Implicit to Explicit: A Framework for Supporting Blended Design Education With Microlearning

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Abstract: Design is an iterative process involving cycles of divergent and convergent thinking. To navigate these cycles effectively, designers need a range of competencies. These include information gathering, sense-making, imagination, ideation, shape-giving, iterative reflection, critical evaluation, collaboration, and discipline-specific knowledge. To develop these competencies, design education typically occurs in a studio environment that follows a learning-by-doing approach, simulating industry practices. However, the tacit knowledge—unspoken insights and intuitions—that informs the application of domain knowledge is often not visible, making it difficult for students to connect theory with practice and potentially hindering their learning. The cognitive apprenticeship model is a pedagogical approach that enhances learning-by-doing by integrating theory and practice throughout the design process, making tacit knowledge explicit and accessible. Within the context of blended learning, where face-to-face classes are complemented by technology-enabled learning, microlearning emerges as an innovative teaching and learning approach that delivers activities in structured, bite-sized pieces. This method is designed to minimise cognitive load and to help students grasp complex implicit concepts. In this paper we explore how microlearning, an innovative teaching and learning approach, might be integrated into learning by doing approaches within blended learning settings in the design studio to make tacit knowledge explicit. The paper is the first part of a larger study exploring how microlearning activities might support learning-by-doing within blended learning environments during the various phases of the design process. An integrative review of literature on the design process and related design competencies, cognitive apprenticeship and microlearning, theoretically informed the development of a conceptual framework outlining the dynamics between learning-by-doing and microlearning activities to foster connections between theory and practice. The framework will be used in subsequent research to inform the design and trialling of microlearning activities to support learning-by-doing in practical design modules. This research contributes to existing understanding of educational approaches that support learning-by-doing in design education and lays the foundation for further research to inform the design of appropriate and meaningful microlearning activities.

Keywords: Microlearning, learning-by-doing, Cognitive apprenticeship, Design competencies, Design education, Blended learning

1. Introduction

Design is an iterative process characterised by cycles of divergent and convergent thinking, essential for developing purposeful and meaningful outcomes (Design Council, 2021). Key competencies required during this process include information gathering, sense-making, imagination and ideation, shape-giving, iterative reflection, critical evaluation, collaboration, and discipline-specific or domain knowledge (Cross, 2007; Dorst, 2017; Sanders, 2017; Burger, 2018). Design education traditionally occurs in a studio environment at many higher education institutions, however due to recent shifts, many design institutions have adopted a blended learning approach, where face-to-face classes are supplemented with online content, activities and lecturers, offering flexible learning experiences in the design classroom (Fleischmann, 2023). This approach emphasises a learning-by-doing approach that mirrors industry practices. Despite these advancements, the tacit knowledge—unspoken insights and intuitions—that inform the application of domain knowledge is often not visible, making it difficult for students to connect theory with practice (Friedman, 2001).

The cognitive apprenticeship model, a pedagogical approach to mentoring in a learning-by-doing setting, supports real-world problem-solving and the integration of theory and practice by making tacit knowledge explicit and more accessible (Collins, Brown & Holum, 1991). Within the context of blended learning, microlearning, an innovative teaching and learning approach, might further enhance connecting theory and practice by guiding students to achieve specific learning goals, accommodating individual learning needs, and providing timely feedback through appropriate activities. By delivering content in structured bite sized chunks, microlearning allows students to consume the content at their own pace, with activities integrated into the larger learning experience (Hug et al., 2006; Kohnke, 2023).

In this paper we explore how microlearning activities might theoretically support the development of appropriate knowledge and understanding to foster principle-based design practice within blended learning settings. A literature review of pedagogical approaches and cognitive processes involved in design education, informed our understanding and the development of a conceptual framework describing the dynamics between microlearning and the cognitive apprenticeship approach. This framework will guide future research about designing and trialling microlearning activities to support learning-by-doing within blended learning environments. The research contributes to existing understanding of assessment approaches that support learning-by-doing in design education and lays the foundation for future research to inform the design of fit-for-purpose and meaningful microlearning activities.

