MIND, BRAIN, AND EDUCATION

Impact of Problem-Based Learning Coaching and Neuroeducation in the Development of 21st Century Lifelong Learners

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ABSTRACT— Over the past century, health knowledge has advanced dramatically, so it is expected that future health professionals will need to learn effectively in the workplace and adapt to novel situations that cannot yet be predicted. Simultaneously, the demographics of university students have changed significantly in regard to age, gender, and socioeconomic background. Health educators must adapt their teaching methods to foster in each student the development of lifelong learning skills. This perspective article examines the concept of neuroeducation through the lens of Problem-Based Learning (PBL), with an emphasis on PBL coaching. Furthermore, it demonstrates the benefit of implementing a PBL coaching approach, using knowledge from neuroscience findings to enhance students' learning and well-being. Following targeted professional development aiming to consolidate the understanding of the brain's structures and functions that increase student learning capacity and build group coaches' skills, existing PBL academics could be an integral part of such a program.

The 21st century has seen unprecedented advances and changes in knowledge and technology. Concurrently, university students are now more diverse with respect to factors including age, gender, and socioeconomic background (Kuh, Buckley, Bridges, & Hayek, 2006). As a result, health

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educators are now facing new teaching challenges because they need to:

1 Engage distinct cohorts of students who present with different learning characteristics, which may vary according to their upbringing. Currently, the two main generations in university are Millennials (born between 1981 and 1996) and Generation Z (born between 1997 and 2012). Individuals within each of these groups may present with significantly different learning needs and skill bases than previous students in terms of creativity, verbal abilities, attention to others, and the knowledge environment (Budiman & Franky, 2021; Rickes, 2016);

2 Invest time and energy into simultaneously engaging with these generations in order to support their learning. Because of the abundance of stimulation and immediate gratification provided by digital platforms, research has indicated that members of these generations may present with a decreased sense of pleasure and satisfaction, be inclined toward perceived entitlement, and lack awareness of their individual accountability, all of which may be influenced by their Internet and computer usage per day (Budiman & Franky, 2021); and

3 Provide new health professionals with lifelong learning skills, including critical reflection to learn effectively in the workplace and the ability to adapt to novel situations that we cannot yet predict (Mylopoulos, Brydges, Woods, Manzone, & Schwartz, 2016).

A shift in education has occurred from rote learning, such as memorization and imitation, toward a movement that fosters intrinsic motivation to pursue learning in order to solve problems (Rege Colet, 2017). This can be seen

worldwide as universities transition from the previously dominant teacher-centered learning (TCL) model toward a more student-centered learning (SCL) approach (Schreurs & Dumbraveanu, 2014). Although SCL has been shown to be beneficial, the wholesale adoption of this new teaching convention is challenging. Many current health educators were taught in a TCL culture and therefore have not always learned themselves how to be continuous, effective learners (Mylopoulos et al., 2016). As such, they may not know how to prepare students for clinical uncertainty, causing anxiety and impacting students' well-being (Moulder, Harris, & Santhosh, 2023; Papanagnou, Ankam, Ebbott, & Ziring, 2021).

In addition, like in other domains, healthcare knowledge is expanding exponentially, outpacing the quantity of information that can be successfully learned during undergraduate training (Densen, 2011). Universities need to better prepare future health professionals to efficiently use acquired knowledge and routines, identify practice gaps, adapt to novel situations, and implement their own innovative approaches. Recognizing this, many universities have implemented educational programs that encourage students to use approaches based around the Plan-Do-Study-Act (PDSA) model (Taylor et al., 2014). This model of improvement revolves around four stages that mirror scientific experimental methods, for example, formulating a hypothesis, testing it by collecting data, analyzing and interpreting the results, and adjusting to increase the chance of obtaining the desired improvement.

