



Metacognition design framework to aid metacognitive skill development in university students supported by the virtual learning environment

Emma J. O'Neill¹ · Crystal Fulton² · James Matthews³ · Carmel Hensey⁴

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Abstract

Metacognitive skills are key transversal skills, strongly linked to academic achievement and essential for effective lifelong learning. They are widely recognized to underpin many of the core competencies required for effective social and professional participation, including core competencies such as critical thinking, problem-solving, and self-awareness, highlighted by United Nations Educational, Scientific and Cultural Organization (UNESCO) as key to Education for Sustainable Development. Digital learning technologies and virtual learning environments increasingly form a core strategic dimension of teaching and learning within Higher Education, however effectively harnessing them to enhance student learning remains challenging. This paper presents the Metacognition Design Framework, an evidence-based learning design that scaffolds the development of metacognitive skills in students through blended learning. It draws on the tools available within the virtual learning environment to provide a unique, and potentially powerful, opportunity to extend 'metacognitive influence' on student activity and learning outside standard class times with realistic levels of staff input. The design provides clarity for planning accessible learning interventions, their linkage with appropriate technology, and for guiding how face-to-face and online, or fully online, components interrelate. It also delivers an effective conduit to convey information in a practical format that readily permits adaptation to local contexts. Overall, it offers a practical way to re-frame educators as designers, increasing educator design capacity and the effective deployment of technology to enhance learning, at the same time targeting a learning outcome with high potential impact.

Keywords Technology supported learning · Learning design · Higher education · Transversal skills · Blended learning · Education for sustainable development

✉ Emma J. O'Neill
emma.oneill@ucd.ie

¹ School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland

² School of Information & Communication Studies, University College Dublin, Belfield, Dublin 4, Ireland

³ School of Public Health, Physiotherapy, & Sports Science, University College Dublin, Belfield, Dublin 4, Ireland

⁴ School of Biomolecular & Biomedical Science, University College Dublin, Belfield, Dublin 4, Ireland

Background

Academic program design and structures should promote strategies that arm graduates with the attributes required for full future professional and social participation (Hill et al., 2016). Sustainable development, and achievement of the 17 United Nations sustainable development goals (SDGs) by 2030, is an international priority (UN 2015), with Quality Education (SDG 4), seen as a powerful means to achieving the other 16 SDGs (UNESCO, 2017). Education for Sustainable Development, underpinned by eight core competencies; critical thinking, integrative problem-solving, strategic, collaborative, self-awareness, anticipatory, normative, and systems thinking, is key to achieving a quality education and transforming society (UNESCO, 2017). Metacognition, popularly dubbed ‘thinking about thinking,’ is crucial for developing these core competencies (Bohm et al., 2024), enabling students to strategize, self-assess and self-regulate as they learn, unlearn, and relearn (Tanner, 2012), honing their approach for effective lifelong learning (UNESCO, 2023a).

Metacognition, a term credited to the psychologist, Flavell, who referred to, “one’s knowledge concerning one’s own cognitive processes or anything related to them” (Flavell, 1976), is widely accepted to be a powerful predictor of learning (Veenman et al., 2006), and is strongly linked to academic performance (Ohtani & Hisasaka, 2018; Wang et al., 1990). There are various perspectives on the different components of metacognition (Efklides, 2006; Nelson & Narens, 1990; Schraw, 1998; Veenman et al., 2006), however most people recognize both knowledge and regulatory components. Metacognitive knowledge reflects what learners know about cognition and their own learning, including knowledge about learning and learning strategies, knowing how and when to use them, and why they might be helpful (Efklides, 2008; Schraw, 1998). Regulation of cognition refers to applied aspects; the application of strategies such as planning, monitoring and regulation of learning with troubleshooting and adjustments based on self-assessment of progress and success (Schraw et al., 2006). These components are thought to be interdependent, with knowledge of cognition required for effective regulation but very much informed and refined by the active use of regulatory strategies (Pressley & Harris, 2008). Efklides’ multi-level model includes additional components such as self-awareness, affective elements, and social influences; all crucial for effective self-regulation (Efklides, 2008; Kim et al., 2013).

This has important implications for teaching. Firstly, students require sufficient cognitive knowledge to start effectively applying their regulatory knowledge (Alexander & Judy, 1988), with refinement of both occurring concurrently as they progress; all requiring effective scaffolding or guidance (Azevedo & Hadwin, 2005). Secondly, students are far more likely to develop metacognitive knowledge and skills if they are provided with opportunities to actively apply them in the appropriate settings (Tanner, 2012). It is debated whether metacognitive skills are broadly applicable across disciplines or are more subject-specific. It likely involves both; some skills are general, while others are specific to certain settings (Schraw, 1998). Initially, students gain metacognitive skills specific to particular contexts, but as they learn more, they refine these skills and apply them more broadly (Gutierrez et al., 2016; Neuenhaus et al., 2011; Schraw & Moshman, 1995). This perspective supports the integration of metacognitive skill teaching with subject-specific instruction rather than as a separate entity.

Many students enter university with limited metacognitive knowledge and skills, (Bjork et al., 2013; Pintrich, 2002), especially lower-achieving students (Isaacson & Fujita, 2006; Kavousi et al., 2020), or those struggling with a fragmented knowledge base (Tuononen et al., 2023). Students require effective metacognitive skills to correctly assess their overall

understanding of their learning (Kruger & Dunning, 1999) and to regulate their learning, through the setting and modification of goals, plans, and approaches (Melissa Ng Lee Yen, 2020). Effective metacognitive skills help students assess and regulate their learning, but those lacking these skills struggle to accurately judge their knowledge (Mathabathe & Potgieter, 2014) and overall performance (Kruger & Dunning, 1999). This has huge implications for student success, both within and outside the classroom (Anthonysamy et al., 2020) and beyond in their future careers (UNESCO, 2023a). In view of this, metacognitive skills become a valuable target for educational programs, with the potential to significantly impact learning; a target that research suggests can be effectively nurtured with appropriate teaching methods (Donker et al., 2014; Gutierrez de Blume, 2022).

The use of technology in higher education is increasingly ubiquitous and has huge potential to innovate and transform educational practice if utilized effectively (Lai & Bower, 2020). However, what became apparent as the COVID pandemic fast-tracked technology usage in education, is that technology is not a panacea for the challenges faced by higher education (Tight, 2024); there is considerable complexity in the relationship between the two that requires both recognition and further exploration (Elen & Depaepe, 2025). What is clear is that whilst technology has a very important and valuable role to play in the transformative changes required within education, supported by appropriate global policies, it is 'the tool' and not 'the solution' (UNESCO, 2023b). Technology itself cannot be the agent of change (Salomon, 2002). Social and human dimensions are at the core of education, and if the prevailing context imposed by these influences remains unchanged then adding technology will not transform educational approaches (Elen & Depaepe, 2025). This has important implications when considering the challenges and barriers to technology adoption and is considered further below. One of the technologies in widespread use are Virtual Learning Environments (VLEs) or Learning Management Systems (LMSs) (Turnbull et al., 2022). VLEs and LMSs are software-based platforms designed to support the online delivery, management, and interactivity of educational / training courses. Although there are nuanced differences, the two terms are often used interchangeably by educators (Williams, 2022). The term VLE is used in this paper, referring to an interactive software system that supports delivery of blended learning.

Blended learning, defined by (Garrison & Kanuka, 2004) as "the thoughtful integration of classroom face-to-face learning with online learning experiences" (p.96), has gained considerable popularity over recent years (Rasheed et al., 2020). This reflects a variety of factors, including the huge potential it affords by combining the positive features from both traditional and online approaches (Anthony et al., 2022) and the impact of the COVID Pandemic (Cobo-Rendón et al., 2022). This wide and varied uptake of blended learning has led to considerable ambiguity in use of the term, and how it is defined (Hrastinski, 2019; Sareen & Mandal, 2024). For the purposes of this work, we have focused on Garrison and Kanuka's (2004) very widely cited definition that emphasizes the importance of meaningfully blending the approaches to improve the educational experience rather than definitions that focus on statements about the quantity of face-to-face or online content (Allen et al., 2016) or other more detailed conceptualizations (Hrastinski, 2019). Typically, in blended learning the blend involves synchronous learning delivery face-to-face combined with asynchronous delivery of online learning (Hrastinski, 2019). However, this is not always the case, with some educators seeking to achieve synchronous interactivity and online flexibility by blending online synchronous and asynchronous approaches (Heilporn et al., 2021). This had initially been termed by some as Blended Online Learning (Power, 2008), but is now increasingly referred to by a separate term, Bichronous online learning, its usage having become more prevalent during and since the COVID Pandemic (Martin

et al., 2023). The term blended learning will be used more flexibly in this paper, to include synchronous and asynchronous learning face-to-face and online, or purely online.

Blended learning affords considerable potential for enhancing student engagement through a variety of means, offering increased flexibility, self-paced learning, the provision of opportunities for collaboration, and generally involving students more actively in the learning process (De Bruijn-Smolters & Prinsen, 2024). Overall, it offers a powerful mechanism to support a social constructivist ethos with student-centered approaches (Hanafin & Land, 1997). However, research shows that students can struggle in virtual, technologically enhanced learning environments if inadequately supported, and generally do not deploy effective metacognitive strategies unless guided by using appropriate scaffolding (Land, 2000; Land & Jonassen, 2012). Thus, with the rise of technology-based blended approaches in education, it is important to explore how technology can be harnessed, and learning appropriately framed, to support deep learning and the development of metacognitive skills. This again highlights the considerable value metacognitive skills represent as an educational target.

