CIPD
Championing better work and working lives

EFFECTIVE VIRTUAL CLASSROOMS

An evidence review

Scientific summary
October 2021

The CIPD is the professional body for HR and people development. The registered charity champions better work and working lives and has been setting the benchmark for excellence in people and organisation development for more than 100 years. It has more than 150,000 members across the world, provides thought leadership through independent research on the world of work, and offers professional training and accreditation for those working in HR and learning and development.

Effective virtual classrooms: an evidence review

Scientific summary

Contents

Acknowledgements

This report was written by Emilia Wrietak, Denise Rousseau and Eric Barends of the Center for Evidence-Based Management (CEBMa). We thank Jonny Gifford and Andy Lancaster of the CIPD, and Donald Clark, Leonard Houx and the Eberly Centre for Teaching Excellence and Educational Innovation for their valuable comments on an early draft.

Please cite this report as: Wietrak, E., Rousseau, D. and Barends, E. (2021) *Effective virtual classrooms: an evidence review.* Scientific summary. London: Chartered Institute of Personnel and Development.

About CEBMa

CEBMa is the leading authority on evidence-based practice in the field of management and leadership. It is an independent, non-profit foundation providing support and resources to managers, leaders, consultants, facilitators or instructors, academics and others interested in evidence-based practice and decision-making. It enjoys the support of prominent universities including Stanford, Carnegie Mellon, the Australian National University, and the Free University of Amsterdam.

1 Background

Virtual or online learning is a growing practice, with enormous expansion during the COVID-19 lockdown. For this reason, the CIPD approached the Center for Evidence-Based Management (CEBMa) to undertake a review of the research literature to learn more about the characteristics of successful virtual classroom learning.

Main question: What does the rapid evidence assessment (REA) answer?

What is known in the scientific literature about the characteristics of successful virtual classroom learning?

Sub-questions are:

1 *What is virtual classroom learning and how is it different from 'in person' classroom learning?*

2 *Does classroom virtuality affect learning effectiveness (and, if so, how)?*

3 *What are the most important factors that enhance (or impede) the effectiveness of virtual classroom learning?*

2 Method

What is a rapid evidence assessment?

Evidence reviews come in many forms. One of the best-known types is the conventional literature review, which provides an overview of the relevant scientific literature published on a topic. However, a conventional literature review's trustworthiness is often low: clear criteria for inclusion are often lacking and studies are selected based on the researcher's personal preferences. As a result, conventional literature reviews are prone to severe bias. 'Rapid evidence assessments' (REAs) are a preferred alternative. This type of review uses a specific research methodology to comprehensively identify the most relevant studies on a specific topic, and selects studies based on explicit criteria. Independent reviewers use explicit criteria to assess the methodological quality of the studies included. Unlike a conventional literature review, the REA is transparent, verifiable, and reproducible, and, as a result, the likelihood of bias is considerably smaller.

Search process: How was the research evidence obtained?

The following databases were used to identify studies: ABI/INFORM Global from ProQuest, Business Source Premier from EBSCO, PsycINFO from Ovid, and the database of the Education Resources Information Centre (ERIC).

A search was conducted using combinations of various search terms, including ‘virtual’, ‘remote’, ‘online’, ‘teaching’, ‘learning’ and ‘classroom’. In addition, the references listed in the retrieved studies were screened in order to identify additional studies for possible inclusion in the REA.

The following generic search filters were applied to all databases during the search:

1 scholarly journals, peer-reviewed

2 published in 1980–2021 for meta-analyses and 2010–2021 for primary studies

3 articles in English.

We conducted six different search queries, which yielded 167 meta-analyses and 149 primary studies.

A separate search was conducted for meta-analyses published in the past ten years on the effectiveness of 12 teaching strategies identified by John Hattie and/or recommended by L&D specialists. This search yielded 143 studies. Finally, we checked 32 references suggested by L&D specialists.

An overview of all search terms and queries is provided in **Appendix 1**.

Selection process: How were studies selected?

Study selection took place in two phases. First, the titles and abstracts of the studies identified were screened for their relevance to this review. In case of doubt or lack of information, the study was included. Duplicate publications were removed. This first phase yielded 14 meta-analyses and 20 primary studies. Second, studies were selected based on a screening of their full text according to the following inclusion criteria:

1 type of studies: focusing on quantitative, empirical studies

2 measurement: only studies in which relationships between virtual classroom learning or teaching, antecedents, moderators, mediators and (learning) outcomes were quantitatively measured

3 delivery: only studies on synchronous virtual classroom learning or teaching

4 time period: only studies published after 2010.[1]

[1] Due to the application of broadband technology, differences between in-person communication and video communication may be less pronounced. Because this technology became widely available after 2010, studies published before this date were excluded.

This second phase yielded a total number of 12 meta-analyses and 12 primary studies.

The additional search for recent meta-analyses on the effect of the learning strategies yielded a total number of 14 additional studies.

An overview of the selection process is provided in **Appendix 2**.

Data extraction: What data was extracted?

Data extraction involves the collation of the results from the studies included. For each study we extracted and interpreted information relevant to the review question, such as year of publication, research design, sample size, population (for example, industry, type of employees), possible moderators or mediators, main findings, effect sizes, and limitations. An overview of all studies included is in **Appendix 3**.

Critical appraisal: How was the quality of included studies judged?

Often, it is possible to find a scientific study to support or refute a given theory or claim. Thus, it is important to determine which studies are trustworthy (that is, valid and reliable) and which are not. The trustworthiness of a scientific study is first determined by its methodological appropriateness. To determine the methodological appropriateness of a study's research design, the classification system of Shadish et al (2002), and Petticrew and Roberts (2006) was used. In addition, a study's trustworthiness is determined by its methodological quality (its strengths and weaknesses). For instance, was the sample size large enough and were reliable measurement methods used? To determine methodological quality, all the studies included were systematically assessed on explicit quality criteria. Finally, the effect sizes were identified. An effect (for example, a correlation, Cohen's d or odd ratio) can be statistically significant but may not necessarily be of practical relevance: even a trivial effect can be statistically significant if the sample size is big enough. For this reason, the effect size – a standard measure of the magnitude of the effect – was assessed. For a detailed explanation of how the quality of included studies was judged, see CEBMa Guideline for Rapid Evidence Assessments in Management and Organisations (Barends et al 2017).

Critical appraisal: What is the quality of the studies included?

Our initial search yielded 13 meta-analyses and systematic reviews, of which 9 included controlled studies, indicating that research on the characteristics on successful online learning is rich in both quantity and quality. Of the 11 primary studies, 9 concerned a controlled design. The secondary search yielded 14 meta-analyses and systematic reviews, of which 10 included controlled studies.

3 Main findings

Question 1: What is virtual classroom teaching?

In line with the learning and development (L&D) profession, we use the term 'learning' to include teaching, education and instruction. The scientific research distinguishes *learning strategies* (for learners to apply) from *teaching strategies* (for teachers, instructors or facilitators to apply) but here we group them together as *learning.* We also use the term *facilitator* rather than *teacher*, *educator* or *instructor*, again in line with the L&D profession, to reflect the less didactic approaches usually taken.

Finding 1: There is no generally agreed-upon definition of virtual classroom learning

Virtual classroom learning is grounded in distance education. The history of distance education goes as far back as 1728, with the first distance course established in Boston using lessons sent by mail. In 1922, Penn State University began offering courses through radio and in the 1950s the first college credit courses were offered through television (Woldeab et al 2020). When personal computers, digital devices and broadband internet became widely available, online learning became affordable and accessible from any part of the world, at any time.

However, the terms online learning and online education are not clearly defined. In both the popular and scientific literatures, the terms virtual-, online-, digital-, remote-, distance-, and e-learning are used interchangeably and are broadly described as *'any instructional format that is mediated by some form of technology, typically the internet and is characterized by geographical and, sometimes, temporal separation between instructor and learner'* (Ananthanarayanan 2014). Online learning varies widely in its configuration (for example, tutorial, discussion, small group lecturing, webcasting) and instructional methods (see George et al 2019). It is often 'blended', combining traditional in-person classroom learning with synchronous online facilitation and lectures and asynchronous online course elements.

Question 2: Does classroom virtuality affect learning effectiveness (and, if so, how)?

Finding 2: There is little difference in the effects of virtual and in-person teaching on learning effectiveness (Level AA)

In the past decades, many studies have examined whether online learning is equivalent to traditional in-person classroom learning. Meta-analyses and randomised controlled studies have consistently demonstrated that there are no significant differences between the two. Online learning shows similar and sometimes greater learning gains than traditional in-person learning, regardless of its configuration, mode of delivery, target group, or type of learning outcome (Asadi et al 2019; Borokhovski et al 2012; Du et al 2013; George et al 2019; Howard 2020; Jurewitsch 2012; McCutcheon et al 2015; Woldeab et al 2020).

Finding 3: Learning strategies effective in an online environment are the same as those found to be effective in traditional in-person classrooms (Level AA)

Decades of learning research have examined the conditions that enable effective learning and instruction. A recent systematic review of 104 studies indicates that most of the strategies with promising effectiveness in an online environment are the same as those found effective in traditional in-person classrooms (Lockman and Schirmer 2020). Although the extent of the research on the effectiveness of learning strategies in traditional settings cannot be covered in a quick précis, the best available evidence is well summarised by authors such as Susan Ambrose and John Hattie (Ambrose et al 2010; Hattie 2012, 2015). Indeed, a recent systematic review of 126 randomised controlled studies found that the core educational strategies identified by Ambrose and Hattie are also effective in an online learning environment (Davis et al 2018).

Table 1 provides an overview of the most relevant and effective learning strategies. The effect sizes in this table are derived from the *Visible Learning* research base, which contains the aggregated findings of more than 1,600 meta-analyses comprising more than 96,000 studies involving more than 300 million students.[2] We include a selection of the highest-impact techniques and those most relevant to adult virtual classrooms, rather than an exhaustive list (the *Visible Learning* research base lists 322 influences).[3] For example, we exclude the influence of 'questioning' because it is a learning practice that shows considerable variation in effect sizes, from d=.13 to d=.86, is a very broadly defined approach which dates back at least to ancient Greece, and is probably already included in more sophisticated techniques, such as classroom discussion, reciprocal teaching, and test-enhanced learning.

