Improving Learning

Rapid Review

Literature related to best practice principles in the design and delivery of digital resources for teachers

Part of the Life Education Australia *Being Healthy, Being Active* project

Core review team: Syeda Kashfee Ahmed, Pru Mitchell and Jenny Trevitt

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Executive Summary

One of the outcomes of the Coronavirus (COVID-19) pandemic is that schools and training providers are actively seeking ways in which they can use digital learning techniques and tools to provide continuous professional development for teachers. This has led to renewed interest in the design features of online resources and knowledge repositories. As professional learning is increasingly expected to be self-directed, self-paced and virtual, teachers are expected to upskill themselves while working remotely, using electronic (e)–resources and collaborating online. While this is an *efficient* means of delivering professional learning and development opportunities to teachers during a difficult time, this rapid review looked to inform the question about how to ensure this mode of professional learning is *effective*.

The review, commissioned by Life Education Australia (LEA), gathered evidence about good practice in the design and delivery of digital professional learning for teachers. Its goal was to inform development of principles to guide the design and delivery of LEA's own digital resources for teachers. The key research question for the review was:

What does the research evidence say about the design and delivery of digital / online resources for teachers and what practice implications and recommendations could be made based on this research evidence?

As a rapid review, the six steps of scope, question, scan, screen and select, and synthesise evidence were streamlined to reflect the limited timeframe. The scan draws on systematic searching of the two key education databases Australian Education Index (known as A+ Education) and Education Resources Information Center (ERIC). These database searches returned 767 references and, after screening and selection using the inclusion and exclusion criteria, 28 papers were included in the initial review. The synthesis of these studies revealed five fundamental design principles for effective online professional learning resources for teachers:

- Principle 1: Relevance: Meeting teachers' needs
- Principle 2: Educational value: Focusing on learning
- Principle 3: Managed and flexible learning environment: Accessing and navigating
- Principle 4: Social presence: Participants engaging with content, facilitator and peers
- Principle 5: Quality Content: Using diverse media and drawing from multiple evidence-based sources

This report provides analysis of each of these principles, highlighting the evidence available globally from online teacher professional learning programs, and cross-checking the findings with other user-centred and instructional design principles in use in Australian education. Applying these principles to the design and delivery of online teacher resources will help to ensure that the teachers find professional learning materials and tools educationally-sound, meaningful and engaging. The goal is for teachers to learn more efficiently and effectively, to become more confident in applying their newly acquired knowledge and ultimately transfer these skills to their classrooms to improve student engagement and learning outcomes.

1: Background

1.1 Rationale

COVID-19 has meant distance learning and teaching has become the only possible way to deliver education in many countries across the world. Distance or remote learning is mostly taking place through online platforms and it is expected that teachers should not only know how to navigate and use these online resources, tools and learning systems but should also be using these for their own learning and professional development.

Pre-2019, online learning was already a powerful medium for delivering low-cost, high-quality, and accessible training to teachers, particularly to those in rural and remote locations (Bragg et al., 2021; Dede, 2016). However, while prior work has identified successful design elements for the delivery of online teachers' learning programs, there remains a gap in understanding how these design elements, such as learner supports, 'assist teachers in gaining knowledge and skills through interactives or engaging in self-reflection through metacognitive interactives' (Bragg et al., 2021, p. 11).

In the wake of the pandemic, schools and training providers are actively seeking ways in which they can use digital learning techniques and tools to provide continuous professional development for teachers. For such attempts to be successful there is a need to synthesise the best principles and techniques for online learning, and to understand which remote learning modes and formats should be utilised in different scenarios to facilitate teachers' ongoing learning goals.

Of particular interest are the design features of teachers' online resources and knowledge repositories. As learning is increasingly expected to be self-paced, self-directed and virtual for the ongoing future, driven by the current pandemic, teachers will be expected to upskill themselves while working remotely, using electronic (e)–resources and online collaborations – an effective means of delivering professional learning and development opportunities to teachers during these difficult times.

1.2 Prior research

There is literature available on the different approaches to synchronous online learning (Martin et al., 2017), and general reviews of online education (Sun et al., 2016). Lately, researchers have also explored the remote learning methods applied in schools that have been used during the pandemic (Education Endowment Foundation [EEF], 2020a), with a focus on *student* learning.

Research on the use of online learning platforms by teachers for their own professional development (PD) is still evolving. An earlier paper helped to identify circumstances where online learning for teachers was most useful and where it could be challenging (Bates et al., 2016). Others have developed concepts around self-directed online learning behaviours useful for understanding how teachers use online professional learning (PL) resources (Beach, 2017). Research suggests the design of effective e-learning resources and systems needs to accommodate specific teaching and learning needs, and to promote interaction between teachers and students to

increase teachers' motivation to use e-learning systems (Schulz et al., 2014). When the e-learning environment is perceived by teachers to be useful, they are willing and motivated to use these systems (Liaw et al., 2007). Additional factors such as level of computer integration, positive beliefs, ease of use, training, and support also influence the teachers' motivation to use e-learning systems (Schieb & Karabenick, 2011).

A study which explored teachers' learner-centred beliefs and attitudes towards technology identified five major teacher types: '1) Learner-centred teachers with technology, 2) Teachers critical of technology use in school, 3) Teachers uncomfortable with technology, 4) Teachers uneasy with learned-centred teaching and 5) Teachers critical of a clear-cut stance' (Admiraal et al., 2017, p. 57). This grouping of teachers is useful for matching the right group of teachers to a particular teacher intervention or to design different digital learning resources for teachers with different attitudes (Admiraal et al., 2017).

Previous reviews have focused mainly on the broad topic of distance or digitally supported professional development and suggested that remote professional development programs can improve the knowledge and skills of educators and therefore lead to improved student outcomes (Basma & Savage, 2018; EEF, 2020b; Kraft et al., 2018; Marsh & Mitchell, 2014). Besides, researchers agree that some design and implementation features are paramount for the success of these distance learning programs (Basma & Savage, 2018; Lynch et al., 2019; Major & Watson, 2018; Reeves & Pedulla, 2013). A recent systematic review suggests key design elements that lead to effective online PL delivery which can improve teachers' knowledge, skills, beliefs, and practices (Bragg et al., 2021). Table 1 lists some relevant reviews in this space and also notes their key characteristics.

Table 1. Previous reviews related to teacher professional development (includes blended, hybrid, online, electronic, and distance learning initiatives)

Author	Year	Title	Intervention approach	Outcome	Number of studies included	Focus on Teacher learning rather than Adult learning?	Reports on program design/ implementation features?
Basma & Savage	2018	Teacher professional development and student literacy growth: A systematic review and meta-analysis	Video exemplars	Student literacy	17	Y	Y
Bragg, Walsh, & Heyeres	2021	Successful design and delivery of online professional development for teachers: A systematic review of the literature	Online Professional development programs	Teacher's content knowledge, pedagogical content knowledge, instructional practices, professional competency, classroom management practices, teacher beliefs, perceived sense of self-efficacy, and program satisfaction	11	Y	Y
Cho, Mansfield & Claughton	2020	The past and future technology in classroom management and school discipline: A systematic review	Videos, interactive simulations, databases	Teacher classroom management knowledge and skills	22	Y	Y
Education Endowment Foundation	2020b	Remote professional development, rapid evidence assessment	Remote (fully or blended) professional development approaches for professionals in education, welfare and public health	Beneficiary outcomes, professionals' behaviour or knowledge change, other outcomes (such as job satisfaction)	17	N	Y

Author	Year	Title	Intervention approach	Outcome	Number of studies included	Focus on Teacher learning rather than Adult learning?	Reports on program design/ implementation features?
Hundey, Anstey, Cruickshank & Watson	2020	Mentoring faculty online: a literature review and recommendations for web-based programs	Online mentoring	Teaching confidence, knowledge and skills	17	Y	Y
Kraft, Blazar & Hogan	2018	The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence	Teacher coaching	Teacher instruction, student achievement	60	Y	Y
Lynch, Hill, Gonzalez & Pollard	2019	Strengthening the research base that informs STEM instructional improvement efforts: A meta-Analysis	STEM teacher development programs	Student achievement	95	Y	Y
Major & Watson	2018	Using video to support in-service teacher professional development: The state of the field, limitations and possibilities	Video-based PD	Teacher cognition and classroom practice	82	Y	N
Marsh & Mitchell	2014	The role of video in teacher professional development	Video-based PD	Teacher knowledge and skills	Not reported	Y	Y

Although most of the reviews undertaken in this space have tried to identify certain design and implementation features that are widely effective for distance learning situations and generally for teacher professional development, there is a gap in evidence on best principles in design and delivery of digital resources for teacher professional learning. This calls for a review of the existing digital / online learning approaches, including any online professional learning and development initiatives for in-service teachers and a comparative analysis of the methods and formats used across them.

1.3 Objectives

The aim of this review is to gather evidence about the best practice principles in the design and delivery of digital resources for teachers. Life Education Australia (LEA) is preparing to roll out online learning resources for teachers and intends to be informed about the current evidence on the successful implementation of such resources. Ideally, the evidence coming out of this rapid review will inform the development of principles to guide the design and delivery of LEA's digital resources for teachers.

2: Methods

2.1 Rapid literature review

The primary method used for this project was a rapid review. While systematic reviews may be the gold standard for evidence synthesis, rapid reviews are increasingly popular as useful, timely and less resource-intensive than traditional systematic reviews, making them more appropriate in situations where time and budget are limited (Garritty et al., 2020). However, since a rapid review is not as rigorous as a systematic review, which usually takes over a year to complete, users must be mindful of the limitations and potential biases in the selection of evidence for the analysis and synthesis. The steps in a rapid review are usually streamlined from that of a traditional systematic review and a few steps may also be omitted to save time (Temple University, 2021). There is no universally accepted process for conducting such a review, however the stages shown in Figure 1 have been adapted from an approach proposed by Khangura et al. (2012) to provide a systematic basis for this review.

Scope
- Define the research scope based on the resources available

Question
- Narrow reseach questions and develop inclusion/exclusion criteria using Problem, Interest and Context (PICo)

Scan
- Search relevant sources
- Provide reproducible and transparent search methods

Screen and Select
- Identify evidence for inclusion based on the inclusion/exclusion criteria
- Document the search and screening processes

Synthesise evidence
- Analyse evidence from included papers
- Summarise evidence and present in a report form

Figure 1. Stages for a rapid review of literature (Adapted from Khangura et al., (2012) Evidence summaries: the evolution of a rapid review approach)

2.2 Research questions

The following broad research question was developed based on the research questions in the Request for Quote (RFQ):

What does the research evidence say about the design and delivery of digital / online resources for teachers and what practice implications and recommendations could be made based on this research evidence?

More specifically, this rapid review focused on the following key questions to answer the broader research question:

1. With regard to online learning platforms for the delivery of resources to teachers: how are these platforms meaningful, engaging and user friendly?
2. Which modes and formats of online resource delivery are most appropriate to reach the teachers, particularly those in rural and remote areas?
3. What modes and formats of online resources could be best used by LEA for the *Being Healthy, Being Active* project?

A framework for this review is provided in Table 4 in Appendix 1. This framework supports the recording and analysis of the evidence included in this review based on the inclusion/exclusion criteria.

2.3 Inclusion and exclusion criteria

A set of Problem, Interest, and Context (PICo) dimensions was developed in consultation with the LEA team to ensure the relevance and usefulness for their planned online resource design. Table 2 shows the inclusion and exclusion criteria that were applied for searching and screening evidence.

Table 2. Inclusion criteria

Inclusion criteria for this review	
Problem (P)	Providing quality online resources to all in-service teachers (Kindergarten to Year 12 schools), including those in mainstream and or special education settings, and those from rural and remote areas.
Interest (I)	Successful design and delivery elements/ features of distance/ online teacher professional development resources. Includes design features and elements of any online facilitated course (synchronous or asynchronous), mentoring, coaching, networking, self-directed learning module, online teacher resources repository, etc.
Context (Co)	Online learning for teachers across Australia and other developed countries, particularly those with similar educational and technological advancement as Australia, such as Canada, United Kingdom and other European countries.

Other eligibility criteria detailed the exclusions and limits placed on the review:

- Limit the scope to in-service teacher learning, rather than pre-service teacher education or professional learning for adults outside the teaching profession.
- Limit timeframe of the publication date from 2010 to 2020.
- Exclude evidence focused on face-to-face instruction, blended learning (components of face to face and online instruction), and self-determined

learning not conducted entirely online, computer-assisted learning, field placements or professional development programs as part of teacher training at tertiary level institutions.

- Exclude papers from countries whose educational technology availability, and the teacher population, differ vastly from the Australian context.
- Exclude books, dissertation, theses and papers which are not easily available in full-text in the timeframe for the rapid review.
- Exclude papers not available in English.