PROBLEM-BASED LEARNING

Problem-Based-Learning (PBL) and its variations have revolutionized medical education (Barrows & Tamblyn, 1980). PBL is fundamentally a constructive SCL approach that places students in real-world situations, for example, be confronted with real-world patient problems, and learn holistically (Mukhalalati & Taylor, 2019). Doing so should theoretically nurture the development of problem-solving and clinical reasoning skills, trigger curiosity, and foster the desire to seek and learn new information. This new knowledge and/or skill can then be critically appraised and evaluated in a collaborative group setting (Wood, 2003). A well-designed health curriculum, appropriately trained PBL academics, and students who are ready to accept both individual and group responsibilities, be autonomous, have intrinsic motivation, and have the freedom to make choices, including mistakes, is needed to ensure success. Unfortunately, this environment can be challenging for young adult learners because of the complex interplay of personal experiences, knowledge, skills, habits, and environmental determinants that influence behavior and

confidence (Russell, Baik, Ryan, & Molloy, 2020). The question that remains unclear in many higher education settings that profess to use PBL is: What roles do the PBL academics need to provide to help students examine and connect a broad range of health aspects in order to deliver high-quality patient-centered care? Do they need to be a teacher, a tutor, a facilitator, an evaluator, or a mix of these? (Neville, 2009).

PBL academics must find the right balance between "directiveness" and "flexibility," for example, achieving an effective mix of the expert and nonexpert skillsets, as more directedness in approach can mean reverting to a more TCL approach where both students and teachers may feel more secure in achieving the desired learning as directiveness supports students' deep learning. Because there is no universal agreement on how to run PBL sessions effectively, approaches vary greatly (Barrows & Tamblyn, 1980; De Grave, Dolmans, & van der Vleuten, 1999).

Additionally, students must be flexible in order for PBL academics to stimulate the development of a growth mindset, a process that is incremental, malleable, and requires personal growth efforts (Dweck & Yeager, 2019). At the learner level, the most frequently described strategy is to teach students about growth and help them develop learning goals that emphasize progress, such as becoming a good healthcare provider by demonstrating self-awareness and confidence, stress management, and resilience, rather than performance. PBL academics can emphasize this by providing feedback on effort and observable behaviors, rather than talent, encouraging self-reflection, and having peer-to-peer open and honest discussions, all of which help create a psychologically safe environment (Wolcott et al., 2021). At the organizational level, prioritizing feedback at all levels, establishing a learning culture, offering growth mindset training, and assisting employees in recognizing their biases and stereotypes should be priorities. This ultimately will prepare future health professionals to work toward goals, being Master Adaptive Learners (Cutrer et al., 2017), who see the benefit of incremental personal growth (i.e., the desire to work hard and improve without an external incentive reward in mind as the outcome) while minimizing the threat of failure and psychological distress (Burnette, Knouse, Vavra, O'Boyle, & Brooks, 2020).

PBL COACHING

Competency-based medical education in the United States has led to the inclusion of "coaching" into the curriculum. This has been shown to improve both academic performance and clinical competencies (Wolff, Hammoud, Santen, Deiorio, & Fix, 2020). According to Whitmore, widely acknowledged as the father of performance coaching, "Coaching is unlocking people's potential to maximise

their own performance … It is helping them to learn rather than teaching them" (Whitmore, 1992). As such, coaching aims to change behavior to facilitate an individual's reaching their full potential (Adams, 2016). Similarly to PBL, coaching is grounded in a constructivist approach but, rather than imparting knowledge, relies on experiences, social interactions, and the environment to help people become self-directed, autonomous, and accountable while maintaining well-being (Gunduz & Hursen, 2015; Hurlow, 2022; Pavlović, 2021).

To successfully incorporate coaching into their approach, PBL academics must delve into behaviorism and humanism practices and work toward achieving five basic objectives with their students (Rostami & Khadjooi, 2010):

1. Promote positive self-direction and independence (development of the regulatory system);
2. Develop the ability to take responsibility for what is learned (regulatory and affective systems);
3. Develop creativity (the divergent thinking aspect of cognition);
4. Curiosity (exploratory behavior, a function of imbalance or dissonance in any of the systems); and
5. Develop an interest in the arts (primarily to develop the affective/emotional system).

Furthermore, they must also use cognitive and social constructivism methods (Hurlow, 2022) because, as stated by the scientist Alfred Korzybski, "*The map is not the territory.*" (Korzybski, 1933). This means that their reality might not be the reality of someone else. Thus, PBL academics must also raise awareness about false assumptions, reframing understanding, and creating shared meaning by encouraging collaboration, group activities, and discussions, all of which could be achieved by using group coaching techniques (Wang, Li, Pang, Liang, & Su, 2016). In this regard, PBL academics must:

1. Ensure group confidentiality, that is, "What's said within the group stays within the group."
2. Tap into previous learners' knowledge to guide discussion and foster collaboration.
3. Combat "groupthink" by encouraging critical and realistic evaluation of their choices and underlying presumptions.