The complexities of successfully harnessing VLE technologies for effective blended learning are extensive (Elen & Depaepe, 2025; Sareen & Mandal, 2024). This reflects the broad range of factors involved ranging from social, political, and economic, all on both micro and macro scales, through to the interplay between learner, technology, and educator (Chugh et al., 2023; Sareen & Mandal, 2024; UNESCO, 2023b). All these are then in turn superimposed on the educational goals and context of the learning, the design of the learning environment and tools, the competencies of both the learner and educator (Sareen & Mandal, 2024), and importantly their overall epistemology of learning (Tsai et al., 2013; Wang et al., 2021). The upshot of this is that there is far from a 'one size fits all' answer to creating effective blended learning strategies, although it is undoubtedly important to consider and learn from the available evidence about what 'works' (De Bruijn-Smolters & Prinsen, 2024; Hill & Smith, 2023) and where the major challenges lie (Sareen & Mandal, 2024).

In the face of such complexity, theoretical frameworks can contribute considerably to both the understanding and design of blended learning (Anthony et al., 2022; Elen & Depaepe, 2025). The Community of Inquiry framework (CoI) (Garrison et al., 1999) is very relevant in this context, having been very widely embraced in blended and online education (Yu & Li, 2022) as a mechanism to support the creation and maintenance of effective collaborative learning opportunities. This framework highlights the importance and interrelationship between teaching, social, and cognitive presences in creating these opportunities, and in turn the co-creation of knowledge. This approach was further developed by Garrison and Vaughan (2008) in their book, "Blended learning in higher education: Framework, principles, and guidelines," (Garrison & Vaughan, 2008) and has more recently been updated and adapted (Vaughan et al., 2023) to emphasize the importance of 'shared metacognition,' a construct described by Garrison and Akyol (2015). A conceptual framework exploring barriers to blended learning has recently been developed through a systematic literature review and analysis informed by the CoI (Sareen & Mandal, 2024). This model identified a broad range of challenges that impact implementation from a staff, student, and institutional perspective. Importantly, inadequate self-regulatory skills and passive approaches to learning were both highlighted as significant barriers for students. Other important barriers included training deficiencies in both staff and students, lack of institutional support and policies, and challenges with learning design encompassing planning, content choice, workload, and overall purpose (Sareen & Mandal, 2024). The lack of

multi-stakeholder and cross disciplinary perspectives within the literature were also noted and highlighted as important deficits.

Virtual Learning Environments provide a unique, and potentially powerful, opportunity to influence student learning outside standard class time with realistic levels of staff input (Daradoumis et al., 2013; Gikandi et al., 2011). A feature we considered offered a compelling mechanism to harness, for supporting and facilitating the development of student metacognitive skills. Here we present the work of an interdisciplinary team representing diverse third level faculty focused on the goal of transforming blended and online course delivery through research to support metacognitive skill development. This work coincided with the adoption of a new VLE by our university and an important aspect of this transformation was to ensure that it would not just serve as a repository for teaching material but would serve as conduit for effective learning and the development of metacognitive skills.

Research aims and research questions

The broad aim of the project was to explore use of the VLE to support metacognitive skill development in university students. The main research question was *What are the effects of VLE-supported interventions on the development of metacognitive skills in students?* The research team sought to inquire how metacognitive approaches supported by the VLE influenced student learning, and whether students perceived an impact on their learning.

Sub-questions posed were:

1. What impact do interventions in modules¹ have on student learning behaviors?
2. What, if any, influence do students perceive these learning interventions have on their learning?
3. What role might the VLE play in the process of developing metacognition?
4. How do staff perceive the utility of a metacognitive approach in learning design?
5. How do wider stakeholders perceive the metacognition design framework?

The sub-questions were designed to support a broad examination of the project implementation and results through capturing the perceptions of a wide range of stakeholders within the university. The questions were refined over the course of the project; for example, the framework sub-question was added as the project progressed.

This paper is one of two linked papers describing this project and its outcomes. This paper explores development of the Metacognition Design Framework, a mechanism for translating theory into practice, supporting pedagogically driven blended learning and VLE usage to aid metacognitive skill development in university students. The second paper, "Creating Opportunities for Metacognitive Development in University Education: Putting Learning Design into Action," (Fulton, Matthews, Hensey, O'Neill; In preparation), presents the outcomes in terms of experiences of using the framework and the impact on student learning viewed through the lenses of students, staff, and other key university stakeholders.

¹ A module is a 5-credit course taken during a 12-week trimester. Refers to 5 ECTS credits (European Credit Transfer and Accumulation System); 30 ECTS credits taken by full time students in each of the two annual trimesters.

Method

Study setting

This study took place within a large university in Ireland within the context of this institution recently transitioning to a new VLE, Brightspace (D2L Corporation, Canada). This provided an opportunity to reimagine how the VLE could be effectively leveraged to support student learning within the institution. The study authors were from diverse academic backgrounds (i.e., Information and Communication Studies, Pharmacology, Sport and Exercise Psychology, and Veterinary Medicine) with many collective years of teaching experience, ensuring consideration of the practicality, relevance, and applicability of the project across broad subject areas. Ethical approval was granted by the University Human Research Ethics Committee. The COVID 19 Pandemic occurred early in the second trimester of this study when case studies two and three were running, case study one ran prior to the onset of COVID.

Study participants

Participants from diverse programs in the university were invited to take part in the study. Overall, 221 undergraduate and postgraduate students were invited to participate in the project by virtue of their enrollment on the relevant modules and, of these, 114 (52%) students consented to participate in the study. Eighteen staff members participated in structured interviews or focus groups.

Research design and context

The project is situated within an Interpretivist paradigm (Willis, 2007), underpinned by the epistemology of social constructivism (Vygotsky, 1978), acknowledging the assumption that knowledge is socially constructed and context dependent (Guba & Lincoln, 1994; Willis, 2007). Our aim was to explore the potential for using the VLE to support metacognitive skill development in university students. The research project adopted an action research design to enable a practical, adaptable, and responsive way to explore this complex real-world challenge in context (Checkland & Holwell, 2007). The four authors participated in this process with the 'dual roles' of both researcher and participant (Checkland & Holwell, 2007), and the 'dual imperative' of both improving teaching practice, and generating and testing new knowledge (Lau, 1997; McKay & Marshall, 2001). The overall process was iterative and cyclical, with reflexive/dialogic, planning, acting, and observation phases (Dickens & Watkins, 1999) which, although inherently 'messy,' can be viewed to have been applied across the five main stages outlined below (Fig. 1). Within this overall process, the 'duality' of the 'problem-solving interest' and the 'research interest' was acknowledged to ensure the required outcomes for each were clearly addressed (McKay & Marshall, 2001).

The first stage comprised a problem identification phase to explore the full context of the problem and meaningful ways to approach it, aligned with our experiences as educators within our institution and our overall social constructivist epistemology of education. In the second stage, a literature review was conducted to provide insight about the existing metacognitive literature, and to identify core metacognitive themes to support metacognitive teaching and learning. The third stage explored mapping of these themes to appropriate learning interventions, and in turn a literature review of design frameworks, the latter

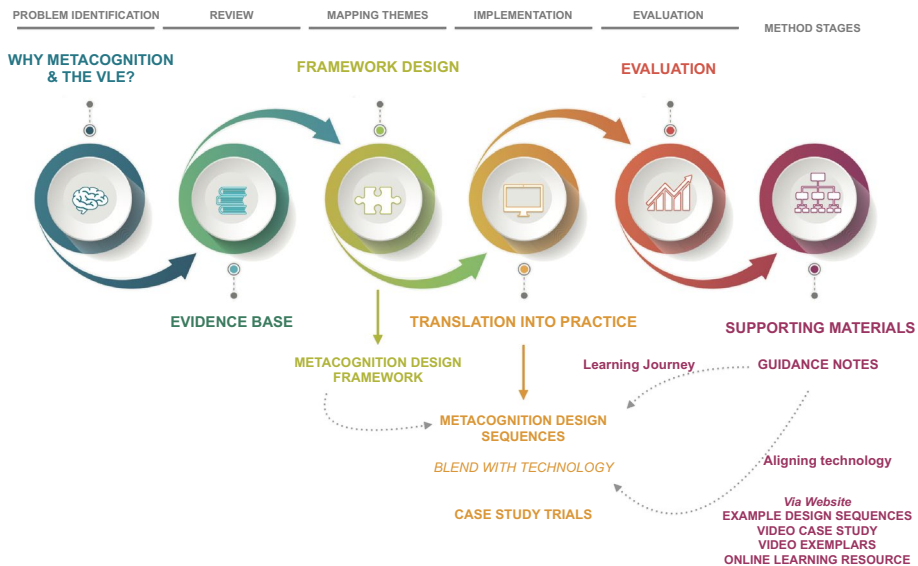


Fig. 1 Evolution of the metacognition design framework. Overview of the evolution of the Metacognition Design Framework showing how this relates to our methods (shown in grey at the top of the figure) and the overall paper structure. This graphic depicts a stepwise process; however, it should be noted that our action research approach was iterative and cyclical, with each phase informed by and building on the previous step through reflection and dialogue between the researchers, a ‘critical friend,’ experts in the field and key stakeholders, and practical trialing of our approaches. The supporting material section highlights the wide range of resources available to support and guide the application of our framework in practice (color figure online)

deemed an appropriate conduit to achieve this mapping goal. The fourth stage of the process entailed three separate case studies performed to trial the approach within our university setting. The final stage was a data analysis phase with final evaluation of the data and review of our learning and outputs.

A reflexive/dialogist component was core to this project, supported by regular discussion meetings between the researchers themselves, and regular presentations with discussion and feedback from a key university stakeholder group (detailed in the Acknowledgements section), incorporating external experts and several educators with expertise in learning design and VLEs. In addition, the group utilized regular meetings with a critical friend who had expertise in curriculum design and online learning; at each stage this person asked provocative questions of the study team, offered critiques of the work, and suggested alternative ideas to consider (Costa & Kallick, 1993; MacPhail et al., 2021). This whole format was designed to enhance the rigor and relevance of the work (Schuiling & Kiewiet, 2016) through challenging and questioning approaches, assumptions, and perspectives, all adding to its overall validity (Kvale, 1995).