2.4 Systematic searches and selection of studies

The literature scan draws on the two key education databases Australian Education Index (known as A+ Education) and Education Resources Information Center (ERIC). Both of these databases have an education-specific thesaurus that were used to ensure inclusion of strategic search terms to match the PICo dimensions. Potential papers were also pursued through hand searching of reference lists, and specific searches of relevant grey literature.

This review has been limited to evidence from 2010 or later since technology-based approaches prior to 2010 are unlikely to be relevant. Papers identified through systematic searches have been screened against the inclusion and exclusion criteria discussed in Section 2.3.

The systematic database searches returned 767 references (see Appendix 3). After removing duplicates, 720 records were screened on title and abstract, and another 88 references were selected for full text screening. The full text for 14 references could not be retrieved and so 74 full texts were thoroughly screened. Of these 74 papers, 28 papers were included in the review. All 28 had data extracted (see Appendix 2). Note in the list of studies under Allen that there are two separate references to the same study (2011 & 2015).

2.5 Evidence synthesis and presentation

The key objective of this step is to summarise what is known about the best practices in the design and delivery of digital or online resources for teachers in the literature.

This stage involved: 1) extracting relevant information from the included papers; 2) summarising the evidence; and 3) providing implications for practice and recommendations (Dobbins, 2017).

The evidence synthesis, analysis and discussion therefore helped to answer the research question:

What does the research evidence say about the design and delivery of digital / online resources for teachers and what practice implications and recommendations could be made based on this research evidence?

3: Analysis of the evidence on effective design of online professional learning resources and programs

This section summarises the findings of the included studies shown in Table 5 (Appendix 2) and categorises the online professional development resources and programs identified in the rapid review. Appendix 4 includes a mapping of six examples of principles of professional learning published by Australian and international organisations (Australian Council for Educational Research [ACER], 2013; Cavanaugh & Dawson, 2010; EEF, 2020b; Global Online Academy [GOA], 2020; Quality Matters [QM], 2015; NSW Education Standards Authority [NESA], 2021).These principles were used to inform the analysis of the literature in the rapid review. While this review focuses on the design elements and features which are most effective for the delivery of online teacher professional development, it is important to acknowledge that professional learning is a complex activity and it is not readily dissected into component parts for the purposes of research, but is inherently holistic, dynamic and contextual (Timperley et al., 2020, p. 3). There are many components that contribute to effective professional learning and this review picks out those elements that most directly relate to the design of online professional learning.

3.1 Effective professional learning

In order to evaluate the effectiveness of professional learning there must be a standard against which to compare, and a means of measuring the outcomes. As the outcome of a program or resource cannot be evaluated until after it has been implemented, organisations often develop a set of principles to guide the development of professional learning. Examples of guidelines for effective professional learning are presented in Appendix 4: Good practice principles of professional learning.

Despite the variation in level of detail in these statements of principles of effective professional learning, there are some commonalities, which are represented in Learning Forward's (2021) framework with its three categories of factors influencing the effectiveness of professional learning: (1) *conditions for success* (such as context, structures, and culture); (2) *transformational processes* that ensure educators learn in ways that brings about change in their knowledge, skills, practices, and mindsets; and (3) *rigorous and inclusive content* that aims for improved student outcomes (p. 8).

Literature about effective teacher professional development in the past twenty years shows that there has been a move away from one-time, large group-focussed delivery, towards learning that is needs-based, content-focused, collaborative and ongoing (Borko, 2004; Garet et al., 2001). Another obvious change in the past ten years is the move to professional learning that is delivered online.

3.2 Effective online professional learning

Online professional learning can take a number of forms and can vary in effectiveness – just as is the case with traditional professional learning. There are a great many factors at play, in learning, that must be controlled for in any research that seeks to measure effectiveness of a specific intervention. In the case of online professional learning these factors include the duration, mode, content, learning design, assessment

and technology, as well as the knowledge, skills and attitudes of the facilitator and participants. Unsurprisingly, there are relatively few studies on the effectiveness of online professional learning, and it is difficult to generalise from those available (Dash et al., 2012). Teachers work in many different contexts in terms of the level of schooling, teaching area, physical location, educational sector and student cohorts. Professional learning resources and programs need to take these contexts into account.

One common feature of the literature about online professional learning is that it focuses less on the content and more on the interactions involved in the learning process. The contribution of teacher or facilitator presence is consistently found to improve completion rates and effectiveness of online professional learning (Stone & Springer, 2019). One MOOC that reported an average completion rate of 53% found that learners who were active in the forums were more likely to complete the course (Murugesan et al., 2017).

Many authors make a strong case for inclusion of social interaction and collaborative spaces for teachers in any online professional learning design (Lantz-Andersson et al., 2018). Design that is deliberately flexible, experiential and supports social interaction between participants is regarded as optimal (Eddy Spicer & Dede, 2006). While interactivity is often cited as a feature of online content, in the context of learning, Moore (1989) points out that all three types of interactivity should be involved: learner-to-content, learner-to-instructor, and learner-to-learner (Zimmerman, 2012).

This focus on human interaction is also reflected in design principles for online professional learning. Cavanaugh & Roe (2019) noting the absence of Australian standards for online and blended learning in the school sector, point professional learning designers to the International Society for K-12 Online and Blended Learning (iNACOL) *National Standards for Quality Online Courses* (2011). Adelstain & Barbour's (2018), in examining the validity and reliability of the iNACOL standards, found there was limited literature and research specific to K-12 online provision, and that they had to supplement their review with research from higher education and other relevant populations (p. 243). Since their review, the iNACOL standards have been consolidated with a set of rubrics for designing continuing and professional education (Quality Matters, 2015) to create a new set of standards (National Standards for Quality (NSQ), 2019). This document provides an extensive set of standards in 14 categories that provide further indication of the complexity inherent in designing effective online professional learning programs. These standards are used to guide planning and evaluation of online professional learning. Of particular interest to those developing online professional learning resources, are standards I: Curriculum and Course Design, J: Instruction, and K: Assessment and Learner Performance, and these have served as a model for the principles discussed in this review.

In critiquing a highly politicised set of Australian online learning resources, Moss (2021), points out that "development of large-scale professional learning resources typically would employ a large team that includes learning designers to work alongside content developers." Learning design as a specialisation has grown in parallel with the development of online delivery of education, and recognises that more than one skillset is needed to ensure a coherent collation of "content, structure, time, pedagogical strategies, and sequences of learning, assessment tasks and the

nature of the technology used to support learning" (Moss, 2021, para 5). As a young profession, the research base underpinning instructional design is emerging.

3.3 Effective design of digital resources for teacher professional learning

This section discusses key findings about the principles underpinning design of digital resources for teacher professional learning, based on the analysis of information from the research included in Appendix 2: Details of included interventions, and from a review of instructional design principles. These principles are centred on relevance, educational value, flexibility within a managed learning environment, presence as well as content.

Principle 1: Relevance: Meeting teachers' needs

The decisions teachers make regarding resources to use in their classroom is a complex process based on a range of factors, including in the case of digital content, the extent to which it is "readily accessible, links with the curriculum, and does what it purports to do (Gaffney, 2010, p. 21). This speaks to the first principle of design which is that it meets user needs. Getting close to the intended participants' context is important. "An understanding of the working contexts of staff is a critical consideration when designing for effective professional development" (Macdonald & Poniatowska, 2011, p. 119).

In order to design online professional learning resources that meet the needs of teachers, it is helpful to know how teachers use such resources. The adoption of digital resources for use with students was the focus of some research in Australia last decade during the rollout of the national digital content initiative known as The Learning Federation (Smith, 2020). This research found that digital resources designed to meet specific elements of the curriculum were highly valued and sites that organised resources according to curriculum themes and topics were popular. Australian resources were particularly valued (Baker, 2010; Maher et al., 2012). In summary, digital educational resources achieve focus on the learning needs of their intended audience when they are:

- contextual – they have purpose and meaning for the intended audience and fit into a learning approach based on the audience's prior understandings and likely future development
- inclusive – when their language and other features (where applicable) are inclusive of the intended audience (Education Services Australia [ESA], 2011, p. 2).

More recent research reviewing how teachers use digital resources for online professional learning is scarce. The Quality Teachers for Quality Students (QTQS) project, identified in this review, used an online professional learning community to support new STEM teachers, and found this approach allowed collaboration and engagement that could be directed by the needs of the group (Suk Hwang, 2012). Professional learning resources and programs that allow for teacher agency in both the design of the program and in how they participate, enhance engagement and learning (Calvert, 2016). This is reinforced in the engagement strand of the popular *Universal Design for Learning* model which refers to "recruiting interest in learning by

optimising individual choice, autonomy, relevance, value, and authenticity, and by minimising threats and distractions" (CAST, 2018).

Professional learning principles also stress the importance of adherence to content standards as a measure of relevance. The *NESA Interim Principles of Effective Professional Learning* (2021) are explicit about the importance of 'coherence' with the *Australian Professional Standards for Teachers* (Australian Institute for Teaching and School Leadership [AITSL], 2011), with NSW curriculum, and with policy, as well as being "practical, and job embedded" (NESA, 2021).

> *One strategy for optimising the effectiveness of web-mediated professional learning is to design such interventions in collaboration with, and using extensive input from, the teachers who ultimately will use it. (Hindman et al., 2015, p. 15).*

Recommendation: Involve teachers in the design, trialling and evaluation of online professional learning programs and resources to ensure relevance.

Principle 2: Educational value: Focusing on learning

Educational value is defined by Australia's national agency charged with developing digital teaching and learning resources, as "a resource's capacity to successfully promote learning and development by students, teachers or school leaders within the Australian school context" (ESA 2011, p. 1). The focus of all professional learning must be the learning, specifically, "evidence-informed learning design in which research evidence and data informs co-designed learning that aims to extend and challenge adult learners" (Bastow, 2016, p. 1).

Learning outcomes

Some form of new knowledge and intentional instruction is required if learning is to take place, and the whole process of professional learning design will be driven by effective learning outcomes. Learning outcomes describe the competencies that learners will be able to do upon completion of the program. Intended outcomes for a learning experience should be clearly articulated and participants need time and support to develop their understanding of the meaning and relevance of those outcomes. Instructional materials should enable learners to achieve stated learning objectives or competencies (Quality Matters [QM], 2015). Criteria for assessing educational value include:

- the purpose, process and intended outcomes of the required learning or development are explicit
- the medium is exploited to maximise the opportunities for the audience to achieve the required learning outcomes
- content is constructed in manageable and meaningful concept chunks to facilitate the required learning (ESA, 2011, p. 5).

This assumes the team of content creators and learning designers developing the program and resources are qualified and experienced, and that presenters and facilitators have deep content knowledge and effective teaching skills.

Beach (2017) analysed primary school teachers' use of a professional learning website about teaching literacy and found there were several factors in play before teachers even began interacting with the content, including the teachers' perception of professional learning, their focus that was on student needs and instructional goals, and students' individual differences. Given this was self-directed PD activity, the navigation of the site assumed particular importance, and two key themes emerged: (1) teachers were constantly evaluating information and choosing their pathway through the content accordingly; and (2) they were encoding information for future retrieval. Teachers demonstrated multiple outcomes from the exercise: including reflection on their learning, continued professional learning, and their intentions for practice (Beach, 2017, p. 65). Teachers' engagement in professional learning is essential if they are to learn, and this requires a high level of cognitive challenge.

Cognitive presence

If learning outcomes are carefully constructed, and if the learning design supports these learning outcomes, one might expect the content knowledge obtained by participants to be equivalent, regardless of the mode in which the professional learning is delivered. However, several studies indicate that the level of 'cognitive presence' can change the effectiveness of professional learning. Cognitive presence is defined as "constructing meaning through sustained reflection and discourse in a critical community of inquiry: cognitive presence reflects higher-order knowledge acquisition and application and is most associated with the literature and research related to critical thinking" (Garrison et al., 2001, p. 17). This is often supported by a focus on 3 Rs:

- Relevance – provoking curiosity and establishing connections to prior learning or knowledge
- Rigour – challenging participants to solve problems that are personally meaningful to them
- Relationships – designing a learning environment where participants work collaboratively together in a community of inquiry (Alman et al., 2012).

Within the review, one study about Norway's *Matematikk MOOC* identified explicitly referenced cognitive presence, and concluded that a meaningful learning experience was created through the interplay of three key elements: social, teaching and cognitive presence. This 3-week program aimed to refine teachers' practice using a Community of Inquiry learning (CoI) model to develop participants' pedagogical content knowledge. The MOOC required collaboration and engagement, with a discussion forum as the main platform for interaction. The facilitator's main role was publishing and explaining problem-based tasks in the discussion forum (Krzyszkowska, 2020). It is observed that interaction is not a guarantee that learners are cognitively present in the learning experience, as they can interact, but at low cognitive levels.