2. Learning-by-Doing: How Design Students Learn

Design is a problem-solving process involving various stakeholders and requiring multiple competencies. Competency encompasses knowledge, skills, abilities, attitudes, values, and behaviours necessary for performing specific tasks within a discipline (Burger, 2018). Design, as a discipline with distinct processes and practices demands distinct competencies such as information gathering, sense-making, imagination, ideation, shape-giving, iterative reflection, critical evaluation, collaboration, and domain knowledge of principles, theories, tools and methods (Cross, 2007; Dorst, 2017; Sanders, 2017; Burger, 2018). Some competencies are applied only in specific phases of the design process while other competencies, such as collaboration and reflection are applied throughout the process.

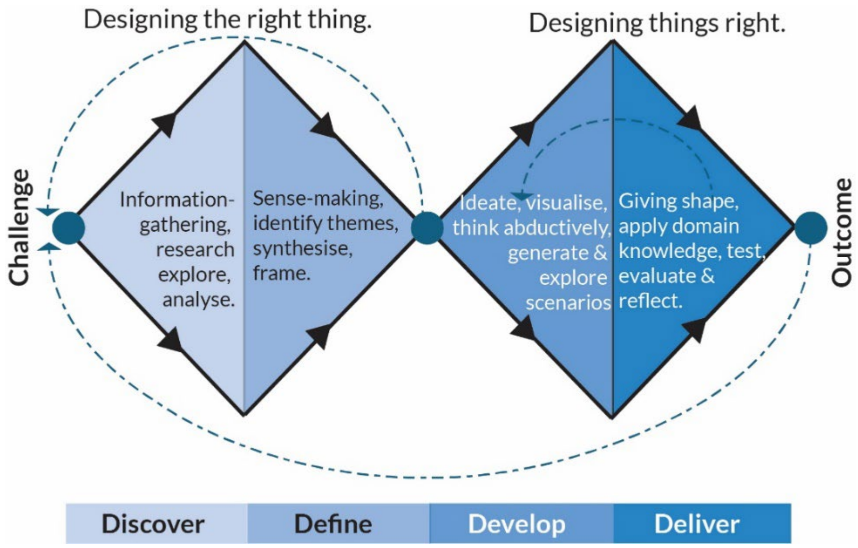

Figure 1: The Double Diamond Design Process (Design Council, 2021)

The Double Diamond Design Process (figure 1), a widely applied model, depicts iterative cycles of the design process involving divergent and convergent thinking and consisting of four different phases: discover, define, develop and deliver (Design Council, 2021). The initial discovery phase requires research competencies for information gathering to explore the existing situation from multiple perspectives and understand stakeholders' needs and expectations (Dorst, 2017). Interpretation competencies are needed for sense-making to analyse findings, identify patterns, synthesise information, and through abductive thinking, identify alternative ways of looking at the design problem to make sense of and frame it (Dorst, 2004; Cross, 2007). In the develop phase, giving shape to possible solutions is crucial (Sanders, 2017). Designers start with vague ideas and test them to explore how they might look and work (Cross, 2007). As ideas are explored and tested, experienced designers reflect on their work and learn from their actions, informing new problem frames, possibilities, and directions (Schön, 1983; Dorst, 2017). This ability to reflect and iteratively develop and test possibilities enables designers to bridge the gap between the problem space and the solution space and select concepts to develop into solutions (Dorst, 2017). In the deliver phase, designers must identify the strengths and weaknesses of ideas and prototypes to deliver refined design outcomes (Sanders, 2017). As the challenges the world faces become ever more complex, designers find themselves working on problems in fields outside of their own discipline that they have not been trained in. Consequently, they become generalists who must reach across disciplines to collaborate and co-create with different designers and non-designer stakeholders (Sanders, 2017; Dorst, 2018).