To achieve this, PBL academics must express authentic belief in the capacities of their students and encourage brainstorming through adequate questioning.

Also, Reynolds (Reynolds, 2020) proposed 12 coaching tips. Four of these could be adapted and used during a PBL session. This includes:

1. Creating a safe SCL environment, by positioning themselves as learners and giving space for strategic planning and self-reflection;

2. Promoting a growth mindset by asking powerful questions in alignment with the Bloom's taxonomy framework (Krathwohl, 2010);
3. Improving self-efficacy, working closely with students to understand their learning histories, (i.e., their successes, challenges, and fears), and respond with appropriate feedback or interventions to improve time management, self-regulated learning, information processing, and test anxiety; and
4. Paying attention to students' emotions and motivations to build rapport and trust through active listening, questioning, probing, summarizing, reflecting techniques, and showing empathy and humanity, which are central elements in achieving positive health outcomes as they are responding to psychological and affective needs that ultimately help students draw on their own resources to find solutions (Costa-Drolon, Verneuil, Manolios, Revah-Levy, & Sibeoni, 2021).

To summarize, PBL coaching strongly emphasizes indirect facilitation and considers emotional and psychological factors to encourage the development of the students' professional identities while maintaining health and well-being.

NEUROEDUCATION AND PBL ACADEMICS

To further improve students' learning, PBL academics would benefit from gaining a basic comprehension of how the brain constructs knowledge as well as how to motivate students to become lifelong learners. This is the domain of neuroeducation, which integrates findings from neuroscience, biology, cognition, psychology, and education (Bhargava & Ramadas, 2022). As such, neuroeducation aims to optimize brain function for learning by combining psychological factors, like working memory, attention, emotions, problem solving, etc., with nonpsychological factors, like diet, sleep, exercise, mindfulness, etc. For example, emotional and mental stimuli, which are crucial to learning, are personal and can be used to boost motivation and, as a result, the learning outcomes.

The PBL tutoring structure usually uses "spiral learning" (Lima, 2016), for example, revisiting topics throughout the entirety of the course to build on previous knowledge. Establishing a balance between fast and slow neuroplasticity is crucial to this process. New knowledges are encoded and translated into short-term memories through the modification of synapses and dendrites—a process called neurogenesis. Reactivation of those short-term memories can consolidate over time neural connections that can be used unconsciously (O'Neill, Pleydell-Bouverie, Dupret, & Csicsvari, 2010). This neuronal remodeling is dependent on a range of environmental, endocrinological, and physiological factors.

The first goal for PBL academics should be to create an environment where students feel safe engaging in collaborative learning to resolve complex problems. To do so, they should encourage student socialization. As a result, they might experience social pleasure but also pain because of differences in life experiences, both of which activate the anterior cingulate cortex (Journee, Mathis, Fillinger, Veinante, & Yalcin, 2023). PBL tutors need to be aware of this and identify disparities among students as humans seek rewards and avoid threats. The SCARF model is valuable in that regard as it highlights five domains of social experiences, for example, status, certainty, autonomy, relatedness, and fairness (Rock, 2008). Experienced PBL academics often implement this intuitively as they try to (1) engage students in the topic by pointing out connections with the environment, people, and social conditions, for example, relatedness; (2) encourage, recognize achievements, and praise contributions to create a nurturing learning environment and increases the sense of status; (3) create certainty by identifying central learning goals and pointing out how people can improve; (4) foster autonomy by breaking down large learning concepts through meaningful questioning; and (5) promote fairness by eliciting perspectives (Javadizadeh, Aplin-Houtz, & Casile, 2022). If done correctly, students have challenging and stimulating learning opportunities where surprise, curiosity, and confusion, which are related to the brain's reward system and the frustration/anger system, will help them explore and learn (Vogl, Pekrun, Murayama, & Loderer, 2020). However, if students find themselves in an ongoing stressful situation that triggers the fight, flight, hide, or freeze response and the release of glucocorticoid hormones (e.g., cortisol), this can lead to structural and functional changes within the hippocampus, amygdala, and prefrontal cortex. Thus, learning-related dysfunctional neuroplasticity (Cabib, Campus, Conversi, Orsini, & Puglisi-Allegra, 2020) and mental health problems like depression, anxiety, sleep disturbances, and substance use might occur (Pascoe, Hetrick, & Parker, 2019).

