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A qualitative exploration of expert perspectives on applying the science of learning to higher education

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Amid the constant change in higher education, a clear-eyed focus on the mission of higher education to support student learning is critical. Supporting student success, in turn, needs to emphasise rigorous evidence about what matters most for facilitating high-quality learning. With the science of learning, an emerging interdisciplinary field, as the study foundation, a series of 20 interviews was conducted with senior academics with research expertize in higher education and learning sciences. Interviews focused on principles for effective learning in the 21st century and relevance of science of learning research and literature to these principles. Using inductive and deductive thematic analysis across six iterative phases, seven key themes critical to contemporary higher education learning emerged, from which the higher education learning principles were developed. The principles provide a powerful tool to guide effective university teaching at an individual, organisation and policy level.

KEYWORDS

learning framework, science of learning, learning principle, higher education, learning

Introduction

The "science of learning" is a rapidly evolving field of investigation that is providing a sophisticated narrative of learning. Emerging in the last decade of the 20th century, researchers in the field employ an interdisciplinary approach across education, psychology, neuroscience, and distal fields such as technology and design, to understand the complex phenomenon that is learning (Hays, 2006; Meltzoff et al., 2009; Hattie and Nugent, 2021). It is the translation of this understanding to academic practice that we aimed to address in the present study through interviews with recognized experts in the science of learning and higher education. This led to the development of a set of guiding principles for learning that addresses the purpose of contemporary higher education drawn from seven themes that emerged during the study. General in applicability, the principles and themes are designed to stimulate learning-centric conversation, informing policy on student learning and evaluation, moving institutional culture towards a learning focus, and guiding individual teacher practice and development.

Science of learning

The emergence of the "science of learning," a multi-disciplinary endeavour bringing together disparate fields including neuroscience, education, and psychology has put the spotlight on how students learn. In recent years, research on the biological and neuropsychological understanding of learning has advanced considerably. Armed with new methods, tools and theoretical frameworks, complemented by existing measures and approaches, since the 1990's researchers in the field have made monumental advances toward understanding the learning process (Seel, 2012; Sigman et al., 2014; Altimus et al., 2020). Using an interdisciplinary perspective, tools and techniques developed to understand learning in the laboratory, are being adapted and evaluated for their ecological validity to complement the study of *in-situ* learning and teaching processes in diverse educational settings (Janssen et al., 2021).

The interdisciplinary approach of the science of learning is helping us to better understand, and disentangle the complexities of learning. Advances in technology, combined with innovative mixed methodologies and expanded worldviews allow for learning to be studied at various levels of granularity, from the synapse to society, recognising learning as an individual as well as a social phenomenon (MacMahon and Carroll, 2023). Core research in the science of learning has contributed to our understanding of cognitive, emotional, social, and metacognitive processes critical for learners' self-regulation of their learning. For example, using a combination of eye tracking, video observation and EEG, researchers are able to examine the role of confusion in learning (Pachman et al., 2016), whilst *in situ* studies are investigating the concept of "productive failure," and the development of resilience and persistence (Kapur, 2008; Kapur, 2016; Sinha and Kapur, 2021). Sociometric badges and physiological measures are being used to develop a deeper understanding of how particular strategies can enhance student engagement and cooperative learning (Gillies et al., 2016; Järvelä et al., 2020). State, trait and epistemic emotions such as anxiety (Gabriel et al., 2020), empathy (Cunnington et al., 2020), curiosity and confusion (Pekrun, 2006; Vogl et al., 2020) and the ability to self-regulate these emotions (Ben-Eliyahu and Linnenbrink-Garcia, 2015; Panadero, 2017) are increasingly recognised for their role in learning (Immordino-Yang et al., 2019). Research from the science of learning is contributing valuable insight into the importance of context to learning, making connections between existing and new knowledge (National Academies of Sciences et al., 2018b), and building on existing knowledge to solve novel challenges (Tokuhama-Espinosa, 2010; Cantor and Osher, 2021).