Table 1: Some key factors in effective learning

	Effect size (S/M/L)	Effect size (d)
Classroom discussion	●●●●○	.82
Scaffolding or mastery learning	●●●●○	.82/.61
Feedback	●●●●○	.73
Reciprocal learning or peer tutoring	●●●◒○	.74/.51
Learning goals and objectives	●●●◒○	.68
Spaced practice	●●●◒○	.65
Direct instruction	●●●○○	.59
Meta-cognitive strategies	●●●○○	.58
Worked examples	●●●○○	.57
Formative evaluation	●●●○○	.48
Test-enhanced learning	●●●○○	.46
Co-operative or social-collaborative learning	●●●○○	.40/.55

Notes: The rule of thumb for effect sizes is: ●●●●● very large; ●●●●○ large, anybody can easily see the difference; ●●●○○ moderate, visible to the naked eye of an expert or careful observer; ●●○○○ small, the difference probably needs to be measured to be detected; ●○○○○ very small.

[2] Retrieved in August 2021 from Global Research Database.

[3] See Global Research Database.

There is a belief in L&D practice that adults learn in different ways from children, in which case research in educational settings may not be applicable to our study. We do not find studies that support this claim and there is some evidence to refute it. For example, one of the included meta-analyses on scaffolding (Belland et al 2017) found no differences in effect between educational levels (primary or, in the US, 'K–5' (kindergarten through grade 5); middle level or grades 6–8; secondary or grades 9–12; college, vocational or technical; and graduate, professional or adult). The approach to teaching adults and children may be different, for example, to optimise the particular group's experience, learning potential, and ability to self-direct, so some of the insights from child education research may need to be adapted to adults. However, most educational scholars agree that the basic principles of learning are the same for both groups, so the research is still valid.

Classroom discussion

Classroom discussion is a learning strategy in which students are invited to discuss the topic at hand. This technique is not so much about a facilitator asking learners questions, but involves learners discussing with each other, often prompted by an open rather than a closed set of questions. Although only a limited number of empirical studies is available, a meta-analysis of 42 studies showed large effect sizes, indicating that learning discussion has a large impact on individual learner comprehension, critical thinking and reasoning outcomes (Murphy et al 2009).

Mastery learning and instructional scaffolding

The basic principle of mastery learning is that learners should first gain a full understanding of one topic before advancing to the next (Davis et al 2018). The rationale behind this principle is that learners' understanding of new topics and skills often relies upon their mastery of prerequisite topics and skills, therefore they should be exposed to new material only when they have mastered all preceding material. This principle is also referred to as 'instructional scaffolding' or 'Vygotsky scaffolding' (Reiser and Tabak 2014). Nowadays scaffolding is used in many instructional approaches, including project-based learning, problem-based learning, and inquiry-based learning (Belland et al 2017) as well as online learning. A large number of studies (500+) and meta-analyses consistently demonstrate that mastery learning and instructional scaffolding enhance learning (Hattie 2015; Doo et al 2020), especially when this is combined with 'spaced', rather than 'massed', practice (see below).

Feedback

Feedback is one of the most powerful learning strategies. Although many definitions are available, in the learning domain it refers to information with which a learner can confirm, add to, overwrite, tune, or restructure domain knowledge, meta-cognitive knowledge, and beliefs about the self. Feedback can be two-way, from learners to facilitators and vice versa. Unlike 'instruction' or teaching, feedback provides information related to a task or learning process that fills the gap between what is understood and what is intended to be understood (Sadler 1989). As such, feedback is the underlying mechanism of many learning strategies, such as discussion, formative evaluation, questioning, and testing. A total number of 26 meta-analyses representing the findings of 1,201 studies clearly indicate that feedback can be a very effective strategy. It should be noted, however, that the effect sizes reported in meta-analyses show considerable variation,

suggesting that some types of feedback are more powerful than others (Kluger and DeNisi 1996).[4] For example, feedback is most powerful from learners to the facilitator or instructor about what they know, where they make errors, where they have misconceptions, and when they are not engaged (see Formative evaluation, below). In addition, it was found that feedback to learners is more effective when it focuses on correct rather than incorrect responses and contains learning-related information. Feedback is less effective when it is perceived as threatening one's self-esteem, focusing on the self rather than learning content (Dimotakis et al 2017).

Feedback from learners may be equally important in face-to-face and virtual classrooms but may be much easier to obtain face-to-face. Here, facilitators can have multiple immediate cues from learners – including facial expressions and body language – that give a sense of whether they are following and absorbing the material. This may well be lost when moving to virtual settings and certainly should not be taken for granted, so facilitators would do well to deliberately obtain in-the-moment learner feedback.

Reciprocal learning and peer tutoring and support

Reciprocal learning is a strategy in which learners take the role of instructor or facilitator and check their knowledge and understanding by using cognitive learning strategies such as summarising, questioning, clarifying, and predicting. A major advantage of this approach is that learners are forced to be clearer in their argumentation and present evidential support for their position taken, providing good learning opportunities. Although this strategy was originally aimed at developing reading comprehension skills, it can also be used for developing deeper understanding of topics or principles taught. A related technique is peer tutoring and support, in which high-achieving learners are used as co-facilitators to support lower-achieving learners. A large number of empirical studies (900+) have found that peer tutoring and support has a positive effect on learning academic, social, behavioural, and functional skills (for example, Zeneli et al 2016).

Learning goals/objectives

Over the past decades, high-quality meta-analyses in a wide range of disciplines (education, management, medicine, sports, rehabilitation, prevention, and so on) and populations (learners, patients, athletes, managers, senior adults, children, and so on) have demonstrated the positive effects of setting goals on performance outcomes. As a result, it is now generally accepted that goal-setting is effective and valuable for steering and improving performance, including learning-related performance. The basic premise of setting goals (also referred to as 'mastery goals') is that the learners have the same idea as their facilitator about the desired learning outcomes. The effect of setting goals, however, is contingent on several moderating factors, such as type of skill, type of outcome, and learner characteristics. For example, specific and challenging objectives usually have a larger effect on performance than non-specific or general 'do your best' objectives. However, when people must first acquire knowledge or skills to perform a certain task, setting learning objectives has a more positive effect than setting performance objectives (for example,

[4] See also the CIPD evidence review on performance appraisal *Could Do Better? What works in performance management*.

Mesmer-Magnus et al 2007). In fact, setting performance goals may even have a negative impact on learning (for example, Rolland 2012). In addition, learning objectives are effective only when they define what learners will learn rather than focusing on performance targets, and when there are clear success criteria. Thus, it is advisable to specify the specific learning outcomes associated with different levels of learning (for example, novice, intermediate or expert) and provide learners with clear expectations (Biggs and Tang 2011).

Spaced practice

Learning takes time – the brain needs time to process the information it has received. A large number (500+) of studies regarding human learning suggest that long periods between learning or practice sessions – several days or at least 24 hours – lead to longer overall retention (for example, Murre and Dros 2015). This phenomenon is referred to as the spacing effect (Shaughnessy 1977). Spaced practices involve practice divided into a number of shorter sessions, over a period of time. Likewise, several meta-analyses and high-quality studies indicate that workplace training, learning and development programmes should be repeated periodically to be effective (for example, Lacerenza et al 2017; Taylor et al 2005) and suggest that programmes with spaced distribution are more effective than lengthy one-off sessions (Au 2005). In addition, the effectiveness of spacing depends on the type of learning outcome sought – complex learning outcomes require longer rest periods than simple learning outcomes (Hattie 2012).

Direct instruction

Direct instruction is a method in which the facilitator gives explicit, guided instructions to learners.[5] Although different direct instruction models are available, most involve the following steps:

1 determining what the learning intentions and success criteria are and making them transparent to learners

2 specifying content, typically in the form of materials and resources

3 presenting the new material and/or demonstrating the new skills

4 providing the opportunity for (guided) practice

5 determining learners' level of mastery and providing feedback

6 providing the opportunity for independent practice

7 evaluation.

Direct instruction is also summarised as 'I do' (facilitator), 'We do' (facilitator and learners), 'You do' (learner practises on their own with facilitator monitoring). Although direct instruction has received some criticism, it has been found to be one of the most effective instructional methods,

[5] Adams, G.L. and Engelmann, S. (1996) *Research on direct instruction: 25 years beyond DISTAR*. Seattle: Educational Achievement Systems. Direct instruction as a general approach should not be confused with the 'direct instruction' developed by Adams and Engelman (1996), a related but somewhat different method.

supported by a large number of studies (600+) and meta-analyses (6) showing large effect sizes (see for example, Stockard et al 2018).

Meta-cognitive strategies

In learning, two types of problem-solving are distinguished: (1) applying a strategy to solve a problem, and (2) selecting, monitoring and evaluating that strategy. The latter is referred to as meta-cognition, also known as 'higher-order thinking' or 'thinking about thinking'. Meta-cognition allows learners to reflect upon, analyse and regulate their own learning. Key meta-cognitive strategies include planning, monitoring, and evaluating (Schraw et al 2006). Although most learners spontaneously develop meta-cognitive skills, some learners remain meta-cognitively weak, whereas others outperform their peers. A large number of studies (600+) and meta-analyses (10) consistently demonstrate a positive effect on learning performance from supporting learners to develop meta-cognitive skills by helping them understand (a) how they (or people in general) learn, (b) their strengths and needs, and (c) how to approach a given learning task (see, for example, Kyriakides et al 2013).

Worked examples

The principle behind worked examples states that it is better to provide learners with worked-out examples of problem solutions and ask the learner to study the solutions rather than simply ask them to solve the problems themselves.[6] This learning strategy is thought to be beneficial because it focuses learners' cognitive capacities on trying to *understand* the concepts that support problem-solving. *'When students just solve practice problems on their own, they often make guesses about which problem-solving procedures may be appropriate and then practice those procedures, thus acquiring and strengthening strategies that may be at best inefficient or ungeneralizable and, at worst, incorrect'* (Booth et al 2015). Several empirical studies found that learning based on worked examples is more effective than conventional problem-solving instruction (for example, Renkl et al 2002; Sweller 2006). It is assumed that worked examples reduce (extraneous) cognitive load (see below): through seeing worked examples, learners focus on a particular learning goal rather than wasting cognitive resources attempting to solve a problem in an unsystematic 'trial-and-error' manner (Chen et al 2014). It should be noted, however, that the effect sizes reported show wide variation, suggesting its impact on learning outcomes may be contingent on contextual factors – for example, whether worked examples are presented in isolation or in combination with problems to be solved; the number of learning opportunities given; or the type of explanation given for the example (Wittwer and Renkl 2010).

Formative evaluation

Formative evaluation refers to activities used to assess or test learners' progress of learning *before* or *during* the learning process itself, whereas summative evaluation assesses what learners know or have learned at *the end* of the process (Black and Wiliam 2009). A total number of five meta-analyses representing a total number of 200+ studies indicate that formative evaluation has a medium positive effect on learning outcomes (for example, Kingston and Nash

[6] The latter is also referred to as problem-based learning, an instructional strategy in which learners are presented with real-life complex problems and are required to generate hypotheses about the causes of the problem and how best to manage it.