PBL's second goal is to deliberate, and link knowledge from unrelated topics. A process highly dependent on the hippocampus and prefrontal cortex (PFC) (Bird, 2017; Eichenbaum, 2017). PBL academics during the open tutorial should encourage students to create flowcharts for group discussion, self-explanation, and respective listening, all of which will improve understanding because of the visual and auditory stimuli (Chi, De Leeuw, Chiu, & LaVancher, 1994; Quintero, Shams, & Kamal, 2022). The PBL model cannot cover all topics under discussion, so self-paced independent study between the open and close tutorials should be spent researching and reading information from different resources. Even if students do not find the correct answer, this step is crucial because it is comparable to the planning step of "vicarious trial-error" (VTE) behavioral events

(Redish, 2016), which enables students to make deliberative decisions based on episodically imagined futures and possible outcomes. During the close tutorial, the new learning plasticity previously developed during the opening tutorial and challenges during the individual search-and-evaluate process need to be further re-evaluated. Self-study findings need to be discussed collaboratively to find the best solution to manage the patient. Because the goal is to build long-term memory and procedural decision-making processes while stimulating critical thinking by questioning every finding, PBL academics must be able to probe students on the topic. These processes rely on both the hippocampusPFC interactions and on the dorsolateral striatum, where lie the neuronal networks of habits or stimulus–response types of tasks (Ferbinteanu, 2020). This background shows that to achieve optimal learning neuroplasticity, students must be placed in a stretch zone with challenges, pressure, and uncertainty but also in an emotionally and socially safe environment to avoid high stress and anxiety (Goldberg, 2022).

Understanding the brain mechanisms behind behavior is the next step to supporting learning. To survive and thrive, the brain has to continuously learn and adapt. Motivational and emotional challenges trigger limbic (emotional) structures, creating associations between stimulus and response that can be remembered vividly and accurately (Tyng, Amin, Saad, & Malik, 2017). As such, neuroscience-relevant educational questions might include:

Why is a student unable to recall the name of a specific bacterium associated with diarrhoea but unlikely to forget the name of the bacteria that killed their grandmother while she was in the hospital?

Why does a student who is doing well during PBL lose all of their abilities in an exam setting?

The answers may lie in the unique way the human brain coordinates multiple functions to help survivability. Students can be informed about optimal psychological and physical brain health factors and motivated to apply them to improve learning. Translating neuroscience findings into coaching sessions that inform on the "what" and the "how" could be used as a framework (McKay & Smith, 2021).

PBL academics can coach students toward their perceived "ideal self," for example, their ideal life and work in 5 or 10 years, by identifying positive emotional attractors (PEA) all of which will give students a sense of possibility and self-empowerment (Boyatzis & Jack, 2018). PBL academics should guide students toward engaging not only in social and emotional understanding of the patient but also in analytic reasoning in order to provide the most

holistic treatment. Succeeding in doing so depends on various factors, as human behaviors (trust, empathy, altruism, and stress) are influenced by gender (Ivan, Daniela, & Jaroslava, 2023), hormones (e.g., cortisol, testosterone, and oxytocin) (Carre & Robinson, 2020; Freitas & Osorio, 2022; Marsh, Marsh, Lee, & Hurlemann, 2021), and the capacity to balance the function of the subregions of the insular cortex (e.g., complex social functions that associate with feelings and emotions and risk prediction and decision-making processes) (Gogolla, 2017). Additionally, organizations that prioritize budgets, problem solving, and metrics, over personal connections view health professionals as resources to be utilized or maximized rather than individuals. Over the long term, this could lead to a decrease in curiosity, patient-centered care, and, as a result, the fear to innovate.