Evidence from these different disciplines and approaches can be collectively interpreted and translated to inform educational strategies that foster improved student learning (Horvath et al., 2017; Thomas, 2019; Darling-Hammond et al., 2020). At a school level the implications for educational practice of the science of learning are already emerging (Darling-Hammond et al., 2020). Equally, knowledge generated from the science of learning provides a pool of evidence from which university policymakers, institutions, teachers and students alike can draw upon (Lang, 2021). Evidence from the science of learning can support teaching and learning initiatives in higher education with both conceptual and prescriptive insights, promoting a culture of learning that prepares students for their place as global citizens, community members, workers, employers and colleagues.

The present study

In the present study, we sought to build an evidence-informed conceptual understanding of learning processes as they occur in the higher education setting using findings from higher education, education, cognitive psychology and neuroscience. Moreover, we sought to develop a guiding set of learning principles to inform higher education policy and practice that could be generalized across subject domains (e.g., sciences, humanities, and law) and student characteristics. In elucidating the themes and prinicples, our aim was to create a framework that had application at (i) an organisational or faculty level - a framework that can be adopted in its entirety or used on an *ad hoc* basis to inform the decisions that impact student learning and (ii) individually – a resource for teachers to reflect on their current practice, finding affirmation for the excellent teaching that is already occurring in the higher education sector, and identifying priority areas for growth and change. To achieve these aims, we conducted a series of interviews with recognized experts in the areas of science of learning and higher education. In doing so, we aimed to answer two key questions: (1) What are the principles for effective learning in higher education (2) How does the emerging science of learning research and literature influence these principles?.

Method

A qualitative study was designed to investigate the views of a range of recognized experts on the learning process in a university context. This qualitative approach enabled the capture of rich perspectives from individuals who hold different perspectives on learning and teaching as a socially constructed phenomenon depending on experiences, disciplinary affiliations, and worldviews (Merriam and Tisdell, 2015).

Participants

The study was designed to capture expertize about learning in higher education from a range of established, empirical researchers in interrelated yet distinct fields. To identify potential study participants, the research team (four science of learning specialists, one higher education specialist, and one member that spanned both fields) and four senior Australian higher education specialists formed a panel. Together, the panel generated a database of over 40 established senior scholars (professorial level, centre or research directors with international profiles) researching in the context of higher education from different disciplinary locations. Criteria for inclusion in the long list included: significant accumulation of citations, a h-index above 40, a substantial international profile through publications and presentations, and the leadership of research centres, departments or projects with a global reputation for quality research. Individually panellists ranked participants in the database based on contribution to their field, not necessarily to the science of learning. Together, the panel considered location, gender, and balance of fields to promote diversity. Participants were then clustered into phase 1, 2 and 3 recruitment categories. Phase 1 and then phase 2 participants were invited to participate in the study. Following 20 interviews with participants drawn from 10 countries across Europe (6), Asia (2), North America (5) and Australia (7), a level of saturation was reached with no new information being gathered (Kumar, 2011) and recruitment was ceased. Table 1 provides an overview of study participants in terms of gender and specialisation in their field of research. Of the 20 participants, 10 identified as learning sciences specialists.

Data collection

Participants were interviewed using a semi-structured protocol in one-to-one online or in-person sessions (depending on participant's location). The interviews explored participants' understanding about how students best learn, and what teaching practices support their learning based on their empirical research and expertize. The interviewer had a list of 17 prompting questions to draw upon (presented in Table A1 of the Appendix). Questions were designed to encourage the participants to consider higher education learning from the perspective of student learning, teaching, emerging teaching and learning research (including from the science of learning), the impact of innovation and emerging technology, and myths and misconceptions. For example, one line of questioning asked, "what does good quality learning look like to you?," "what do you think universities are doing well to support student learning?," and "what do you think could be improved, or receive greater emphasis?." Another line of questioning asked, "what are some exciting developments, or research, that you are aware of in higher education teaching and learning?" and a third line of prompting questions asked, "if you were going to discern a set of principles for guiding teaching practices about how students learn, what are some of the considerations you would offer?".

