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Key pedagogical implications of learning sciences research for higher education teaching

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Abstract

For more than a century, neurologists, cognitive psychologists, and experts from other disciplines have contributed to what now is an incredibly large body of research about how humans learn best. Despite this being key research for anyone in the teaching profession, there is still a gap between research and teaching practice in higher education. In the last thirty years, the learning sciences (LS), an interdisciplinary field that seeks the application of research to real teaching and learning situations, has made a significant contribution to bring research closer to teaching practice. The purpose of this paper is twofold: firstly, to present an updated review of learning sciences research, focusing on its pedagogical implications for higher education teaching; and secondly, to provide teachers with a series of guidelines to reflect and implement research-based knowledge in their teaching. LS research highlights the critical role that emotions play in the learning process. Teachers' own emotions and attitudes are key to create safe learning environments where students' positive emotions are fostered, and motivation and engagement are enhanced. Emotions also affect cognitive functions like attention and memory. Teaching techniques that promote curiosity and offer choice can maximise the power of positive emotions to catch and hold attention. Learning designs that provide scaffolding and align with learners' prior knowledge are effective to avoid overloading working memory. Furthermore, research on learning has shown that learning environments are highly varied in terms of how learners engage, access information, and approach activities. The Universal Design for Learning (UDL) guidelines address this variability and support the design of accessible and inclusive learning experiences, by offering learners multiple means of getting engaged, comprehending information, and expressing the knowledge and skills they have acquired.

Keywords: attention; emotions; inclusiveness; memory; research-based teaching

1. Introduction

The learning sciences (henceforth LS) is an interdisciplinary field that studies how learning takes place, both in formal educational settings (e.g., universities) and more informal environments (e.g., libraries). The LS include a wide range of disciplines, such as cognitive science, neuroscience and instructional design (Sawyer, 2006). In the last few decades, the collaboration of researchers from these different fields has improved our understanding of

learning considerably. For example, we learn about attention and memory through the research of cognitive psychologists, and this knowledge is further enriched by neurosciencists' work on the brain mechanisms that underpin those mental processes.

Design-based research (DBR) is the characteristic research methodology of the LS. DBR studies single learning events in authentic learning contexts. Typically, a design study involves the detailed investigation of a learning situation throughout several iterations, taking into account multiple aspects, such as learners' prior knowledge or peer interactions (Confrey, 2006). Design researchers work in close collaboration with teachers, and many researchers are also teachers themselves. This has made the findings of DBR more accessible for educators and easier to apply in practice, in line with learning scientists' conviction that "any conversation about effective teaching must begin with a consideration of how students learn" (Ambrose et al., 2010).

The LS' goal is "to better understand the cognitive and social processes that result in the most effective learning, and to use this knowledge to redesign classrooms and other learning environments so that people learn more deeply and more effectively" (Sawyer, 2008). Unlike much of the previous educational research, which remained within the academic community where it was conducted, the LS have been successful in providing useable guidance for teachers, based on key research-based findings with implications "for the design of curricula, instruction, assessments, and learning environments" (Donovan et al., 1999). LS research has a key role to play in improving teaching practices in higher education. Teachers' understanding of how learning takes place is essential for them to make informed decisions about a range of aspects that impact student learning directly, such as activity design and engagement. Teachers' knowledge of core scientific findings about learning has been proved to lead to more pedagogically sound decisions (Ansari et al., 2017; Betts et al., 2019).

The purpose of this paper is to highlight some key pedagogical implications of LS research for teaching in higher education and to provide teachers with research-based guidelines and reflection prompts to implement this research in their practice. The focus on higher education teaching implies that the reflection prompts and guidelines are provided with higher education teachers in mind. However, the research findings on learning mentioned here cannot be regarded as specifically applicable to learners in higher education; for the most part, they refer to learning in general, regardless of age or educational context. The role of emotions in learning and their connection with the cognitive processes of attention and memory is the main thematic thread of the sections in this paper. The purpose is to emphasize the understanding of learning as the result of both emotional and cognitive processes combined and to shed some light into how higher education teaching can align with that understanding.