Assessment and feedback

In order to demonstrate that learning has occurred, some form of learning assurance task or assessment is required. Assessment strategies are integral to the learning process and are designed to evaluate learner progress in achieving the stated learning objectives or mastering the competencies (QM, 2015). Thus, assessment needs to be

consistent with the stated learning outcomes, as well as being valid, reliable, and appropriate to context. Many of the programs in this review included an assessment component (Hilli, 2020; Hindman et al., 2015; Marrero et al., 2010). Demonstration of a teacher's learning ideally involves application of acquired knowledge and skills in practice which can be a challenge for an online professional learning program that is not school-based. Effective assessments are aligned to learners and learning goals, allow for multiple attempts, and support students working at their own pace (GOA, 2020). Online learning programs typically rely on online quizzes and polls, as formative assessment opportunities, as in the *Virtual Live, Short-Courses for NASA Explorer Schools* (Marrero et al., 2010). However, the platform on which professional learning resources are hosted can constrain best practice and cognitive engagement by only offering certain tools for assessment (Hilli, 2020).

Providing opportunities for feedback to teachers and reflection by teachers is equally important (NESA, 2021). Documenting formal and informal reflection and peer feedback through forum posts is one of the affordances of traditional online learning platforms. Effective learning design can encourage and incorporate feedback in multiple formats, and focus on diversifying feedback channels to include facilitator-to-participant, facilitator to-participant(s) (i.e. groups), participant to participant, as well as participant to facilitator.

Closing the loop on assessment involves using participants' assessment results to evaluate the professional learning activities on an ongoing basis to improve quality (ACER, 2013).

Recommendation: Commence development of online professional learning from a strong shared understanding of the learning outcomes and how to effectively assess teachers' learning of those outcomes.

Principle 3: Managed and flexible learning environment

There is tension between providing a seamless, user-friendly experience for teachers, and at the same giving them flexibility to move through resources in a way that works for them. Online professional learning programs and resources must balance usability and flexibility. The stricter the designer is, about consistency and simplicity of navigation, visual elements, chunking of text – the quicker the end-user will learn what they can access, how the platform works and where things are. The Digital Transformation Agency of the Australian Government provides a set of 13 criteria to help design and deliver online services that are simple, clear and fast (see Appendix 5: Digital Service Standard Criteria (Digital Transformation Agency [DTA], 2011). These criteria can be readily applied to design of digital services for education. Education Services Australia also provides very detailed advice to designers of online learning resources (Handley, 2014).

Modes of delivery

When categorising and comparing online professional learning programs, one of the first delineators is the mode of delivery. There are fundamentally three modes: synchronous, asynchronous, or blended. Within each of these modes, professional learning may be facilitated, self-directed or a blend of both.

Asynchronous self-directed

In an asynchronous self-directed mode of learning, participants can learn at their own pace, usually within a given timeframe. Some units have assessment components which need to be completed (sometimes with a minimum score) to get to the next unit. An example of online professional learning delivery through this mode is provided in *Case study 1: iPlan tool* (Tekkumru-Kisa, 2019).

Asynchronous facilitated

Asynchronous facilitated professional learning is a model that has designated facilitators who are responsible for guiding learners through learning content, and stimulating discussion. In this mode, communication can take place at different times (usually through forum posts and blogs) and participants can choose to respond at times that are suitable to them.

Examples of asynchronous facilitated learning include the Reconceptualising Mathematics and Science Teacher Education Programs (ReMSTEP) and Contemporary Science Practice in Schools programs which consist of a website of videos and modules of work about contemporary science with a focus on how scientists practice science. Teachers in this program could apply this knowledge and contextualise the curriculum for their students, modelling practices, experiments and activities based on how scientists practise science. Screenshots of the learning modules and materials are shown in *Case study 2: Reconceptualising Mathematics and Science Teacher Education Programs (ReMSTEP)* (Blom et al., 2019, p. 9).

Synchronous facilitated

Synchronous facilitated professional learning is live – with all participants present and interacting in real time. Most of the time there is a facilitator present to guide the discussions. 'Teacher presence' is an often-referenced factor in successful online learning. Student perception of helpful strategies that enhance teacher presence include timely response to questions and timely feedback on assignments (Martin et al., 2018). Examples of this popular form of professional learning online include webinars, consultation and online conferences and workshops. *Case study 3: NASA Explorer schools presents an example of live short-courses delivered to NASA Explorer schools*.

Blended

Delivery via any mixture of modes is referred to as a blended mode of delivery. This could include a mix of any of the above modes and the multiple modes are usually selected to support maximum engagement and collaboration among the participants. There are potentially many variations on blended or mixed mode delivery. Case study 3: NASA Explorer schools*Case study 4: Virtual Learning Environments* is just one example of a blended online professional learning program. Another is *Case study 5: CSER Digital* Technologies Education MOOC.

Learning management platforms

Program websites are a common way for organisations to make digital professional learning resources available to participants beyond their own institution. The

information architecture upon which a website is built is as flexible as the vision and skills of the programmer designing it. In many cases some kind of programming will be required to develop a website that is appropriate for hosting the resources and tools relevant for effective delivery of a professional learning program.

Learning Management Systems are platforms built specifically for online learning, and the many affordances of this are seen in the research that was conducted in formal school or higher education settings. Selection of a learning management platform is a major investment and may not be an appropriate fit for standalone professional learning programs or resources.

Recommendation: Consider the pros and cons of different modes of professional learning, including blended approaches, and determine the learning approach prior to selecting a learning management platform.

Principle 4: Social presence: Participants engaging with content, facilitators and peers

One of the recurring findings about online learning is the value of 'social presence'. A definition of social presence is the extent to which a person feels 'socially connected' to others in their online environment (Stone & Springer, 2019). In an educational context, there is a specific focus on 'teacher-presence', or how the facilitator welcomes participants, connects with them, and communicates throughout the program.

Research across face-to-face, online, and blended learning experiences across different modalities, contexts, and audiences, shows that "for students and instructors alike, one concept has remained the key to a successful experience: the power of human connectedness for learning" (Whiteside et al., 2014). Social presence contributes to participant satisfaction, motivation and retention. It involves personal dimensions such as immediacy, community, interaction, trust and off-topic exchanges. When social presence is low, group dynamics suffers. There is emerging research about whether video interaction contributes better to engagement in learning than text or audio-only communication, because it more closely parallels in-person communication.

Provision of learner support is a common theme in the literature on online professional learning. Salmon's (2011) five-stage framework shown in Figure 2 is widely used and makes the strong point that before participants can be effective at information exchange, knowledge construction or development, they need to move through the stages of access and motivation, and online socialisation. In order to make these steps they require both technical and facilitator support (p. 11).
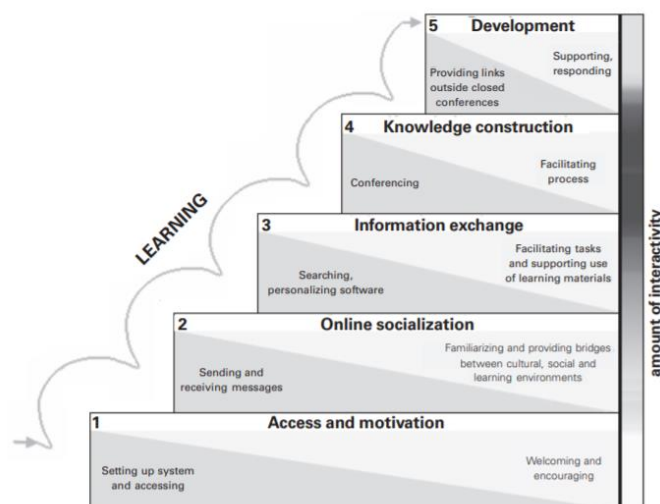
Figure 2 Salmon's 5-stage model of teaching and learning online through online networking (Salmon 2011, p. 11 Licence: CC-by-nc-nd-4.0)

A highly personalised, high-touch form of online professional learning is digital coaching or mentoring. Kraft and Hill (2019) point to the benefits of web-based coaching programs as a form of professional learning that "can be operated at relatively lower costs, are scalable, and make it more feasible to pair teachers with coaches who have expertise in their content area and grade level" (p. 1).

Professional Learning Networks (PLNs) are defined as a system of interpersonal connections and relationships and resources that support information learning (Trust, 2012). These networks provide connections to others worldwide who can offer support, feedback, and collaboration opportunities that allow educators to stay up to date on the latest teaching techniques, pedagogies and practices, and updates in the field of education (Beach, 2012).

Social media is a feature in a number of studies reviewed. Teacher collaboration through social media sites like Twitter, Facebook and YouTube, and LinkedIn are being used as *professional learning networks* to offer 'just-in-time' access to information on evolving technologies and allowing teachers to connect globally through social media live features (Jones & Dexter, 2014). A number of studies have reported how the *Twitter* platform in particular has filled the gap in face-to-face professional learning, providing opportunities for educators to share information, knowledge, resources, and classroom experience, as well as to collaborate and reflect with other educators (Ross et al., 2015; Trust, 2012). The possibility of anonymous participation in some of these networks, has allowed teachers the capacity to discuss issues they feel are inappropriate for their school-supported platforms, and a way of seeking support without feeling intimidated (Jones & Dexter, 2014).

One of the MOOC designs reviewed, reportedly overlooked the significance of a sense of belonging and the connectedness among the course participants and did not include explicit steps for building a community. The researchers concluded that the design and organisation (procedures, course content and the scheduled events predefined in the LMS) had been considered more important than facilitation and direct instruction (Krzyszkowska, 2020). The tendency to focus on the tangible

technology and content building is something to guard against in designing online resources and programs.

Recommendation: Note the importance of social presence for effective online professional learning and identify strategies for incorporating these benefits into the development of resources and programs.

Principle 5: Quality content

Multimedia courseware is a term used in the early research literature for online learning resources or 'assets'. There is natural focus on multimedia in online learning as this is one of the features that the online environment provides that was missing in previous distance education or asynchronous learning. From this research comparing the benefits of multimedia learning resources, over text-only resources, there are findings such as Cowan & Morey (2007) to suggest that individuals learn better from multimedia messages when they are designed in ways that are consistent with how the human mind works. This is supported by the Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2001) which is a theoretical framework that explains how multimedia benefits learners, and also provides design guidelines for the production of educationally effective multimedia materials to reduce cognitive load imposed on working memory.

Evaluating Digital Content for Instructional and Teaching Excellence (EDCITE) was a year-long professional development program focused on supporting teachers in evaluating and selecting educational digital resources (EDRs) (Xie et al., 2018). They identified that educational digital resources can range from "single online videos to interactive websites, from games and apps to adaptive problem sets, from lesson material developed by individual teachers to academic publishers' resources based on state adopted standards." Each of these formats has distinct features that influence how it might be used in professional learning. Selecting an approach involves considering which approach will best meet the identified professional learning need, what challenges may occur and how can these challenges be managed?

There are several checklists available that provide criteria of quality, providing statements to consider such as:

- Playlists, Not Packets: Give choice in content. Content selection should include diverse media and draw from a variety of sources, academic and otherwise (GOA, 2020).
- Integrity of a resource is a critical component of educational value, requiring the source of a digital resource and/or of its content is reputable, current and accurate (ESA, 2011, p. 2).
- This includes the level of professionalism of media: attractive which should be functional and appropriate for teachers (Cavanaugh & Dawson, 2010).
- Content should be edited, referenced correctly, with no broken links. All content will be clearly licensed and labelled with its provenance and copyright and re-use status (ACER, 2013).

Recommendation: Focus on quality content, using diverse media and drawing from reputable, current and accurate sources, that is correctly referenced and labelled, and is attractive, functional and appropriate for the teacher audience.

3.4 Bringing it all together

The secret to effective online professional learning is to incorporate these principles into a coherent program or resource. One example of a program that has been demonstrated to achieve this is a MOOC (Massive Open Online Course).

A MOOC is "an online course with the option of free and open registration, a publicly shared curriculum, and open-ended outcomes. MOOCs integrate social networking, accessible online resources, and are facilitated by leading practitioners in the field of study" (McAuley et al., 2010, p. 10). MOOCs are structured, usually on a weekly basis, and include learning activities and resources that learners use in a self-directed way. MOOCs that also offer connection with others doing the course, numbering sometimes up to thousands of people, are known as cMOOCs. Another form, known as an xMOOC provides the same content with limited interaction with facilitator or other participants. MOOCs have been recognised as a new form of online learning and professional development in various occupation fields, including for teacher professional development (Koutsodimou & Jimoyiannis, 2015; Laurillard, 2016).

Vivian et al. (2014) were commissioned by the Australian Government to develop a MOOC for teachers to support the implementation of the Australian Curriculum Digital Technologies learning area. The design principles of this MOOC included meeting teacher needs whilst allowing for flexibility, ad hoc interactions, support, and the open sharing of resources. The MOOC was supported by expert facilitators and coordinators in each state and territory. It also integrated social media for knowledge exchange and resource building. The MOOC platform once built, was used to support additional professional learning programs as new topics were needed.