Design education occurs in a studio environment and follows a learning-by-doing approach (Meyer & Norman 2020; Pontis & van der Waarde, 2020). The studio serves as a space where students are supported while they complete carefully designed learning activities that simulate industry practices, both in physical face to face and virtual environments, providing opportunities for exploration and productive failure, facilitated by constant dialogue and cooperation, which are crucial for learning (Celikoglu & Ogut, 2013). Studio culture aims to cultivate autonomy, curiosity, and motivation among students, fostering a deeper understanding of design principles and practices (Pontis & van der Waarde, 2020). Students are required to constantly consider the "bigger picture" (Kirschner & Hendrick, 2020 ; Southall, 2016), emphasising the importance of thinking about the entire design process and not just individual design tasks (Southall, 2016). Knowledge in this context can be described as “active” and integrated into cognitive processes such as perception, judgement, problem solving and decision making and metacognitive processes such as modification, articulation and reflection, related to design (Southall 2016:54). These cognitive processes are informed by tacit knowledge which Southall (2016:54) describes as “the informed guesses or hunches that are part of an exploratory act.” Tacit knowledge is predominantly personal and requires pedagogical methods and strategies that reveal the processes associated with such knowledge.

To make tacit knowledge more explicit, requires breaking the lineage from a traditional ‘Master-apprentice’ model to a pedagogical approach that integrates knowledge, skills, and understanding in design education within blended learning environments, rooted in heutagogy, user-centred research, and scientific explanations (Pontis & van der Waarde, 2020). While the ‘Master-apprentice’ model is very effective in skills transfer, as the apprentice copies the master faithfully, it can result in a carbon copy of the master and apprentices that do not evolve beyond their master’s abilities. This model is therefore inadequate to support design as action informed by theoretical knowledge and demanding an awareness of *what* must be known and *when* during the design process.

Students must become aware of cognitive and metacognitive processes early in their learning journey to develop the required depth of knowledge and understanding of the design process. Theory supports practice and provides contextual awareness. Celikoglu and Ogut (2013) note students struggle to transfer theoretical knowledge, especially across different modules, into their design practice. Attaining contextual awareness promotes a deeper appreciation for the historical context of design and its implications for sustainable practice (Calvelli, 2010), highlighting the interconnectedness of historical study and practical application in the field of design (Ghefaili, 2003). Given the complexities, these elements are in continual flux requiring students to constantly adapt and to develop a critical awareness of how the design process can be adapted in response to create positive impact (Findeli, 2001).

There is a clear shift towards an appreciation for the cognitive processes in the design process beyond mere skills transfer (Findeli, 2001; Meyer & Norman, 2020). One such pedagogical approach can be found in the cognitive apprenticeship model (Burger & van Zyl , 2020, Pontis & van der Waarde, 2020) which addresses the gap in design education by emphasising learning-by-doing through problem-solving approaches (Roux & Batchelor, 2023). Recent literature demonstrates the impact of cognitive apprenticeship on critical thinking and interaction, particularly in online learning environments (Alwafi, 2023).

3. What is Cognitive Apprenticeship Theory?

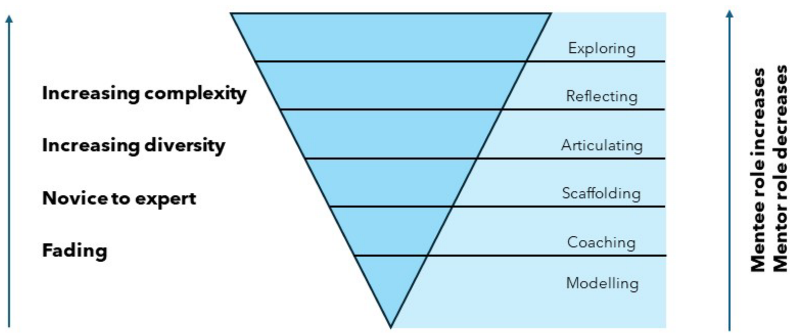

Figure 2: The Cognitive Apprenticeship Model (adapted from (Collins et al., 1991)

The cognitive apprentice approach draws on real-world problem-solving experiences to support learning in authentic contexts. The approach aids students in developing expertise through meaningful encounters with the subject matter (Wilson and Cole, 1996) and highlights the complementary nature of problem-solving and perception, suggesting that experts develop expertise through progressive encounters with the domain (Wilson & Cole, 1996). One of the defining features of the approach is its usefulness to teach complex tasks (Collins, Brown & Holum, 1991). Initially developed for secondary education, the approach has been adopted in creative disciplines-where the Master Apprentice model is still prevalent, to address the changing needs of industry and emphasise 21st century skills. Highlighting the cognitive and metacognitive processes in design equips students with the ability to adapt and expand their knowledge to diverse and complex situations. Wilson and Cole (1996) stress the importance of supporting students in becoming efficient in procedural performance and deliberate in self-reflection and understanding, emphasising the grounding of instruction in complex problems, cases, or performance opportunities. Burger and van Zyl (2020) highlight the importance of theory and evidence-based design activities in transforming learning, while Southall (2016) highlights the need to nurture diverse forms of knowledge to enhance problem-solving and creative thinking skills.