TABLE 1 Overview of interview participants.

Field of research	Female	Male	Total
Education	0	4	4
Higher education	2	3	5
Education technology	2	3	5
Educational psychology	1	3	4
Cognitive psychology	0	2	2
Total	5	15	20

Procedure

The design of this study was approved by the Human Research Ethics Committee of the administering institution. The average interview length was 60 min. Interviews were conducted in person or via videoconferencing software by a single research assistant. All interviews were recorded and transcribed. De-identified interview transcripts were labelled (A) to (R).

Data analysis

Interviews were transcribed and analysed using NVivo software, which allowed for inter-coder consistency and reliability. Transcript data were coded to minimize selection bias. Our analytical framework drew on the Braun and Clark (2006) integrated (inductive and deductive) thematic analysis approach and comprised six phases: familiarisation with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes (involved generation of principles in our study), and producing the report. This iterative analytic process facilitated by NVivo and done between research team members provided feedback and revision on the credibility of the interpretation of 20 h of transcribed data into a set of overarching yet interrelated principles (Creswell and Miller, 2000).

Results and discussion

Initially, over 136 inter-connected codes emerged from the first two phases of analysis. Through several cycles of deductive and inductive analysis, these were condensed into 24 broad codes. Seeking to reduce the number of themes, but at the same time be inclusive of all key concepts, after several iterations, the authors agreed on seven key themes critical to contemporary higher education learning from which principles were drawn, summarized in Table 2. These seven themes are discussed in detail below. They are not ordered in terms of priority or prominence in the data. Broad codes and related concepts mapping to the themes provided in Table A1 of the Appendix.

TABLE 2 Emerging themes and principles.

Theme	Principle
Deep and meaningful learning	Learning is built on prior knowledge and engages students in deep and meaningful thinking.
Learning as becoming	A university education provides a learning experience that broadens students' knowing and being for life beyond the classroom.
Learning to learn and higher order thinking	When students employ effective methods of thinking, and understand how they learn, they can improve the way they learn.
Contextual learning	Learning occurs in context, and context can be used to enhance the learning experience.
Emotions and learning	Emotions play a role in how and why students learn.
Learning challenges and difficulty	Challenge and difficulty can be beneficial for students' learning process.
Interactive learning	The social dynamics of learning can be leveraged to enhance the learning experience.

Deep and meaningful learning – learning is built on prior knowledge and engages students in deep and meaningful thinking

Numerous dichotomies have been developed to describe learning and associated phenomena. While educational researchers contrast deep learning with shallow or surface learning (Marton and Säljö, 1976), experimental psychology has focused on constructs such as fast and slow information processing systems (Kahneman, 2011). Critical of the advancement in our understanding of cognitive processing, building on the two-dimensional deep-surface model Dinsmore et al. (2023) have postulated a more dynamic model taking into account self-regulation and one's ability to control engagement, and the nature of the learning environment. How memory is encoded is contemplated by cognitive psychologists, for example Craik's level of processing theory predicts the deeper information is processed, the longer a memory trace will last (Craik and Lockhart, 1972; Craik and Tulving, 1975). Meanwhile, neuroscientists seek to map various regions of the brain to particular tasks, associating the frontal lobe with high level thinking (Catani, 2019). Despite general agreement that deep learning is a key feature of a quality tertiary education, the lack of a common terminology to describe the phenomena that we loosely characterize as "deep and meaningful learning" presents a challenge to implementation.