Stage 1: problem identification phase

In January 2019, the researchers were brought together as part of a university education research fellowship program, charged with the overall remit of reimagining how a VLE could be effectively leveraged to support student learning. In seeking to understand the

context of the problem, the researchers examined and discussed their individual perspectives and motivations as educators that had been working within the university setting for many years. In addition, a wider perspective was gained through dialogue with colleagues and key university stakeholders. The dual development of both a practical plan and a linked research question stemmed from this original refinement phase. The phase resulted in identification of metacognitive skill development as a key area of interest.

Stage 2: review phase

Between March 2019 and June 2019, a review of literature on metacognition and educational approaches designed to support metacognitive skill development was conducted to identify and evaluate research on how to promote metacognitive learning. Study authors met on a regular basis to discuss the literature and synthesize key findings.

To examine the literature, each researcher explored the literature in their field for metacognitive educational approaches, the fields being Veterinary Medicine, Social Sciences, Health & Performance Science, and Science. In addition, the whole team examined literature published in Education databases for articles on the topic of metacognition in teaching and learning, particularly in a university environment.

Stage 3: mapping metacognitive themes to learning interventions

A core goal was to take an evidence-based approach, clearly identifying educational strategies known to support metacognitive skill development, and then to translate theory into practice, informing and developing pedagogically driven blended learning and VLE usage. After exploration of the literature, the development of a learning design framework was considered an effective strategy to achieve this. Firstly, the creation of a graphical representation of the learning interventions would provide clarity for planning, including the linkage with appropriate technology and guiding how the face-to-face and online components interrelate (Agostinho, 2011). Secondly, learning designs provide an effective conduit to share ideas and facilitate dialogue between educators around best practice, clearly conveying information in a practical format that readily permits adaptation and refinement relevant to the local context (Dalziel et al., 2016). A review of the literature on learning design frameworks, best practice in blended learning, and mechanisms for considering the integration of technology in learning, was performed to explore mechanisms for the practical translation of theory into practice. This phase culminated in the development of a learning design framework and design sequences that could then be trialed in practice.

Stage 4: implementation in three separate case studies

Three separate mixed methods case studies were performed in three diverse academic disciplines to explore the impact of applying learning interventions in practice, guided by our metacognition design framework. This case study approach aligned with our overall action research process, with one running in trimester one (September to December 2019) and the other two in trimester two (January to May 2020), and provided a powerful mechanism to gather varied, rich data, supporting our exploration of this topic in complex, real-world settings (Crowe et al., 2011). The case studies each examined the effects of redesigning a module guided by our metacognition framework, incorporating appropriate

learning strategies supported by the VLE. The selected modules were within Social Sciences, Health & Performance Science, and Veterinary Science, reflecting the taught disciplines of the study researchers.

The methods and approach to data collection for these case studies are described in more detail in our linked paper, “Creating Opportunities for Metacognitive Development in University Education: Putting Learning Design into Action” (In preparation), but is briefly outlined here for clarity as the papers are interlinked. The quantitative component of the study involved the completion of a pre- and post-intervention survey by student participants as they started and completed the modules. The core qualitative component of the studies comprised a series of focus groups and structured interviews with students and university staff, that explored their experiences of the learning approaches and their application in practice. The staff involved comprised those teaching the modules, including the researchers themselves, and key staff involved in relevant programs at School and College levels, including Directors and Vice Principals of Teaching and Learning, Deans, External Examiners, and Educational Technologists and Information Technology staff. The overall aim was to gain insight into their experiences of the process and perceptions of the impact on student learning. A final component of the qualitative data collection included evaluation of critical reflections on learning submitted by students as part of their participation in the modules. These integrated approaches provided methodological and data collection triangulation (Carter et al., 2014), which when added to the investigator triangulation, all increase the likely validity and reliability of the findings (Thurmond, 2001). This triangulation, in addition to reflexivity, and extensive feedback, also served as a mitigation strategy against any potential lack of researcher impartiality (Creswell & Poth, 2016).

Stage 5: data analysis and evaluation of the findings

Qualitative data from interviews and focus groups were digitally recorded and then transcribed. These data, qualitative survey questions, and student reflections were then coded and analyzed using NVivo software to explore metacognitive learning outcomes. Data were compared both within and across focus / interviewee groups to explore common and diverging views or participants. A constant comparative method entailing a combined approach of explicit coding and theoretical development was applied (Glaser, 1965). This process is reflective, with four stages (comparing incidents applicable to each category, integrating categories and their properties, delimiting the theory, and writing the theory) progressing linearly, but also reverting to previous stages continuously until completion (Glaser, 1965). Full details of the approach to data analysis for the case studies is provided in our linked paper, “Creating Opportunities for Metacognitive Development in University Education: Putting Learning Design into Action” (in preparation).

Stakeholder perceptions of use of our metacognition design framework were explored through these three case studies. In addition, having completed the case studies and related data analysis, the utility of the metacognition design framework was assessed against Bower and Vlachopoulos's (2018) criteria for analyzing technology-enhanced learning design frameworks. These criteria had built on the previous work of (Dalziel et al., 2016), with the dual purpose of both detailing a set of ‘explicit criteria’ to aid educators selecting learning design frameworks for use in their teaching and additionally providing an ‘analytical framework’ to aid researchers when creating and evaluating learning frameworks.

Results

Stage 1: problem identification phase

This process allowed identification of a shared motivation between the researchers and key university stakeholders to move away from VLE use purely as a repository and upload/download platform, towards its use to promote deep and critical learning in a blended environment. In addition, we aimed to improve student engagement in their overall approach to learning, progressing from fragmented learning of facts towards greater integration of concepts and critical problem-solving. With further refinement, metacognitive skills were identified as key skills on which to focus, due to their potential for significant educational impact, and in turn to explore ways in which the VLE and blended learning could be utilized to support their development.

Stage 2: review phase

Our literature review identified an extensive guidance report written for the Education Endowment Foundation (EEF, UK), an independent charity specializing in the practical application of educational research. This guidance report (Quigley et al., 2018) detailed practical recommendations for translating metacognition and self-regulated learning into practice in schools, based on information gained from their evidence synthesis on this topic (Muijs & Bokhove, 2020). Whilst designed for this environment, the approaches outlined align closely with models of metacognition and self-regulated learning used in higher education (Nicol & Macfarlane-Dick, 2006; Panadero, 2017; Winne & Hadwin, 1998). The EEF report detailed seven evidence-based recommendations to support the teaching of metacognitive skills in secondary-level education. Following our review of the published literature for university settings, we focused on five of the EEF recommendations (detailed in Table 1) specifically centered around teaching approaches:

1. Explicit teaching of metacognitive strategies
2. Modelling of metacognitive thinking
3. Setting the appropriate level of challenge
4. Promoting and developing metacognitive dialogue
5. Explicit teaching of management and organization of learning

Evidence to support these five recommendations drawn from the literature on tertiary education is presented here:

Considering the first, explicit teaching and training of students in the use of metacognitive strategies (theme 1), a systematic review has highlighted the positive effect of self-regulation training programs on university students' academic performance (Theobald, 2021). This effect was particularly strong where programs were underpinned by metacognitive theory. Evidence to support the modelling of metacognitive thinking by teachers in university settings (theme 2), is provided by a study which detailed how modelling of metacognitive thinking by a university teacher via "think aloud" was perceived by students as enhancing their learning experience (Wulfemeyer, 2019). Alongside the explicit teaching of metacognitive strategies and modelling of this type of thinking, the setting of an appropriate level of challenge for students is also required (theme 3). Deciding what constitutes

Table 1 Five evidence-based metacognitive themes that form the core of the metacognition design framework

Metacognitive themes	Examples of the types of learning approaches
Explicitly teach metacognitive strategies	Introduction and explanation Introduce strategies—plan, monitor, evaluate Activate prior knowledge Structured reflection
Model metacognitive thinking	Explain thought processes Model reflective practice Encourage linkage with prior knowledge Verbalize and explain out loud Scaffold tasks
Set appropriate level of challenge	Complex task Gradual build in complexity Avoid overloading cognitive processes—chunking
Promote and develop metacognitive dialogue	Group / class discussion Self-reflection Ensure purposeful dialogue—guided / example questions Guided peer assessment / self-assessment
Explicitly teach students management / organization of their own learning	Scaffold learning—guided progression to independent practice Formative feedback Quizzes Checklists

This table lists the five evidence-based metacognitive themes (adapted from Education Endowment Guidance report (Quigley et al., 2018)) that form the core of the metacognition design framework. Examples of the types of learning approaches that each encompasses are provided

an appropriate level of challenge is a critical question for educators. The application of cognitive load theory (Sweller, 1988), and more specifically considering the capacity of our working memory to process information, can provide some guidance in answering this question. Once again, there is evidence in university settings to support the use of strategies such as worked examples, and structured processing of information to help free capacity of working memory to deal with the challenge presented to students (Nückles et al., 2020). Promoting metacognitive talk in the classroom via dialogic teaching is also a recommended approach (theme 4). This form of teaching encourages teachers and students to collaborate in the generation and evaluation of knowledge (Burbules, 1993) and has relevance for promoting students' metacognitive skills. For example, one study in a university setting compared different forms of teaching and found that a dialogic approach facilitated increased use of skills such as planning, monitoring and evaluating (Hajhosseiny, 2012). Finally, encouraging students to develop skills to manage their learning independently is important (theme 5), and there is considerable evidence to support this recommendation within a university cohort. For example, a study using meta-learning tasks (i.e., tasks that promoted consideration of knowledge in the context of what students already know, and planning what they still needed to learn) found that students increased their use of self-regulatory strategies when studying, and that these meta-learning tasks were a useful tool to develop students' reflective and independent learning ability (Colthorpe et al., 2018).

