frontiers | Frontiers in Education

TYPE Policy Brief
PUBLISHED 27 June 2024
DOI 10.3389/feduc.2024.1369394

OPEN ACCESS

EDITED BY
Raona Williams,
Ministry of Education (United Arab Emirates), United Arab Emirates

REVIEWED BY
Remy Low,
The University of Sydney, Australia
Gregory Siy Ching,
National Chengchi University, Taiwan

*CORRESPONDENCE
Inna Shvarts-Serebro
shvartsi@gmail.com

RECEIVED 12 January 2024
ACCEPTED 24 May 2024
PUBLISHED 27 June 2024

CITATION
Shvarts-Serebro I, Ben-Yehudah G, Elgavi-Hershler O, Grobgeld E, Katzof A, Luzzatto E, Shalom M and Zohar-Harel T (2024) Agents of change: integration of neuropedagogy in pre-service teacher education.
Front. Educ. 9:1369394.
doi: 10.3389/feduc.2024.1369394

Agents of change: integration of neuropedagogy in pre-service teacher education

Inna Shvarts-Serebro[1]*, Gal Ben-Yehudah[2], Orit Elgavi-Hershler[3], Etty Grobgeld[3], Ayelet Katzof[4], Efrat Luzzatto[4], Maya Shalom[5] and Tamar Zohar-Harel[6]

[1]Faculty of Education, Bar-Ilan University, Ramat Gan, Israel, [2]The MOFET Institute, Tel Aviv, Israel, [3]Achva Academic College, Arugot, Israel, [4]The Levinsky-Wingate Academic Center, Tel Aviv, Israel, [5]Department of Education, Beit Berl College, Kfar Saba, Israel, [6]Educational Psychology Service Jerusalem Municipality, Jerusalem, Israel

Neuropedagogy, an interdisciplinary field at the nexus of neuroscience, psychology, and education, seeks to enhance teaching and learning processes. This paper advocates for the integration of neuropedagogical principles into teacher training, underscoring the pivotal role educators play in influencing students' brain development. Incorporating neuroscientific knowledge in teaching can optimize educational outcomes. We explore key neuropedagogical principles, and highlight global developments in neuropedagogy. Three strategic avenues for integrating neuropedagogy in teacher training are proposed: promoting innovative teaching practices in teacher training, encouraging neuropedagogical research, and explicitly teaching neuroscientific knowledge to pre-service teachers. Our conclusion emphasizes the invaluable contribution of neuropedagogy to education and calls for its inclusion in pre-service teacher training.

KEYWORDS

neuropedagogy, neuro-education, teacher education, teacher training, pre-service teachers

Introduction

Neuropedagogy (Neuroeducation/Educational Neurosciences) is an interdisciplinary field, integrating neuroscience, psychology and education (Figure 1). The field invites dialog among educators, neuroscientists, psychologists and learners of all ages to improve, deepen, and refine the theoretical and applied understanding of teaching-learning processes (Carew and Magsamen, 2010; Devonshire and Dommett, 2010; Rodgers, 2015; Nouri, 2016; Elgavi - Hershler, 2023).

The concept that educators can influence the brain development of their students lies at the basis of the ability to shape the educational future. The purpose of the new field of knowledge called "neuropedagogy" is to bridge the accumulated knowledge from neuroscientific, psychological and educational research, mainly in practical aspects of teaching and learning processes. An in-depth acquaintance with the field of neuropedagogy will promote and enhance educational processes in the cognitive and social–emotional learning (SEL) dimensions based on scientific findings from the field of brain research (Jones and Kahn, 2017; Jansen and Kiefer, 2020). The systematic exposure of educational researchers, teacher educators, pre- and in-service teachers and policymakers to the field