Connectivity and conceptual change are described in the literature as key elements of deep and meaningful learning. Deep and meaningful learning builds on prior knowledge, with the ability to transfer established concepts to different areas which connect with future learning opportunities (Barnett and Ceci, 2002; Jackson, 2016). At a psychological level, this involves the acquisition and updating of complex conceptual ideas, rearrangement of mental schema and the overcoming of intuitive misconceptions (Ohlsson, 2011). Conceptual change results from employing deeper thinking to understand and apply complex artefacts (Meyer, 2005). These two elements were identified as features of quality learning by the experts.

Experts referred to connectivity in describing quality learning – "to understand the connections between the new thing that they are learning and previous learning … transfer to novel situations" (A). Meaningful learning occurs "not because you have rote memorized it, but because it's connected to other things that you have learned" (A). "The learning has to be appropriate activation of prior knowledge" (Q). "Learning is all about seeing things differently, because if there is not any change, then we are not learning" (L), a reinforced or changed view.

The over-simplification of using dichotomies such as deep and meaningful and surface learning to characterize complexities of student learning in higher education has been questioned (e.g., Lodge and Bosanquet, 2014). Indeed, the two can be mutually dependent, with surface learning required to reap the benefits of deep learning (Hattie and Donoghue, 2016). However, only one expert focused on this line of discussion, reflecting "it could be that certain learning is supposed to only be learnt by rote and that it's not very deep, but it could be very effective" (R).

Although having a deep understanding was considered an indicator of successful learning, there was no clear definition of what that is, "what do we mean when we say that students understand something?" (K). There was concern "there is still a view in universities that learning equals turning up to lectures, going to tutorials, and so on, and so forth" (L). Further, university assessment was considered counter to deep and meaningful learning, "most of education is geared towards getting students to, pass exams" (A).

Learning as becoming – a university education provides a learning experience that broadens students' knowing and being for life beyond the classroom

Explicitly mentioned by only one expert, learning as becoming was referred to on numerous occasions and in varied contexts, for example in relation to assessment – "we are not teaching for school, we are teaching for something else" (M). "Because I think all professionals have a responsibility to provide a kind of responsible, ethical service to the society. That is why we are educating them; not to be knowledgeable" (N).

When a neuroscientist contemplates learning she does not think about it in terms of a single event that occurs in a lecture theatre, or during the course of a semester. Occurring at a cellular level neuroplasticity is a continual process, as our neural connectivity responds and adapts to each and every use and experience (Martin et al., 2000; Langille and Brown, 2018). Educational researchers interested in learning across the lifespan also recognise it is a continual, iterative as well as deeply subjective experience, one shaped by individual as well as environmental forces (Webster-Wright, 2009; Billett, 2018; Wenger, 2018). Similarly, "learning as becoming" recognizes learning as a life-long event, not restricted to a particular time or place such as within the walls of a classroom. With an ontological consideration, knowing becomes situated or arises from personal, social, historical and cultural experiences of being-in-the-world (Barnett, 2004; Dall'Alba and Barnacle, 2007). A concept first put forward by proponents such as Heidegger (1977), the notion of becoming has grown in prominence. In its broad sense, it is a perspective on learning "which allows the individual to sort of grow and move and change in a way that leads them to alter themselves" (F).

Ontological consideration in higher education prepares students for dealing with the ambiguities of becoming (Dall'Alba, 2009), as well as the challenges they face in an uncertain and changing world. In doing so they learn to become more capable of adaptability and reflectivity as creative and critical beings (Barnett, 2012). Learning is an integrated lifelong experience as "being" that also addresses social, emotional, and other qualities (Su, 2011; Barnett, 2012), such that students are on a lifelong learning pathway before, during, and after they are a student in that discipline. Technology enhanced learning can be employed to provide opportunity to harness the sociocultural aspects of occupational identity (Chan, 2021).

Although the concept "learning as becoming" extends far beyond preparing students for future employment, the idea of preparing students to be workforce ready was reinforced by a number of experts for example "the industry would have sufficient information to say, "I want to hire you because I have seen you work with my people." (Q), "I talk about "teaching for working skills" … where the skill is taught/practised … throughout the curriculum" (M), "So of course in education, they are building a relationship with the professional community outside the university" (B).