2011). It should be noted that formative evaluation concerns *feedback to the facilitator or instructor* about how learners are progressing with their learning, rather than feedback to the learners. It concerns whether the learning approach is successful and which learning outcomes are met, where learners are *not* doing well, and so on – such that the facilitator can see whether the learning process should be modified to address strengths and gaps in learner performance.

Test-enhanced learning or retrieval practice

The act of recalling information from memory, as occurs when taking a test, provides not only an assessment of prior learning, but also an effective new learning opportunity. This insight is based on the results of more than 500 studies and four meta-analyses from over a century of research (for example, Kulik et al 1984; Rowland 2014) and stems from the finding that long-term memory is increased when some of the learning period is devoted to retrieving the to-be-remembered information. In fact, the scientific literature on this topic suggests that students learn more from retrieving information than having it presented. For this reason, the strategy is also known as retrieval practice, as the benefits of retrieval-related testing are not limited to tests but can also be induced by using tools like flash cards and quizzes. In addition, a recent meta-analysis of controlled studies (Pan and Rickard 2018) found that learning transfer is more likely when:

- the questions in the initial and final test are different but when the answers are the same
- the initial test involves discriminating between different concepts, constructing an explanation, or recalling a specific concept using several questions that address different levels of knowledge
- the final test involves restudy of materials or provides other forms of elaborative feedback.

Co-operative or social collaborative learning

‘Co-operative learning’, commonly referred to by practitioners as ‘social collaborative’ learning, is one of the most widely studied learning strategies – in the past 40 years more than 20 meta-analyses were published (for example, Kyndt et al 2013). In simple terms, it is when two or more learners collaborate to achieve a common learning goal. The rationale is that it helps learners engage in more complex subject matter than they would typically be able to master individually.

A specific type of co-operative learning is the ‘jigsaw method’ developed by Elliot Aronson. Following this method, the facilitator introduces the main topic (the puzzle) and its subtopics (the pieces). Students are then placed into two different groups of four to six students: a ‘home group’ and an ‘expert group’. Then, each member of the home group is assigned a subtopic which they research and discuss with their co-students in the expert group. Then, after the students have mastered the subtopic in question, they return to their home group to report on their findings. This way, each student learns about each subtopic from either a member of an expert group or through their own investigation (Costouros 2020; Hattie 2015).

Question 3: What are the most important factors that enhance (or impede) the effectiveness of virtual classroom learning?

Finding 4: The effectiveness of virtual classroom teaching is moderated by contextual factors (Level AA)

This REA identified several studies that examined the impact of moderating factors. These studies demonstrate that contextual factors can have a pronounced (positive or negative) impact on learning transfer in both traditional and synchronous virtual settings. Below an overview is provided of six widely researched and impactful factors.

Cognitive load

Cognitive load is a construct developed in the fields of education and instructional design that relates to the amount of information a learner's working memory can hold and process at one time. Cognitive load theory (CLT) states that storage and information processing are based on two interdependent systems: (1) the working memory – also referred to as short-term memory – which deals with the temporary storage and processing of information, and (2) the long-term memory, which stores information in the form of *schemata* – that is, mental structures and categories that help us organise knowledge (Sweller 1988). CLT suggests that information can only be stored in long-term memory after first being stored and processed by working memory. The working memory, however, is limited in both capacity and duration. It is believed that an average adult human has a capacity to retain only four chunks of information at a given time (Wickens 2013). CLT states that this limitation impedes learning, and therefore instructional design should take into account cognitive load. Since its development in the 1980s, CLT has been found to provide the underlying mechanism for many effective learning strategies, such as worked examples, spaced practice, and instructional scaffolding (for narrative summaries, see Hutchins et al 2013; Kirschner et al 2011; Sweller 1999; Van Merriënboer and Sweller 2005).

Cognitive load is partially determined by what is referred to as 'extrinsic load' – the circumstances in which the learning content is presented. In the context of virtual classroom teaching, attention should therefore be paid to circumstances such as ease of use (video interface, navigation), learning environment (temperature, noise, intelligible speech), and disturbances (interruptions, delays, distractions, technology breakdowns). For example, when learners participate in a virtual class from a noisy place with limited privacy and a poor internet connection, their cognitive load will increase and negatively affect learning performance. The same applies to a virtual class in which all learners are displayed at the same time (also referred to as 'gallery view') or when multiple communication channels are used simultaneously (for example, video, audio, emoticons, and a chat box, see also Multimedia learning).

Media richness

When facilitating virtual classes, communication with learners can take various forms, which differ in terms of *media richness* – that is, the medium's ability to reproduce information sent over it. The richest medium is in-person face-to-face communication, followed by video communication,

audio-conferencing, chat, and email. Meta-analyses found that media richness moderates the effects of computer-mediated communication (for example, Hassel and Limayem 2020; Mesmer-Magnus et al 2011; Ortiz de Guinea et al 2012) and consequently learning performance (Amaka and Goeman 2017). However, with broadband internet connections now widely available, the difference between video communication and face-to-face communication is less (Lira et al 2007; Martínez-Moreno et al 2012), suggesting that video communication can be a good alternative for in-person communication – provided that the technology is easy to use (Lockman and Schirmer 2020; Wei et al 2012; Woldeab et al 2020; see also cognitive load). Although media-richness theory states that in the context of distance learning, richer communication media are more effective than less rich media (for example, Shepherd and Martz 2006; Timmerman and Kruepke 2006), this does not automatically imply that multimedia learning is more effective than single-medium learning (see below).

Multimedia learning

Multimedia learning is a rapidly developing instructional method that has grown in tandem with the use of technology in learning and an increase of instructional design incorporating more than one media channel. However, several empirical studies have found the use of multimedia can increase extraneous cognitive load and as a result may negatively impact learning transfer (for an overview, see Grunwald and Corsbie-Massay 2006; Kirschner et al 2011; and Mutlu-Bayraktar 2019). For example, computer animation and video were no more effective than pages in a book or text on a screen (for example, Kalyuga 2011; Koedinger et al 2015; Kühl et al 2011; Tversky et al 2002). In addition, when using multimedia, it is important to consider what is known in cognitive load theory as ‘the split-attention effect’ (Sweller et al 2011): when learners need to split their attention between multiple sources of information, such as speech, slides, pictures, tables or graphics, learning may be impeded (Fiorella et al 2020; Pouw et al 2019). For example, when presenting text on slides that learners need to read, facilitators should stop speaking so that they don’t detract from it.

Interactivity

Interaction refers to the active exchange of actions and information between facilitators and learners, but also the learners’ interaction with the content. Many of the above-mentioned effective learning strategies are based on some form of interaction, such as classroom discussion, reciprocal teaching, peer tutoring, and social collaborative learning. Not surprisingly, several meta-analyses found that interactivity is an essential attribute of effective virtual classroom teaching (Amaka and Goeman 2017; Davis et al 2018; Lockman and Schirmer 2020). The scientific literature has identified three main interactions that affect the success of the learning process, namely learner–learner, learner–teacher, and learner–content interactions (Borokhovski et al 2012). It was found that interaction between learners has a larger positive effect than learner–content and learner–facilitator interaction. In addition, interactivity is considered by educational scholars as a prerequisite to engage learners, which is in turn is assumed to increase learning (Groccia 2018).

Social presence

Social presence refers to the feeling and perception of being connected to the instructor or facilitator and other learners. Two recent meta-analyses found that in an online learning environment, learners' perceived social presence is positively associated with their self-rated learning performance (Amaka and Goeman 2017; Richardson et al 2017). However, the impact on more robust measures of learning seems to be less important: a controlled before–after study found that social presence has a large positive effect on learner satisfaction, but only a small effect on objective learners' grades (Han 2013). Perceived social presence can be enhanced through the use of social cues (words, facial expressions, gestures, tones, emoticons, signs), and through interaction and discussion (Dixson et al 2017; Wei et al 2012).

Group cohesion and trust

Several meta-analyses and high-quality studies consistently demonstrate that a high level of intra-team trust is an important attribute of effective teams (for example, Breuer et al 2016; De Jong et al 2016; Webber 2008). The same was found for 'social cohesion', a construct that refers to emotional bonds of friendship, caring and closeness among group members, and enjoyment of each other's company (Chiocchio and Hélène 2009; Evans and Dion 2012; Mathieu 2015). A recent meta-analysis of 104 studies found that these two attributes are also relevant to online learning as they are a strong predictor of student collaboration and learning (Lockman and Schirmer 2020; see also Hattie 2012). It is therefore recommended that facilitators foster trust and social cohesion among learners in order to promote collaborative learning, especially when they have no common past and have never met face-to-face (Lin et al 2008).[7]

4 Conclusion

In the past decades, a large number of high-quality studies have been published on the attributes of effective online learning. These studies consistently demonstrate that good-quality virtual classroom learning is equally effective as traditional in-person classroom learning. In addition, learning strategies that are effective in traditional in-person classrooms – such as formative evaluation, feedback, meta-cognitive strategies, direct instruction, mastery learning, scaffolding, worked examples, and goal-setting – are also effective in an online classroom environment. Although there are several factors that moderate the effectiveness of virtual classroom teaching, these factors can also be used as a lever to enhance effectiveness – for example, by reducing cognitive load, increasing interactivity, enhancing social presence, and building social cohesion and trust.

Limitations

This REA aims to provide a balanced assessment of what is known in the scientific literature about the attributes of effective virtual classroom teaching by using the systematic review method to search and critically appraise empirical studies. To be 'rapid', concessions were made in relation to the breadth and depth of the search process, such as the exclusion of unpublished

[7] See also CEBMa's REA on attributes of effective teams.

studies, the use of a limited number of databases, and a focus on studies published in the past ten years. In consequence, some relevant studies may have been missed.

A second limitation concerns the critical appraisal of the studies included, which did not incorporate a comprehensive review of the psychometric properties of their measures, including tests, scales and questionnaires.

A third limitation concerns the focus on meta-analyses and controlled, longitudinal studies. Thus, new, promising findings from cross-sectional studies may have been missed.

Given these limitations, care must be taken not to present the findings presented in this REA as conclusive.

5 References

Amaka, I.H. and Goeman, K. (2017) Selecting media for effective learning in online and blended courses: a review study. *Journal of Educational Multimedia and Hypermedia*. Vol 26, No 1. pp29–59.

Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C. and Norman, M.K. (2010) *How learning works: seven research-based principles for smart teaching*. Hoboken, NJ: John Wiley & Sons.

Ananthanarayanan, V. (2014) Social presence in culturally mediated online learning environments. In: Wright, R.D. (ed.). *Student–teacher interaction in online learning environments*. Hershey, PA: IGI Global. pp1–21.