Stage 3: mapping metacognitive themes to learning interventions

Having identified the core themes to support metacognitive teaching and learning, the overall aim of the researchers was to integrate these approaches within a blended learning environment, and to do so aligning with social constructivist principles. Since the effective use of blended learning was fundamental to how we would deliver these metacognitive themes to students, we needed a clear rationale for the choices made with respect to how we developed a framework to support this learning approach (McGee & Reis, 2012). Consequently, we chose the TPACK framework (Koehler & Mishra, 2009) to guide our decision making in this regard. This framework highlights this complex balance between technology, pedagogy and content knowledge and the requirement to consider the interaction between them to teach effectively with technology. Reference to both the Community of Inquiry (Garrison et al., 1999) and Conversational theoretical frameworks (Laurillard, 2002) allowed us to design ways to support a student-centered, social constructivist learning environment, deemed fundamental to promote meaningful student engagement and drive deep learning (Sivan, 1986). We were also aware that this approach would also support the social and environmental components of metacognitive development (Efklides, 2008; Kim et al., 2013).

Following the identification of metacognitive recommendations and the decision to apply them using a learning design framework, iterative discussions amongst the researcher group, probing discussions with a critical friend, and discussion with expert key stakeholder groups, explored proposed metacognitive recommendations, the design criteria for the framework, the initial draft of the framework with its themes, and potential challenges for its use. The main criteria were that the metacognitive themes should empower students for the twenty-first century, with a focus on how these skills could be developed and delivered across disciplines, the framework should be specifically aimed at educational technology and blended learning. Overall, the framework should be recognizable and useful for educational professionals in Higher Education, supporting them in improving their educational practice. Throughout this process the framework was refined and reviewed, resulting in a new practical framework to support metacognitive skill development.

The overall aim was to design a framework that integrated metacognitive approaches with subject-specific teaching, cognizant of the necessity for students to have opportunities to learn and practice the skills within relevant, authentic contexts (Ben-David & Zohar, 2009). This ensures they have relevant prior knowledge of both subject content and metacognitive knowledge prior to starting to apply them (Tarchi, 2015) and allows skill development within the relevant context before they progress and learn to transfer their skills more generally (Schraw & Moshman, 1995). Students working in this way learn by actively applying their approaches in a 'real' situation and are thus far more likely to be intrinsically motivated through increased appreciation of the skills' relevance to them (Lee & Hannafin, 2016).

Following consideration of our requirements for a learning design framework using the theoretical frameworks outlined above and engagement with the critical friend and expert stakeholder group, we chose Oliver & Herrington's approach to designing for technology integration (Oliver, 1999; Oliver & Herrington, 2003). They describe the use of more procedural learning design sequences to clearly map student-centered activities within the VLE, a broad approach that we thought could be adapted to meet our requirements. Their model, developed for a fully online environment, places the learner centrally within the learning process, and provides a mechanism to methodically map the activities and tasks

that will help them progress, highlighting the learning resources and supports available to help them. Our learning framework was heavily influenced by these learning design sequences. However, we built on and significantly adapted this approach as a practical way of translating the five metacognitive themes into blended practice within higher education. We extended Oliver and Herrington online *task*, *resources* and *supports* classification to provide a coherent way to frame blended learning in our model, providing clarity around the linkages between the online, face-to-face, synchronous, and asynchronous components.

Metacognition design framework

Overview

The student's learning journey, comprising activities and tasks, is centrally placed within the Metacognition Design Framework (Fig. 2), constructively aligned with the learning outcomes (Biggs, 1996). The core student activities include an authentic, complex project or assignment, focused on a challenging problem of core relevance to their field of study (Herrington, 2005), and a critical reflection on learning. The latter is included in recognition of the key linkage of reflection to metacognitive development (Kavousi et al., 2020; Rhem, 2013). The *learning resources* and *learning supports* available to aid students in effectively completing their learning activities, and successfully achieving their learning outcomes, are depicted aligned to this central pathway (left and right respectively). The delivery method (online / face-to-face; asynchronous / synchronous) of individual components is indicated by their spatial arrangement on the framework. The colors of elements within the framework broadly indicate how they map to the five metacognitive themes, although it should be noted that several fulfil multiple functions. The overall approach provides student-centered learning, grounded in social constructivism and constructionism (Ackermann, 2001), with a strong emphasis placed on collaboration (Laurillard, 2009) and dialogue around learning (Hajhosseiny, 2012), group discussion and the creation of artefacts for sharing (Papert, 1993). Key to the overall approach is the modelling of metacognitive thinking relevant to the discipline or professional practice (Vaughan et al., 2013), the discussion of strategy usage and, the provision of opportunities to try out and practice approaches using scaffolded learning tasks that gradually build in complexity (Azevedo & Hadwin, 2005). This holistic approach targeting multiple aspects of metacognition (knowledge, regulation, and social components) was selected as it is likely to have a greater impact on learning (Muijs & Bokhove, 2020; Perry et al., 2012). Our framework also aligns with the three core principles of universal design for learning (multiple means of engagement, representation, action / expression) (CAST, 2024), helping to ensure accessibility of the learning resources created and supporting learning opportunities for diverse groups of learners.

'I-SEE' learning strategies

To aid clarity, we broadly grouped the learning resources and supports outlined within the Metacognition Design Framework into four overarching 'I-SEE' learning strategies, designed to support metacognitive development as the student progresses on their learning journey, actively completing individual and collaborative learning activities. In brief, these

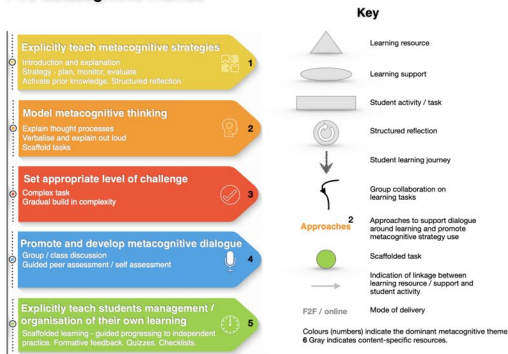
Fig. 2 Metacognition design framework showing the 'I-SEE' strategies for learning. This figure shows the five evidence-based metacognitive themes that form the core of the Metacognition Design Framework (key below figure). This learning design framework was developed by mapping learning approaches aligned to the five metacognition themes (coded by colour), building on and adapting the task, resources, and supports classification developed by Oliver (1999); Oliver and Harrington (2003). It shows the student learning activities / tasks (rectangles) to be completed as the student progress on their learning journey towards attainment of the learning outcomes. Learning resources (triangles) and supports (ellipses) available to aid them as they progress are shown to the left and right respectively. These resources / supports are available either online or face-to-face (F2F; this can also be substituted for synchronous online), as depicted by their location (left / right) on the framework. The colours broadly depict linkage to the five metacognitive themes, although many items target more than one of theme. Reflection on learning (circle with arrows) is a core student activity, introduced and developed through discussion and feedback, all designed to promote dialogue around learning. Other approaches to support dialogue around learning and promote metacognitive strategy use are indicated in orange text. Group collaboration on learning tasks is also a core part of the learning journey with all learning supported by the appropriate scaffolding of tasks. The resources and supports can be broadly grouped into themes; Introducing, Signposting, Enabling, and Evaluating; the 'I-SEE' strategies for learning occupying the four quadrants of the framework. These overarching strategies are depicted as interlinking parts of a cog, symbolising that, whilst Introducing and Signposting strategies are presented first initially, with Enabling and Evaluating occurring next, all become recursive elements integrated throughout the learning journey and applied within multiple learning elements over time. The overall result is an iterative process that scaffolds student learning and the development of metacognitive skills as they progress towards achievement of their learning outcomes (color figure online)

strategies, predominantly delivered asynchronously online using the VLE, are outlined as follows:

- *Introducing* metacognition through resources (for example, YouTube videos or weblinks) and teaching centered around metacognition and metacognitive strategies, starts the process by aiding the development of metacognitive knowledge. This also allows students to gain insight into the importance of metacognitive skills for effective learning (Tanner, 2012). The concurrent aim is to help students to develop well-structured subject knowledge, integrating new knowledge with prior knowledge (Tarchi, 2015), and targeting core and threshold concepts (Barradell, 2013). Linking this to active discussion of important concepts such as growth mindset and SOLO or Bloom's taxonomy when introducing learning approaches, aligns with self-determination theory (Ryan & Deci, 2000) enhancing motivation, encouraging self-esteem and creating an awareness that they can improve (Bloom, 1973) if they actively engage with learning tasks and reflect on their approaches (Lee & Hannafin, 2016).
- *Signposting* (for example, guidance documents, e-mails or announcements, rubrics, exemplars) provides clarity to students as they progress through the learning tasks, and communicates to them the expectations and requirements for completing these to a high standard (Chickering & Ehrmann, 1996; Chickering & Gamson, 1987).
- *Enabling* the students to plan, monitor, and assess their learning (for example, quizzes, checklists, and reusable learning objects) is essential for them to develop metacognitive regulatory skills and requires the provision of appropriate opportunities for them to practice theses in context as they learn (Schraw & Moshman, 1995). They also require opportunities for developing shared understanding of their subject-specific and metacognitive knowledge (Garrison & Akyol, 2015) through discussion (synchronous and / or asynchronous), modeling of metacognitive thinking (for example, educator modeling, reflective questions), and practiced and refined application through learning activities.



