does it require a licence or login? *

Mark only one oval.

- ☐ Free
- ☐ Requires licence
- ☐ Other:

6. Explain how you checked that the technology meets privacy, security, and Department of Education policy guidelines. *

7. After your own testing, how well does the technology fulfil the intended purpose for the selected activity? *

Mark only one oval.

1 2 3 4 5

Mini ☐ ☐ ☐ ☐ ☐ Extremely well

8. Briefly explain the reason for your decision about the technology fulfilling intended purpose. *

14/09/2026, 15:45

Technologies in Action Evaluation Form

9. Consider how the technology used for the planned activity changes the learning process of experience for students *

Mark only one oval per row.

	All students	Some students
Augments learning	☐	☐
Modifies learning	☐	☐
Provides a new learning experience	☐	☐

10. Explain how the use of the technology changes the learning process or experience for some or all students. *
11. Why is this technology appropriate for the learning activity and your discipline, compared with other technological or non technological options? *
12. What specific evidence would you be looking for to determine that students are learning effectively through the use of the selected technology? *
13. What would this evidence tell you about the impact of the technology on student learning? *
14. Based on your evaluation, would you retain, modify or replace this technology for the activity? *

Mark only one oval.

- ☐ Retain
- ☐ Modify
- ☐ Replace

15. Briefly explain the reason for your decision. *
16. Is there anything else you would like to add about your experience of selecting, using or evaluating this technology?