2. Emotions

The critical role that emotions play in learning can hardly be overstated. The relationship between emotions and learning is largely explained by the functioning of two almond-shaped clusters of neurons (brain cells) called amygdalae. Located in the temporal lobes of the brain, one in each hemisphere, the amygdalae deal with emotional responses. When we are dealing with negative emotions such as fear or worry, the amygdalae become highly active and prevent new sensory input from reaching other parts of the brain in charge of cognitive skills such as memory and attention, which are essential for learning. On the other hand, the amigdalae also react to positive emotions, in this case enhancing attention and memory, facilitating the processing of new input and consequently supporting learning (Eyler, 2018). The emotional and cognitive mechanisms of the brain are so intertwined that we cannot have a full understanding of the learning process if we think of it as an exclusively cognitive process.

Positive emotions like joy, wonder and curiosity grab attention and enhance memory, make students more resilient towards challenges and can increase motivation. Negative emotions like worry, boredom and anxiety, on the contrary, divert attention, overload working memory, and can lead to low motivation and disengagement (Cavanagh, 2016). However, not all the emotions we would normally regard as negative are at all times detrimental for learning. Confusion and frustration, for example, depending on their intensity and duration, can sometimes have positive effects on learning. Under the right circumstances (e.g., learner feels capable and receives appropriate guidance), those emotions can help students allocate additional attention and effort to solve a task or clarify misunderstandings, therefore resulting in deeper learning (Tyng et al., 2017).

The classroom is a "highly emotional environment" (Cavanagh, 2016), where emotional contagion is likely to take place. Emotional contagion explains how emotions are transmitted among people who interact; in such a way that they mimic each other's behavior and converge together emotionally. There seems to be a close connection between perceived teachers' emotions and students' own emotions, meaning that teachers' emotions have a significant influence on the emotional atmosphere of the class. Thus, a teacher showing enthusiasm for the subject, empathy and genuine interest in what students are contributing can spread positive emotions in the classroom (Becker et al., 2014).

Teachers also have a key role to play in creating a safe and socially positive classroom. There are a variety of reasons why students might not be engaging cognitively, many of which can relate to their emotions. Students may be prevented from asking questions because they fear appearing unintelligent, from answering questions because they feel embarrassed, or from participating in activities because they are confused about the goals of the task. Perceiving the teacher as approachable and supportive can make the classroom feel safer for learners and remove those barriers that prevent cognitive engagement and hinder learning. Specific actions

that teachers can take in this respect are providing options for students to ask questions anonymously; presenting goals and expectations in a transparent way; and normalizing both making mistakes and asking for help (Eyler, 2018; Lang, 2021).

Another aspect that has been proved to contribute to an atmosphere of warmth and transparency in the classroom is teacher self-disclosure, i.e., teachers sharing something about themselves. When relevant and carried out in an appropriate manner, self-disclosure increases the atmosphere of trust in the classroom and the perception of the teacher's credibility and competence (Cavanagh, 2016). Teachers sharing with students what attracted them to the subject initially or their own difficulties when learning certain topics for the first time are examples of self-disclosure.

What researchers call pedagogical caring also contributes to creating an emotional positive learning environment. In *How Humans Learn*, Joshua R. Eyler points out that "the research on positive emotions and learning reveals that the single most important strategy we can use to help our students succeed in our courses is to care about them as learners and as human beings" (2018). Pedagogical caring is not about losing professional boundaries between teachers and students, but rather about recognizing learners as unique individuals at a personal level and as people with certain pedagogical needs and expectations (Hawk & Lyons, 2008). Pedagogical caring can be implemented in practice by making an effort to learn students' names (or use name tents in large classes), providing feedback that focusses on development, and getting to know students as individuals (e.g., their background, experience and interests).

The role of emotions in learning will be highlighted again in subsequent sections of this paper, in particular regarding the interrelatedness between attention and curiosity, well-being and cognitive load, and engagement and accessibility.

2.1 Reflection prompts

- To what extent have you thought of emotions as a fundamental aspect of learning and consequently, as a fundamental aspect of teaching?
- In your courses, can you identify instances of lack of cognitive engagement that could relate to students' negative emotions? And instances of cognitive engagement that could relate to positive emotions?
- Reflecting on the concepts of self-disclosure and pedagogical caring, how do you contribute to create a safe and positive emotional environment in your classes? Is there anything else that you would like to try?

3. Attention

Attention is the capacity to select relevant stimuli and information**,** while keeping non-relevant information or stimuli at bay (Miller, 2014)**.** Attention is a prerequesite for learning,

i.e., to learn something, first we must attend to it, so that we can then involve our memory mechanisms to process it. One of the most relevant facts about attention in relation to learning is that it is a very limited resource, as illustrated by the concept of Inattentional Blindness. Inattentional blindness is the failure to notice an object or event that is easily seen once noticed, but completely missed when attention is engaged elsewhere. It is a highly counterintuitive phenomenon; most of us have difficulty believing that we could fail so badly at noticing something that, once it is paid attention to, is so easy to perceive (Rensink, 2009).