Some easily modifiable factors have been shown to improve neuroplasticity and, therefore, learning and well-being. Research findings show that a range of good habits, for example, healthy eating, exercising, rest and sleep, optimism, managing stress, making autonomous decisions, variety and challenges, social interactions, learning new things, and repetition, influence brain structures, functions, and cognition and, as such, health and lifelong learning (Ekman et al., 2021). This could be brought to the attention of the students.

FROM THEORIES TO APPLICATION

With appropriate training and experiences, PBL academics can master SCL as they gain the abilities to ask insightful questions, use analogies to improve concepts and mechanism understanding, and establish relationships, all of which help the students make informed decisions. PBL academics can counter the teacher-learner hierarchy by showing vulnerability and forging an alliance built on trust, for example, the belief that they are reliable, good, honest, effective, and willing to assist. Also, they are in an ideal position to assist students in reaching their full potential by evaluating their students' performances across various assessments and observations to identify areas for improvement. This is comparable to what happens during effective longitudinal coaching sessions, where the coach asks questions to promote self-development toward personal goals, allowing them to be vulnerable rather than afraid to make uncertain choices if needed (Sklar & McMahon, 2019).

Coaching sessions can inform on the "what" by discussing research showing the benefits of sleep, eating healthy food, exercising, practising mindfulness, and using social connections as accountability buddies and/or to buffer stress. In terms of the "how," informing students about active and cooperative learning and how to make learning more relevant to their lived experience and their lives outside of the curriculum while also instructing them about the memories (e.g., sensory, short- and long-term) and the techniques to improve content retention and habit formation. Discussing how having a growth mindset can improve grades, help to persist in challenging situations, and overcome adversity would be relevant.

In addition to the PBL groups that change frequently, creating smaller long-term coaching groups and matching them with an academic PBL coach who will follow them across an entire phase of the curriculum will allow the students and the coach to build and foster quality relationships based on seeking the "goodness" in one another and accepting and understanding differences in beliefs and values. This will result in peer-emotional support, trust, well-being, involvement, and curiosity about other people's perspectives. Ultimately, by doing so, the PBL coach will foster the idea that developing an action plan that promotes responsibility and shared decision-making is the best way to provide personalized health care that respects patients' autonomy. Evidence-based medicine reduces unnecessary and ineffective care, but treatment is often given under uncertain circumstances and the evidence for certain choices is not always solid.

Therefore, the ultimate goal should be to assist students develop a professional identity based on their long-term personal choices. This will result in good patient-personalized care, where patient understanding will result in providing deliberate tailor-made information and, as a result, treatment based on the patient's preferences.

CONCLUSION

To enhance students' learning and well-being, PBL academics should foster the development of self-confidence and awareness, encourage healthy stress management strategies, and foster resilience, rather than performance. Group coaching techniques that foster confidentiality, collaboration, and critical and realistic evaluation of choices will promote a growth mindset and the development of the students' professional identities. Trust, positive relationships, and emotional health could be built on neuroscience findings around the SCARF model, the neuroplasticity process, and the various factors impending human behavior. Existing PBL academics who already work closely with students could be an integral part of this program. Some professional development to build coaches' skills, as well as information about the brain's structures and functions and how to engage them to increase learning and memory, might be required, but ultimately this will result in the development of healthcare professionals that are adaptive learners capable of providing personalized care.

ETHICS STATEMENT

FUNDING INFORMATION

CONFLICT OF INTEREST

REFERENCES

Adams, M. (2016). Coaching psychology: An approach to practice for educational psychologists. *Educational Psychology in Practice*, *32*(3), 231–244. https://doi.org/10.1080/02667363.2016.1152460

Barrows, H. S., & Tamblyn, R. M. (1980) *Problem-based learning: An approach to medical education*. New York: Springer Publishing Company. https://books.google.com.au/books?id=9u-5DJuQq2UC

Bhargava, A., & Ramadas, V. (2022). Implications of neuroscience/neuroeducation in the field of education to enhance the learning outcomes of the students. *Journal of Positive School Psychology*, *6*(6), 6502–6510.