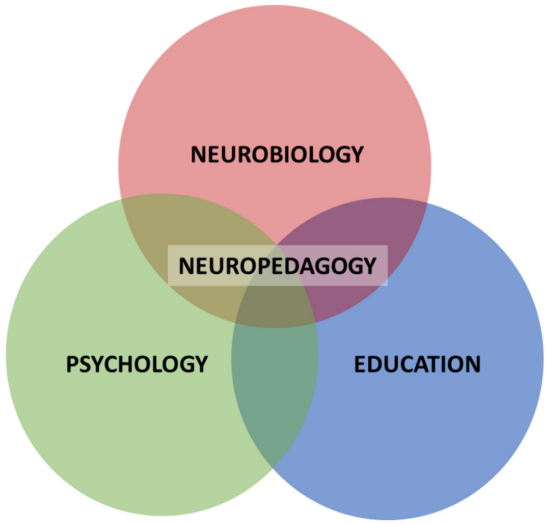

FIGURE 1
The areas of knowledge that define neuropedagogy [based on Sousa (2010)].

of neuropedagogy will deepen and promote their understanding and implementation of educational goals. Neuropedagogy needs to be embedded in teachers training and throughout their professional development. This approach complements the lifelong learning perspective as defined by UNESCO (Akther, 2020) and others. Neuroeducational research conducted both in Israel and internationally underscores the invaluable contribution of neuroscientific knowledge to deepen pedagogical understanding, educational practices, self-efficacy, and the professional competence of educators (Dubinsky et al., 2019; Friedman et al., 2019). Therefore, it is essential to raise awareness of the field and create an informed discourse on the subject of neuroeducation among academic faculty and prospective educators. This policy brief seeks to raise the awareness of neuropedagogy by leaders in teacher training. It includes some examples of neuropedagogical principles in the educational space, a quick review of the main international platforms of the field, and operative proposals for the assimilation of this new knowledge field in teacher training institutions.

Examples of the applications of neuropedagogical principles in educational settings

Neuropedagogical understanding of the way we learn may help in the development of teaching methods and curricula, in the development of learning strategies and in creating educational policies based on empirical findings of brain research (Hardiman, 2012; Busso and Pollack, 2015; Marchak and Shvarts-Serebro, 2021). One of the basic premises of the field is that knowledge about brain functions and mechanisms involved in learning processes such as emotion, motivation and memory can influence the optimal choice of strategies in educational settings (Blakemore and Frith, 2005). Neuropedagogy intersects with pivotal dimensions within the educational sphere: cognitive, emotional, environmental, and social. Illustrative examples include.

The connection between cognition and emotion

Our understanding of the connection between cognition and emotion has undergone a transformative evolution. The dichotomy that once delineated cognitive processes from emotional responses, a prevalent perspective throughout the 20th century, has changed in light of recent findings from brain research. These show the interdependence of cognitive processes and emotions, both on the macro level of brain anatomy, and on the micro level of synaptic connections (Pessoa, 2008; Pessoa et al., 2019). Furthermore, a reciprocal relationship exists between emotional states and the motivation for learning, investment in learning, and achievement (Immordino-Yang and Gotlieb, 2017). Insights derived from brain research underscore the significance of incorporating Social Emotional Learning (SEL) within the educational framework (Immordino-Yang et al., 2019).

Brain plasticity

From a neurobiological point of view, learning is expressed as the production of new neural connections and the pruning or strengthening of existing connections between different brain areas following practice and experience. In contrast to what was previously believed, a growing number of studies point to the brain's ability to make these connections and change throughout life, with important windows of opportunity throughout development, especially in early childhood and the teenage years (Rees et al., 2016). Teachers' awareness of the neural processes that occur during learning will allow them to plan the teaching so that the brain's flexibility is utilized (Rueda, 2020; Bueno, 2021). Other findings indicate that students' awareness of the brain's ability to change may improve their achievements (Yeager et al., 2019).