In a learning environment, it is critical to guide learners' attention to relevant aspects of the content. One way of directing and sustaining students' attention is by increasing situational interest. Whereas individual interest refers to a person's personal inclination to engage with specific content and tends to last over time, situational interest is spontaneous and triggered by what is happening in the environment (Hidi and Renninger, 2006). Although both individual and situational interest have an impact on attention, situational interest is particularly relevant for teachers because it can be influenced through the choice of teaching techniques and the design of instructional materials.

Research has shown that cognitive activation increases situational interest (Hidi and Renninger, 2006; Schraw et al., 2001). Cognitive activation involves prompting students to engage with the material or practice the skills they are learning, so that they can actively process information at a deeper level. Students should be activated as often as possible, providing clear goals and appropriate feedback. Posing questions or asking learners to provide questions themselves, presenting a problem to be solved, discussing, summarising and making predictions are all examples of techniques that can contribute to cognitive activation. In the case of lectures or pre-recorded videos in online learning contexts, where students are more likely to be passively listening and watching, cognitive activation needs to be more deliberately planned. Activation in lectures can be encouraged by using opening questions to activate prior knowledge, integrating short activities for the application of concepts, or including closing reflection exercises (Quinlan, 2019). Online pre-recorded videos can integrate questions or be linked to an activity (e.g., watch and contribute to an online discussion).

Situational interest is also positively affected by teachers' cognitive congruence. A cognitive congruent teacher communicates in a way that facilitates students' grasp of complex concepts by providing scaffolding to support student thinking, for example, through questions that increase in complexity towards the required level of understanding (Rotgans and Schmidt, 2011). Whereas experts have a general overview of complex ideas and can distinguish between key points and supporting details, novices frequently focus on details, missing major ideas and connections. Cognitive congruence provides support to move students towards more expert knowledge and skills, for example by emphasizing main ideas, supporting awareness of core takeaways, and providing structure to make connections (Lang, 2020).

The possibility of having certain choices has also been linked to an increase in situational interest. Providing choice allows students to select what they are most curious about and aligns best with their prior knowledge or skills. Furthermore, choice gives students a sense of ownership, increasing their engagement and motivation (Schraw et al., 2001). Without compromising the standard of the intended learning outcomes, a variety of meaningful choices can be given to learners, for example in relation to activity presentation formats (e.g., in writing, in video or audio format) or ways in which activities are completed (e.g., individually, in pairs or in groups).

Curiosity is a powerful emotion to catch and hold attention. Being curious sparks a desire to find out information that can fill in gaps in our knowledge and as such it is "one of the great drivers of human attention" (Lang, 2020). Questioning can be an effective technique to engage curiosity, with the design of the questions being key to ensure their effectiveness. Open-ended questions that prompt students to explore the "why" of issues are more likely to instill curiosity than close-ended questions. However, Eyler cautions against the use of questions that are too open or general (e.g. "What do you think about X?"), explaining that "curiosity can only be activated if we are invested in the answer" and questions that are too open "allow students to fall back on easy opinion in which they do not have much at stake" (2018).

Psychological research shows that for curiosity to be stimulated, students must feel that the gaps in their knowledge are manageable (Pluck and Johnson, 2011). It is relevant to assess students' prior understanding so that questions or problems can be set at an appropriate level. This is particularly important in the case of novice learners, who will benefit from the presentation of challenging ideas in stages, to maximise their curiosity and lower the level of potential fear or anxiety (Eyler, 2018). Providing regular feedback is also an efficient way to support curiosity, it helps students identify gaps in their knowledge and can increase their urge to find out what they do not know or need to improve.

3.1 Reflection prompts

- How aware have you been of the role of attention in learning? How much do you consider attention when designing or planning your teaching?
- Which of the aspects that contribute to situational interest (e.g. activation, choices) can you identify in your teaching? Which ones could you use more often?
- How do you spark curiosity in your students? What other ideas could you try to hold their attention through curiosity?