Bird, C. M. (2017). The role of the hippocampus in recognition memory. *Cortex*, *93*, 155–165. https://doi.org/10.1016/j.cortex.2017.05.016

Boyatzis, R. E., & Jack, A. I. (2018). The neuroscience of coaching. *Consulting Psychology Journal: Practice and Research*, *70*(1), 11–27. https://doi.org/10.1037/cpb0000095

Budiman, T., & Franky, F. (2021). The relationship pattern of internet usage frequency, generation Z characteristics, and teaching method in the millennium era. *International Journal of Interactive Mobile Technologies*, *15*(18), 178–185. https://doi.org/10.3991/ijim.v15i18.24555

Burnette, J. L., Knouse, L. E., Vavra, D. T., O'Boyle, E., & Brooks, M. A. (2020). Growth mindsets and psychological distress: A meta-analysis. *Clinical Psychology Review*, *77*, 101816. https://doi.org/10.1016/j.cpr.2020.101816

Cabib, S., Campus, P., Conversi, D., Orsini, C., & Puglisi-Allegra, S. (2020). Functional and dysfunctional neuroplasticity in learning to cope with stress. *Brain Sciences*, *10*(2), 127. https://doi.org/10.3390/brainsci10020127

Carre, J. M., & Robinson, B. A. (2020). Testosterone administration in human social neuroendocrinology: Past, present, and future. *Hormones and Behavior*, *122*, 104754. https://doi.org/10.1016/j.yhbeh.2020.104754

Chi, M. T., De Leeuw, N., Chiu, M.-H., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science*, *18*(3), 439–477.

Costa-Drolon, E., Verneuil, L., Manolios, E., Revah-Levy, A., & Sibeoni, J. (2021). Medical Students' perspectives on empathy: A systematic review and Metasynthesis. *Academic Medicine*, *96*(1), 142–154. https://doi.org/10.1097/ACM.0000000000003655

Cutrer, W. B., Miller, B., Pusic, M. V., Mejicano, G., Mangrulkar, R. S., Gruppen, L. D., … Moore, D. E., Jr. (2017). Fostering the development of master adaptive learners: A conceptual model to guide skill Acquisition in Medical Education. *Academic Medicine*, *92*(1), 70–75. https://doi.org/10.1097/ACM.0000000000001323

De Grave, W. S., Dolmans, D. H., & van der Vleuten, C. P. (1999). Profiles of effective tutors in problem-based learning: Scaffolding student learning. *Medical Education*, *33*(12), 901–906. https://doi.org/10.1046/j.1365-2923.1999.00492.x

Densen, P. (2011). Challenges and opportunities facing medical education. *Transactions of the American Clinical and Climatological Association*, *122*, 48–58.

Dweck, C. S., & Yeager, D. S. (2019). Mindsets: A view from two eras. *Perspectives on Psychological Science*, *14*(3), 481–496. https://doi.org/10.1177/1745691618804166

Eichenbaum, H. (2017). Prefrontal-hippocampal interactions in episodic memory. *Nature Reviews Neuroscience*, *18*(9), 547–558. https://doi.org/10.1038/nrn.2017.74

Ekman, R., Fletcher, A., Giota, J., Eriksson, A., Thomas, B., & Bååthe, F. (2021). A flourishing brain in the 21st century: A scoping review of the impact of developing good habits for mind, brain, well-being, and learning. *Mind, Brain, and Education*, *16*(1), 13–23. https://doi.org/10.1111/mbe.12305

Ferbinteanu, J. (2020). The hippocampus and dorsolateral striatum integrate distinct types of memories through time and space, respectively. *The Journal of Neuroscience*, *40*(47), 9055–9065. https://doi.org/10.1523/JNEUROSCI.1084-20.2020

Freitas, C., & Osorio, F. L. (2022). Moral judgment and hormones: A systematic literature review. *PLoS One*, *17*(4), e0265693. https://doi.org/10.1371/journal.pone.0265693

Gogolla, N. (2017). The insular cortex. *Current Biology*, *27*(12), R580–R586. https://doi.org/10.1016/j.cub.2017.05.010

Goldberg, H. (2022). Growing brains, nurturing minds-neuroscience as an educational tool to support Students' development as life-long learners. *Brain Sciences*, *12*(12), 1622. https://doi.org/10.3390/brainsci12121622

Gunduz, N., & Hursen, C. (2015). Constructivism in teaching and learning; content analysis evaluation. *Procedia—Social and Behavioral Sciences*, *191*, 526–533. https://doi.org/10.1016/j.sbspro.2015.04.640