However, there was criticism that "the employability agenda is too narrow" (N), with one expert stating "this vocational notion of education is death to thinking" (F). The question should not be "what content do we need to include in the program? but what kind of contribution do we want our students to be making to society beyond the program?" (N).

Learning to learn and higher order thinking – when students employ effective methods of thinking, and understand how they learn, they can improve the way they learn

If the goal of a university education is to prepare students for life beyond university, then they must be equipped not only with the knowledge that exists in the here and now, but they must be ready for future learning. "We are now teaching them how to teach themselves for the rest of their lives" (O). Indeed, from a policy perspective, citizens of the knowledge economy must be prepared for a lifetime of learning.

Higher-order thinking requires the ability to self-regulate. To be an effective, self-regulated learner, a range of explicit skills need to be developed, including executive functioning skills and metacognitive awareness (Bjork et al., 2013). Executive functioning skills are those skills that enable learners to plan, focus, inhibit behaviours, remember instructions, set priorities, problem solve and be cognitively flexible (Huizinga et al., 2006). Metacognition allows effective learners to draw on their knowledge and awareness of thinking processes and regulate their attention in order to modify their thinking whilst engaged in a learning task (Efklides, 2008; Zimmerman and Moylan, 2009; Spruce and Bol, 2015). Being able to regulate both emotions and cognitions are needed for effective learning (Ben-Eliyahu and Linnenbrink-Garcia, 2015). In higher education, autonomy-supportive teacher behaviour has been shown to be effective in promoting self-regulation (Duchatelet and Donch, 2019), and the training of self-regulated learning skills positively influences a range of learner outcomes, including motivation, effective strategy use and achievement (Davis and Hadwin, 2021; Theobald, 2021; MacMahon et al., 2022).

Experts described higher order thinking as requiring learners to be able to make judgements about their own thinking. The aim is for "students understanding more about their own capacities and learning how to learn" (H). One approach that has been adopted is to have students grade their own work, but this approach only has merit when students understand what they are assessing, "it's about students identifying and making sense of and owning the criteria that they need to apply to their own work" (L). Learners being aware of their thinking still does not go far enough "in terms of improving your thinking, and that's the next step" (K).

In order to develop higher order thinking, students need to be invited to "take responsibility for learning" (J). Teachers "have to let go, we have to set up the task so students can think, then we have to let them go to think" (K). Students need the opportunity to "use what they have learnt and add to it in meaningful ways: and now we are teaching them how to teach themselves for the rest of their life" (O). Before we ask students to take on the responsibility for their leaning, we must first show them. "If you want people to learn deeply by making abstracts of synthesis of what they have read, you first have to teach them how to make such a synthesis because most do not know how to do it well" (R). Self-regulation of a metacognitive level, "means thinking about your own learning process, and understanding your learning processes" (G). It is "thinking about how I solve the problem and then actually the problem solving, and then reflecting about the problem solving" (G). What makes entrepreneurial learners unique "that is probably different to everyone else is that they notice opportunity (to learn)" (I).

Contextual learning – learning occurs in context, and context can be used to enhance the learning experience

Contextualized learning as a concept was discussed by seven experts. Interchangeable terminology was used by interviewees to discuss the concept that included contextual, project-based, authentic, and situated learning. This reflects the breadth of constructs identified in the literature used to describe what the authors classify "contextual learning" in this study - for example, situated cognition (Brown et al., 1989), situated learning (Lave and Wenger, 1991), project-based learning (Bell, 2010), contextual teaching and learning (Johnson, 2002); context-based adult learning (Hansman, 2001); real-world learning (Brundiers et al., 2010); embedded instruction (Rakap and Parlak-Rakap, 2011); project-based learning (Bell, 2010); and case-based learning (McCabe et al., 2009).