Neuronal basis of learning and memory

Learning and memory are integrated processes during which neural connections are formed between and within the brain areas that were involved in learning. Understanding the basic mechanisms of learning and memory can greatly contribute to the design of teaching based on how our brain works. Here are examples of several neuropedagogical factors that can optimize the learning process: First, in order for learning to occur, the new knowledge needs to connect to existing knowledge, that is already represented by a network of neural connections, and expand it (Grossberg, 1999; Bassett et al., 2011). In order for this to occur, these neural networks need to be activated prior to learning. This can be seen as the neuronal corollary to schema activation in cognitive load theory (Kalyuga, 2010). Teachers who are aware of this rule will find out what the students' previous knowledge is and will develop teaching methods that connect the new information to their existing knowledge. In addition, to create the neural network and strengthen it, its repeated activation is required through repetition

and practice (van Kesteren et al., 2018). And finally, the creation of the neural network requires time and resources, and therefore it is important that the learning be spaced, and the teaching must be planned so that there are breaks between repetitions (Kelley and Whatson, 2013).

Sleep, biological clock, and learning

Sleep is important for learning because during sleep the brain consolidates declarative and non-declarative memory, with different proposed roles for REM and NREM sleep (Ackermann and Rasch, 2014). In addition, during adolescence the biological clock changes, so that melatonin – a hormone important for sleep, is secreted late at night and remains in the body until a later hour in the morning (Alfonsi et al., 2020). Consequently, teenagers are more alert at night and tired during morning classes. When adolescents' biological clock is not considered, their sleep at night shortens, thus preventing the beneficial effects of sleep for learning and brain health. In addition, beginning the school day at an early hour, when students are tired, harms their concentration and learning ability. Delaying the beginning of the school day to a later time improves adolescents' academic achievements, their mental health and the school climate (McKeever and Clark, 2017; Ziporyn et al., 2022).

Executive functions

Executive functions involve higher-order cognitive control, including emotional regulation, inhibition control, cognitive flexibility, working memory and attention. These functions are responsible, among other things, for the individual's ability to plan, regulate emotions, delay a response and initiate and persist in goal-directed behavior (Meltzer, 2018). These functions are largely responsible for the development of social and learning skills that promote the individual's well-being aligned with their goals, ambitions and desires (Wiebe and Karbach, 2018). The prefrontal lobe is the brain area most associated with executive functions and is responsible for their integration during goal-directed behavior (Dawson and Guare, 2018). The development of executive functions predicts how well children will function in educational settings, their ability to deal with challenges in school, and eventually, with the challenges of adult life (Meltzer, 2018; Spiegel et al., 2021). Expanding educators' understanding regarding the development of executive functions may help them understand why they are central to wellbeing and learning, how executive functioning relates to neurodiversity, and help them design educational plans to foster executive functioning in appropriate ways throughout development (Diamond, 2016).

Neuropedagogy: platforms and developments around the world

During the last few years, the field of neuropedagogy has gained momentum around the world and consequently in Israel, both in research and in practice. The growth of the field has led to the development of platforms that can be divided into four central channels:

- The founding of international organizations such as IMBES (International Mind, Brain, and Education Society, www.imbes.org) in 2004, and the Special Interest Group (SIG) entitled "Neuroscience and Education" by the European Association for Research on Learning and Instruction (EARLI), which has held biannual meetings since 2010.
- Continuing research and the creation of field-specific journals such as *Trends in Neuroscience and Education; Mind, Brain, and Education,* and *Educational Neuroscience.* These journals are a focus for theoretical and empirical research on the intersection between neuroscience, psychology, and education.
- Research centers for educational neuroscience have been established at leading universities such as Cambridge University, University of Bristol, University College London, Harvard University and Stanford.
- The creation of advanced degrees in neuropedagogy at institutes of higher education. Most of these programs are in Schools of Education, sometimes in cooperation with Departments of Neuroscience. Examples can be found at the University College of London, University of Bristol, or Columbia University.