4. Memory

Memory is a brain mechanism that allows us to make sense of information, connect it to existing knowledge, and recall it when needed (Miller, 2014). Working memory and long-

term memory are the two main processes involved in what we call memory. Working memory has a very limited capacity and is easily overloaded, it can only hold and manipulate small amounts of information for a short period of time. Long-term memory deals with the storage and later recalling of information. It is unlimited in terms of capacity, but it is difficult to retrieve information from it. Each of the limitations of working and long-term memory, i.e., limited capacity and difficulty of retrieval respectively, have key implications for teaching.

Relevant manipulation of information can only take place if working memory is not overloaded. Cognitive Load Theory (henceforth CLT), developed in the late 1980s, proposed a series of instructional recommendations to avoid overburding working memory. Three different types of cognitive load were identified: intrinsic load, determined by the inherent complexity of the material; extraneous load, caused by poorly designed instruction or an unfavourable environment; and germane load, the required mental effort for processing information (Sweller et al., 1998). Whereas intrinsic load cannot be changed by instructional interventions because it is inherent to the material, extraneous load can be decreased and germane load increased through instructional design. CLT originally reported seven instructional effects which influenced cognitive load; a few more have been added later. We focus here on the implications of some of them.

Studies in different subject areas have indicated that worked examples, problems that include their solution steps, are more efficient than solving the equivalent problems in the case of novice learners (worked-example effect). However, more independent problem-solving activities, like completion problems (with a partial solution) or conventional problems, are more beneficial as students gain expertise (completion problem effect) (Sweller et al., 2019). This is explained by the expertise reversal effect, which shows that certain instructional techniques, such as worked examples, that are effective in tackling cognitive load for novice learners, can be inefficient for more experienced learners. This effect highlights the importance of assessing students' prior knowledge to anticipate cognitive load appropriately and design activities that align with students' level of understanding.

Two of the most influential CLT instructional effects have been the redundancy effect and the modality effect, partly because of how relevant they have become for the design of multimedia materials. The redundancy effect refers to the cognitive load caused by presenting the same information in multiple forms (e.g., text and diagrams that present the same content but are not integrated; PowerPoint slides where the text is also read aloud by the teacher). According to the modality effect, working memory capacity increases when information is presented through both the visual and auditory channels, instead of either of them in isolation (Sweller et al., 1998). These CLT effects imply that instructional materials can reduce cognitive load if they do not present the same words as both on-screen text and narration, and if narration is used in combination with relevant graphics or images (Chong, 2005).

Recent developments of CLT have studied how emotions affect cognitive load. Negative emotions such as stress contribute to cognitive overload when the limited working memory resources are utilised to regulate those emotions. On the contrary, positive emotions can increase germane load by sparking motivation that supports the mental effort needed to achieve goals (Plass and Kalyuga, 2019). Unsurprinsingly, similar results have been obtained regarding the influence of well-being on cognitive load. Well-being can be defined as a state that involves feeling more positive emotions than negative ones (feeling good) and also being able to deal with unpleasant situations in a productive way (functioning effectively). The feeling good aspect of well-being, through positive emotions, can increase germane load prior to a task, and the functioning effectively aspect of well-being, through the self-regulation of negative emotions, can reduce extraneous load (Hawthorne et al., 2019).

Working memory continuously retrieves related information from long-term memory to make sense of new input. The retrieval of information from long-term memory can be challenging. In Michelle D. Miller's words, "long-term memory is rather like having a vast amount of closet space - it is easy to store many items, but it is difficult to retrieve the needed item in a timely fashion" (2011). Cognitive scientists talk about three long-term memory stages: encoding (new input is made sense of and moved to long-term memory), consolidation (memories are reinforced) and retrieval (information is brought to mind from long-term memory) (Weinstein et al., 2019). For deep learning to take place, we must focus on the consolidation and retrieval stages, which are closely related: the deeper we consolidate information, the easier it will be to retrieve at a later stage.

Deep consolidation of information requires deliberate effort from learners. This effort can be elicited by exposing students to "desirable difficulties", a term coined by psychologist Robert A. Bjork to refer to conditions that initially make learning more challenging but result in deeper learning and better long-term performance (Bjork and Bjork, 2011). Retrieval, spaced practice, interleaving and elaboration are well-researched strategies that create desirable difficulties for learners. Retrieval involves bringing previously learned information to mind from long-term memory or "getting information *out* of students' heads" (Agarwal and Bain, 2019). Retrieval practice increases learners' long-term retention of information and transfer of knowledge. It also helps students and teachers identify gaps in knowledge (Weinstein et al., 2019). Some ways for students to do retrieval practice are:

- answering questions about content previously covered in the course (ideally combining lower and higher-order questions)
- completing quizzes, short-answer questions, etc.
- using a concept previously learned in a new situation or generating new examples of it
- producing questions about a topic previously studied (if done in groups, students can exchange questions with other groups and then work on the answers)

(Agarwal and Bain, 2019; Jones, 2019; Persellin and Daniels, 2018)

Retrieval practice is more effective when it takes place spaced out over time in a series of shorter sessions (spaced practice) instead of concentrated in a single learning event of the same total duration (massing practice). Massing practice (e.g., cramming for exams) can result in good test performance, but will not result in long-term retention. Brown et al. explain that whereas "massed practice gives us the warm sensation of mastery because we're looping information through short-term memory", spaced practice is "the effortful process of reconstructing the knowledge that triggers reconsolidation and deeper learning" (2014).

The benefits of retrieval practice are also maximized when combined with interleaving, which involves mixing related topics or skills in one single practice event, instead of focusing on each of those topics one at a time (blocked practice). Compared to blocked practice, interleaved practice leads to superior performance in the long term, due to the promotion of discrimination, i.e., learners must notice similarities and differences between similar concepts (Weinstein et al., 2019). The implementation of interleaving requires careful planning; teachers need to assess whether students are ready to work with a combination of related topics or they need more time to master the topics individually. Research indicates that a "hybrid approach may be more effective for student learning, where some blocked practice initially is followed by interleaved practice" (Agarwal and Bain, 2019).

Elaboration, defined as "the process of giving new material meaning by expressing it in your own words and connecting it with what you already know" (Brown et al., 2014), is also a desirable difficulty with positive effects on learning. Elaborative interrogation is one specific method of elaboration. Students, individually or in groups, produce "why" and "how" questions and find answers for them. This leads to explaining key ideas and establishing connections between them, which in turn will facilitate the retrieval of concepts at a later stage. This technique is most efficient when students already have solid background knowledge and feedback is provided on the answers to the questions (Weinstein et al., 2019).

Learning activities that create desirable difficulties should be planned considering not only the cognitive effort required to complete the tasks but also the emotional components that can help students be resilient and motivated throughout the activity. Students' resistance to embark on effortful or challenging activities can be minimized by explaining to them why such tasks have been included in the course and what are the expected learning benefits (Persellin and Daniels, 2018). The perceived value of an activity has a strong influence on learner engagement. Students will be more engaged in activities that they perceive as useful or related to their personal life or interests. Setting tasks at the appropriate level of challenge is also important: learners can disengage if the task is too difficult or lose interest if it is too easy. Determining students' level of understanding is essential to set up activities that represent an appropriate challenge (Zepeda et al., 2020).

4.1 Reflection prompts

- When designing instructional materials or planning teaching, what can you take into account to avoid working memory overload?
- To what extent do the learning activities in your courses already support retrieval, spaced practice, interleaving and elaboration? Can you think of other ways of further exploiting these learning strategies?
- Desirable difficulties present challenging learning situations for students, how can you support a positive emotional atmosphere that fosters motivation and resilience?

5. Accessibility and inclusiveness: Universal Design for Learning

Based on LS research on how learning happens, the Universal Design for Learning (henceforth UDL) Framework includes a series of guidelines to design accessible and inclusive learning experiences. The framework, developed at the Center for Applied Special Technology (CAST) in the US, was first published in 2008; several updates have been produced since then, the latest in 2018. CAST had been founded in 1984 to study how new technologies could support students with disabilities. Several assistive technology (AT) solutions were developed in the first few years, mostly computer-based tools. As CAST researchers started testing AT in schools, they observed that "the appeal and benefits of technology-based learning supports, such as digital talking book, extend beyond students with disabilities" (Center for Applied Special Technology, CAST). This observation is the origin of UDL and what differentiates it from AT. Both UDL and AT try to reduce barriers for learners, but whereas AT is intended for reducing barriers for individuals with disabilities specifically, UDL aims at reducing barriers for everyone (Meyer et al., 2014).

Apart from barriers to learning caused by learning disabilities, there are other types of challenges that can affect non-disabled students as well, such as academic (lack of content preparation), technological (poor technical skills) and instructional challenges (weak course design) (Novak and Thibodeau, 2015). Within the academic challenges, students can experience for example reading difficulties (e.g., mastering new vocabulary) or writing difficulties (e.g., organizing ideas in writing) (Gradel and Edson, 2009). The student population in higher education institutions is increasingly diverse and learners bring with them a broad range of skills. Diversity, cognitive or otherwise, will be present in every classroom. UDL addresses these predicted challenges in the design stage, to create barrier-free learning environments that include all students.