Underlying this principle is the proposition that learning is enhanced when knowledge and skill acquisition are embedded within relevant contexts that reflect their utility in real life (Brown et al., 1989; Lave and Wenger, 1991; Webster-Wright, 2009; Billett, 2018; Wenger, 2018). Overall receiving positive endorsement, "it cannot be like a disconnected learning" (G), the degree to which experts viewed the application of contextualized learning varied. For some "it has to be contextualized in the actual practice of the discipline …. to design their learning experience in ways that mirror the actual disciplinary practice" (Q). Generally, it was considered in a far broader sense "a learner can see that what they are doing has some analogue in the world, outside academia" (L). Taking contextual learning to the extreme would be "to get students in these authentic contexts and evaluate them holistically" (Q). In such a scenario, "maybe assessment would become irrelevant because practice itself will take over" (Q).

Two experts discussed contextualized learning in relation to the students' prior knowledge. "I've learned it today because of other things I knew in the past" (A). One expert reflected on the idea of "transmission of context" to students, and of "constructivism," where students are constructing their own knowledge. However, there was criticism of this approach "we go too far in undervaluing and downplaying the role that the teacher plays" (N).

There were mixed opinions regarding the effectiveness to which universities were addressing contextualized learning, particularly in relation to assessment. "Nobody in the world out there writes essays" (K). There was also caution in relation to work placements, with the learnings from the program depending on the nature of the experience, with students often seen as a cheap pair of hands, or only capable of meaningless task – "Oh, good for coming. Great, I have all of these Excel spreadsheets…" (M).

Emotions and learning – emotions play a role in how and why students learn

Emotions and learning was a theme that emerged from the expert interviews. "Emotions are part and parcel of what you do on a day-to-day basis" (A). Triggering the release of hormones and neurotransmitters that modulate learning and memory, emotions highly influence learning outcomes (Vogel and Schwabe, 2016). Whilst at the school level much research has been conducted on the emotional state of teachers and students (Carroll and Bower, 2021; Carroll et al., 2022), the need to understand and address emotions in learning at a higher education level has only recently been highlighted (Pekrun, 2019). Emotions surrounding learning are highly complex due to their subjective nature (Immordino-Yang and Damasio, 2007; Vogl et al., 2020), but an understanding and appreciation of their role in learning can be leveraged to inform the design of engaging learning experiences (Linnenbrink-Garcia et al., 2016; Immordino-Yang et al., 2019). Covering pre, during and post learning, emotions were discussed in relation to students' motivation to learn, the learning process *per se*, and post learning feelings.

High quality learning was described as having a "sense of intrinsic motivation" (H), being self-fulfilling. Motivation is generally acknowledged as a condition critical to learning and achievement (National Academies of Sciences et al., 2018a). In discussing what shapes a student's motivation to learn, the care-factor was mentioned explicitly by four experts. "A student may care because it is an interesting topic to them, they like the person teaching it or the team they are working with" (A). A "sense of valuing what they are learning" (N) leads to greater engagement. Students are more likely to engage in learning if they feel there is some sort of 'pay-off… "oh, that was a good use of my time"' (L). Moreover, students are more likely to engage positively if they believe "they are valued" (F) – a sense of belonging. A second factor shaping students' motivation to learn was the belief that they can learn. "If you do not believe you can succeed, why would you want to put the effort in to do so?" (F). These ideas align with Eccles expectancy-value theory of motivation which has as the central constructs individuals' expectancy for success and the value they have for succeeding (Wigfield and Eccles, 2000).

Turning to the learning process, experts named a number of emotions that arise during learning, most focussing on what would normally be considered undesirable. Both the education and psychology literature describe how the valence of an emotional state can promote or impede learning. Strong negative emotions can increase awareness of the difficulty of a task, interrupt cognitive function due to the activation of the stress response, and promote negative psychological and physical consequences, whilst positive emotional states can broaden awareness, enhance creative and flexible thinking, increase perspective taking, and promote persistence (Fredrickson, 2009).