Mobile learning researchers also bring together the various components of online teacher professional learning into a holistic solution, and the conceptualisation in Figure 3 provides a helpful map for those designing online professional learning.
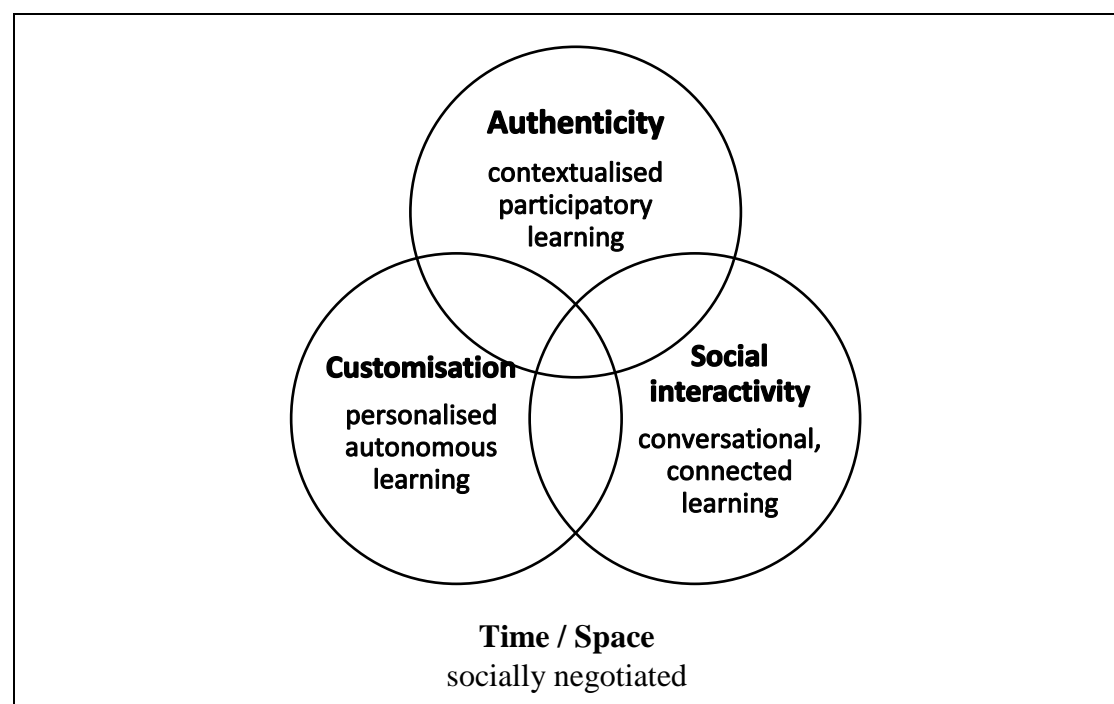

Figure 3 Pedagogical framework for mobile learning presented at mLearn 2010 by Kearney, Schuck & Burden

4: Discussion and next steps

This final section summarises the findings and responds to the broad research question:

What does the research evidence say about the design and delivery of digital, online resources for teachers and what practice implications and recommendations could be made based on this research evidence?

Based on these findings, this section offers key recommendations and next steps for LEA about the development of online teachers' resources as part of the *Being Healthy Being Active* project. The limitations and potential biases in the selection of evidence for synthesis for this current review are also outlined.

4.1 Key success factors contributing to positive learning outcomes

Ultimately the end point of most teacher professional learning is to improve the learning outcomes of the students they are teaching. Making the connection between professional learning activities undertaken by a teacher and improvement in their students' learning is a challenge that researchers continue to face. For reasons discussed at the outset of this report, professional learning is a challenging area to research as it involves so many intersecting factors. However, there is some indicative evidence about the impact of teacher professional learning on student learning.

As referenced in Table 1 of this review, teacher coaching is one form of professional learning where randomised control trials or rigorous quasi experimental methods have been used to evaluate the impact of programs on student outcomes. A recent meta-analysis of 60 studies found that, on average, the programs improved instructional quality by half a standard deviation and student achievement by almost one fifth of a standard deviation (Kraft et al., 2018).

Potential barriers faced by teachers in realising the benefits of professional learning can be summarised as barriers related to:

- resources: whether relating to subject content, format or technical issues
- institutional and administrative barriers: such as workload, time factors and priorities in their local context
- training and experience: prior knowledge, lack of support, irrelevant or confusing information
- attitudinal barriers: negative perceptions, fear of discomfort, change or failure (Ming et al., 2010, p. 406).

The following key success factors have been identified from the analyses of the key design features and elements of the online teacher professional learning interventions that are included in this review:

1. A blended (mixed modal) design offers the flexibility of both asynchronous, synchronous, self-directed learning and facilitated modes.

2. Facilitation that effectively supports an online intervention, even if just to guide the consultations in discussion forums or to support the participants with the selection of tools and resources for a particular topic, is valuable.

3. Technological support as a vital design element recognising that not all participants will have the knowledge and skills to navigate through any specific online platform.

4. The online registration feature for participants is a useful element to track participation and use of online resources. Such data could also be used to decide on future program directions.

5. The ease of use of an online platform is another key design feature since complex designs will make it harder to the participants to navigate through and find the resources/tools that they need to find. Tutorials or short 'how to' videos are good elements to add in additional to technical support (such as support to explain hardware requirements / software needs).

6. Short videos on key topics or 'bite-size' professional development chunks are less time and resource intensive and very convenient.

7. Creation of 'special interest groups' for specific topics is another good way to bring together those participants with knowledge and expertise on a topic. Such arrangements are more productive than general forum discussions.

8. Participants' feedback for platform design and online engagement and learning delivery is valuable and increases ownership and participation.

4.2 Implications for practice

This section discusses the implications for the design and delivery of online teacher professional development resources. It directly addresses the three research questions:

1. With regard to online learning platforms for the delivery of resources to teachers: how are these platforms meaningful, engaging and user friendly?
2. Which modes and formats of online resource delivery are most appropriate to reach the teachers, particularly those in rural and remote areas?
3. What modes and formats of online resources could be best used by LEA for the Being Healthy, Being Active project?

What makes platforms meaningful, interesting and engaging?

Drawing from the key findings of this rapid review, Figure 4 represents the key features which are desirable for online teacher professional resources design and delivery. A blend of these features will help to ensure that the teachers find the resources and tools to be meaningful, interesting and engaging. The participating teachers are therefore expected to learn better and become more confident in applying their newly acquired knowledge and skills in their classrooms. Section 4.3 provides some guidelines for using each of these "best practice" features.
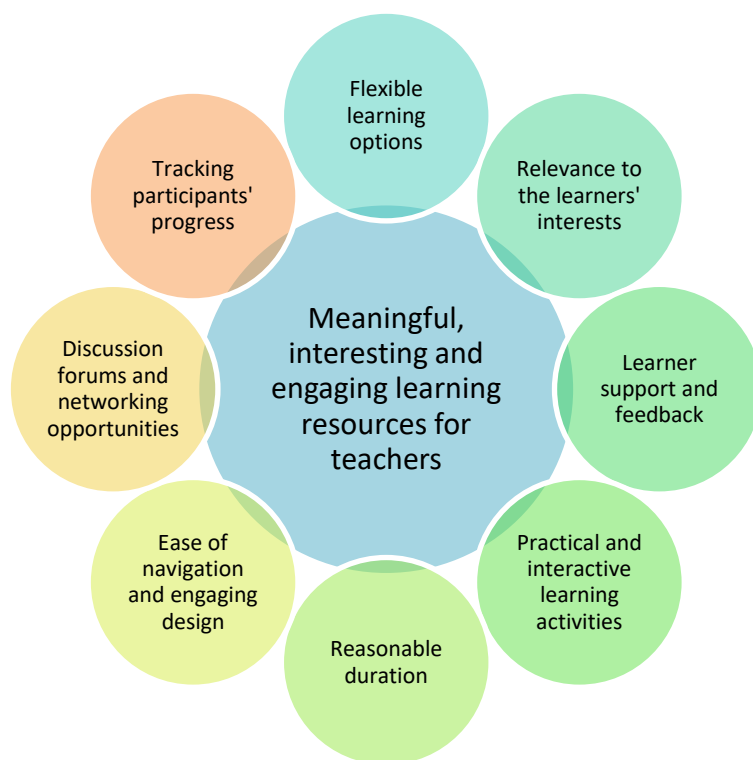
Flexible learning options

Tracking participants' progress

Relevance to the learners' interests

Discussion forums and networking opportunities

Meaningful, interesting and engaging learning resources for teachers

Learner support and feedback

Ease of navigation and engaging design

Practical and interactive learning activities

Reasonable duration

Figure 4. Key features for designing a meaningful, engaging and user-friendly online resources

Which modes and formats of online resource delivery are most appropriate to reach teachers, particularly those in rural and remote areas?

A collaborative learning online learning environment appears to be positively linked to participants' learning outcomes (Hilli, 2020; Tekkumru-Kisa, 2019). The impact of online collaborative learning environments has been seen across all subject areas and also for teacher collaboration on general topics such as using ICT or collaborative reasoning (see Table 5 Appendix 2). Besides, collaboration fosters reflective practices and group problem-solving (Bradshaw et al., 2012; Chitanana, 2012; Marrero et al., 2010). However, some training may be required to ensure proper online etiquette, in addition to effective facilitation, which is necessary for nurturing group engagement (Krzyszkowska, 2020).

Based on this review there is not enough evidence to suggest synchronous communication is more effective than asynchronous but there are benefits of either approach for different aspects of PL. For example, synchronous communication seemed to be more effectively applied across online/ digital coaching and mentoring for teachers (Randolph & Duffy, 2019) yet asynchronous approaches were also helpful for supporting such programs– for example, through asynchronous video feedback that allow teachers to review their own practice (Kraft, 2019; Allen et al., 2015, 2011; Suk Hwang, 2012).

As mentioned above, the use of videos can be particularly helpful to enable teacher-participants to review their own work and reflect on others' actions in the classroom (Kraft, 2019). However, use of video unaccompanied by other features is unlikely to be effective and therefore needs be paired with other tools and resources, or activities such as role playing and practice or discussion with other professionals (Kraft, 2019; Hindman et al., 2015)

With regards to remote and rural settings where internet connectivity may not be the strongest, a combination of blended modes and formats seem to work well. An example of a blended program with various formats is provided in Box 1.

Box 1 A blended online coaching program in a remote/ rural context

The iCoaching initiative (Randolph & Duffy, 2019)

The iCoaching initiative comprises of sessions where the coach sends a prompt to remind the participating teacher to deliver the desired behaviour in classroom through a bug-in-ear (BIE) coaching using iPods, Bluetooth earpieces, and the FaceTime application. Overall, the coach provides both support and connections in professional development, implementation, and generalisation.

Requirements:

- The teacher and coach works as a team throughout the process.
- The teacher and coach either attend a PD session on evidence based practices (EBP), or complete an online training or module focused on the topic.

Benefits:

The technology ensures that teachers receive real-time coaching comments.

Outcomes:

Teachers' pedagogical practices and collaboration and engagement.

As well as rural and remote teachers, AITSL has identified early childhood teachers and casual relief teachers as two other cohorts who are particularly disadvantaged in terms of access to professional learning (AITSL, 2017). Online delivery of high-quality professional learning programs and resources is of particular relevance to these teachers who typically cannot access school-based professional learning.

While the pre-service teacher cohort is out of scope for this review, it is worth noting that this group may be highly motivated to investigate low cost, accessible online resources, and are typically heavy users of the internet with free access provided by their institution (Mansfield et al., 2020).

What modes and formats of online resources could be best utilised by LEA for the Being Healthy Being Active project?

Section 4.3 addresses the third research question and the overall remit of the review by distilling the review findings into a set of good practice guidelines for the development of online teacher resources. These guidelines address findings that are directly pertinent to Life Education Australia's planned *Being Healthy Being Active* project.

4.3 Good practice guidelines for development of online teacher resources

In this section, the principles underpinning design of digital resources for teacher professional learning have been linked to the key design features (as depicted in Figure 4) and summarised into a set of good practice guidelines for the development of online teacher resources (in Table 3).