Six methods are commonly used to promote the development of expertise within the cognitive apprenticeship approach (figure 2). These methods include modelling, coaching and scaffolding, where the mentor or lecturer is the main actor, and articulation, reflection and exploration where the mentee or student becomes the main actor (Collins et al. 1991). During modelling the mentor demonstrates the task or project at hand. Mentees observe the activity, which helps them develop a conceptual model of the completed activity before attempting it themselves Coaching involves guidance and feedback from the mentor, although in a studio setting coaching can also come from peers. The mentor scaffolds learning by initially offering clear support and then gradually withdraws, providing less structured support, asking guiding questions instead.

Articulation is encouraged by the mentor throughout the process with the aim to make tacit knowledge and thinking processes explicit. Ghefaili (2003:2) describes this as "teaching the cognitive and metacognitive skills associated with a specific domain of knowledge". The mentor also articulates their tacit knowledge to help the mentee understand the process. Reflection and self-evaluation are strategies to help mentees evaluate their progress and determine what they need to do to achieve their goals. Finally, exploration results from independent exploration by mentees and furthering of knowledge and experience.

During application of the six methods the focus gradually shifts from the mentor to the mentee with the desired outcome for the mentee to eventually complete the activity independently. Mentees are actively involved in determining their own learning path and develop some agency over their own learning process (Celikoglu & Ogut, 2013). While they initially participate from the periphery, they gradually become central to the activity and critical members of the community and eventually, the experts (Collins et al., 1991; Dennen & Burner, 2007).

4. How do Cognitive Apprenticeship Approaches Support Design Learning?

The cognitive apprenticeship approach guides students through authentic tasks and processes rather than isolated instances, to develop skills, understanding and knowledge (Southall, 2016). There is a constant interplay between learning and doing, where knowledge acquisition and practical application do not always align (De Rosa, 2015). As a result, a complex inter-relationship exists between conceptual- content knowledge and procedural knowledge. This inter-relationship underscores the importance of dynamically integrating theoretical knowledge with practical skills in design learning to develop a comprehensive understanding of design principles and techniques (Southall, 2016). With an eye on the whole picture, knowledge and understanding are accessed only when needed (Southall 2016; Kirschner & Hendrick, 2020) and the mentor uses their role as coach to establish clear links between knowledge and practice throughout the creative process. While the cognitive apprentice approach provides a useful outline for how to share the different types of knowledge that creates the expert, in the context of design education, much room is left for interpretation.

Using the methods put forward in the cognitive apprentice model, students can complete different activities to support their learning and depth of understanding. Articulation can be done using visual tools, such as sketches, diagrams, and prototypes to communicate their tacit understanding of a design solution, making it more tangible and understandable to others involved in the design process (Burger & van Zyl, 2020). Throughout the design process tacit knowledge is articulated and exchanged in discussions, critiques, and collaboration with various stakeholders, leading to a deeper understanding and appreciation of diverse perspectives and approaches. Reflecting on their design decisions, processes, and outcomes, students can articulate and document their tacit experience, making it accessible and transferable to others (Roux & Batchelor, 2023). Design educators should therefore foster a culture of independent reflection, collaboration, documentation, and knowledge sharing to support future designers in articulating and sharing tacit knowledge, enhance their design capabilities and contribute meaningfully to the increasingly complex field of design (Southall, 2016; Burger & van Zyl, 2020; Meyer & Norman, 2020).

A significant shift towards technology-enhanced learning, brought about by wider access to online learning materials, the internet and consumption of content on smartphones, is altering learning expectation and demands (Shatte & Teague, 2020). However, media multitasking reduces students' information processing capabilities, making them more susceptible to distraction and cognitive overload (Uzun, 2023). The question therefore arises how the adoption of microlearning to break learning into small, manageable chunks might enhance a learning-by-doing approach in design education.