Asadi, N., Khodabandeh, F. and Yekta, R.R. (2019) Comparing and contrasting the interactional performance of teachers and students in traditional and virtual classrooms of advanced writing course in distance education university. *Turkish Online Journal of Distance Education*. Vol 20, No 4. pp135–48.

Au, K.Y. (2005) *Evaluating the effectiveness of leadership training programs.* Doctoral dissertation. Chinese University of Hong Kong.

Barends, E., Rousseau, D.M. and Briner, R.B. (eds). (2017) *CEBMa guideline for rapid evidence assessments in management and organisations*. Version 1.0. Amsterdam: Center for Evidence Based Management.

Belland, B.R., Walker, A.E., Kim, N.J. and Lefler, M. (2017) Synthesizing results from empirical research on computer-based scaffolding in STEM education: a meta- analysis. *Review of Educational Research*. Vol 87. pp309–44.

Biggs, J. and Tang, C. (2011) Train-the-trainers: implementing outcomes-based teaching and learning in Malaysian higher education. *Malaysian Journal of Learning and Instruction*. Vol 8. pp1–19.

Black, P.J. and Wiliam, D. (2009) Developing the theory of formative assessment. *Educational Assessment, Evaluation, and Accountability*. Vol 21, No 1. pp5–31.

Booth, J.L., McGinn, K.M., Young, L.K. and Barbieri, C. (2015) Simple practice doesn't always make perfect: evidence from the worked example effect. *Policy Insights from the Behavioral and Brain Sciences*. Vol 2, No 1. pp24–32.

Borokhovski, E., Tamim, R., Bernard, R.M., Abrami, P.C. and Sokolovskaya, A. (2012) Are contextual and designed student-student interaction treatments equally effective in distance education? *Distance Education*. Vol 33, No 3. pp311–29.

Breuer, C., Hüffmeier, J. and Hertel, G. (2016) Does trust matter more in virtual teams? A meta-analysis of trust and team effectiveness considering virtuality and documentation as moderators. *Journal of Applied Psychology*. Vol 101, No 8. p1151.

Chen, R., Dore, K., Grierson, L.E., Hatala, R. and Norman, G. (2014) Cognitive load theory: implications for nursing education and research. *Canadian Journal of Nursing Research Archive*. pp28–41.

Chiocchio, F. and Hélène, E. (2009) Cohesion and performance: a meta-analytic review of disparities between project teams, production teams, and service teams. *Small Group Research*. Vol 40, No 4. pp382–420.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates.

Costouros, T. (2020) Jigsaw learning versus traditional lectures: impact on student grades and learning experience. *Teaching and Learning Inquiry*. Vol 8, No 1. pp154–72.

Davis, D., Chen, G., Hauff, C. and Houben, G. (2018) Activating learning at scale: a review of innovations in online learning strategies. *Computers and Education*. Vol 125. pp327–44.

De Jong, B.A., Dirks, K.T. and Gillespie, N. (2016) Trust and team performance: a meta-analysis of main effects, moderators, and covariates. *Journal of Applied Psychology*. Vol 101, No 8. p1134.

Dimotakis, N., Mitchell, D. and Maurer, T. (2017) Positive and negative assessment centre feedback in relation to development self-efficacy, feedback seeking, and promotion. *Journal of Applied Psychology*. Vol 102, No 11. p1514.

Dixson, M.D., Greenwell, M.R., Rogers-Stacy, C., Weister, T. and Lauer, S. (2017) Nonverbal immediacy behaviors and online student engagement: bringing past instructional research into the present virtual classroom. *Communication Education*. Vol 66, No 1. pp37–53.

Doo, M.Y., Bonk, C.J. and Heo, H. (2020) A meta-analysis of scaffolding effects in online learning in higher education. *International Review of Research in Open and Distributed Learning*. Vol 21, No 3. pp60–80.

Du, S., Liu, Z., Liu, S., Yin, H., Xu, G., Zhang, H. and Wang, A. (2013) Web-based distance learning for nurse education: a systematic review. *International Nursing Review*. Vol 60, No 2. pp167–77.

Evans, C.R. and Dion, K.L. (2012) Group cohesion and performance: a meta-analysis. *Small Group Research*. Vol 43, No 6. pp690–701.

Fiorella, L., Stull, A.T., Kuhlmann, S. and Mayer, R.E. (2020) Fostering generative learning from video lessons: benefits of instructor-generated drawings and learner-generated explanations. *Journal of Educational Psychology*. Vol 112, No 5. p895.

George, P.P., Zhabenko, O., Kyaw, B.M., Antoniou, P., Posadzki, P., Saxena, N. and Car, J. (2019) Online digital education for postregistration training of medical doctors: systematic review by the digital health education collaboration. *Journal of Medical Internet Research*. Vol 21, No 2.

Groccia, J.E. (2018) What is student engagement? *New Directions for Teaching and Learning*. Vol 154. pp11–20.

Grunwald, T. and Corsbie-Massay, C. (2006) Guidelines for cognitively efficient multimedia learning tools: educational strategies, cognitive load, and interface design. *Academic Medicine*. Vol 81, No 3. pp213–23.

Han, H. (2013) Do nonverbal emotional cues matter? Effects of video casting in synchronous virtual classrooms. *American Journal of Distance Education*. Vol 27, No 4. pp253–64.

Hassell, M.D. and Limayem, M. (2020) Media impacts and performance in dispersed teams. *Journal of Computer Information Systems*. Vol 60, No 1. pp18-–25.

Hattie, J. (2012) *Visible learning for teachers: maximizing impact on learning*. London: Routledge.

Hattie, J. (2015) The applicability of visible learning to higher education. *Scholarship of Teaching and Learning in Psychology*. Vol 1, No 1. pp79–91

Howard, T.O., Winkelmes, M.A. and Shegog, M. (2020) Transparency teaching in the virtual classroom: Assessing the opportunities and challenges of integrating transparency teaching methods with online learning. *Journal of Political Science Education*. Vol 16, No 2. pp198–211.

Hutchins, S.D., Wickens, C.D., Carolan, T.F. and Cumming, J.M. (2013) The influence of cognitive load on transfer with error prevention training methods: a meta-analysis. *Human Factors*. Vol 55, No 4. pp854–74.

Jurewitsch, B. (2012) A meta-analytic and qualitative review of online versus face-to-face problem-based learning. *Journal of Distance Education*. Vol 26, No 2.

Kalyuga, S. (2011) Effects of information transiency in multimedia learning. *Procedia-Social and Behavioral Sciences*. Vol 30. pp307–11.

Kingston, N. and Nash, B. (2011) Formative assessment: a meta-analysis and a call for research. *Educational Measurement: Issues and Practice*. Vol 30, No 4. pp28–37.

Kirschner, P.A., Ayres, P. and Chandler, P. (2011) Contemporary cognitive load theory research: the good, the bad and the ugly. *Computers in Human Behavior*. Vol 27, No 1. pp99–105.

Kluger, A.N. and DeNisi, A. (1996) The effects of feedback interventions on performance: a historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin*. Vol 119, No 2. p254.

Koedinger, K.R., Kim,J., Jia, J.Z., McLaughlin, E.A. and Bier, N.L. (2015) Learning is not a spectator sport: doing is better than watching for learning from a MOOC. In: *Proceedings of the 2nd ACM Conference on learning@scale*. pp111–20.

Kühl, T., Scheiter, K., Gerjets, P. and Edelmann, J. (2011) The influence of text modality on learning with static and dynamic visualizations. *Computers in Human Behavior*. Vol 27. pp29–35.

Kulik, J.A., Kulik, C.L.C. and Bangert, R.L. (1984) Effects of practice on aptitude and achievement test scores. *American Educational Research Journal*. Vol 21, No 2. pp435–47.

Kyndt, E., Raes, E., Lismont, B., Timmers, F., Cascallar, E. and Dochy, F. (2013) A meta-analysis of the effects of face-to-face co-operative learning: do recent studies falsify or verify earlier findings? *Educational Research Review*. Vol 10. pp133–49.

Kyriakides, L., Christoforou, C. and Charalambous, C.Y. (2013) What matters for student learning outcomes: a meta-analysis of studies exploring factors of effective teaching. *Teaching and Teacher Education*. Vol 36. pp143–52.

Lacerenza, C.N., Reyes, D.L., Marlow, S.L., Joseph, D.L. and Salas, E. (2017) Leadership training design, delivery, and implementation: a meta-analysis. *Journal of Applied Psychology*. Vol 102, No 12. p1686.

Lin, C., Standing, C. and Liu, Y.-C. (2008) A model to develop effective virtual teams. *Decision Support Systems*. Vol 45, No 4. p1031.

Lira, E.M., Ripoll, P., Peiró, J.M. and González, P. (2007) The roles of group potency and information and communication technologies in the relationship between task conflict and team effectiveness: a longitudinal study. *Computers in Human Behavior*. Vol 23, No 6. pp2888–2903.

Lockman, A.S. and Schirmer, B.R. (2020) Online instruction in higher education: promising, research-based, and evidence-based practices. *Journal of Education and e-Learning Research*. Vol 7, No 2. pp130–52.

Martínez-Moreno, E., Zornoza, A., González-Navarro, P. and Thompson, L.F. (2012) Investigating face-to-face and virtual teamwork over time: when does early task conflict trigger relationship conflict? *Group Dynamics: Theory, Research, and Practice*. Vol 16, No 3. pp159–71.

Mathieu, J., Maynard, M.T., Rapp, T. and Gilson, L. (2008) Team effectiveness 1997–2007: a review of recent advancements and a glimpse into the future. *Journal of Management*. Vol 34, No 3. pp410–76.

Mathieu, J.E., Kukenberger, M.R., D'innocenzo, L. and Reilly, G. (2015) Modeling reciprocal team cohesion–performance relationships, as impacted by shared leadership and members' competence. *Journal of Applied Psychology*. Vol 100, No 3. p713.

Mayer, R.E. and Moreno, R. (2003) Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*. Vol 38, No 1. pp43–52.

McCutcheon, K., Lohan, M., Traynor, M. and Martin, D. (2015) A systematic review evaluating the impact of online or blended learning vs face-to-face learning of clinical skills in undergraduate nurse education. *Journal of Advanced Nursing*. Vol 71, No 2. pp255–70.

Mesmer-Magnus, J.R., DeChurch, L.A., Jimenez-Rodriguez, M., Wildman, J. and Shuffler, M. (2011) A meta-analytic investigation of virtuality and information sharing in teams. *Organisational Behavior and Human Decision Processes*. Vol 115, No 2. p214.

Mesmer-Magnus, J. and Viswesvaran, C. (2007) Inducing maximal versus typical learning through the provision of a pretraining goal orientation. *Human Performance*. Vol 20, No 3. pp205–222.