Table 3. Good practice principles summarised

Good practice features	Course of action	Pros	Cons
Tracking learners' performance	Use an online registration system to monitor engagement and progress for various modules. Suggest additional resources and tools upon completion of each topic.	Online registration function enables tracking of participants as they attend courses and events and/or collaborate to access and share resources. Also useful for targeting additional resources.	May be more resource intensive and requires learning management software.
Active participation	Use online collaborative and networking tools. Introduce special interest groups for key topics. Set up discussion forums that are guided by a skilled facilitator. Use participants' feedback to make upgrades to platforms, intervention design and implementation process.	The collaboration, reflection and engagement helps the teacher participants to move from being "users" to active "members". Skilled facilitation that foster learning oriented community of practice could positively influence the interactions among the participants. Special interest groups and professional networks often live and are active beyond the project's lifetime. Nihuka & Voogt (2012) suggest peer support and collaboration promotes teachers' confidence and creates a favourable learning environment (Nihuka & Voogt, 2012).	A lot of time is often needed for these socialising activities and for building active communities.
Flexibility of choosing learning modes	Offer participants the options for learning synchronously (live), usually facilitated or asynchronously at their own pace (self-directed may include some amount of facilitation).	Caters for learners who prefer to study in their own time as well as those who prefer synchronous/ live learning.	More expensive as need to plan and support multiple modes.
Support for learners' and feedback	Provide timely technical support. Include content / instruction support and feedback structures (often managed through the facilitator / course instructor/ module developer).	Support and feedback from facilitators can help teachers to identify their learning needs, and can thus contribute to their knowledge and skill development (Nihuka & Voogt, 2012).	
Ease of navigation and engaging design	Provide structured, well-planned learning materials that uses interactive and appropriate digital learning resources and tools (video, animations, quizzes and games). The platform also needs to be user-friendly and simple. Use inclusive tools, platforms and devices that consider different web content and accessibility	Participants find the resources and tools interesting and are appropriately engaged. Users with varied level of technical competence or accessibility needs are able to navigate the platform with ease and are able to find resources effortlessly.	May be more resource intensive and requires research on learners' needs and accessibility requirements.

Good practice features	Course of action	Pros	Cons
	guidelines (e.g., WCAG 2.0) to make the resources useful for a wider range of people, such as people with disabilities (Ferri et al., 2020).		
Practical and interactive learning activities	Provide teachers the option to participate in activities that require them to use and apply their professional knowledge and work collaboratively to solve problems related to their practices (Randi & Zeichner, 2004).	Activities that require participants to tap into their professional knowledge and work collaboratively to apply this knowledge for solving problems keeps them engaged and interested in learning.	Highly-structured, organizationally orientated PD is costly (Brooks & Gibson, 2012).
Relevance to learners' interest	Provide a diverse set of resources and tools to match participants' needs and interests on a topic. Provide different formats of resources such as reading materials, presentation slides, videos, podcasts, live webinar, and links to websites/ portals etc. from reputable and current sources to meet the learning needs of a diverse group of learners.	Teachers who experience a more personalised approach to learning, incorporate contemporary technologies and make authentic connections to their practice are more likely try similar approaches with their students (Brooks & Gibson, 2012).	
Reasonable duration	Select a feasible duration for the program / intervention.	Lack of time is often identified as a potential barrier to either participation in a PD or program implementation (Philipsen et al., 2019), therefore a reasonable timeframe will be useful to keep the teachers engaged for the entire duration of a program.	

4.4 Limitations

What limitations were present in the existing body of research?

- Only papers published in English language have been included in this review, thus some papers from non-English speaking high performing education systems could have been missed.
- Due to the short timeframe only two educational databases have been systematically searched supported by some additional searches through snowballing and reference list scanning.

What sources of bias could have been introduced in the review of literature?

- Studies were included in the final evidence synthesis only if the design and delivery features and elements were noted under the description of the interventions. Thus, some effective programs may have been dropped if there were no focus on program design and delivery approaches.
- Successful design and delivery models for online resources and interventions could also exist in education systems in the low-and-middle-income countries, however, due to the nature of this review the screening only focused on interventions in countries and education systems that are comparable to Australia.
- The implications and recommendations for this review are the results of the contextual environment and backgrounds of the reviewers, therefore, we acknowledge that other views and assumptions towards good practice guidelines for online teachers' resource development are likely to exist which could have been missed.

4.5 Conclusion

This rapid review has identified many aspects related to the design of online professional learning programs and resources. These have been aggregated to produce the following set of overarching design principles that apply regardless of the specific audience, format or content of a professional learning activity:

- Principle 1: Relevance: Meeting teachers' needs

- Principle 2: Educational value: Focusing on learning

- Principle 3: Managed and flexible learning environment: Accessing and navigating

- Principle 4: Social presence: Participants engaging with content, facilitator and peers

- Principle 5: Quality content: Using diverse media and drawing from multiple evidence-based sources.

In doing so the review proposes that learning designers should ideally consider each of these principles, and use them to develop a coherent program or resource by involving teachers in the design, trialling and evaluation of online professional learning programs and resources to ensure relevance. Additionally, development of online professional learning should begin from a strong shared understanding of the learning outcomes and how to effectively assess teachers' learning of those outcomes. Designers also need to consider the pros and cons of different modes of professional learning. Besides, social presence is central for effective online professional learning and identifying strategies for incorporating these benefits into the development of resources and programs is a necessary feature.

Finally, the key features identified in this review include: tracking learners' performance, active participation, flexibility of choosing learning modes, support for learners and feedback, ease of navigation and engaging design, practical and interactive learning activities, relevance to learners' interest and reasonable duration. These features are expected to support learning designers and program developers of teachers' online resources with their planning, design and delivery decisions. The good practice guidelines (see Table 3) presented in this review are expected to act as a starting point for the designers and developers of teachers' online resources and inform them about the important features as identified in this review.

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Appendices

Appendix 1: Review framework

Table 4. Review framework

Types of digital education resources for teachers	Delivery mode	Delivery platform	Design elements and features	Outcomes (for teachers)	Outcomes (for students)
• Multimedia courseware • Multimedia material (text, pictures, animation, video, audio, etc.) • Electronic lesson plans • Teaching cases and example videos of good teacher practice • Question bank/test papers • Micro-lecture/micro-video • Subject software and tools (Geometry, virtual lab, etc.) • Online professional development courses / training modules/ workshops/ seminars / webinars • Thematic pages/websites • E-books/periodicals • Online coaching, mentoring and expert support groups e-learning systems • Informal online teacher collaboration	Synchronous (live) Asynchronous (facilitated) Asynchronous (self-directed)	Professional Learning Networks (PLN) Social platforms - Twitter, YouTube, LinkedIn, and Facebook Learning management system Resource hosted in websites – such as resource banks/ repositories	Accommodation of individual differences in access to learning, prior knowledge and learning needs Participant engagement and interactive content Provision of learner supports Acquisition or further development of Pedagogical Content Knowledge (PCK) Practical learning activities and usefulness Application of acquired knowledge and skills in practice Flexibility of study mode Relevance goal orientation, individual differences in learners (curriculum) Reflection and collaboration Program length Use of video Open access or restricted	Content knowledge Instructional practices Self-efficacy and confidence Pedagogical content knowledge Collaboration and engagement Attitudes and beliefs Inquiry Motivation and job satisfaction	Learning Engagement Connectedness

Appendix 2: Details of included interventions

Table 5. Comparisons of the various types of interventions that provide digital resources for in-service online teachers' professional development (OTPD)

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
1	Blended	Blended	Vital- continuous professional development (CPD); *Electronic learning management systems*	**Bradshaw, 2012; England**	General	19 months	Vital Web site; Moodle (for hosting courses), forums and wikis, Drupal (for content management of static resources), and Elluminate Live! to provide open access videoconferencing; TeachShares (for synchronous events)	Help participants (teachers) use information communication technology (ICT) to add value to lessons and find new ways to engage their students. Teacher level: Pedagogical practices; Collaboration and engagement Student level: Student engagement	• Online registration function for tracking participants' engagement • Tools for designing, facilitating, and hosting participants' own events • Local, face-to-face technology support • Courses offered in multiple formats • "Fifteen-minute CPD" - online structured and facilitated staff development opportunities in "bite-size" chunks • Recording of the live sessions which could be downloaded by participants who could not attend • Special interest groups established for further engagement and collaboration	The approach and ethos of recognizing, and building on, the expertise of practitioners and developing an infrastructure to support bottom-up sharing of that expertise. The collaboration and engagement promoted through the program helped teachers move from being "users" to active "members".	

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
2	Asynchronous	Facilitated	International Education and Resource Network Science Technology and Math (iEARN-STM) online professional development course; *Multimedia courseware*	**Chitanana, 2012 ; Cameroon, China, Egypt, Indonesia, Iran, Jordan, Lebanon, Nigeria, Oman, Pakistan, Palestine, Romania, USA and Zimbabwe**	General	8 weeks	Moodle learning management system	Upskill teachers and provide them a highly interactive platform to learn collaboratively and share their students' work Teacher level: Pedagogical practices; Collaboration and engagement	• Use of multimedia content, including videos to capture real life contexts • Online conversations through discussion forums for collaborative/peer-learning and reflective thinking • Hyper-textuality of the online medium	Encourage high levels of learning through collaboration and reflection from the participants.	Feedback could be limited due to late responses by participants and some may become disengaged and demotivated because they have higher expectations of social interactions through the forums.
3	Blended	Blended	Virtual Learning Environments (VLEs); *Electronic learning management systems*	**Hilli, 2020; Finland**	General	1.5 years	LMS Fronter and the integrated video conferencing system- Blackboard Collaborate	Create interactive, communicative, collaborative, and digital environments Teacher level: Pedagogical practices; Attitudes and beliefs; Collaboration and engagement	• Combined social media and Learning Management Systems (LMS) • Provided assessment practices and tools	Supported professional development and reduced the teachers' professional isolation, especially in rural areas. Improved the efficacy of assessment through collaborative writing (e.g., evaluation forms), systematised evaluation (e.g., written measurements) and they brought parents into the assessment process.	VLEs can constrain teaching practices by offering only certain tools for assessment.
4	Asynchronous	Self-directed	Social Emotional Learning for Teachers (SELF-T) course and its components;	**Lang, 2020; USA**	General	3 hours	Department website	Train early childhood teachers on stress-reduction and resiliency strategies.	• Learn, Explore, Apply and Demonstrate (LEAD) format was used • Learners reflected on how stress works in their bodies, how they typically respond to stress	Easy to understand, useful, and positively affected early	It may have been more efficient to provide online activities and record keeping instead of asking participants to

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
			Multimedia courseware					Teacher level: Attitudes and beliefs;	• Introduced participants to new stress-reduction strategies such as belief disputation, emotional reappraisal, controlled breathing, and visualization	childhood educators' work with children. Participants move at their own pace, and complete a number of small exercises throughout the course to explore and apply concepts. Provides ECE professionals important information in an efficient manner that is easily scalable across cities, regions or States.	complete the course activities in their printed activity sheets provided in the course-packet.
5	Asynchronous	Facilitated	My Teaching Partner-Secondary (MTP-S); *Digital coaching and mentoring*	**Allen, 2015, 2011; USA**	General	2 years	Private, password-protected program Web site, phone	Improve teacher–student interactions and student achievement. Teacher level: Pedagogical practices; Collaboration and engagement Student level: Student engagement	• Participating teachers send their coaches video recordings of themselves in which they are delivering a lesson. • Coaches review these recordings and provided feedback on a private, password-protected web site. • Teachers review feedback and respond to the coaches' prompts • A 20- to 30-minute phone conference follows where the coaches and teachers plan ways to enhance interaction • Student academic achievement was assessed using the Commonwealth of Virginia Standards of Learning (SOL) testing system	Improved the quality of secondary school teaching and lead to meaningful gains in student achievement. Highly cost-effective even when conducted across a two-year period. Only requires about 20 hours of teacher in-service training, (over the two years).	
6	Blended	Blended	The Quality Teachers for Quality Students (QTQS) project: Electronic mentoring system for beginning teachers; *Digital*	**Suk Hwang, 2012; USA**	General	_	Blackboard and Skype	Support the development of an electronic professional learning. Teacher level: Pedagogical practices;	• Provided initial training and orientation, ongoing support, frequent updates and current issues in student achievement, best instruction practices, and individual mentoring support from online mentors to address immediate concerns	Reduced the time constraints of face-to-face mentoring, allowing teachers to communicate and receive constructive feedback at times that best suited them.	It took very long to convert mentee video recordings into a format compatible with the Blackboard Digital Drop Box.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
			coaching and mentoring					Collaboration and engagement	- Electronic mentoring activities through Blackboard system setup and electronic tasks; - Video-Based Self-Reflection of Instruction (VSRI) activity—VSRI checklist, procedures of VSRI, and mentoring; and - Evaluation of electronic mentoring system - survey instrument, data analysis, and summary of findings		
7	Blended	Blended	iCoaching; *Digital coaching and mentoring*	**Randolph, 2019; USA**	General	_	FaceTime	Improve coaching efficiency. Teacher level: Pedagogical practices; Collaboration and engagement	- Used a bug-in-ear (BIE) coaching method using iPods, Bluetooth earpieces, and the FaceTime application - Coaches send prompts to remind the teachers to deliver the desired behaviour in classroom - The teacher and coach work as a team throughout the process - The teacher and coach either attend a PD session based on the evidence based practices (EBP), or complete an online training or module focused on the EBP	The program involves teachers from the beginning to empower them and engage them in every step of the process. Technology enables teachers to receive real-time coaching comments.	