Finally, comes the completion of the task, and two of the experts considered the emotion associated therewith and what it said about the learning experience. A good learning experience has "got some satisfaction" (L). Learners that are more satisfied "have been able to make those connections through reflection and actually feel a little bit more accomplished along the way" (O) whereas "those that are relieved have not found any meaning/relevance" (O).

Learning challenges and difficulty – challenge and difficulty can be beneficial for students' learning process

Learning challenge and difficulty was the most contentious theme to emerge with many terms used by experts during the interviews including confusion and failure, productive failure and cognitive disequilibrium. With the potential to impact learning, both positively and negatively, challenge and difficulty is increasingly studied by science of learning researchers. A meta-analysis performed by Darabi et al. (2018) did reveal a moderately positive outcome as a result of learning from failure, however only 12 out of 62 studies quantified learning outcomes (Darabi et al., 2018). On the debate of whether a new concept should begin with instruction or problem solving, a meta-analysis of 53 studies with 166 comparisions showed a moderate effect in favour of problem-solving followed by instruction design (Sinha and Kapur, 2021).

When an individual is faced with cognitive complexities that challenge their existing knowledge or goals – through contradiction, dissonance, uncertainty, or knowledge gaps – it can result in the subjective experience of confusion (D'Mello and Graesser, 2012; Arguel et al., 2017). Experiencing confusion in the university learning environment can be productive, resulting in deeper understanding, or destructive, resulting in frustration and potential disengagement if the appropriate scaffolding is not in place to resolve confusion and uncertainty (D'Mello and Graesser, 2012; Arguel et al., 2017).

Although the eight experts who spoke to the theme agreed with the notion that cognitive challenge has a role in the learning process and improving learning outcomes, it can also have a detrimental effect and should be applied as a learning strategy with caution. On the flip side, it is "dangerous for students to have to experience only success, because it does not make you resilient" (B).

Two lines of thought emerged to circumvent the negative emotions associated with learning challenge and difficulty. Some experts described approaches to "normalize" challenge and failure so that it was not automatically associated with negative connotations. Other experts focused on the turning point between productive and unproductive confusion and failure.

Teachers are in the position of having to assume how much challenge and difficulty a student can tolerate. It is very dangerous to underestimate "the level of challenge the students want and enjoy" (B). If there is not enough opportunity for trial and error, and to get things wrong, students will perceive struggle, mistakes and dead ends as personal flaws. Experts spoke of creating situations that allowed for "non-fatal failure" (B), with low-risk assessment being an example, and letting students know "we are assessing you on your response to the failure" (I). Academics are able to normalize struggle, difficulty and failure by being more honest "exploring where the struggles are in the field" (N).

In addition to normalising learning challenge and difficulty, experts spoke of the balance between productive and unproductive struggle to ensure students remain engaged and motivated. Students need to be uncomfortable "you have got to be in the pit and struggling" (I). Learners will "go in and out and at some point you have your 'aha' moment and you see things differently" (J). Teachers should aim to create learning situations with "desirable difficulty, cognitive disequilibrium" (R). The learning experience should not be "too difficult to the point that they cannot understand what you are going on about" (A). It is important learners "do not stay confused for too long and move into unproductive confusion" (H). There needs to be scaffolding "and if you fall it's alright, I'll pick you up" (B). "An activity that involves productive failure, requires follow-on activities so the students can learn from productive failure" (P). This lead one expert to suggest "the more you look at constructive failure, the more it just becomes decided failure, or actually instruction" (R).

Interactive learning – the social dynamics of learning can be leveraged to enhance the learning experience

Specific instances of interactive learning, such as cooperative learning and collaboration, were discussed by nine experts. Interacting with others promotes group productivity and achievement, engagement, as well as wellbeing (Barsade and Gibson, 2012; Yano, 2013; Bevilacqua et al., 2019). Therefore, understanding the processes underpinning interactive learning can assist in designing learning opportunities that capitalize on the innate human desire to socially interact. Developments in brain imaging, physiological devices and multi-disciplinary approaches means that researchers are now able to track the interaction of a whole classroom, and are thus able to study real-time emotional, cognitive and physiological synchrony (Bevilacqua et al., 2019; Carroll et al., 2019; Haataja et al., 2022).