Murphy, P.K., Wilkinson, I.A., Soter, A.O., Hennessey, M.N. and Alexander, J.F. (2009) Examining the effects of classroom discussion on students' comprehension of text: a meta-analysis. *Journal of Educational Psychology*. Vol 101, No 3. p740.

Murre, J.M. and Dros, J. (2015) Replication and analysis of Ebbinghaus' forgetting curve. *PloS One*. Vol 10, No 7.

Mutlu-Bayraktar, D., Cosgun, V. and Altan, T. (2019) Cognitive load in multimedia learning environments: A systematic review. *Computers & Education*. Vol 141, 103618.

Ortiz de Guinea, A., Webster, J. and Staples, D.S. (2012) A meta-analysis of the consequences of virtualness on team functioning. *Information and Management*. Vol 49, No 6. p301.

Pan, S.C. and Rickard, T.C. (2018) Transfer of test-enhanced learning: meta-analytic review and synthesis. *Psychological Bulletin*. Vol 144, No 7. p710.

Petticrew, M. and Roberts, H. (2006) How to appraise the studies: an introduction to assessing study quality. *Systematic Reviews in the Social Sciences: A Practical Guide*. pp125–63.

Pouw, W., Rop, G., De Koning, B. and Paas, F. (2019) The cognitive basis for the split-attention effect. *Journal of Experimental Psychology: General*. Vol 148, No 11. p2058.

Powers, S.R., Rauh, C., Henning, R.A., Buck, R.W. and West, T.V. (2011) The effect of video feedback delay on frustration and emotion communication accuracy. *Computers in Human Behavior*. Vol 27, No 5. pp1651–57.

Reiser, B.J. and Tabak, I. (2014) Scaffolding. In: Sawyer, R.K. (ed.). *The Cambridge handbook of the learning sciences.* 2nd ed. Cambridge: Cambridge University Press. pp44–62.

Renkl, A., Atkinson, R. and Grobe, C.S. (2004) How fading worked solution steps works – a cognitive load perspective. *Instructional Science*. Vol 32, No 1–2.

Renkl, A., Atkinson, R.K., Maier, U.H. and Staley, R. (2002) From example study to problem-solving: smooth transitions help learning. *Journal of Experimental Education*. Vol 70, No 4.

Richardson, J.C., Maeda, Y., Lv, J. and Caskurlu, S. (2017) Social presence in relation to students' satisfaction and learning in the online environment: a meta-analysis. *Computers in Human Behavior*. Vol 71. pp402–17.

Rolland, R.G. (2012) Synthesizing the evidence on classroom goal structures in middle and secondary schools: a meta-analysis and narrative review. *Review of Educational Research*. Vol 82, No 4. pp396–435.

Rowland, C.A. (2014) The effect of testing versus restudy on retention: a meta-analytic review of the testing effect. *Psychological Bulletin*. Vol 140, No 6. pp1432–63.

Sadler, D.R. (1989) Formative assessment and the design of instructional systems. *Instructional Science*. Vol 18, No 2. pp119–44.

Schraw, G., Crippen, K.J. and Hartley, K. (2006) Promoting self-regulation in science education: metacognition as part of a broader perspective on learning, *Research in Science Education*. Vol 36. pp111–39.

Shadish, W.R., Cook, T.D. and Campbell, D.T. (2002) *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton, Mifflin & Company.

Shaughnessy, J. (1977) Long-term retention and the spacing effect in free-recall and frequency judgments. *American Journal of Psychology*. Vol 90, No 4. pp587–98.

Shaughnessy, J.J. and Zechmeister, E.B. (1985) *Research methods in psychology*. New Yorki: Alfred A. Knopf.

Shepherd, M.M. and Martz Jr, W.B. (2006) Media richness theory and the distance education environment. *Journal of Computer Information Systems*. Vol 47, No 1. pp114–22.

Stockard, J., Wood, T.W., Coughlin, C. and Rasplica Khoury, C. (2018) The effectiveness of direct instruction curricula: a meta-analysis of a half century of research. *Review of Educational Research*. Vol 88, No 4. pp479–507.

Sweller, J. (1988) Cognitive load during problem solving: Effects on learning. *Cognitive science*. Vol 12, No 2. pp257–285.

Sweller, J. (1999) *Instructional design in technical areas*. Camberwell, Australia: ACER Press.

Sweller, J. (2006) The worked example effect and human cognition. *Learning and Instruction*. Vol 16. pp165–69.

Sweller, J., Ayres, P. and Kalyuga, S. (2011) The split-attention effect. In: *Cognitive Load Theory*. New York: Springer. pp111–28.

Taylor, P.J., Russ-Eft, D.F. and Chan, D.W.L. (2005) A meta-analytic review of behavior modeling training. *Journal of Applied Psychology*. Vol 90, No 4. pp692–709.

Timmerman, C. and Kruepke, K.A. (2006) Computer-assisted instruction, media richness, and college student performance. *Communication Education*. Vol 55, No 1. pp73–104.

Tversky, B., Morrison, J.B. and Betrancourt, M. (2002) Animation: can it facilitate? *International Journal of Human–Computer Studies*. Vol 57. pp247–62.

Van Merriënboer, J.J.G. and Sweller, J. (2005) Cognitive load theory and complex learning: recent developments and future directions. *Educational Psychology Review*. Vol 17. pp147–77.

Webber, S.S. (2008) Development of cognitive and affective trust in teams: a longitudinal study. *Small Group Research*. Vol 39, No 6. pp746–69.

Wei, C.-W., Chen, N.-S. and Kinshuk (2012) A model for social presence in online classrooms. *Educational Technology Research and Development*. Vol 60, No 3. pp529–45.

Wickens, C.D., Hutchins, S., Carolan, T. and Cumming, J. (2013) Effectiveness of part-task training and increasing-difficulty training strategies: a meta-analysis approach. *Human Factors*. Vol 55, No 2. pp461–470.

Wittwer, J. and Renkl, A. (2010) How effective are instructional explanations in example-based learning? A meta-analytic review. *Educational Psychology Review*. Vol 22, No 4. pp393–409.

Woldeab, D., Yawson, R.M. and Osafo, E. (2020) A systematic meta-analytic review of thinking beyond the comparison of online versus traditional learning. *The e-Journal of Business Education and Scholarship of Teaching*. Vol 14, No 1. pp1–24.

Zeneli, M., Thurston, A. and Roseth, C. (2016) The influence of experimental design on the magnitude of the effect size-peer tutoring for elementary, middle and high school settings: a meta-analysis. *International Journal of Educational Research*. Vol 76. pp211–23.

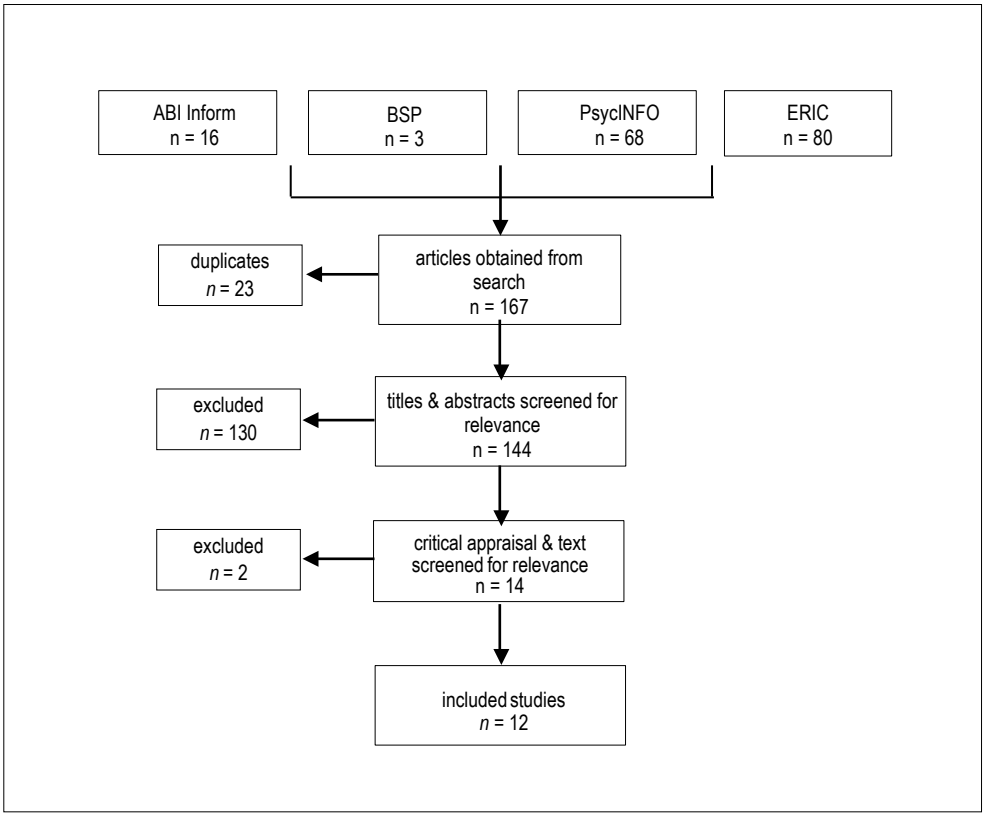
Appendix 1: Search terms and hits

ABI/Inform Global, Business Source Elite, PsycINFO, ERIC peer-reviewed, scholarly journals, July 2021				
Search terms	**ABI**	**BSP**	**PSY**	**ERIC**
S1: ti(learn*) OR ti(educat*) OR ti(train*)	139,578	91,369	227,199	453,635
S2: ti(online) OR ti(virtual) OR ti(remote) OR ti(distan*) OR ti(webinar*)	46,648	34,004	32,492	27,886
S3: S1 AND S2	4,768	2,514	5,207	14,378
S4: S3 AND filter MAs or SRs limit: date > 2000	6	3	63	57
S5: ab('professional learning') OR ab('professional development') OR ab('learning and development') OR ab('workplace learning')	6,726	4,169	12,031	41,423
S6: S5 AND S2	172	74	315	1,125
S7: filter MAs, SRs or longitudinal studies limit: date > 2000	10	0	5	23
S8: S3 OR S7	**16**	**3**	**68**	**80**
S8: ti('virtual classroom*') OR ti('online classroom*') OR ti('virtual teach*') OR ti('online teach')	81	42	63	312
S9: S8 AND filter empirical studies limit: date > 2010	**27**	**8**	**29**	**85**