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
8	Asynchronous	Blended	Teacher professional development MOOC; *Massive Open Online Courses*	**Koukis, 2018; Greece**	Language (Greek)	_	Open eClass learning management system; Google Docs	Enhance Greek teachers' knowledge, skills and attitudes to integrate collaborative writing in their instruction. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• Short tutorials in the form of video-lessons were produced and made available through the on-line platform • Active engagement in the learning tasks, peer support and discussions, and reflections on teachers' achievements • One tutor and one assistant acted as the moderators-facilitators for teachers' e-tivities	Supported teachers' ability to complete this course and enhanced their achievements through individual engagement, peer interaction and mutual support, and collaborative creation of writing artefacts using Google Docs. Discussion forums appeared to be a very effective tool in this MOOC and the majority of teachers were very active contributors to the forum.	The participating teachers chose to interact mainly with peers in their own group rather than with other colleagues in the MOOC.
9	Blended	Blended	Exceptional Coaching for Early Language and Literacy—enhanced (ExCELL-e); *Digital coaching and mentoring*	**Hindman, 2015; USA**	Language (English)	1 year	Online – web-based platform; Skype or phone	Develop preschool, kindergarten, and first-grade teachers in high-poverty settings. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• All modules addressed instruction of native speakers of English, as well as Dual-language learners (DLLs) • Teachers completed an embedded check your understanding assessment, including multiple-choice or true–false items, on which they aim to score 100% (with missed items resulting in a check-in from a coach) • At the end of each module teachers videotaped themselves using target strategies in their classrooms, and received personalized feedback from an expert coach with whom they work throughout the year	Having an advisory-board of teachers was invaluable in constructing content and presenting it in appealing and comprehensible ways.	It involved a considerable time commitment from the teachers.
10	Blended	Facilitated	Mathematical Quality of Instruction (MQI) - *Digital coaching and mentoring*	**Kraft, 2019; USA**	Mathematics	>1 year	Video; Adobe connect web;	Coach teachers' on existing practices and long-term plans for the year through one-on-one conversations	• Teachers used self-captured video to analyse their own instruction, and reflect on how to improve their instruction on specific MQI items	Participating teachers engaged in critical analysis of their own instruction and had shared responsibility	There were no detectable effects on student achievement from the changes in teachers' instructional practices.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
								Teacher level: Pedagogical practices; Attitudes and beliefs; Collaboration and engagement; Pedagogical content knowledge	• Regular web-based meetings with coaches fostered a degree of informal accountability and helped teachers to stay engaged	for making a plan of action. Web-based programs like MQI Coaching (per-cycle basis) are likely to be more cost effective than site-based programs.	
11	Asynchronous	Facilitated	Matematikk Mooc 1 ; *Massive Open Online Courses*	**Krzyszkowska, 2020; Norway**	Mathematics	3 weeks	MOOC - LMS	Refine teachers' practice by aligning an existing learning design with the Collaborative learning (CoI) model. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• A discussion forum was used as the main platform for interaction • Facilitator's main role was publishing and explaining problem-based tasks in the discussion forum	A meaningful learning experience was created through the interplay of the three key elements: social, teaching and cognitive presence. The design and organisation (procedures, course content and the scheduled events predefined in the LMS) was considered to be more important than facilitation and direct instruction.	The design overlooked the significance of a sense of belonging and the connectedness among the course participants and did not include explicit steps for building a community.
12	Asynchronous	Blended	GeoGebra : an open-source Dynamic and Interactive Mathematics Learning Environment (DIMLE) ; *Electronic learning management systems*	**Bu, 2013; USA**	Mathematics	1 year	Course Management System (CMS) and open-source DIMLE technologies; interactive web-units designed using Quandary®	Supports mathematics teaching and learning Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge Teacher level: Pedagogical practices;	• Applied dynamic demonstration, computation, graphing, exploration, alternative solutions, and online mathematical communication • Instructional videos illustrating the functions of GeoGebra, the processes of problem solving, and their relevance for mathematics teaching was shared with the participants • Interactive web-units provided instructional support • Weekly forums was a very useful social channel of communication and problem solving	Participants found Quandary-based support very helpful; another resource, team scaffolding (from DIMLE tools) was judged to be more flexible and appropriate than that traditional instruction.	Some participants were overwhelmed by the combination of the unfamiliar mathematical problems, new ways of thinking, and the use of new DIMLE technology tools.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
								Collaboration and engagement; Pedagogical content knowledge			
13	Asynchronous	Blended	Online mathematics lessons, offered through a distant education course; *Electronic learning management systems*	**Brodahl, 2016; Norway**	Mathematics	_	On-Line - text and video podcasts ; through the LMS- Fronter	Understand how in-service teachers perceived podcast quality based on design dimensions. Teacher level: Pedagogical practices; Pedagogical content knowledge	• Video podcasts were recorded using the screen casting software Camtasia (v.7) and power point slides • Each podcast was developed with stand-alone instructions created for and implemented in a particular online lesson, along with a PDF-copy of the power point presentation • For one topic, two series of podcasts were offered each with a clickable, two level, table of contents • Content and activities were arranged across nine online lessons provided as a multimedia text consisting of an introduction, table of contents, learning goals, and followed by chapters of different topics in the subject area • A digital text-video format was chosen with clickable video thumbnails integrated in the body text in a tabloid fashion • Chapters comprised of tasks and exercises as well as quizzes and surveys created in the LMS test tool with links to external resources	Teachers found the quality and design of the video podcasts including voice and graphic delivery, and length and chunking of information to be quite useful.	Teachers identified some obstacles such as, video lengths, narrator mispronunciations, and the verbatim reading of materials.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
14	Blended	Blended	"Robotics and Hands-on Activities in the Classroom" online teacher professional development (oTPD) courselet; *Multimedia courseware*	Ostashewski, 2011; Canada	Science (robotics)	_	Customised social networking website (Web 2.0 tools)	Delivery of instructional packages and the creation of learning artefacts (i.e. online lesson plan) to demonstrate learning, (delivered within a social networking site) Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• An online educator community was established via social networking software that was customized to provide members with tools commonly found in social media sites like Facebook and Ning or learner management systems like Moodle	Effectively supported TPD learning about the LEGO robotics content. Allowed teachers to control their access and participation in relevant activities and promoted the development of a network of relationships.	While some participants were familiar with the Web 2.0 tools it was new to other teachers and they required additional time to learn how to navigate and use the platform. Required about 10–15 hours of teacher interaction through online forums, blogs, videos, and other social media.
15	Asynchronous	Self-directed	Exploring Florida Science environment; *Electronic learning management systems*	Cavanaugh, 2010; USA	Science	_	LMS	Increase the content knowledge and skills of all secondary science teachers, and provide a rich and innovative classroom resource for science students. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• The module development was guided by E-Learning for Educators standards and evaluated for content, pedagogy and usability based on established guidelines using rubrics on science content and technology for delivery • Materials designed to connect teachers with practitioners in the field used personal stories to increase closeness • Content was examined for accuracy, currency, completeness for grade level, thoroughness for benchmarks, and appropriateness of science skills • An accessibility review for the module design was undertaken by an instructional designer	The intervention used compelling media to increase participants' (teachers and students) engagement with the platform.	

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
16	Synchronous	Facilitated	Live, Short-Courses for NASA Explorer Schools; *Multimedia courseware*	**Marrero, 2010; USA**	Science	4- 6 one-hour sessions	NASA's DLN (digital learning network); a videoconferencing tool	Provide participants an opportunity to actively learn content and applications for the classroom. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• Seven short- live/ online courses (4-6 one-hour sessions), with independent assignments as follow-up activities between the sessions • Teachers participated simultaneously logging into an online classroom or using a telephone to dial into a conference call. • The course instructors used embedded technological resources, such as online quizzes/polls, as a formative assessment and as a way for participants to share ideas quickly. • Real-time Q&A during the live sessions. • Other distance learning opportunities were also additionally offered for e.g., one-session webinars and events through NASA's DLN, a videoconferencing tool.	Provided participants expert training and resources, which they may not have had access to through their local district. The live format was valuable for professional development in science education as the content can often be challenging.	Some participants had issues with the technology during the session and not much technological support was provided as part of the intervention.
17	Asynchronous	Self-directed	GO! Network 'learning paths'; *Electronic learning management systems*	**De Smet, 2016; Belgium**	Science (Biology)	_	Information systems running on a server (web-based)	Support biology teachers to set learning paths for their grade 8 students on a topic and develop a road map for individual learners. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge Student level: Learning outcomes; Engagement	• Interactive web-based tools supported the learning of specific concepts by enhancing, amplifying, and/or guiding the cognitive processes of learners • Learning activities' were used for learners and instructors to share knowledge and experiences • Offered additional tools like document publishing, assessment modules, and wiki	Useful features related to the quality and multimedia functionality.	Problems with computer access, training and support to help teachers becoming more effective or efficient. Teachers took some time to adjust to the new learning methods while their students adapted quickly.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
18	Asynchronous	Self-directed	iPlan tool; *Electronic learning management systems*	**Tekkumru-Kisa; 2019, USA**	Science (Biology-Genetics)	4 weeks	Web –based - Online learning communities	Support both the communication and the practice Science teachers. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• Tasks designed with macro and micro views - the macro view included a verbal task description, and helped to situate the task within the larger curriculum; the micro view included many practical details, such as amount of time, class grouping (i.e. whole class, small group or individual work) and even particular questions that could be asked of students • Other useful functional features included, the 'target icon' to help teachers understand how much conceptual progress on a big idea students may require, and the 'important icon' for supplemental information	Fostered a learning-oriented community of practice.	Several specific macro view features were not considered helpful by some teachers. Not having a facilitator slightly limited participants' engagement.
19	Asynchronous	Facilitated	CSER MOOC series	**Vivian, 2014; Australia**	Digital Technologies	21 hours	Google Course Builder; WordPress for posting tasks	Equip teachers to teach the Australian Curriculum Digital Technologies courses Teacher level: Pedagogical practices; Collaboration and engagement;	• All course materials were available online at https://csermoocs.adelaide.edu.au • 5-minute concept videos and worked examples that were linked to curriculum learning objectives were quite useful	All materials are openly licensed. The MOOC is mapped to national teacher standards. There are specific learning goals.	Technical development (in the form of coding) was required to construct the course using the web guides, as well as support and maintenance. The MOOC was expensive to develop and deliver. It is funded by the Australian government and Google.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
20	Blended	Facilitated	Online role-play	Zhang, 2016; China	General	3 weeks	Chat room	Help teachers simulate online role-play as a tool to teach collaborative reasoning. Teacher level: Pedagogical practices; Collaboration and engagement	• The course instructor participated in the activity by assuming a role or stepped out of the role to send online messages, monitoring and guiding the process • The asynchronous Professional Learning activity was followed by a 1 hour synchronous debriefing, reflection session	Participants developed their ideas through collaboration. The asynchronous forum helped collaborative argument, improved interaction & encouraged thoughtful communication. It enabled less vocal learners to share opinions. Participants recognised the value of conducting research on the topic and collecting evidence before posting. Some participants felt more comfortable by the anonymity of the platform.	Success hinges on topics being intriguing and challenging – this is time consuming, specialist skill. There was difficulty in keeping track of the asynchronous conversation, involving lots of scrolling back, and participants missed exchanges when they were typing. It was difficult for some participants to maintain the assigned role. Accessibility was an issue with a screen reader not working in the chat room.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
21	Blended	Blended	Agile professional development; *Electronic learning management systems*	**Flavell, 2019; Australia**	General	1 semester	LMS	Support participants' teaching strategies Teacher level: Pedagogical practices; Collaboration and engagement	• The emphasis was on regular feedback, flexibility and student-centred approach • After a 2 day initial workshop, the participants taught in pairs for 1 semester • Participants explored a variety of teaching strategies, e.g., Fishbowl, You-Tube technology, goal setting, and the flipped classroom) as well as new technologies	Post-surveys showed improved ease of use in intervention group. Intervention group more aware of the resources. Participants provided useful applications and tips, and practical strategies when technologies did not go to plan. Increase in curiosity and confidence. Participants reported learning varied teaching strategies. Participants increased their understanding of the drivers for educational technology use.	Resourcing and timetabling was challenging. Casual tutors had little opportunity to embed innovations into their teaching.
22	Asynchronous	Facilitated	Connectivist open online class (OOC); MOOC	**Graham, 2015; Alaska**	General	6 weeks	Multiple online tools PLN Social bookmarking Communication forums	Develop connectivist pedagogy in practising teachers. Teacher level: Pedagogical practices; Collaboration and engagement	• A learning design incorporated within an In-service Masters of Educational Technology • The class focussed on knowledge generation and networked learning • The class had 1-week of orientation at the beginning of each phase of the course, then 4 weeks of guided interaction, with a final week for those taking the course for credit to present their final products	Provided an opportunity for authentic professional development and collaboration, particularly for teachers in remote areas. Course was for credit, and 98% completed successfully. Resources curated by participants were available to all participants.	The unfamiliar pedagogical framework was met with confusion: people thought they were signing up for an online course. High frustration amongst some 20% of participants who remained resistant to connectivist pedagogy throughout the experience. Required too many accounts and logins.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
23	Blended	Facilitated	Carpe Diem; MOOC	**Salmon, 2017; UK**	General		Multiple online tools; social learning techniques	Help staff develop an online module and understand online tools available. Teacher level: Pedagogical practices; Collaboration and engagement	• Staff learned to design the module, collected online examples of good practice, illustrated by audio clips of staff • The module included online tutorials, and linked to a separate website of learning designs • Participants were taught to concentrate first on the jobs that teachers need to be able to do, rather than starting with tool functionality • Participants reflected on their objectives in a learning diary • The platform automatically generated certificates of completion • The course was staffed by trained facilitators	Helped inform staff of innovations in learning and teaching practice. Occurred within teachers' normal working environment. Catered for staff who preferred to study in their own time as well as those who preferred synchronous. Cohort learning proved extremely popular with participants; and peer learning greatly contributed to the experience.	
24	Blended	Facilitated	iLearn about ESL 2.0 Professional Learning Community ; *Electronic learning management systems*	**Haratsis, 2011; Australia (NSW)**	General	2 years	Moodle Ning	Develop teachers' knowledge, skills and understanding in effective English as Second Language (ESL), literacy and numeracy teaching. Teacher level: Pedagogical practices; Collaboration and engagement; Pedagogical content knowledge	• The ESL executives led a range of face-to-face and online professional learning for whole school teams • A closed online professional learning community was established, first on Moodle, then migrated to Ning • Developed e-tips for building an architecture of participation	The professional learning community enhanced networking, resourcing and communicating. Led to adoption by other professional networks. Accommodated mobile technologies. Archive on DVD made resources available beyond the life of the project.	This was a high cost program. A lot of time was spent on socialising activities to build community. The online platform affected participation. Changing tools midstream was quite disruptive, and inefficient. Some tools become outdated/lost support.