Concern was expressed that true collaborative learning opportunities are scarce in higher education. Working with other people was considered important as it provides an opportunity "to get counter-ideas because that is the only way we become informed" (N). "Some of the students will bring up issues that other students will not think of" (N). When teachers think about the resources available, they should include students, "resources include other people too, so fellow students in the class" (B).

Cooperative learning, the pedagogical practice of working interdependently in small social learning groups towards the attainment of a shared goal (Gillies, 2007), is one way in which this social dynamic can be harnessed. Cooperative learning practices, as opposed to group instruction, enhance engagement and participation, increase motivation, have greater innate task value, and provide opportunities for appropriate learner challenge (Peterson and Miller, 2004). However, several experts noted the challenge of establishing an environment for collaborative learning within the physical and policy constraints of a university.

Designing opportunities for collaborative learning within the university context can have its challenges and "not all engagements are positive, not all engagement leads students to believe they are valued" (F). The learning space and class size is not always inducive to collaboration, teachers need to work towards building "relationships at a distance" (B) and "building in opportunities in the lecture for students to talk to each other" (B). Some experts see the environment of a massive lecture setting as too big a hurdle to overcome "it cannot be two-way because there's too many minds" (K). Others argue meaningful collaboration "is a longer time-scale development" (Q). "If you are generally mirroring disciplinary practice, collaboration naturally emerges" (Q). Moreover, collaboration associated with assessment is even more likely to be ineffective. "You can design the best collaboration but if the culture is one of high stakes/competition, then you are not going to develop those things, no matter whatever sophisticated method you deploy" (Q).

Conclusion

In this study we identified seven themes and guiding principles relating to higher education. The principles are neither novel nor unrelated, but their formulation into a cohesive framework, with interpretation and application provided by learning experts provides a powerful tool to guide effective university teaching at an individual, organisation and policy level. These principles compliment others in the literature. For example, the learning principles provided here align well with the pedagogical "pillars" of online pedagogy outlined by Archambault et al. (2022). Importantly, these principles provide a foundation for shifting the emphasis of pedagogy and assessment from outcomes to processes (as per Swiecki et al., 2022), particularly when considered in concert with Archambault et al.'s pillars. For example, at a university policy level the themes provoke discussion on the evaluation of student learning and alignment with learning principles. A greater focus on the process of learning allows for more targeted teaching preparation programs and ongoing professional development for university teachers, whilst university teachers can use the principles to reflect on their own teaching practices.

The principles are not intended to be prescriptive and we do not suggest that a high-quality learning experience requires all the principles to be addressed. Nor is the order of presentation of the principles intended to be sequential or hierarchical. Whilst in this study we focus on the development of the themes and principles, other authors have contemplated reduction of the priniciples to practice in an academic setting (Osika et al., 2022).

An overwhelming observation to emerge from our study is the lack of a common language to describe similar concepts, and for the pivotal concept of learning – no shared definition. Whilst the former may in part be due to the multi-disciplinary aspect of the science of learning with experts grounded in education, psychological science and neuroscience, the latter may be attributed to the complexity of the concept. Lack of agreement among researchers around what learning is underpins the challenge in translating principles for effective university teaching into practice by teachers, organisations and policy makers, and in and of itself is a topic for further exploration.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The University of Queensland Human Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AN, AC, PS, KM, and SM: conceptualisation and design. AN: Collection, formal analysis of data, and drafting the manuscript. AN, AC, JL, PS, KM, and SM: analysis, interpretation of data, and reviewing and editing the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2023.1233651/full#supplementary-material

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