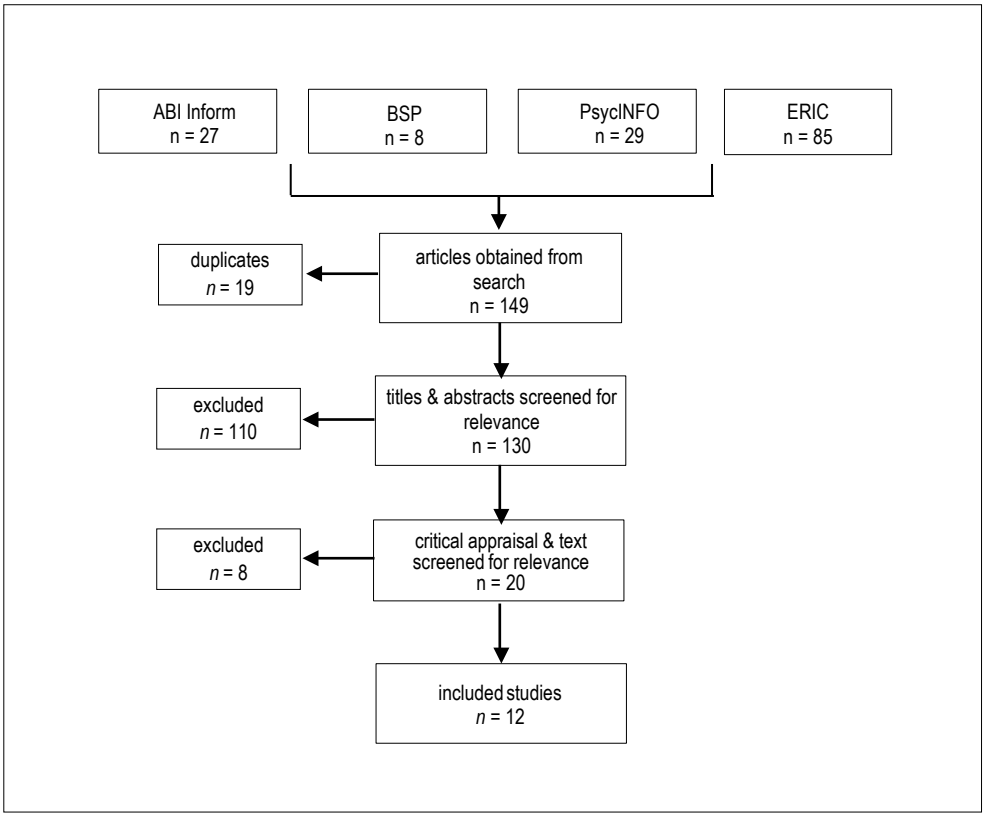
ABI/Inform Global, Business Source Elite, PsycINFO, ERIC peer-reviewed, scholarly journals, August 2021				
Search terms	**ABI**	**BSP**	**PSY**	**ERIC**
S1: ti(learn*) OR ti(teach*) OR ti(instruct*) OR ti(educat*) OR ti(train*) OR ab(learn*) OR ab(teach*) OR ab(instruct*) OR ab(educat*) OR ab(train*)	564,613	107,089	2,103,585	
S2: ti('formative evaluation*') AND S1 AND filter MAs or SRs, limit: date > 2010	0	0	3	
S3: ti('reciprocal teaching') OR ti('peer tutor*') AND S1 AND filter MAs or SRs, limit: date > 2010	0	0	5	
S4: ti('meta-cognitive') AND S1 AND filter MAs or SRs, limit: date > 2010	0	1	1	
S5: ti('direct instruction') AND S1 AND filter MAs or SRs, limit: date > 2010	0	0	2	
S6: ti('mastery learning') OR ti('scaffolding') AND S1 AND filter MAs or SRs, limit: date > 2010	0	0	15	
S7: ti('worked example*') AND S1 AND filter MAs or SRs, limit: date > 2010	0	1	2	
S8: ti('goal*') OR ti('objective*') AND S1 AND filter MAs or SRs, limit: date > 2010	14	6	45	
S9: ti('cognitive load') AND S1 AND filter MAs or SRs, limit: date > 2000	0	2	17	
S10: ti('media rich*') AND S1 AND filter MAs or SRs, limit: date > 2000	0	2	1	
S11: ti('retrieval practice') AND S1 AND filter MAs or SRs, limit: date > 2000	0	0	3	
S12: ti('learner engagement') OR ti('student engagement') AND S1 AND filter MAs or SRs, limit: date > 2000	0	0	14	
S13: ti(spaced) AND S1 AND filter MAs or SRs, limit: date > 2000	0	0	9	
S14: ti('social aspects') AND S1 AND filter MAs or SRs, limit: date > 2000	0	0	3	
S17: ti('testing effect') AND S1 AND filter MAs or SRs, limit: date > 2000	1	0	4	
Total	**15**	**12**	**124**	

Appendix 2: Study selection

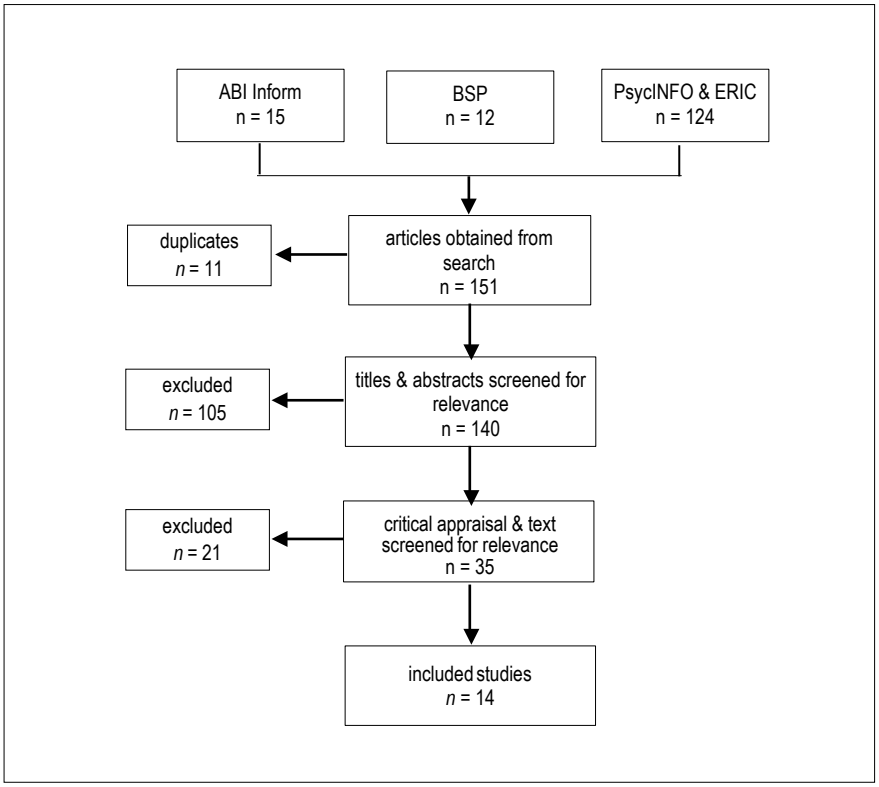
Meta-analyses and systematic reviews



Primary studies



Additional search – teaching strategies



Appendix 3: Data extraction tables and excluded studies

Data extraction table – initial search

Author & year	Design & sample size	Sector/population	Main findings	Effect sizes	Limitations	Level
1 Amaka and Goeman (2017)	systematic review of quasi-exp and RCTs k = 24	higher education students	Examines what attributes should be considered when selecting the most appropriate media format for online or blended learning. 1 Ten media attributes were found to be of paramount importance for effective learning in OBL courses: interactivity, navigability, (a)synchronicity, flexibility, media richness, ease of use, individualisation, mobility, proximity and responsiveness.	not reported	Narrative synthesis, no pooled effect sizes. Some findings are based on a small number of studies.	AA
2 Asadi et al (2019)	non-randomised controlled before–after study n = 99	EFL learners at two Iranian universities	1 The participants in the virtual class performed better than their peers in the traditional one (post-test). 2 The number of interactions between the participants and teacher was higher in the virtual class.	Not reported	The analysis of the effect of interaction between the students and teacher on performance and learning is not clear.	B
3 Aydemir (2016)	longitudinal design (repeated measures, no control group) n = 28	Turkish postgraduate students (age: 35–40)	The purpose of this study was to investigate the effects of question type ('open-ended' vs 'closed-ended') and answer format ('all learner answers' vs 'the quickest answer') used in synchronous class implementations on perceived interest and usefulness. 1 Open-ended questions were perceived as more interesting than closed-ended questions. This effect was not found for the question format ('all learner answers' vs 'the quickest answer'). 2 'All learners answers' format of questions were perceived as more useful than 'the quickest answer'. Such effect was not found for the question type ('open-ended' vs 'closed-ended').	1 η2 = .026 2 η2 = .004	Small sample size Very small effect sizes	C

4 Borokhovski et al (2012)	systematic review k = 36 n = 3,634	students in a distant-learning condition	1 The results favoured designed student-to-student interaction treatments over contextual interaction treatments. 2 None of the other moderator variables (methodological and demographic) significantly contributed to explaining variability in observed effect sizes. Contextual interaction = interaction among the students by providing options and alternatives for communication (eg two-way video, face-to-face communication). Designed interaction = strategies or setups incorporated into the course design, enabling and supporting student–student collaboration.	1 Designed: g = .50 95%CI [.32; .67] student–student: g = .49 student–content: g = .46 student–teacher: g = .32 Contextual: g = .22 95%CI [.10; .34]	Design of the included studies not reported	C
5 Cross (2015)	controlled study without pre-test n = 28	Undergraduate students at 8-week algebra courses	The purpose of this research was to study the impact of classroom assessment techniques (CAT, a type of formative assessment) on frequency of forum conversation from students and student quiz scores. 1 In classes that used CAT, the discussion forum posting frequencies were higher. 2 In classes that used CAT, the students' quiz scores were higher.	not reported	Vague information about the sample (for example, sample size is missing) Results are vague (only p value is reported)	D
6 Davis et al (2018)	systematic review of RCTs k = 126	adult learners participating in MOOCs	Reviews research published between 2009 and 2017 that presents empirical evaluations of John Hattie's learning strategies that facilitate active learning: mastery learning, meta-cognitive strategies, questioning, spaced vs massed practice, feedback, co-operative learning, simulations and gaming, programmed instruction, interactive multimedia methods. 1 Co-operative learning, simulations and gaming, and interactive multimedia were found to be the three most promising strategies for most effectively activating learning at scale.	not reported	Concerns massive open online courses (MOOCs) Identification of the three most effective strategies seems to be based on vote-counting	AA
7 Dixson et al (2017)	non-randomised controlled study n = 178	Students at a regional midwestern comprehensive university (USA) in 51 entirely online courses	1 Student engagement was significantly higher in courses with high levels of teacher non-verbal immediacy behaviours* than those with low levels of non-verbal immediacy behaviours (H1). 2 The courses with higher immediacy scores report stronger perceptions of instructor presence. 3 The categories of non-verbal immediacy behaviours that showed the strongest effect on engagement were 'tone' (use of fonts/emoticons, colour and cohesion/harmony/unity all contributed to the aesthetic of the class; F3a) and 'forums' (F3b). * Online non-verbal immediacy behaviours: emoticons/figurative language, colour, cohesion, visual imagery, and audio in course design; response latency, length, time of day, and message frequency in forums; and type and promptness of feedback via grading and email.	1 $\eta 2 = 0.19$ 2 $\eta 2 = 0.004$	Low response rate (19%)	C