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
25	**Asynchronous**	Self-directed	Digital science resources and videos on website: *Contemporary Science Practice in Schools* *Digi Explanations*	**Blom, 2019; Australian (VIC)**	Science	Self-directed	Website	To provide professional learning resources relating to contemporary issues in science	• Collection of resources purposefully designed and organised for Australian science context • suite of engaging and varied resources and activities • updated with new resources to reflect current research in science	Produced by universities in collaboration with scientists, pre-service teachers, teachers, and education academics. Aligned with the Australian and/or Victorian Curriculum for secondary schools. Accessible to any teacher, user-friendly website with simple navigation.	Lack of coherence due to multiple contributors Series of separate sites
26	**Synchronous**	Facilitated	Video conference *Sydney Opera House's Digital Education Program*	**Dezuanni, 2015; Australia (NSW)**	Music	2 hours	Connected Classrooms (NSW DoE)	observational and videotape data collected during this live professional development	• Synchronous one-off live event that aimed to replicate a typical 'live' professional development event • While there are significant differences in the type of learning that occurs in a remote music interaction, the online space provides a legitimate and potentially transforming experience for primary school teachers.	Collapses space and time to bring people together in a way that would otherwise be impossible	Communication was difficult between the presenter and all the remote sites, particularly audio back from remote No live online chat

No.	Communications mode: Asynchronous / Synchronous / Blended	Delivery mode: Self-directed / facilitated / Blended	Intervention name; type	Study details (first author, year; Country)	Focus (content/ subject area)	Length	Platforms	Purpose; Outcomes	Key features	Pros	Cons
27	Asynchronous	Self-directed	Professional learning smartphone app	Dwyer, 2019; Australia (NSW & NT)	Early childhood	Self-directed	Mobile phone	How do educators use existing digital technology (particularly smartphones), in and out of the workplace, to support their professional role and to construct a Professional knowledge base?	• use of commercially available apps and software designated for professional use • a) formal resources (i.e. websites etc.), which we classified as those existing in the .gov.au domain, reserved for Australian government entities, the .org.au domain, occupied by non-profit organisations, or the .edu.au domain • b) informal resources, classified as any other digital resources, including commercial websites, social networking websites, discussion forums and other multimedia-sharing platforms.	25.7% of educators (19/74) reported using existing childcare apps for lesson planning	Most educators (79.5%; 58/73) did not list any formal resources. Of the 20.5% (15/73) who did, eight listed one, and seven listed two. Educators listed between zero and six informal resources Educators working in centres in higher SES suburbs listed more informal resources than those working in lower SES suburbs 13.9% were interested in 'professional development' apps
28				Herbert, 2016; Australia				What are rural teachers' perceptions of online professional learning, with particular respect to its value in enhancing their understandings? What features of online professional learning would meet the needs of rural teachers?	•		

Appendix 3: Search terms

ERIC Search – conducted 2 March 2021

Publication date range 2010-2021

S1 - 345,889 results

SU Teacher*

AND

S2 - 60,782 results

SU ("professional development" OR "professional education" OR "Professional training" OR "professional continuing education" OR "inservice teacher education")

OR

S3 - 24,659 results

SU ("educational resources" OR mentors OR coaching OR "teacher collaboration" OR "communities of practice") OR "pedagogy support"

AND

SU (elementary OR primary OR secondary OR school* OR grade OR "preschool education" OR "early childhood education")

S4 - 82,069 results

S2 OR S3 = S4

AND

S5 - 45,092 results

SU ("online courses" OR "distance education" OR "electronic learning" OR "asynchronous communication" OR "synchronous communication" OR "web based instruction" OR "virtual classrooms" OR "social media") OR "remote learning" OR "learning management system*" OR "digital resource*"

AND

S6 - 833,983 results

SU "best practices" OR SU evidence OR SU success OR SU change OR improve* OR SU "educational quality" OR SU "outcome measures" OR effective* OR SU "teaching skills" OR SU "pedagogical content knowledge" OR SU "self esteem" OR SU "self efficacy" OR SU beliefs OR SU "program evaluation" OR SU "literature reviews" OR SU "meta analysis" OR SU "randomized controlled trials" OR SU "pretests posttests" OR positive OR impact* OR SU "outcomes of education" OR increase* OR SU "teacher competencies" OR DE "teacher attitudes"

S7 - 1,371 results

S1 AND S4 AND S5 AND S6=S7

S8

S7

- Limited to 2010 to 2021 publication date range – **731 results**
- limited to English papers only – **727 results**
- remove publication types: dissertations and conference/speech/meeting papers – **662 results**

=**S8** – final result list - **662**

A+ Education Search (Australian studies) 3 March 2021

Publication date range 2010-2021

FINAL RESULTS 105

S1 -

47,897

SU Teacher*

<mark style="background-color:#00ff00">AND</mark>

> **S2 –**
> **12,246**
> SU ("professional development" OR "professional education" OR "Professional training" OR "professional continuing education" OR "inservice teacher education")
> <mark style="background-color:#00ffff">OR</mark>
> **S3**
> 2,270
> SU ("educational resources" OR mentors OR coaching OR "teacher collaboration" OR "learning communities") OR "pedagogy support" OR "communities of practice"
> <mark style="background-color:#00ff00">AND</mark>
> SU (primary OR secondary OR school* OR grade OR "preschool education" OR "early childhood education")

S4

13,941

S2 OR S3 = S4

<mark style="background-color:#00ff00">AND</mark>

S5

10,945

SU ("online education" OR "distance education" OR "e learning" OR "online learning" OR "online learners" OR "asynchronous communication" OR "synchronous communication" OR "online teaching" OR "virtual classrooms" OR "social media" OR "learning management systems") OR "remote learning" OR "digital resource*"

<mark style="background-color:#00ff00">AND</mark>

S6

93,814

SU "best practice" OR SU evidence OR SU success OR SU change OR improve* OR SU "educational quality" OR "outcome measures" OR effective* OR SU "teaching skills" OR SU "pedagogical content knowledge" OR SU "self esteem" OR SU "self efficacy" OR SU beliefs OR SU "program evaluation" OR SU "literature reviews" OR "systematic reviews" OR SU "meta analysis" OR SU "randomised controlled trials" OR SU "pretests posttests" OR positive OR impact* OR SU "outcomes of education" OR increase* OR SU "teacher competencies" OR DE "teacher attitudes"

S7 –

334
S1 AND S4 AND S5 AND S6=S7

S8

105

S7
- Limited to 2010 to 2021 publication date range –**results 148**
- limited to English papers only –**results 148**
- remove publication types: dissertations and conference papers –**results 105**

=S8 –

Final result list -105

Appendix 4: Good practice principles of professional learning

Table 6 shows a mapping of six examples of principles of professional learning from Australian and international organisations, that were used to inform the analysis of the literature in the rapid review.

Table 6 Mapping of professional learning principles

Principle	Sub principle	EEF 2020b	Cavanaugh & Dawson 2010	QM 2015	ACER 2013	Global Online Academy	NESA 2021
1. Relevance	Accreditation				Contribute to ongoing career development and in many cases can be credited towards qualifications		Coherence between teacher professional learning and external factors such as government, school/service and sector policy, as well as teaching standards and assessment are linked to clear and relevant goals that are related to student/child outcomes
	Needs-based				Based on evidence of participants' current performance context and available resources; participants' knowledge and capabilities		Content-focused: relevant, focus on specific subject knowledge together with pedagogical content knowledge teaching strategies associated with specific curriculum content

Principle	Sub principle	EEF 2020b	Cavanaugh & Dawson 2010	QM 2015	ACER 2013	Global Online Academy	NESA 2021
2. Educational value	Assessment & evaluation			Assessment strategies are integral to the learning process and are designed to evaluate learner progress in achieving the stated learning objectives or mastering the competencies.	Continually evaluate professional learning activities to improve quality.	Assessments are aligned to learners and learning goals: allow for multiple attempts, support students working at their own pace	Recognise the experience and prior knowledge of learners
	Engagement in learning, Intensity and duration				High expectations: set achievable high-level goals for all participants	Challenge participants: cognitively complex, personalised work that asks them to apply knowledge in order to demonstrate learning outcomes.	Of a sustained duration that allows teachers to: plan and consider how their new learning might best support their students/children evaluate the impact of the learning refine future approaches
	Feedback				Encourage and incorporate formal and informal feedback in multiple formats.	Diversifying feedback: Teacher-to-Student, Teacher-to-Student(s) (class or groups), Student-to-Student, and Student-to-Teacher.	Include opportunities for feedback and reflection
	Instruction and learning activities				Active & reflective: focused on addressing participants' concerns using and modelling teaching and learning methods such as collaboration, action research, use of tools and frameworks, data analysis, presentations and reflection in a wider context	Instructions cover essential information students need in order to drive their own learning: Who, What, Where, When, Why, How	Model effective practice: have a vision of practice on which to anchor their own learning and growth

Principle	Sub principle	EEF 2020b	Cavanaugh & Dawson 2010	QM 2015	ACER 2013	Global Online Academy	NESA 2021
	Learning outcomes clearly stated			Learning objectives or competencies describe what learners will be able to do upon completion of the course		Intended outcomes for a learning experience are clearly articulated. Time and support to develop understanding of the meaning and relevance of those outcomes	
	Reflection and application of learning					Reflection: compose and share reflections and self-assessments that capture what and how they have learned.	Job-embedded and/or provide opportunities for transference of learning
	Structure of learning and self-direction			The overall design of the course is made clear to the learner at the beginning of the course.		Pacing Guide: visual or graphic guide to how to organize time and tasks for the learning experience is posted Motivation, skills, and habits associated with more self-driven learning	
3. Managed & flexible learning environment	Accessibility, Equity		Accessibility: Free from bias, accessible for all or has appropriate accommodations	The course design reflects a commitment to accessibility and usability for all learners.		Ensure online tools and experiences are accessible to all learners Privacy and parameters you must work within to ensure your and students' online safety and privacy Equity: aware of learners' technological capabilities as well as the support available to them Online safety. Acceptable Use Policy	