Hurlow, S. (2022). Revisiting the relationship between coaching and learning: The problems and possibilities. *Academy of Management Learning & Education*, *21*(1), 121–138. https://doi.org/10.5465/amle.2019.0345

Ivan, S., Daniela, O., & Jaroslava, B. D. (2023). Sex differences matter: Males and females are equal but not the same. *Physiology & Behavior*, *259*, 114038. https://doi.org/10.1016/j.physbeh.2022.114038

Javadizadeh, B., Aplin-Houtz, M., & Casile, M. (2022). Using SCARF as a motivational tool to enhance students' class

performance. *The International Journal of Management Education*, *20*(1), 100594. https://doi.org/10.1016/j.ijme.2021.100594

Journee, S. H., Mathis, V. P., Fillinger, C., Veinante, P., & Yalcin, I. (2023). Janus effect of the anterior cingulate cortex: Pain and emotion. *Neuroscience & Biobehavioral Reviews*, *153*, 105362. https://doi.org/10.1016/j.neubiorev.2023.105362

Korzybski, A. (1933). A non-aristotelian system and its necessity for rigour in mathematics and physics. In *Science and sanity: An introduction to non-aristotelian systems and general semantics*. Brooklyn, NY: Institute of General Semantic.

Krathwohl, D. R. (2010). A revision of Bloom's taxonomy: An overview. *Theory Into Practice*, *41*(4), 212–218. https://doi.org/10.1207/s15430421tip4104_2

Kuh, G. D., Buckley, J. A., Bridges, B. K., & Hayek, J. C. (2006). What matters to student success: A review of the literature. https://nces.ed.gov/npec/pdf/kuh_team_report.pdf

Lima, V. V. (2016). Espiral construtivista: uma metodologia ativa de ensino-aprendizagem. *Interface—Comunicação, Saúde, Educação*, *21*(61), 421–434. https://doi.org/10.1590/1807-57622016.0316

Marsh, N., Marsh, A. A., Lee, M. R., & Hurlemann, R. (2021). Oxytocin and the neurobiology of prosocial behavior. *The Neuroscientist*, *27*(6), 604–619. https://doi.org/10.1177/1073858420960111

McKay, S. M., & Smith, S. (2021). Towards a neuroscience-informed coaching practice: Opportunities and limitations. In W.-A. Smith, I. Boniwell & S. Green (Eds.), *Positive psychology coaching in the workplace*. (pp. 399–416). Cham, Switzerland: Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-79952-6_21

Moulder, G., Harris, E., & Santhosh, L. (2023). Teaching the science of uncertainty. *Diagnosis*, *10*(1), 13–18. https://doi.org/10.1515/dx-2022-0045

Mukhalalati, B. A., & Taylor, A. (2019). Adult learning theories in context: A quick guide for healthcare professional educators. *Journal of Medical Education and Curricular Development*, *6*, 2382120519840332. https://doi.org/10.1177/2382120519840332

Mylopoulos, M., Brydges, R., Woods, N. N., Manzone, J., & Schwartz, D. L. (2016). Preparation for future learning: A missing competency in health professions education? *Medical Education*, *50*(1), 115–123. https://doi.org/10.1111/medu.12893

Neville, A. J. (2009). The problem-based learning tutor: Teacher? Facilitator? Evaluator? *Medical Teacher*, *21*(4), 393–401. https://doi.org/10.1080/01421599979338

O'Neill, J., Pleydell-Bouverie, B., Dupret, D., & Csicsvari, J. (2010). Play it again: Reactivation of waking experience and memory. *Trends in Neurosciences*, *33*(5), 220–229. https://doi.org/10.1016/j.tins.2010.01.006

Papanagnou, D., Ankam, N., Ebbott, D., & Ziring, D. (2021). Towards a medical school curriculum for uncertainty in clinical practice. *Medical Education Online*, *26*(1), 1972762. https://doi.org/10.1080/10872981.2021.1972762

Pascoe, M. C., Hetrick, S. E., & Parker, A. G. (2019). The impact of stress on students in secondary school and higher education. *International Journal of Adolescence and Youth*, *25*(1), 104–112. https://doi.org/10.1080/02673843.2019.1596823