Five Metacognitive Themes



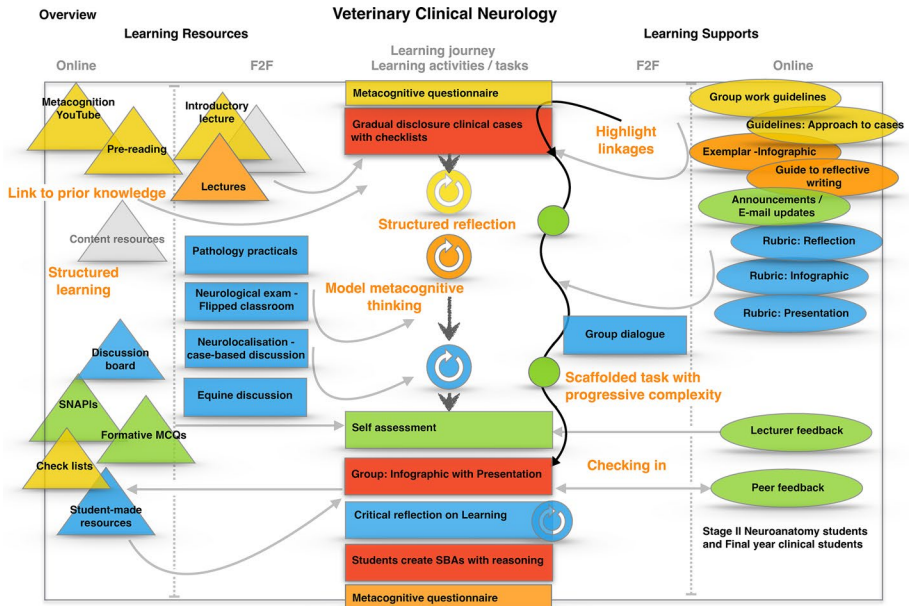
- Evaluating** their work guided by feedback delivered in a variety of formats (for example, automated formative feedback, peer and educator feedback) is key to allowing students to learn to accurately assess their progress (Kruger & Dunning, 1999), troubleshoot, and adjust their approaches accordingly (Nietfeld & Schraw, 2002). This overall approach incorporates all seven of the principles of good feedback practice (Nicol & Macfarlane-Dick, 2006).

Fig. 3 Metacognition design sequences developed for the case studies guided by the metacognition design framework. These examples all show a whole module summarised in one image. They can be also used to create a series of images depicting the module in a more granular way over several sections (for examples of this please refer to our open access Learning Resource). The metacognitive questionnaire listed in the learning journey refers to the pre- and post-module survey administered to students as they participated in the module. This survey comprised the Metacognitive Awareness Inventory (MAI), composed of eight subscales designed to allow students to self-evaluate their awareness of both their metacognitive knowledge and regulation (Schraw & Dennison, 1994), and the self-efficacy for learning subscale from the Motivation for Learning Questionnaire (Paul R Pintrich & De Groot, 1990). The questionnaires were included to gather data for our case studies but also functioned to encourage students to start considering their learning.

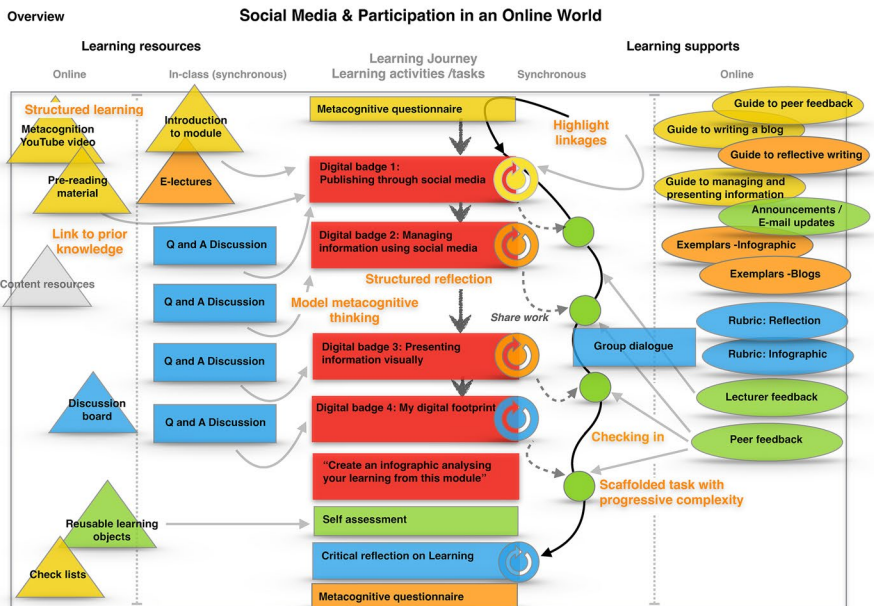
a Example from veterinary medicine: veterinary clinical neurology. Stage 3 postgraduate and stage 4 undergraduate students on Bachelor of Veterinary Medicine (MVB) program enrolled on this normally face-to-face module, Veterinary Clinical Neurology, which was redesigned as a blended module. They participated in group work, peer- and self-assessment, and reflective practice. Students within Stages 2 & 5 of the MVB program aided the peer review process which centred around presentations of Infographics made during group work centred around gradual release clinical cases. **b** Example from Social Sciences: “DigiLife: Social Media & Participation in an Online World.” Stage 2 students from across the Bachelor of Social Sciences program enrolled for a newly designed module, “DigiLife: Social Media & Participation in an Online World.” They participated in a series of digitally badged social media activities, involving use of social media tools and analysis of issues relating to social media. Students submitted reflections on their acquired learning and used video peer review to deepen their reflections. A VLE checklist tool facilitated students’ self-assessment of their learning. Additional tools aided communication. This module was designed to run fully online and took place during the COVID-19 pandemic. **c** Example from sports sciences: psychology of sport and health 2. Stage 2 students on the BSc in Health & Performance Science enrolled in this normally face-to-face module, redesigned as a blended module. The module transitioned to fully on-line during the COVID-19 pandemic (color figure online)

Throughout the whole learning process, students are encouraged to consider their learning through structured reflection, working towards an overall critical reflection on their learning (Rhem, 2013). The promotion of ongoing dialogue around learning (Laurillard, 2009), facilitated both synchronously within class and asynchronously outside class using the VLE, cultivates ‘visible learning;’ educators “SEE learning through the eyes of their students” and “students SEE themselves as their own teachers” (Hattie & Yates, 2013). Group work and peer-peer interaction, discussion, and feedback are all key components of the framework, with the VLE acting a conduit to facilitate this process and providing the an opportunity to influence student learning behavior outside standard class time (Garrison et al., 1999). The learning community developed should foster ‘open communication and trust,’ nurturing mutual respect and a collective responsibility for learning (Vaughan et al., 2013).

The ‘I-SEE’ learning strategies, *Introducing*, *Signposting*, *Enabling* and *Evaluating* are shown within the four quadrants of the Metacognition Design Framework (Fig. 2). Whilst presented sequentially for clarity, it should be appreciated that these strategies are applied collectively as recursive elements within a variety of learning approaches that all integrate and collectively facilitate the scaffolded progression of student learning. The whole process being iterative and ongoing as the module or learning unit progresses. In view of this, within the framework they are presented as quadrants of a jigsaw cog to symbolize the interrelation they have with each other. This is conceptualized as a cyclical process, facilitating the progression of student learning scaffolded by these broad learning approaches.



(a)



(b)

Application in practice

Creation of metacognition design sequences for application in practice

The Metacognition Design Framework was designed as a conceptual framework to depict the student's learning journey and learning approaches within a generic learning module. This generic 'blueprint' provides a practical guide for the creation of more procedural Metacognition Design Sequences, specific to a particular educational setting. Whilst designed for application within a module, it has the flexibility to allow adaptation to frame smaller elements or broad programmatic approaches. Examples of Metacognition Design Sequences developed for three different modules within our institution, and all successfully trialed with students ("Creating Opportunities for Metacognitive Development in University Education: Putting Learning Design into Action" In preparation) are shown in Fig. 3. The spatial arrangement of the elements on the design sequences facilitates planning, aiding consideration of the timing and linkage of face-to-face and online learning activities as a module or learning unit is developed. They can also be used to provide clarity in the form of a map for students as they approach their learning. The overall aim is that the Metacognition Design Framework provides a platform to support educators as designers, enabling them to adapt the approach and create bespoke, procedural learning design sequences suited to their own specific setting.

Guidance notes for creating Metacognition Design Sequences are provided in online Appendix 1, which provides a detailed explanation of how to plan a Learning Journey and apply the 'I-SEE' learning strategies.