8 Doo et al (2020)	meta-analysis of mostly RCTs k = 64/18	higher education setting	1 Scaffolding in an online learning environment has a large and statistically significant effect on learning outcomes. 2 The meta-cognitive domain yielded a larger effect size than did the affective and cognitive domains. 3 In terms of types of scaffolding activities, meta-cognitive scaffolding yielded a larger effect size than did other types of scaffolding. 4 In terms of sources of scaffolding activities, scaffolding from peer students yielded the largest effect sizes Scaffolding = 'process that enables a student to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts'. Affective domain = students' feelings or psychological states during the learning process, such as emotions, motivations, values, satisfaction, and attitudes. Cognitive domain = context knowledge and the development of intellectual skills. Meta-cognitive domain = knowledge about one's own cognitive processes of monitoring and controlling thoughts including self-regulation.	1 g = .87 95% CI [.66, 1.07] 2 Affective g = .67 95%CI [.17, 1.19] Cognitive g = .65 95%CI [.42, .89] Meta cog g = 1.6 95%CI [1.20, 2.0] 3 Procedural g = .39 95%CI [.02, .77] Conceptual g = .96 95%CI [.29, 1.64] Strategic g = .44 95%CI [−.24, 1.12] Meta cog g = 1.1 95%CI [.86, 1.34] 4 Teachers g = .84 95%CI [.43, 1.24] Peers g = 1.81 95%CI [1.12, 2.50] Computers g = .76 95%CI [.53, 1.01]	no serious limitations	AA
9 Du et al (2013)	systematic review of RCTs k = 9	nurses	1 Results showed that web-based distance learning produced equivalent or better effects in both knowledge acquisition and skills performance (compared with conventional teaching methods such as face-to-face lecture and skill demonstration).	not reported	no serious limitations	AA

10 Evans (2017)	RCT n = 96	First-year undergraduate students	1 Students had a higher quantity of posts on an online discussion forum when non-personalised subject headings are used for instructor-generated discussion posts.	not reported	Unclear whether it concerns synchronous or asynchronous learning	A
11 George et al (2019)	systematic review of RCTs k = 93	physicians	1 The results showed that online digital education and blended learning may be equivalent to self-directed and face-to-face learning for improving doctors' knowledge, skills, and attitudes. Self-directed learning = self-learning through books and journals.	not reported due to statistical and clinical heterogeneity	no serious limitations	AA
12 Han (2013)	non-randomised controlled before–after study n = 33	online graduate students who were pursuing a master's degree in education	1 The results showed a significant positive effect of the video casting on students' feeling of instructor co-presence. No significant effect of video casting was found on either students' satisfaction or learning achievement. 2 Three social presence variables – co-presence (2a), psychological involvement (2b), and discussion engagement (2c) – were related with satisfaction. 3 Neither the social presence variables nor the satisfaction had significant correlation with students' grades.	1: d = 0.70 2a: r = .73 2b: r = .72 2c: r = .73	no serious limitation	B
13 Howard (2020)	non-randomised controlled study n = 103	students at the University of Nevada	1 Students performed better (higher GPA) when taught in person as opposed to online (note: *p* = .06). 2 When applying transparent teaching* in the online context (but not in the traditional context), the difference became insignificant (*p* = .21). * Transparency teaching – a combination of teaching practices that are explicit in the articulation of instructor expectations for student learning and classroom success, that rely upon unambiguous language and techniques to develop and enhance analytical and critical thinking skills and deepen student learning.	1: d = 0.48, 95% CI [−0.12; 1.08]	no serious limitation	C
14 Howell (2017)	non-randomised controlled study n = 65	online graduate students at a university in a south Atlantic state (USA)	1 The group, in which focal prompt*** design was used, obtained higher scores on 'knowledge construction'****. Such effect was not found for playground prompt* and brainstorm prompt**. * Playground prompt focuses on 'a promising sub-aspect of the material,' such as a specific aspect of literature, history, or concept being studied. ** Brainstorm prompt focuses on generating ideas and solutions by encouraging students to discover different connections together, which produces collaboration.	not reported	results somewhat unclear	C

			*** Focal prompt involves a complex controversy with more than one possible solution, which forces students to choose an argument and prepare a supportive rationale. **** Five levels of knowledge construction (interaction analysis model): (1) sharing and comparing information, (2) identifying areas of disagreement, (3) negotiating meaning and co-construction of knowledge, (4) evaluation and modification of new schemas that result from co-construction, and (5) reaching and stating agreement and application of co-constructed knowledge.			
15 Jurewitsch (2012)	meta-analysis of quasi-experimental designs k = 5	n/a	1 An overall effect size was found to be slightly in favour of online problem-based learning compared with face-t-face problem-based learning. Online learning = interaction through email, online chat, videoconferencing, phone, discussion boards, and document exchange. Problem-based learning = instructional strategy in which students are presented with real-life complex problems and are required to generate hypotheses about the causes of the problem and how best to manage it.	pooled effect size unclear	small sample size In two studies the face-to-face condition was favoured	A
16 Lee (2019)	systematic review k = 21	n/a	1 Findings indicate that self-regulated learning positively influences learning in MOOCs. Self-regulated learning = an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, intentions and behaviour, guided and constrained by their goals and the contextual features of the environment. For dimensions of SRL strategies, see Table 3.	not reported	design of the included studies not reported	C
17 Lockman and Schirmer (2020)	systematic review of correlational and quasi-experimental studies k = 104	n/a	1 Most of the strategies with promising effectiveness in the online environment are the same ones that are considered to be effective in face-to-face classrooms, including the use of multiple pedagogies and learning resources to address different student learning needs, high instructor presence, quality of faculty–student interaction, academic support outside of class, and promotion of classroom cohesion and trust. 2 Unique to the online environment are user-friendly technology tools, orientation to online instruction, opportunities for synchronous class sessions, and incorporation of social media.	not reported	narrative synthesis	B

18 McCutcheon et al (2015)	systematic review, includes controlled studies k = 19	undergraduate nurses	1 Results indicate that online learning proved to have a similar, if not improved, benefit to students' clinical skill knowledge as traditional means. Online learning = a mode of learning that is technology-based and is primarily conducted through the Internet and is exclusive of face-to-face contact with a lecturer.	not reported	design of the included studies not reported	A
19 Raes (2020)	non-randomised controlled study n = 14	secondary education students	1 Students' IM was found to be higher during quiz moments than during other moments of the lecture (H5). *Additional findings (mechanisms behind the main findings – the need for relatedness and intrinsic motivation):* 2 Students' experienced relatedness towards the teacher is higher if students participate F2F in the course, either in the pure F2F setting (2a) or in the hybrid-F2F setting (2b), than if students participate virtual in the course, either in the pure virtual setting (2c) or in the hybrid-virtual setting (2d). (H1a) 3 Students' relatedness to peers was the highest in the pure F2F setting (F3a), and lower in the hybrid-F2F setting (F3b) and the pure virtual setting (F3c), and in the hybrid-virtual setting (F3d). (H1b) 4 Students in the pure F2F setting yielded higher scores (F4a) than students in the hybrid-virtual setting (F4b). (H2) 5 Students' intrinsic motivation had a significant effect on their learning achievement (H3).	1: β = .28 2a: β = .61 2b: β = .94 2c: β = −.75 2d: β = −.75 3a: β = .87 3b: β = .14 3c: β = −.15 3d: β = −.85 4a: β = .27 4b: β = −.48 5: β = .29	no serious limitation	C
20 Richardson et al (2017)	meta-analysis k = 25	n/a	1 Results showed a moderately large positive correlation between social presence and perceived learning. 2 Large variation among correlations indicated systematic differences among these correlations due to online course settings. 3 The relationship between social presence and perceived learning was moderated by the (a) course length (the longer the course lasted, the stronger the relationship between social presence and perceived learning), (b) discipline area, and (c) target audience of the course. Social presence = the ability to perceive others in an online environment	1 r = .51 2a 16 weeks r = .58 8 weeks r = .49 6 weeks r = .45 2b Education r = .42 Business r = .32 Other r = .62 2c Certification r = .59 Undergrad r = .35 Grad r = .47	design of the included studies not reported outcome concerns perceived learning	C

21 Steele (2014)	non-randomised controlled study n = 171 (?)	university students	1 There was a significant increase in participation in the online classrooms that used KWLs*. * KWL is a classroom assessment technique (CAT) to gain an understanding of students' perspectives regarding thinking and learning (K – 'what we know'; W – 'what we want to know'; L – 'what we learned').	not reported	sample size unclear	C
22 Steele (2018)	RCT n = 79 (31 exp, 46 control)	first-year undergraduate students at a university in the southwest	1 Quantitative analysis did not confirm differences in student engagement and perception of usefulness of audio lectures between experimental (personalised audio lecture) and control group (standardised audio lecture). [However, qualitative data indicated higher satisfaction, connection, and engagement by students listening to personalised audio lecture.]	ns	no serious limitation	A
23 Wei et al (2012)	cross-sectional study n = 522	learners from 3 schools in Taiwan	1 User interface* had a positive effect on learners' perceived social presence* in online classrooms (H1). 2 User interface had a positive effect on learners' perceived social cues** in online classrooms (H2). 3 Social cues had a positive effect on learners' perceived social presence in online classrooms (H3). 4 Perceived social presence had a positive effect on learners' learning interaction in online classrooms (H4). 5 Learning interaction had a positive effect on learners' perception of their learning performance in online classrooms. * User interface – learners' perception about the learning system's ease of use, naturalness, ease of understanding, and helpfulness in online classrooms. ** Social presence – degree of feeling, perception and reaction of being connected to other intellectual entities in online classrooms. *** Social cues – learners' perception of the richness of social cues in online classrooms (verbal – for example, words, or non-verbal – for example, facial expressions, gestures, light, volume, tones, signs).	1: β = .32 2: β = .46 3: β = .51 4: β = .78 5: β = .63	sample unclear	D