5. What is Microlearning?

Cognitive Load Theory (CLT), a framework that explains how the human brain processes and stores information, suggests that working memory has a limited capacity, capable of handling only a certain amount of information at a time. When this capacity is exceeded, cognitive overload occurs, hindering both learning and problem-solving. To mitigate cognitive overload, learning design must account for students' intrinsic load (related to the complexity of the material) as well as extraneous (how content is presented) and germane (effort required to understand and process information) loads. Effective learning design should aim to optimise these cognitive loads to facilitate better learning outcomes (Sweller et al, 2011).

Microlearning has emerged as a promising educational approach that focuses on integrating short learning activities into students' daily routines. In the context of blended learning, where online and face-to-face instruction are combined, microlearning closely aligns with the principles of CLT, as content is delivered in structured, small segments designed to minimise cognitive load, followed by small activities completed within a limited timeframe to help students grasp complex, implicit concepts. This approach support students in meeting specific learning outcomes and retaining core principles before applying them (Samala et al., 2023) and keeps them engaged by providing practice opportunities and immediate feedback. Bite-sized chunks of information help students better process material, improve knowledge retention, and foster engagement and active learning (Uzun, 2023; Lopez, 2024), resulting in improved grades, increased participation, and faster, more accurate task completion (Shatte & Teague, 2020). By reducing extraneous load through thoughtful content design and focusing on essential concepts (intrinsic load) and the construction of meaningful mental structures (germane load), educators can leverage microlearning within blended learning environments to improve learning outcomes (Lopez, 2024).

6. Guiding Principles of Microlearning Activities

Microlearning design involves not only the creation of microcontent but also the development of micro activities based on that content (Buchem & Hamelmann, 2010). Key design principles for microcontent include a small format for immediate perception, a clear focus, autonomy (requiring no external information), structure as a single resource and addressability. Microlearning activities must address what students need to know, provide useful resources, and positively impact their learning (Kohnke, 2023). Activities should be clear and focused, presented one step at a time, without oversimplifying the content (Kohnke, 2023).

Various forms of media and formats can be used in microlearning activities, including text-based micro copy such as contextual short messages, error messages, hints and tooltips as well as videos followed by interactions such as fill in the blank, a quiz, poll, etc. Other formats also include micro challenges and games such as quizzes, polls, flashcards, simulations, doodles, prototyping, learner recordings and infographics, microblogging, podcasts, AI chatbots with reflective questioning, discussion boards and peer feedback. The chosen media and format must be specific and relevant to the topic, considering what students need to know before, during, and after the activity (Kohnke, 2023; Samala et al. 2023; Peters, 2020, Gabrielli et al, 2005; Javorcik, 2022; Marshalsey &Sclater, 2020, Wang & Bonk, 2001).

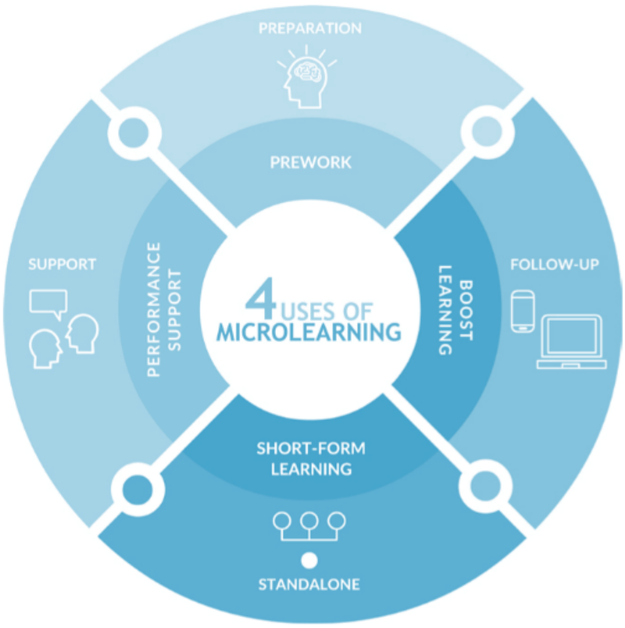

Figure 3: The four uses of microlearning (Torgerson and Iannone, 2020: 111)

Torgerson and Iannone (2020) identify four ways to use microlearning: As preparation before a learning event, as follow-up to reinforce a learning event, as standalone training, or as performance support (figure 3). These four tactics can be integrated into the cognitive apprenticeship approach (figure 4), to support learning-by-doing.