Blending the learning approaches with technology

The second component required for practical application involves translation of the learning approaches and requirements, depicted by Metacognition Design Sequences, into

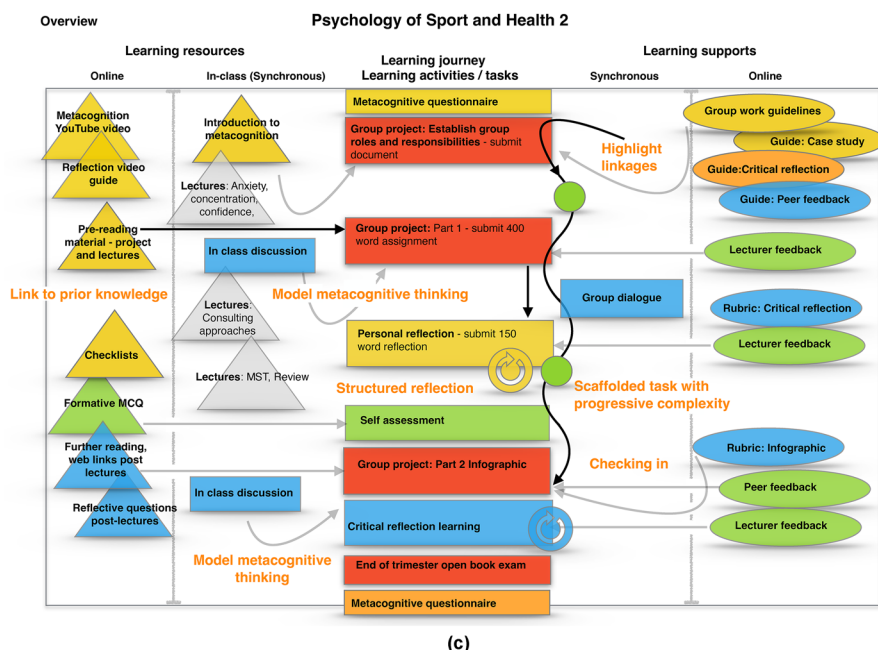


Fig. 3 (continued)

a coherent plan involving the VLE. This necessitates consideration of the affordance requirements for each learning task, including the specific requirements and abilities of both the students and staff, and how these can be aligned to specific technology or learning approaches, based on the functional affordances each has to offer. Whilst this type of affordance analysis was developed for guiding technology choices (Bower, 2008) it can be broadly considered in relation to any mechanism of learning facilitation (for example, a face-to-face class is one option for supporting synchronous discussion), allowing the educator to methodically plan a holistic, accessible approach to blended learning. The overall focus is on the 'Learning Journey' through the module / learning unit within the VLE, considered from both student- and staff-facing perspectives, and how this asynchronous learning with technology interfaces coherently with synchronous face-to-face or online components of the module, as mapped out and depicted by the Metacognition Design Sequences.

Online Appendix 2 explores the alignment of technology with the 'I-SEE' learning strategies, considered through the lens of affordances in relation to staff / student requirements and abilities. It provides a mechanism to consider the 'tripartite relationship between learner-tool-teacher' and recognize the importance of agency both from student and staff perspectives (Elen & Depaepe, 2025).

Overall, this flexible and adaptable approach (Laurillard, 2013), along with the provision of guidance advice and graphical representations, have been suggested as key mechanisms to support use of learning designs by educators (Bennett et al., 2016).

Stage 4: implementation in three separate case studies

Case study 1: veterinary medicine

'Veterinary Clinical Neurology,' is a combined fourth year undergraduate and third year postgraduate module within the Bachelor of Veterinary Medicine program, that explores a clinical subject that students tend to find conceptually challenging. This module was redesigned implementing the I-SEE approach from the Metacognitive Design Framework (See Fig. 3a) and 118 students (approximately 1/3: 2/3 split postgraduate to undergraduate) enrolled on and completed the module. A core component of the module entailed students working together in groups of 6 or 7 on authentic gradual disclosure clinical cases, creating dialogue around problem solving and clinical decision making. The clinical case materials, such as case records, videos, diagnostic imaging findings, etc. were all available to them within the VLE. Strategic discussion classes incorporating a flipped classroom approach to clarify prior knowledge and identify 'muddy points' supported and deepened learning (Entwistle & Peterson, 2004). At the end of the module, they presented these cases, summarized as infographics, to students in earlier years to promote the integration of basic science and clinical knowledge, thus benefitting both groups. Introducing content with a clear, structured pathway broken down into four, three-week themed sections in the VLE provided clarity. There were links to external content such as videos, journal articles, and virtual cases, to promote interest and enquiry. Rubrics and exemplars were provided for each assessment to ensure clear signposting, allowing students to plan and self-regulate their learning. The clinical cases were linked to checklists guiding students through their clinical approach. On completion of a section and submission of a summary, the next part of the case was released, all enabling students to learn key strategies for case management. Reusable learning objects, or SNAPIs (small nuggets applied practically to inform), and formative quizzes provided tailored feedback affording students the opportunity to practice

skills and evaluate their progress. The overall result of this approach was very positive. Students all engaged well with the process and really enjoyed the authentic clinical case material. Overall, the module gained very positive feedback, students liked gaining opportunities for feedback from reusable learning resources and quizzes, valuing the authentic approach to clinical cases and discussion classes.

Case study 2: sport and exercise psychology

This second year Sport Science module, 'The Psychology of Sport and Health 2,' which explored the role of psychology in optimizing sport performance, was adapted to be delivered in a blended face-to-face and online format. However, halfway through the module, it moved fully online due to the Covid-19 pandemic with blending provided using asynchronous and synchronous online components. The primary change to the module was that any scheduled face to face lectures were delivered synchronously online. As part of this module, students are asked to work together on a case study, learning how to build a case formulation and support an athlete in a hypothetical situation. The I-SEE approach from the Metacognitive Design Framework (See Fig. 3b) was implemented. Specifically, core concepts and theories were introduced to students by using weekly targeted pre-reading on topics with supporting reading guides to build students' knowledge. Signposting to students what was expected of them, was done by providing rubrics for each assessment component, allowing them to plan their learning approach. Students monitored their own learning process using periodic checklists completed in the virtual learning environment. Finally, students were provided with the opportunity to evaluate their learning guided by feedback delivered through the virtual learning environment such as quizzes with automated feedback, and formative video feedback from the lecturer, thus prompting them to reflect on their approach to learning. The results of this approach were promising. The 37 undergraduate students registered to the module all engaged fully in this process, with student feedback on the module very positive; in particular, they liked this form of learning.

Case study 3: information and communication studies, social sciences

This stage two module, 'DigiLife: Social Media & Participation in an Online World' was one available to undergraduate students across the Bachelor of Social Sciences. The module was redesigned using the I-SEE approach from the Metacognitive Design Framework (See Fig. 3c) and ran fully online with synchronous and asynchronous components. There were 66 undergraduate students in the class. As students started their learning journey, personalization of the VLE landing page welcomed them by name, offering a closer link for the student to the module. During the module, they participated in a series of digitally badged social media activities, involving use of social media tools and analysis of issues attending social media. Signposting was provided using exemplars, rubrics and emails/announcements. Embedded reusable learning objects, such as e-tutorials and quizzes enabled students to consider their learning progress throughout the module. A checklist tool in the VLE allowed gradual release of content, facilitated students' self-assessment of their learning and encouraged self-regulation. Students also increased their confidence in evaluating their learning by helping others to assess their learning. Peer feedback using video and text enabled students to assess their learning collaboratively, as well as to practice presenting themselves as they will need to do in the workplace. They described peer feedback

as a process that helped them achieve a deeper understanding of what they were required to do in assessment.

Students on this module were less affected by the pandemic than other cohorts in the university for two reasons: first, the module was already a fully online offering, and this meant that the module had been developed to work in the online environment; second, the pandemic and the move to online learning took place in March 2020, two months after students had begun study for their second term. As a result, students in this case study were well prepared for online study, and some even commented that they were well prepared already for online study during COVID, and that they were coaching their fellow students on other modules because they had this knowledge.

Stage 5: data analysis and evaluation of the findings

Stakeholder perceptions of implementation of the Metacognition Design Framework in three case studies were explored through the lenses of the researchers, staff delivering on the modules involved, External Examiners, Education Technologists and Information Technology staff, Program Directors, Vice Principals of Teaching and Learning, and Deans. The collective experiences of this approach, and the effectiveness of learning interventions delivered in the case studies guided by the metacognition design framework are detailed in our linked paper (“Creating Opportunities for Metacognitive Development in University Education: Putting Learning Design into Action”, in preparation), which explores the perceived impact of taking this approach on student learning. Perceived usefulness and perceived ease of use are recognized as core determinants of the acceptance of technology (Davis, 1989) that have also been shown to have clear relevance to education technology acceptance (Granić, 2023), and hence are valuable to consider when evaluating a technology-focused learning framework. In view of this, key findings of relevance to these areas that were evident as we explored research sub-questions 3 and 5 are presented here.

Perceived usefulness

Key stakeholders were resoundingly positive when asked for their thoughts on the utility of the framework. All groups commented on the value they perceived it provided in terms of structure and clarity, both from the educator-facing perspective of module planning, and the student-facing perspective of signposting and improved learning experience. Education Technologists were particularly interested in the latter, aware that student navigation within the VLE and module layout were key challenges they recognized. For example, the Head of Education Technology spoke of the framework as, “a really impactful piece,” going on to say, “what you’ve managed to do in the modules ... is appropriate and easy for students to grasp, and they don’t have to think about where to go to find things.” They also thought the framework had a role to play in improving student engagement, considering that it would help them become more invested in their learning by virtue of having more variety and control. As a group, they also discussed the potential value they thought the framework could offer for broader application across campus, in helping to guide module design and technology application. This was nicely captured by the comment, “What this map...does is, it gives clarity to when to deploy the tools that are available, and what their role is in the teaching and learning process.....I think that is something that would really, I suppose, resonate with a lot of the lectures and the module coordinators. They can see where these different tools add value in a framework, you know. And that’s why you’re going to get a

lot of traction from this, to be honest.” (Education Technologist). This was borne out in the interviews with staff involved in teaching within the modules, who thought that the framework had clear potential in the module design process. They considered that it offered a mechanism to help them to order their thoughts with regards to what they were trying to achieve with a module and how different elements could be linked together. Summed up by one person as helping, “to sort of crystallize all the sort of complexities of what you’re trying to do.” Staff also spoke to the framework offering a valuable mechanism to help draw together the different types of technology being used and clearly link them with the types of learning they were being used to target. Speaking to this, one person commented that they could, “see how this could help people frame how they need to think about different elements to be mixing it up and drawing on different skill sets.” They commented that they found the framework clear and logical, particularly with the color coding to provide clarity around linkages to metacognitive themes.