The UDL guidelines are organised under three overarching principles: engagement, representation, and action and expression; each of them connecting to main brain networks involved in learning. Engagement relates to the affective brain networks (emotion, motivation, and engagement), representation is connected to the recognition networks (understanding of information), and action and expression are linked to the strategic networks (planning and execution of tasks) (Nelson, 2014). The common feature in these three

principles is variability, i.e., how learners engage, understand and approach tasks varies from individual to individual. To account for these expected individual differences, the UDL guidelines support the design of courses that facilitate engagement, representation, and action and expression in multiple ways.

The large number of guidelines can be overwhelming when using UDL for the first time. The framework should be approached as a tool to address barriers to learning in an intentional way, rather than as a collection of prescriptive guidelines. Some ideas recommended to teachers who are new to UDL are: identifying first of all guidelines already being implemented in their courses; focussing on one principle (e.g., engagement) before exploring the guidelines for the other two; working with part of the activities or assessments in one course before continuing with the rest; or starting with a selection of guidelines like the one below before considering further guidelines.

Table 1: Selection of UDL guidelines to implement multiple means of engagement, representation, and action and expression.

ENGAGEMENT	REPRESENTATION	ACTION AND EXPRESSION
• use activities that are relevant and valuable to students' personal interests	• activate or supply background information	• make expectations explicit, for students to plan strategies and steps
• highlight the utility and relevance of tasks and information provided	• highlight patterns, key ideas and main connections	• break large projects into smaller tasks that build on one another
• include activities that are appropriate for different racial, cultural, ethnic and gender groups	• encourage and support students to transfer and use knowledge in new contexts	• provide checklists, project planning templates, etc. to support planning skills
• invite students' personal response and evaluation to content and activities	• provide opportunities for students to familiarize themselves with new vocabulary or concepts	• give options for the format of deliverables (e.g. written, video or audio format)
• create a safe classroom environment	• illustrate content through multiple media (diagrams, video, images, text, etc.)	• give specific suggestions for improvement
• support self-reflection to help students set personal goals	• include written transcripts for videos or auditory clips	• help students self-assess and self-monitor their progress

5.1 Reflection prompts

- To what extent have you thought of the concepts of accessibility and inclusiveness as being relevant for all students, and not just those with learning disabilities?
- What types of diversity have you identified in your courses? Consider for example race, language, gender, cognitive diversity, educational background.
- If you are new to UDL, which of the guidelines in the table above are you already implementing/could you easily implement? If you have used UDL before, what

changes have you made in your courses to make them more accessible and inclusive? What other changes are you planning to implement?

6. Conclusion

LS research has shown that emotion and cognition are intertwined and equally important aspects of learning. This has significant implications for teaching in higher education, a context where the emotional aspect of learning has not traditionally been paid sufficient attention. Emotions can either inhibit or enhance essential cognitive skills such as attention and memory in such a critical way that they should not be disregarded when designing learning experiences and planning instruction. Classrooms perceived as safe and teachers seen as genuinely interested in students as individuals are key elements that foster positive emotions. In these circumstances, attention and memory resources are enhanced to engage in the cognitive processes involved in learning, such as activating prior knowledge, processing new input, and building new understanding.

The research on attention and memory is also of great relevance for higher education teachers, particularly in relation to engagement and the promotion of deep learning. The design of learning materials, the facilitation of activities, and the guidance provided by the teacher for the acquisition of complex concepts are key aspects of instruction that need to align with the limitations of our attentional resources if they are to support learning effectively. Both working and long-term memory are involved in the promotion of deep and long-term learning, which is best achieved through activities that create desirable difficulties for learners. Retrieval practice, especially combined with spaced practice and interleaving, and elaboration are examples of well-researched efficient learning strategies. Their successful implementation requires a careful consideration of students' prior knowledge and the emotional conditions needed to create resilience and motivation.

Apart from the common aspects that characterise learning for everyone (e.g., attention and memory), as individuals, learners make use of emotional and cognitive resources in a unique and diverse way. This diversity results in considerable variability in how students are motivated, process information and can demonstrate their learning. The UDL Framework addresses this variability by means of a set of guidelines that teachers can use to create learning experiences that are more inclusive and accessible.

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