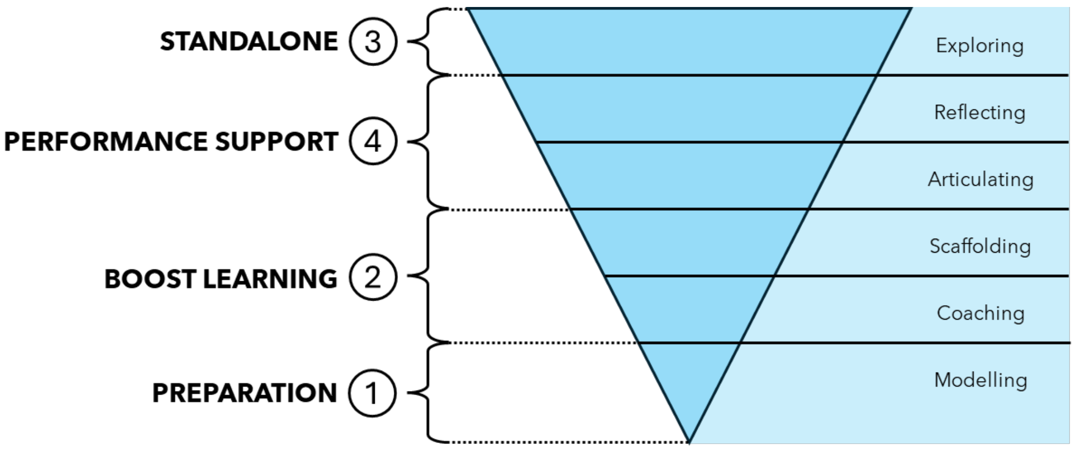

Figure 4: Four ways of microlearning overlapped in the Cognitive Apprenticeship Model

Firstly, microlearning activities can be used as preparation for a learning event. For example, when a lecturer employs modelling as the initial step in the cognitive apprenticeship approach to develop a specific design competency, students may first need to observe the activity before attempting it themselves. This observation requires them to understand a significant amount of didactic content before they can meaningfully engage in discussions or activities (Torgerson & Iannone, 2020). Pre-event preparation, such as short videos introducing key ideas (introductory teasers) can support students in grasping this didactic content more effectively (Kohnke, 2023).

Coaching and scaffolding require the lecturer to provide guidance and feedback, initially offering clear and structured support. Over time, this support is gradually reduced, transitioning to less structured assistance while incorporating guiding questions to promote independent thinking. Here, microlearning activities can be used strategically to reinforce or supplement learning events. Learning could be enhanced through challenges such as quizzes that test comprehension and reinforce key concepts, or infographics that summarise or clarify complex ideas. Additionally, AI chatbots might be employed to simulate conversations and pose guiding questions, fading the direct involvement of the mentor (Kohnke, 2023).

Articulation and reflection can be supported by microlearning activities that offer performance support, helping students articulate their understanding, reflect on their learning and foster expertise. Performance support can be provided through microblogging or discussion forums, where students are required to articulate their thought processes and the reasoning behind their interpretations and to exchange ideas (Wang & Bonk, 2001). Small reflection activities such as self-assessment, goal setting or reflective questions, for example, might enable students to quickly assess their performances and identify areas for improvement (Kohnke, 2023).

During exploration, microlearning activities can be standalone. Standalone activities support just-in-time learning, which renders learning more realistic and contextual. For example, short video tutorials may guide a student through a specific topic or skill they are struggling with or quick interactions with AI chatbots may allow them to test ideas or receive feedback or role play scenarios (Kohnke, 2023).