External Examiners, Program Directors, Vice Principals of Teaching and Learning, and Deans provided a lens with a strong focus on the potential usefulness for impacting learning. From a student-facing perspective, they considered that clear signposting of both module components and expectations supported students in taking responsibility for their own learning. An external examiner encapsulated this saying, “[it was] enlightening in the way that you kind of map out the role that every element of the module has....it was really powerful and I’m kind of thinking whether I can steal that sort of approach... I think this does a really nice job of, kind of, trying to map the purpose to the material, to the technology.” They then went on to explain that they thought it was, “building up an awareness within students. I think it makes it much more tangible and for the students to see where they’re going in their learning.” Other stakeholders in this group spoke of the value of engendering a dialogue around learning, helping students to question what they did, or did not know, legitimizing not knowing and uncertainty, and guiding them in managing this. One Vice Principal of Teaching and Learning said, “It struck me as something that actually gave them a sort of toolkit for managing their own learning and accepting responsibility for it and responsibility for their part in it.” This stakeholder group also spoke of the huge value added by clearly and thoughtfully scaffolding the approach to learning, and the impact to learning they had witnessed in terms of high-level outputs produced by students at the end of the process. The signposting of information and expectations, and the additionally the provision of smaller pieces of information using multiple formats were also highlighted. Viewed more from the educator-facing perspective they also spoke very positively about the usefulness of the framework to guide the overall structure and technology linkage within a module, commenting on how they had seen this work well in all three case studies. In summing up, an External Examiner said, “I really think it has changed things dramatically, and think it’s worth it. I think it’s making a big difference” and a Dean, “for me it’s exciting. It’s innovative, and I would love to see it be embedded in a practical way... in the program in the future.”

Perceived ease of use

Initial perceptions were that the framework was complex, but once stakeholders spent time exploring it, understanding the rationale behind it, and looking at the color coding, they were typically very positive about it. Highlighted by these comments captured from all the main stakeholder groups, “it is very clear, and it is very logical,” “I think it’s really good. I think it does take...a little bit of time to study it and think about that. But once you’ve done

that, I think it's very transferable to other modules, other disciplines," and "I really liked the way it's done with the color-coding. It makes sense, but it takes time to understand it." An External Examiner considered how they would use it themselves saying, "For me, ... it would have been useful when I had to design a module... a nice graph like this, really helps you to see how you can integrate different ways of teaching and not do [it] all the same way all the time."

The researchers learnt a lot through the iterative, reflexive approach to the project, using the framework themselves in practice alongside other educators and stakeholders. First in case study one, and then in case studies two and three, that ran in parallel. This led to refinement of the framework, first adjusting the colors of the framework, then grouping and naming 'I-SEE' elements. This all helped considerably with peoples' responses and improved the overall clarity. Showing the build of the framework in a video or with a gradual build in sequential slides during presentations also helped people to perceive it as easier to understand and use. All staff stakeholder groups believed explaining the framework to people would really help to improve their perception of its complexity and improve the perceived ease of use. Education Technologists and Information Technology staff spoke broadly of their experiences of a general reluctance amongst staff to embrace change, and the potential this might have to impact their readiness to use the framework and their overall perception of its ease of use. They thought that the use of exemplars showing application in varied subject areas would allow educators to imagine the framework used in their own settings. Also suggesting that, "an exemplar module that shows how this approach can be adapted," and a set of video examples or screencasts could increase perceived ease of use and adoption. These suggestions (and the self-review process below) helped to clarify requirements for the development of the additional supporting resources.

Within the Program Directors, Vice Principals of Teaching and Learning, and Deans stakeholder groups, the complexity was mentioned but discussions were more focused on the perceived benefits of the framework. These groups had a particular interest in application of the framework at a program level to examine how active student learning approaches are being supported, referring to, "What are we actually doing and how are we supporting the students to get to that end goal." Another spoke of using the framework as a mechanism to spark discussion around learning at a program level, and how it could be used to guide approaches for less experienced staff. In view of this, there were more discussions around how to support educators in using the framework, with various suggestions similar to those highlighted above, along with suggestions to explore additional institutional support mechanisms to help and guide staff as they started to use the framework in their own settings. They thought that this way it could gain far greater traction across campus. This group also acknowledged the progression of the framework, a Vice Principals of Teaching and Learning commenting, "It's really nice to see... the evolution of this from what you originally presented... to now actually having... conducted this as part of your modules."

Self-evaluation of the framework against an analytical framework

An evaluation of the Metacognition Design Framework against Bower & Vlachopoulos' criteria for analyzing technology-enhanced learning design frameworks (Bower & Vlachopoulos, 2018) is presented in Table 2. Overall, our framework performs well, providing details in areas highlighted as by these researchers as lacking in many previously reported learning design frameworks. For example, we clarify the epistemological basis and pedagogical orientation of our framework, along with the context for which it was designed.

Previously reported models only rarely consider staff-student interaction in a substantive way, and authors often fail to provide examples that illustrate the practical application of their frameworks; two areas which this paper, our paper in preparation, and our supporting resources (online Appendix 1 and online resources) address in detail. Our framework is also substantially strengthened by the provision of guidance on technology selection and the translation of theory into practice (online Appendix 2), along with the evaluation of our model through case study trials (paper in preparation). These are all features very rarely present in other models and certainly not all within the same model. Another key feature of our Metacognition Design Framework is the provision of extensive resources (accessible via our website—<https://www.ucd.ie/cshe/metacognitivelearning/>). Example Learning Design Sequences and video exemplars, available on our website, allow other educators to clearly relate to the overall design process and how it could translate to their own practice. Our online interactive experiential Learning Resource allows them to utilize the approach for themselves, directly experiencing the framework in action as part of a Community of Inquiry and informing iterative enhancement of our model.

Discussion

Why the metacognition design framework?

In this paper we present a robust, research-informed framework for guiding accessible teaching, learning, and assessment practices that aid metacognitive skill development in higher education students. This learning design framework guides technology use to support blended learning, informed by clear pedagogical principles and is designed to be broadly applicable across a wide range of disciplines. Utilizing blended learning supported by the VLE, it offers the opportunity to draw on the advantages afforded by both face-to-face and online learning (Vaughan et al., 2013) and provides the added advantage of influencing student learning outside standard class time with realistic levels of staff input (Dara-doumis et al., 2013; Gikandi et al., 2011). The Metacognition Design Framework targets metacognitive skill development in university students, outlining a clear way to improve this core graduate attribute, positively impacting learning, supporting key competency development (Bohm et al., 2024; UNESCO, 2017), and effective lifelong learning (UNESCO, 2023a). It also offers a practical way to support educators as designers providing a mechanism for them to create learning designs for application in their own disciplines. We provide details of its implementation in three different case studies, highlighting our experiences of this process and perceptions of the framework's utility and ease of use examined through the lens of key stakeholders.

Rapid changes in higher education have led to increased technology use and a heightened focus on blended learning (Pelletier et al., 2021). There is a growing need for clear theoretical grounding of the latter (Vaughan et al., 2023), along with the appropriate mechanisms to support educators in meaningfully engaging with this process (Land & Jonassen, 2012), particularly since a lack of educator training and support have been identified as significant barriers (Sareen & Mandal, 2024). Learning designs offer a valuable way for educators to create educational interventions utilizing technology, presenting them clearly in an accessible way that is readily shared (Dalziel et al., 2016). In turn, they provide a powerful mechanism to start a conversation around learning approaches, allowing adaptation and refinement to suit specific local needs (Bennett et al., 2018). Our Metacognition

Table 2 Evaluation of the metacognition design framework against key evidence-based criteria (Bower & Vlachopoulos, 2018)

Framework evaluation criteria	Metacognition design framework
Framework nature	Overall conceptual framework designed as a broad 'blueprint' to guide in the development of procedural Metacognition Design Sequences for use in specific settings
Epistemological/pedagogical values	Social constructivist epistemology Authentic learner-centred collaborative approaches with a reflective practice core to the overall process
Context explicitly and substantially considered as part of the model	Designed for blended learning using a VLE but with flexibility to allow mapping of learning approaches for fully online, hybrid or blended using other types of technology
Level of granularity	Designed to allow considerable flexibility. Designed to guide teaching within modules but suitable for extrapolation to programs or for use to frame smaller elements. The learning design sequences can be expanded to increase the level of granularity to the presentation of module sections or learning tasks
Examples provided to illustrate the model	Yes Three exemplars of Metacognition Design Sequences are provided (Fig. 3). These show bespoke designs developed, guided by the Metacognition Design Framework, for specific modules. They have been successfully trialed with results described in our linked publication A video case study outlining the whole design and trial process along with three video exemplars outlining the key approaches within the trial modules are also available on our website (add link after review https://www.ucd.ie/cshe/metacognitivelearning/)
Consideration of interaction between students and teachers	Yes The ongoing dialogue around metacognition is a core theme in this framework. Student reflection on learning is key, in turn linked to dialogue with both peers and teachers <i>This is explored through reference to the metacognitive themes and the guide to applying the framework</i>
Practical and structured guidance for selecting learning technologies	Yes This is detailed in online Appendices 1 and 2. Also explained in both our linked video case study, video exemplars and online experiential learning resource (available on our website https://www.ucd.ie/cshe/metacognitivelearning/)
Evaluation of the model	Yes This paper explores development of the model and experiences of applying it in practice. Our linked paper (in preparation) presents the impact on student learning, viewed through the lenses of students, staff, and other key university stakeholders, when the framework was applied in three separate subject settings

Design Framework offers a practical way to start a conversation around harnessing blended learning to promote metacognitive skill development, offering educators a clear mechanism to act as co-designers in this process. A novel feature of our framework is that it bridges the gap between theoretical frameworks on blended learning and metacognition, and their practical application. Functioning as a more procedural framework, it provides an approach that is both accessible to, and actionable by, educators with broad ranges of experience in the field. Key stakeholders referred to this when they spoke of their perceptions of the usefulness of the framework based on their experiences of its implementation in our three case studies.