24 Woldeab et al (2020)	systematic review, includes controlled and experimental studies k = 69	n/a	1 Findings showed no significant difference between onsite and online courses. 2 The review affirmed that the most important aspects when considering online education are the course design and delivery – specifically, through greater alignment between technology and pedagogy.	ns	no serious limitations	AA

Excluded studies – initial search

Author & year	Reason for exclusion
1 Chadha (2019)	Study evaluates peer deliberations on a collaborative website (asynchronous learning) for students enrolled in an American politics course at two institutions. The sections 'Method' and 'Results' are underdeveloped.
2 Espasa (2010)	Study focuses on asynchronous interaction environment between teacher and student.
3 Fanguy (2018)	Study focuses on the relationship between students' motivation and the likelihood that students engage in lecture behaviours in general; it doesn't provide insights on effective virtual classroom teaching.
4 Gayman (2020)	Study focuses on asynchronous online learning format.
5 Jones (2011)	Paper describes and analyses two online legal environment courses to determine whether the instructor successfully used technology to create an effective online teaching and learning environment. However, the author does not provide any empirical analysis of the data (only discusses the results of the evaluation survey completed by the students).
6 Martin (2017)	Scoping review, no findings regarding effect or impact of IVs are reported.
7 Park (2015)	Study focuses mainly on qualitative analysis; the quantitative data is scarce and insufficient to draw conclusions about group differences.
8 Ruthotto (2020)	Study examines how demographic differences affect participation of graduate students in online-only classrooms; it doesn't provide insights on effective virtual classroom teaching.
9 Wong (2019)	No general/synthesised findings regarding the effect of SRL are presented, only findings from individual studies.
10 Zhang (2020)	Study describes survey data on students' perceptions of quality online instruction. However, the study doesn't analyse how these may affect outcomes relevant in the online learning context.

Data extraction table – additional search

Author & year	Design & sample size	Sector/population	Main findings	Effect sizes	Limitations	Level
1 Belland et al (2017)	Bayesian network meta-analysis of controlled and pre–post studies k = 56	mixed	1 The pre–post gains are consistently positive and substantial across educational populations (primary/K–5, middle level/6–8, secondary/9–12, college/vocational/technical, and graduate/professional, adult). 2 A strong effect was found when scaffolding was used with most problem-centred instructional models.	1 primary g = .74 middle g = .48 secondary g = .22 college g = 1.16 graduate g = 1.20 2 project-based learn. g = 1.21 problem-solving g = .86 inquiry-based learning g = 0 problem-based learn. g = .61 design-based learn g = .78	wide confidence intervals sample size for some outcomes rather small concerns computer-based scaffolding	A
2 Belland (2017-II)	meta-analysis of RCTs k = 144	mixed	1 Computer-based scaffolding showed a consistently positive effect on cognitive outcomes across various contexts of use, scaffolding characteristics, and levels of assessment. 2 Scaffolding's influence was greatest when measured at the principles level and among adult learners.	1 g = .46 2 g = .86	concerns computer-based scaffolding	AA
3 Cook (2013)	meta-analysis of controlled and pre–post studies k = 41	medical education	1 Mastery SBME was associated with large effects on skills and moderate effects on patient outcomes. 2 Pre-training and additional practice improved outcomes but took longer.	1 skills g = 1.29 patient outcomes g = .73	concerns mastery learning simulation-based medical education	A
4 Eisenkraemer (2013)	systematic review k = 31	mixed	1 Results demonstrated that tests can be remarkably beneficial to the retention of long-term memories.	not reported	narrative synthesis, no quantitative findings are reported	C

5 Grunwald and Corsbie-Massay (2006)	literature review of mainly RCTs k = ?	medical education	1 Techniques common to existing multimedia learning tools often neglect to account for theories of cognitive load and may be detrimental to the learning process.	not reported	number included studies not reported very limited reporting of review process narrative synthesis of findings	B
6 Hutchins et al (2013)	meta-analysis of controlled studies k = 31	US Army	1 Both training wheels (eg worked examples) and scaffolding demonstrated positive transfer as training strategies and reduce intrinsic cognitive load.	training wheels > 30% transfer advantage, g = .21 scaffolding > 60% transfer advantage, g = .46	main effect size reported concerns transfer ratio (TR) concerns error prevention training strategies note: lockouts failed to demonstrate the clear benefit of worked examples, but lockouts were not a common form of error prevention in the literature examined	A
7 Kim (2018)	Bayesian meta-analysis of controlled studies k = 21	mixed	1 Computer-based scaffolding significantly impacted cognitive outcomes in problem-based learning. 2 The effect size was largest for metacognitive scaffolding, followed by strategic and conceptual scaffolding. 3 The effect size for expert modelling and feedback approached a middle level.	1 g = .39 2 meta cogn g = .38 strategic g = .35 conceptual g = .13 3 expert mod g = .52 feedback g = .47 hints g = .38 multi-forms g = .34	concerns computer-based scaffolding in problem-based learning for STEM education	A
8 Kim (2020)	meta-analysis of controlled and experimental studies k = 145	mixed	1 CBS leads to positive cognitive learning effects when students solve problems individually, as well as working in pairs, triads, and small groups. 2 Moderator analyses indicated that effect sizes are higher when students worked in pairs than when they worked in triads, small groups, or individually.	1 overall g = .46 2 individual g = .47 pair group g = .59 triad group g = .41 small group g = .34	concerns computer-based scaffolding in problem-based learning for STEM education	AA
9 Lei (2018)	meta-analysis of correlational studies k = 69	mixed	1 Results showed a moderately strong and positive correlation between overall student engagement and academic achievement. 2 Analysis of the domains of behavioural, emotional, and cognitive engagement showed that almost all had a positive correlation with students' academic achievement.	1 r = .27 2 behavioural r = .35 emotional r = .22 cognitive r= .25	no serious limitations	C

10 Mesmer-Magnus (2007)	meta-analysis, includes controlled and pre–post studies k = 61		1 Trainees provided with a pre-training goal (whether mastery or performance) had greater learning performance than trainees not provided with a pre-training goal. 2 Performance-oriented goals facilitated better performance on measures of declarative knowledge (a), whereas mastery-oriented goals yielded greater learning on higher levels of cognitive learning (b) and for all levels of skill-based learning (c).	1 ρ = .22 2a ρ = .25 vs. ρ = .15 2b ρ = .29 vs. ρ = .22 2c ρ = .26 vs. ρ = .42	no serious limitations	A
11 Rowland (2014)	meta-analysis of controlled studies k = 61	mixed, mostly undergraduate students	1 Results indicate support for the role of effortful processing as a contributor to the testing effect, with initial recall tests yielding larger testing benefits than recognition tests.	1 overall effect g = .50 cued recall g = .61 free recall g = .29 recognition g = .29	no serious limitations	A
12 Schwieren (2017)	meta-analysis of controlled pre–post studies k = 19	psychology students	1 Results demonstrated that testing was beneficial to the learning outcomes.	d = .54	no serious limitations	A
13 Stockard et al (2018)	meta-analysis, includes controlled and longitudinal studies k = 328	mixed, mostly K12	1 Positive effects were reported for reading, maths, language, spelling, and other academic subjects.	overall effect: d = .54	most included studies involved reading, maths, language, and spelling	A
14 Timmerman and Kruepke (2006)	meta-analysis k = 118	graduate and undergraduate students	1 Analyses of media richness constructs indicate that computer-assisted instruction increases performance when delivered with an audio channel.	1 text r = .14 graphics r = .12 audio r = .26 video r = .07	design of the included studies not reported	C

Excluded studies – additional search

Author & year	Reason for exclusion
1 Baddeley (1992)	Essay on the concept of working memory, not an empirical study, 30 years old.
2 Burns (2020)	Primary study.
3 Bowman (2014)	Examines effects of peer tutoring on social and behavioural outcomes for children in pre-kindergarten through grade 12.
4 Chen et al (2014)	Overview of cognitive load theory, not an empirical study.
5 Fauville (2021)	Concerns the validation of the Zoom Exhaustion and Fatigue Scale; however, the context concerns video-conferencing rather than teaching/learning.
6 Ferran (2008)	Examines how people process information differently when it is delivered via video-conference rather than when it is delivered face-to face (people in video-conferences tend to be more influenced by heuristic cues – such as how likeable they perceive the speaker to be – than by the quality of the arguments presented by the speaker). The context, however, is video-conferencing rather than teaching/learning.
7 Gerjets (2004)	Narrative summary of five studies that indicate that processing modular examples is associated with a lower degree of intrinsic cognitive load and, thus, improves learning.
8 Grunwald (2006)	Narrative summary of research findings on the effectiveness of multimedia learning tools.
9 Halabi (2005)	Primary study.
10 Hepplestone (2011)	Traditional, narrative literature review, no quantitative findings are reported.
11 Iwata (2014)	Primary study.
12 Kirschner (2021)	Reviews 16 contributions to a special issue entitled *Current Research in Cognitive Load Theory*. Each paper is briefly summarised and some critical comments made.
13 Martin (2015)	Systematic review on measuring cognitive load, narrative summary of findings.

14 Mutlu-Bayraktar (2019)	Systematic review of 94 studies, mainly descriptive, no information regarding effect or impact is provided.
15 Noe (2010)	Conceptual paper.
16 Schroeder (2020)	Explorative systematic review examining why the spatial split-attention principle (presenting related words and pictures spatially close to one another will improve learning compared with a spatially distant design) occurs.
17 Senko (2017)	Examines whether students' motivation affects the outcome of different types of goals (in particular 'demonstrating competence' goals vs 'outperforming peers' goals). Findings remain unclear, in particular whether the type of goals concerns mastery goals vs performance goals and how student motivation was measured/coded.
18 Shepherd and Martz (2006)	Outcome measure is students' satisfaction.
19 Vogel (2017)	Concerns socio-cognitive scaffolding to enhance computer-supported collaborative learning.
20 Xie (2017)	Concerns the impact of cueing on cognitive load in multimedia learning. The term cueing refers to the non-content information (for example, arrows, colour-coding, highlighting) added in learning materials to attract learners' attention.
21 Zepke (2010)	Narrative review, mainly a conceptual paper, no effect sizes are reported.

CIPD

Chartered Institute of Personnel and Development
151 The Broadway London SW19 1JQ United Kingdom
T +44 (0)20 8612 6200 **F** +44 (0)20 8612 6201
E cipd@cipd.co.uk **W** cipd.co.uk

Incorporated by Royal Charter
Registered as a charity in England and Wales (1079797)
and Scotland (SC045154)

Issued: October 2021 Reference: 8179

CEBMa
center for
Evidence-Based Management