Principle	Sub principle	EEF 2020b	Cavanaugh & Dawson 2010	QM 2015	ACER 2013	Global Online Academy	NESA 2021
	Delivery mode	Professional development can be supported effectively remotely Remote coaching, mentoring and expert support can be effective alone or as part of broader PD programs				Use of time: Balance. When should we learn synchronously / asynchronously and what is the best use of that time?	
	Navigation, Usability		Efficiency of navigation: well-organised, visually and functionally consistent and easy for teachers to navigate Usability of the media by the intended audience: works with school technology and typical teacher skills	Course technologies support learners' achievement of course objectives or competencies		Balance: The experience uses video, images, hyperlinks, audio, and other multimedia elements to support students in contextualizing, navigating, and focusing on learning goals.	
4. Social presence	**Learning with others**			Course activities facilitate and support learner interaction and engagement	Practice-oriented: conducted in a social context, tailored to individual and local needs and designed to encourage immediate practice and	Diversify interactions: teacher to class, teacher to individual, learner to class, learner to learner, small group	Involve active collaboration

Principle	Sub principle	EEF 2020b	Cavanaugh & Dawson 2010	QM 2015	ACER 2013	Global Online Academy	NESA 2021
					sharing in participants' workplaces		
	Support for all aspects, including from school leaders: protected time, training, platform ease of access	Remote professional development requires supportive school conditions (support from leaders, protected time, tech-specific training, platform ease of access)				Routine: Establish and publish a clear, predictable routine for publishing and organizing online learning material and for communicating with students.	
	Teacher Presence					Presence: Make presence known through frequent asynchronous and synchronous communication that includes your face and voice, through rapid and helpful responses to questions, through timely and effective feedback, and through active participation in class activities. Build trust. Teacher demonstrates care, is clear and responsive in communications and expectations. Relationships: Made time before, during, and after an online experience to personally know, check in	

Principle	Sub principle	EEF 2020b	Cavanaugh & Dawson 2010	QM 2015	ACER 2013	Global Online Academy	NESA 2021
						on, and get feedback from students	
	Technical support		Adequacy of support for users: technical support to enable independent use	The course facilitates learner access to support services essential to learner success.		Support: Create and publish a clear process for how students can get support, how you will intervene in the event that they need support	
5. Quality content	Instructional materials, Resources	Interactive content and opportunities for collaboration hold promise for remote professional development The use of video can enhance remote PD	Professionalism of media: attractive, functional and appropriate for teachers Clarity of visual design: aesthetic design presents and communicates information clearly throughout	Instructional materials enable learners to achieve stated learning objectives or competencies.	Presenters and facilitators have deep content knowledge and teaching skills. Informed by evidence from: large scale data collections and international research, and research into practices that have worked in similar settings	Playlists, Not Packets: Give choice in content. Content selection is diverse media and draws from a variety of sources, academic and otherwise	

Appendix 5: Digital Service Standard Criteria

The *Digital Service Standard* (Digital Transformation Office, 2011) is made up of 13 criteria to help government agencies design and deliver services that are simple, clear and fast. These criteria can be readily applied to design of digital services for education.

01 Understand user needs. Research to develop a deep knowledge of the users and their context for using the service.

02 Establish a sustainable multidisciplinary team to design, build, operate and iterate the service, led by an experienced product manager with decision making responsibility.

03 Design and build the product using the service design and delivery process, taking an agile and user-centred approach.

04 Understand the tools and systems required to build, host, operate and measure the service and how to adopt, adapt or procure them.

05 Identify the data and information the service will use or create. Put appropriate legal, privacy and security measures in place.

06 Build the service with responsive design methods using common design patterns and the style guide.

07 Build using open standards and common government platforms where appropriate.

08 Make all new source code open by default.

09 Ensure the service is accessible to all users regardless of their ability and environment.

10 Test the service from end to end, in an environment that replicates the live version.

11 Measure performance against KPIs set out in the guides. Report on public dashboard.

12 Ensure that people who use the digital service can also use the other available channels if needed, without repetition or confusion.

13 Encourage users to choose the digital service and consolidate or phase out existing alternative channels where appropriate

- Choose obvious over clever, every time
- Describe the task, not the technology.
- User research is a team sport.

Appendix 6: Definitions and abbreviations

Table 7. Key definitions of terms used in this report

Terms	Definitions
Asynchronous	Participants are not physically present at the same time as each other and learn in their own time
Blended	Content delivery occurs in both face-to-face or in-person and online or remote modes
cMOOC	Connectivist Massive Open Online Course involving groups of people learning together
Cognitive presence	Concept of constructing meaning through sustained reflection and discourse in a critical community of inquiry
Face-to-face	Participants and facilitators are located in the same physical location
Intervention	In the context of education, an instructional intervention is a specific set of steps or a formal program used to target a learning need
LMS	Learning Management System
LEA	Life Education Australia
Livestreaming	Making visual and/or audio material available for viewing via the internet at the same time as a facilitator is presenting. Often a recording is made at the same time
MOOC	Massive Open Online Course
Online learning resources	Learning materials such as e-books, slides, videos, podcasts etc. that are available through the internet via some platform (such as website, LMS)
oTPD	Online Teacher Professional Development
PCK	Pedagogical Content Knowledge whereby teachers transform subject content for learners.
PL	Professional Learning
PD	Professional Development

Terms	Definitions
Remote delivery	Participants and facilitators are in not in the same physical location as each other
Self-directed	Participants access learning materials independently and proceed at their own pace, often with some guidance
Self-determined	Participants take initiative for identifying learning needs and goals, looking for the resources, and implementing the complete learning process
Social presence	The extent to which a person feels socially connected to others in their online environment.
Synchronous	Participants attend to learning at the same time as the facilitator and/or other participants, whether in-person or online
Teacher presence	The extent to which a learner feels connected to the teacher or facilitator in their online learning environment
TMPL	Technology-Mediated Professional Learning
xMOOC	eXtended Massive Open Online Course delivered by an instructor with limited interaction

Case studies

The following five case studies use screenshots to highlight key design elements for online professional learning.

Case study 1: iPlan tool

Box 1 iPlan tool (Study: Tekkumru-Kisa and Schunn, 2019). Screenshots from:
https://www.tandfonline.com/doi/full/10.1080/1475939X.2019.1595707

The iPlan tool: A resources and education curriculum materials hub in an online interactive learning platform
Length: four-weeks
Context: USA

Design elements

- ☐ Tasks are designed with macro and micro view
- ☐ The macro view includes a verbal task description, and helps to situate the task within the larger curriculum

Source: Tekkumru-Kisa and Schunn, 2019; p 140

The micro view includes many practical details, such as amount of time, class grouping (i.e. whole class, small group or individual work) and even particular questions that could be asked of students

Source: Tekkumru-Kisa and Schunn, 2019; p 142

- Other useful functional features include the 'target icon' to help teachers understand how much conceptual progress students may require on a topic;
- The 'important icon' provided links to supplemental information.

Outcomes:
Teachers' pedagogical practices; collaboration and engagement; and Pedagogical Content Knowledge (PCK)

Learning points
A skilled facilitation could change the interactions about the participants.

Case study 2: Reconceptualising Mathematics and Science Teacher Education Programs (ReMSTEP)

Box 2 REMSTEP (Study: Blom et al., 2019. Screenshots from <u>http://remstep.org.au/outcomes/resources</u> Licence: <u>CC-BY-SA</u>)

Reconceptualising Mathematics and Science Teacher Education Programs (ReMSTEP)
Context: Australia
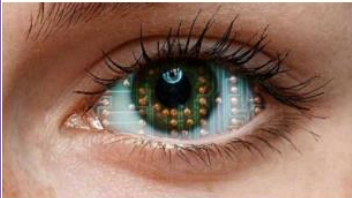
Bionic Eye Teaching Sequence

for maths/science level 9 of the Australian Curriculum

Home   Module 1   Module 2   Module 3   Module 4   Summative task

Bionic eye module 1

Overview   Australian Curriculum links   Learning sequence

Learning sequence

Download the resource pack for this module: Bionic-eye-module1.zip (6.2MB) ↓

Learning activities summary

More details are contained within the detail design document in the resource pack above.

Part 1	5-10 min

Quiz

Teacher activity	Student activity
Disseminate quiz for students to assess misconceptions they have about light and seeing.	Students work through a quiz, which identifies their misconceptions around light and seeing.
Monitor student responses.	**Resources required**
Teacher resources	• Student-Worksheets / **01-Quiz.docx**
• Teacher notes / **00-Traffic-Lights.docx**	

Part 2	5-10 min (30 minutes at home)

'Mythbusters' flipped classroom activity

Teacher activity	Student activity
Give students feedback on the quiz in the form of investigations to undertake to disprove identified misconceptions.	Students work through guided investigations which seek to disprove their misconceptions (at home).

Case study 3: NASA Explorer schools

Box 3 Short-live courses for NASA Explorer Schools (Study: Marrero et al., 2010)

Live, Short-Courses for NASA Explorer Schools
Multimedia courseware
Length: Short
Context: USA (Grades 4-9 Science teachers)

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Design elements

- ☐ This intervention included seven short-courses that were live online courses each comprising 4-6 one-hour sessions, with some independent assignments as follow-up activities between the sessions.
- ☐ Teachers participated simultaneously logging into an online classroom and using a telephone to dial into a conference call.
- ☐ The interactive atmosphere of the short-course provided an opportunity to ask and answer questions aloud and to share unique, personal experiences.
- ☐ Instructors for the courses used embedded technological resources, such as online quizzes/polls, as a formative assessment and as a way for participants to share ideas quickly.
- ☐ Other distance learning opportunities were also additionally offered for e.g., one-session webinars and events through NASA's DLN, a videoconferencing tool.

Outcomes

Teachers' pedagogical practices; collaboration and engagement; and Pedagogical Content Knowledge (PCK)

Learning points

Participants had issues with the technology during the session since technological support was not provided during the program–reported as a design and implementation flaw.

The live format worked well for teacher professional development in science education since the content was challenging and this design allowed participants to ask and receive answers in real time and eliminated some of the frustrations that may be the result of learning difficult content.

Case study 4: Virtual Learning Environments

Box 4 Virtual Learning Environments (Study: Hilli, 2020) – an example of blended mode

Virtual Learning Environments (VLEs)
Electronic learning management systems
Length: 1.5 years
Context: Finland (rural primary schools)
_____

Design elements

- It combined social media and Learning Management Systems (LMS) and also comprised of assessment practices and tools.
- The elements were a combination of virtual group discussions, interviews, and video blogs.
- In virtual group discussions the facilitator engaged the teachers to address questions, concerns, successes and their professional reflections.
- The interviews were semi-structured lasting around forty-five to sixty minutes and the individual interviews offered opportunities to confidentially critique the project and therefore were helpful for making adjustments along the way.
- The video blog was a reflective and individual space for the teachers and offered 'snapshots' from a complex practice.
- It supported their professional development and reduced the teachers' professional isolation.

Outcomes

Teachers' pedagogical practices; attitudes and beliefs; collaboration and engagement

Learning points

Digital competence of the teachers and digital infrastructure present at their schools are important for extending classrooms into a virtual space.
VLEs can sometimes constrain teaching practices by only offering certain tools for assessment.

Case study 5: CSER Digital Technologies Education MOOC

Box 5 CSER MOOC (University of Adelaide) Source: <u>https://csermoocs.adelaide.edu.au/resources</u> Licence: <u>CC-BY-NC-SA 4.0</u>)

CSER MOOC (University of Adelaide)
Context: Australia

CSER DIGITAL TECHNOLOGIES EDUCATION

home / Resources   ⇥ Login

RESOURCES

There are many available resources to support you in learning more about Digital Technologies.

Here we have included information on some of the resources that we have created, as well as information on local clubs, associations and competitions that will be able to support you and your classroom.

Expand

CSER webinars and videos   ⌄

Resources for Teachers   ⌄

Professional Learning Resources for Leadership & Facilitators   ⌄

Resources to Support Parents and Families   ⌄

Professional Learning Resources for Leadership & Facilitators

We have a range of professional learning resources to help you deliver in-school or community-based professional learning sessions for the topics below. This includes quick reference guides and PL-in-a-Box (professional learning packs with slides and speaker notes). You are welcome to freely download and customise our resources to suit your needs.

Professional Learning Guide ⬀ - A get-started resource with information about our programs and resources and how you can use them to support professional learning in your school and community, face-to-face or virtually.

AI and Emerging Technologies (AR, VR) Resources

- AI and Emerging Technologies Quick Guide ⬀
- AI, AR, VR Classroom Usage Guide ⬀
- PL-in-Box: Introduction to Emerging Technologies ⬀
- PL-in-a-Box: Artificial Intelligence ⬀
- PL-in-a-Box: Augmented Reality ⬀
- PL-in-a-Box: Virtual Reality ⬀
- AR Activity Ideas ⬀Handout
- AI Activity Ideas ⬀ Handout

Cybersecurity & Awareness Resources

We have the following PL-in-a-Box packs for download that include a series of workshop slides that can be used to run professional learning sessions alongside our Cyber Security & Awareness MOOC. You can run each unit as an individual session or combine and customise slides to suit your needs. We recommend running this along side participation in our MOOCs so that teachers can engage with our MOOC community ⬀ network who are sharing resources and ideas.