What does this framework provide?

Our Metacognition Design Framework is underpinned by five core evidence-based themes, derived from an extensive evidence summary published by the EEF (Muijs & Bokhove, 2020). These themes outline practical ways to support learners in developing both metacognitive knowledge and skills. Taking these recommendations, originally developed for use with school children in a classroom setting, we refined them for use in higher education, maintaining alignment with important metacognition frameworks (Efklides, 2006, 2011; Garrison & Akyol, 2015; Nelson & Narens, 1990; Schraw & Moshman, 1995; Winne & Hadwin, 1998). This process involved adapting them to align with best practice approaches to learning (Nicol & Macfarlane-Dick, 2006; Panadero, 2017; Stanton et al., 2021; Tanner, 2012), and more specifically blended learning (Land & Jonassen, 2012; Vaughan et al., 2023), in higher education. The Metacognition Design Framework makes explicit the expectations of active student participation and learning dialogue core to Chickering and Gamson's influential publication outlining good practices in Higher Education (Chickering & Gamson, 1987) and later extended to include 'Technology as a Lever' (Chickering & Ehrmann, 1996). Our framework places students centrally within the learning process, clearly communicating learning requirements and expectations through 'signposting' with exemplars and rubrics. This work builds substantially on the Learning Design Sequences described by Oliver and Herrington (Oliver, 1999; Oliver & Herrington, 2003), adapting their use of a task, resources and supports classification, to identify linkages between learning components in a blended setting. Our framework supports development of a 'Community of Inquiry (CoI)' (Garrison & Anderson, 2003) through its blended use of technology to facilitate 'cognitive, social and teaching presence' (Garrison et al., 1999) and aligns with best practice guidelines for blended learning incorporating the seven principles for blended learning design derived from the CoI (Vaughan et al., 2013), thus addressing many of the commonly identified challenges (Sareen & Mandal, 2024). Addition, it clearly aligns with the core principles of the 'shared metacognition' and CoI, although not formally developed using this framework (Vaughan et al., 2023).

A principal aim as we developed our framework was to make explicit the effective use of VLE technology explored from a pedagogical perspective, with the overall aim of promoting deep student learning (Jackson, 2012). We identified metacognitive capacity as a high impact target in achievement of this aim (Magno, 2010). A novel feature of our framework is that it models a clear, blended learning journey focused on the outcome of developing student metacognitive capacity (detailed guidance in online Appendix 1). This learning journey acknowledges co-creation of the CoI (Vaughan et al., 2023) through its recognition of both the student-facing and educator-facing perspectives of the learning journey. It highlights how the 'I-SEE'-guided synchronous and asynchronous components (face-to-face /

online) are meaningfully linked to facilitate this journey, providing clarity in the learning design (Sareen & Mandal, 2024). In turn, the appropriate selection of learning activities and technology is supported through consideration of the learning requirements (balancing both staff and student capabilities) and the affordances that available technology offers to support these needs (detailed guidance in online Appendix 2). Thus, recognizing the ‘tri-partite relationship of learner-tool-teacher,’ and the importance both educator and student agency in the process (Elen & Depaepe, 2025). Overall, the framework provides a practical way to support educators in the effective use technology, ‘re-framing teaching as design’ to highlight the consideration required to plan education tailored to learner’s needs (Bennett et al., 2018). It also functions to as a guide for students, aiding navigation and providing clarity through explicitly connecting learning elements, highlighting the supports and resources available to them; all commonly identified challenges (Sareen & Mandal, 2024). This duality of function was clearly referenced by stakeholders as they shared their experiences of the framework implementation in the case studies. Collectively they perceived the framework as useful in this regard from both student and educator perspectives. The impact of establishing a clear structure and explicit connections in a blended environment was one of the key themes identified in a large study of educator strategies for engagement (Heilporn et al., 2021).

What does this framework offer moving forwards?

Our framework offers value to three broad audiences: faculty, instructional designers, and educational policy makers. It clearly frames and addresses many recognized key elements of best practice in Higher Education, providing a practical mechanism to apply them through effective use of technology in blended learning. The opportunities afforded by technology to transform approaches to learning are huge, however the relationship between technology and learning is complex (Elen & Depaepe, 2025) and it is important to avoid the expectation that the addition of technology will deliver transformative results just by virtue of its inclusion (Salomon, 2002). Failing to recognize the key role of the teacher as the ‘agent of change,’ (Kirkwood, 2009) or indeed the impact of prevailing views about the nature of knowledge and educational epistemology (Salomon, 2002), and pinning the expectation on the technology itself to deliver educational enhancement typically has poor results (Elen & Depaepe, 2025; Kirkwood, 2009; Salomon, 2002). Teacher beliefs about learning, particularly whether they conceptualize the transmission of information or the construction of knowledge (Gibbs & Coffey, 2004), have an important overarching influence on how they utilize technology (González, 2009, 2012). This, in turn, has an important bearing on the types of professional development training that will impact effective technology adoption within institutions (Beetham & MacNeill, 2023; Kirkwood & Price, 2014; Wang et al., 2021). Our framework offers a conduit for educational policy makers to start a conversation with staff around their epistemology of learning and the achievement of more transformational approaches to technology usage and really starting to effect valuable pedagogical change and aligning with opinion in this area.

Continuous, situated professional learning is important for educators. This framework represents a valuable teaching tool for established educators, allowing them to reflect on their own practice using critical tools. It also offers clear guidance for early educators, providing a mechanism for them to conceptualize their work in diagrammatic form, addressing the “shortage of relevant practical and conceptual tools to support teacher design” (Bennett et al., 2017), at the same time integrating “informed practice” supported by the literature

(Hrastinski, 2021). A variety of resources are available to support the use of this framework by other educators, including an open-access learning resource that allows educators to experience the framework first-hand, learning through design and developing 'shared metacognition' within a Community of Inquiry (Vaughan et al., 2023). This approach mirrors the social constructivist and constructionist epistemology that underpins the framework (Ackermann, 2001), allowing educators to create an authentic artefact (Papert, 1993), experiencing accessible, student-centered learning (Lee & Hannafin, 2016) and social metacognition (Efklides, 2011; Schraw & Moshman, 1995; Vaughan et al., 2023) in action. All of this is important when lack of educator training is such a commonly cited barrier to blended learning (Sareen & Mandal, 2024).

Our framework has been designed to broadly align with best practice for blended learning design in higher education, underpinned by key theoretical frameworks for metacognition and blended learning, and hence should be broadly applicable for adaption in a wide range of educational contexts. Implementation of learning approaches guided by the Metacognition Design Framework in three separate case studies in different disciplines provided rich data relating to the experiences of using this framework in our university setting and explored multiple stakeholder perspectives. The impact on student learning in this setting is also explored in our linked paper, "Creating Opportunities for Metacognitive Development in University Education: Putting Learning Design into Action" (In preparation). Whilst these case studies provide valuable insights on the perceptions of taking this approach in a local setting, the nature of this type of qualitative study impacts the potential transferability of the findings. We reviewed our framework against the benchmarks provided in a systematic review of learning designs (Bower & Vlachopoulos, 2018), clearly demonstrating good performance against their broad criteria and its potential value. However, future work is required to validate the framework, entailing a methodical evaluation of the effectiveness, utility, and usability in broader educational settings.

Conclusion

In summary, the Metacognition Design Framework provides an evidence-based, practical way to frame learning in Higher Education to aid the development of metacognitive skills. This framework provides a clear, potentially widely applicable way to plan blended learning, harnessing the potential of virtual learning environment technology to support the development of these key skills. It also provides an effective way to methodically consider blended learning from a pedagogical best-practice perspective. The use of a learning design offers huge potential for adaption across wide contexts, supporting educators as designers and scalability for use across institutions to frame effective, pedagogically informed accessible, blended learning with rational and constructive use of technology.

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Data availability The data that support the findings of this study can be made available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare no conflict of interest in the work reported here.

Ethical approval The overall Fellowship project, including the work presented in this paper and our linked paper our linked paper, "Creating Opportunities for Metacognitive Development in University Education: Putting Learning Design into Action" (Fulton, Hensey, Matthews, and O'Neill 2025, in preparation), was subject to University College Dublin's ethical guidelines; approval of the ethics application was granted by the University Human Research Ethics Committee.

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Emma J. O'Neill is Professor in the UCD School of Veterinary Medicine and a recognized European Specialist in Small Animal Medicine. She is a UCD Fellow in Teaching & Academic Development and member of UCD's Centre for the Study of Higher Education. Her teaching-related research interests focus on skills-based learning including metacognitive learning in Higher Education, reflective practice, evidence-based practice, and Education for Sustainable Development. She is also interested in the use of technology to enhance student engagement and effective learning.

Crystal Fulton is Emeritus Professor of Information Science in the School of Information and Communication Studies, a UCD Fellow in Teaching & Academic Development and member of UCD's Centre for the Study of Higher Education. Her work focuses on metacognitive learning in HE, digital literacies, competences, and digital resilience leading to social inclusion and increased digital citizenship.

James Matthews is a chartered psychologist and Associate Professor at the UCD School of Public Health, Physiotherapy and Sports Science. He is a UCD Fellow in Teaching & Academic Development and member of UCD's Centre for the Study of Higher Education. His teaching related research interests focus on how to develop theory informed, technology-based interventions to enhance student learning.

Carmel Hensey is Associate Professor and Head of Pharmacology in the School Biomolecular & Biomedical Science, a UCD Fellow in Teaching & Academic Development and member of UCD's Centre for the Study of Higher Education. Her teaching-related research interests focus on the support of metacognitive skill development and use of the VLE to promote student engagement.