7. The Conceptual Framework

The conceptual model in figure 5, integrates the six steps or methods of the cognitive apprenticeship approach with the four different applications of microlearning activities to support the development of competencies during each phase of the design process. The four quadrants in the circle represents the phases of the design process, each requiring distinct competencies, and some competencies required across all phases. Using a cognitive apprenticeship approach in a blended learning context, lecturers and students' progress through the learning steps during each phase of the design process to develop each competency, as presented in the inverse blue pyramid. As they progress through the learning steps the lecturer's role fades and the student's increases. The green concentric circles denote the increasing complexity and depth of knowledge as students move from preparation microlearning activities (Prep) to activities that boost their learning (Boost), to activities that support performance (Support), to standalone microlearning activities (Standalone).

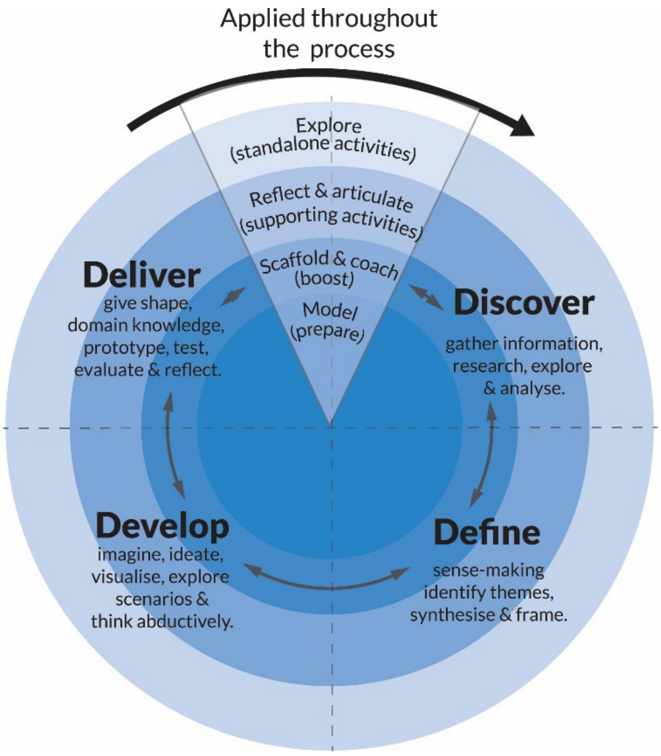

Figure 5: Conceptual framework of the way microlearning activities support learning-by-doing throughout the design process

For example, during the discovery phase of the design process, students must develop information-gathering competencies. Using the cognitive apprenticeship approach, the lecturer selects a suitable a micro activity to prepare students before modelling information-gathering methods and tools. Subsequently, activities that boost learning are used to support coaching and scaffolding. As the student's role in learning increases in the articulation and reflection steps, appropriate micro activities for performance-support and self-evaluation are included in the learning material. The learning cycle completes with students exploring the application of information-gathering methods in new contexts. Standalone, micro activities support them in doing so. As the class progresses through the phases of the design process the cognitive apprenticeship steps repeat for each competency with fit-for-purpose micro-activities that support learning-by-doing.

8. Summary

This study employed a literature review to conceptually explore the integration of microlearning activities within a learning-by-doing approach across the various phases of the design process, particularly within the context of blended learning environments. The purpose of the study was to theoretically explore how the key competencies required during the various phases of the design process, might be supported in blended learning settings. The study started with identifying key competencies required in each phase of the widely accepted double diamond design process. Subsequently different types and uses of microlearning activities were identified from the literature. By focusing on the intended purpose of the intended activities rather than the type and aligning these different uses with the various steps in the cognitive apprenticeship approach, a framework was established for integrating microlearning activities and a learn-by-doing approach. Overlaying the design process with this framework we developed a conceptual model for introducing microlearning activities that help students develop a deeper understanding of the design process and an ability to apply theoretical knowledge in practical settings. This study adds to current knowledge on educational approaches that facilitate learning-by-doing in design education, especially in technology-enhanced blended learning contexts. More research is needed to test the ideas presented in this framework, but we hope that this integrated approach can foster design competencies that ultimately support structured and accessible learning and application of complex design principles. This approach aims to ensure that students can make the connection between theory and practice by making implicit knowledge explicit.

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