Pavlović, J. (2021) *Coaching psychology: Constructivist approaches*. (1st ed.). Abingdon, Oxon: Taylor & Francis Group. https://doi.org/10.4324/9781003016878

Quintero, S. I., Shams, L., & Kamal, K. (2022). Changing the tendency to integrate the senses. *Brain Sciences*, *12*(10), 1384. https://doi.org/10.3390/brainsci12101384

Redish, A. D. (2016). Vicarious trial and error. *Nature Reviews Neuroscience*, *17*(3), 147–159. https://doi.org/10.1038/nrn.2015.30

Rege Colet, N. M. (2017). From content-centred to learning-centred approaches: Shifting educational paradigm in higher education. *Journal of Educational Administration and History*, *49*(1), 72–86.

Reynolds, A. K. (2020). Academic coaching for learners in medical education: Twelve tips for the learning specialist. *Medical Teacher*, *42*(6), 616–621. https://doi.org/10.1080/0142159X.2019.1607271

Rickes, P. C. (2016). Generations in flux: How gen Z will continue to transform higher education space. *Planning for Higher Education*, *44*(4), 21–45.

Rock, D. (2008). SCARF: A brain-based model for collaborating with and influencing others. *NeuroLeadership Journal*, *1*(1), 44–52.

Rostami, K., & Khadjooi, K. (2010). The implications of behaviorism and humanism theories in medical education. *Gastroenterology and Hepatology from Bed to Bench*, *3*(2), 65–70. https://doi.org/10.22037/ghfbb.v3i2.81

Russell, J. M., Baik, C., Ryan, A. T., & Molloy, E. (2020). Fostering self-regulated learning in higher education: Making self-regulation visible. *Active Learning in Higher Education*, *23*(2), 97–113. https://doi.org/10.1177/1469787420982378

Schreurs, J., & Dumbraveanu, R. (2014). A shift from teacher centered to learner centered approach. *International Journal of Engineering Pedagogy*, *4*(3), 31–37. https://doi.org/10.3991/ijep.v4i3.3395

Sklar, D. P., & McMahon, G. T. (2019). Trust between teachers and learners. *JAMA*, *321*(22), 2157–2158. https://doi.org/10.1001/jama.2018.22130

Taylor, M. J., McNicholas, C., Nicolay, C., Darzi, A., Bell, D., & Reed, J. E. (2014). Systematic review of the application of the plan-do-study-act method to improve quality in healthcare. *BMJ Quality & Safety*, *23*(4), 290–298. https://doi.org/10.1136/bmjqs-2013-001862

Tyng, C. M., Amin, H. U., Saad, M. N. M., & Malik, A. S. (2017). The influences of emotion on learning and memory. *Frontiers in Psychology*, *8*, 1454. https://doi.org/10.3389/fpsyg.2017.01454

Vogl, E., Pekrun, R., Murayama, K., & Loderer, K. (2020). Surprised-curious-confused: Epistemic emotions and knowledge exploration. *Emotion*, *20*(4), 625–641. https://doi.org/10.1037/emo0000578

Wang, Q., Li, H., Pang, W., Liang, S., & Su, Y. (2016). Developing an integrated framework of problem-based learning and coaching psychology for medical education: A participatory research. *BMC Medical Education*, *16*, 2. https://doi.org/10.1186/s12909-015-0516-x

Whitmore, J. (1992) *Coaching for performance: A practical guide to growing your own skills*. London, UK: Nicholas

Brealey Publishing. https://books.google.com.au/books?id=B9thPwAACAAJ

Wolcott, M. D., McLaughlin, J. E., Hann, A., Miklavec, A., Beck Dallaghan, G. L., Rhoney, D. H., & Zomorodi, M. (2021). A review to characterise and map the growth mindset theory in health professions education. *Medical Education*, *55*(4), 430–440. https://doi.org/10.1111/medu.14381

Wolff, M., Hammoud, M., Santen, S., Deiorio, N., & Fix, M. (2020). Coaching in undergraduate medical education: A national survey. *Medical Education Online*, *25*(1), 1699765. https://doi.org/10.1080/10872981.2019.1699765

Wood, D. F. (2003). Problem based learning. *BMJ*, *326*(7384), 328–330. https://doi.org/10.1136/bmj.326.7384.328