These developments and platforms have great importance for the global research community in neuropedagogy. In addition, for in-service teachers, there are professional development courses and workshops in the field of neuropedagogy. However, these are usually short programs, from a few hours to a few weeks (Privitera, 2021). In contrast, the current policy brief focuses on teacher educators, and we make a case for the integration of neuropedagogy in teacher training.

We see teacher training institutes as natural partners in this process of integrating neuropedagogy into the future of innovative and excellent education. In the past few years, there is an increased momentum to create programs for integrating neuropedagogy in teacher training institutions. The current authors are involved in a number of innovative initiatives in Israel integrating neuroscience in pre- and in-service teacher education. For pre-service teachers, these include neuropedagogy courses in B.Ed. programs for special education and physical education (Levinsky-Wingate Academic Center), early childhood (Efrata Academic College), and a recently launched neuropedagogy-based teacher training program in the field of chemistry (Bar-Ilan University). For in-service teachers, these include an M.Ed in Neuropedagogy at Achva Academic College. These programs exist together with a number of other Israeli initiatives focusing more on research and outreach, such as the Sagol Center for Brain and Mind at Reichman University, and the Safra Center for Brain and Learning at Haifa University.

To expand the impact of neuropedagogy on education, it is crucial to include teacher educators as stakeholders in the process. Teacher educators are among the most important agents of change in both pre- and in-service teacher training (Cochran-Smith et al., 2018). Therefore, we engaged in a two-year think-tank on the integration of neuropedagogy in education via the professional learning of teacher educators. The think tank included teachers, teacher educators, brain scientists and policy makers. This process led to the development of a pioneering interdisciplinary and multi-cultural program for teacher educators at The Mofet Institute, the national research and development center for teacher education. The program included multiple stakeholders: teacher educators, school principals and policy makers; from multicultural, diverse religious backgrounds, and multidisciplinary fields of education.

The program was taught with a unique approach of co-teaching, with instructors coming from complementary neuropedagogy backgrounds. This program, in contrast to the short-term workshops described above, extended for a full academic year, one day a week for 6 h. The course focused on neuropedagogical topics such as neuro-anatomy, neuromyths, emotion and motivation, learning and memory, executive function and neurodiversity, and was taught using neuropedagogical methods and principles, including experiential learning, spaced learning, learning from context and didactic discussions. Participants submitted projects for the application of neuropedagogy in colleges of teacher training.

In the current paper, we offer three options for the integration of neuroeducation within teacher training.

Three options for the integration of neuroeducation within teacher training

We suggest three strategic avenues for the incorporation of neuropedagogy within teacher training institutions: the promotion of innovative teaching and learning practices based on neuropedagogical principles, encouraging teacher educators to conduct neuropedagogical research, and the explicit teaching of neuropedagogical knowledge to train pre-service teachers as shapers of the future educational system. These three avenues are based on three mainstays of teacher training institutes: the modeling of teaching practices, educational research, and explicit teaching of educational and pedagogical knowledge (see Figure 2).

Channel 1: promotion of innovative teaching and learning practices among teacher educators

The imperative to instill 21st-century skills in students necessitates a re-evaluation of contemporary methods of instruction, assessment, and learning. Teacher training institutes should take the lead in steering innovation in both teaching and learning. Neuropedagogy, by its very nature and definition, introduces profound and evidence-informed thinking from the forefront of brain science research into instructional practice that contributes to effective and meaningful learning. This approach draws on key findings in neuroscience but applies it in a context-sensitive way and is open to emerging evidence that may deepen or shift our understanding of effective teaching and learning. Faculty members should receive training to understand teaching and learning processes in a way that is founded on neuropedagogical principles, enabling them to model innovative pedagogical strategies across all disciplines. We propose the following ideas for implementation at the level of teacher educators:

1. Conduct workshops and/or specialized courses on applied neuropedagogy for teacher educators to equip them with knowledge and teaching methods rooted in neuropedagogical principles.
2. Establish professional learning communities to develop neuropedagogy-based instruction for courses in various disciplines.
3. Formulate task forces for the implementation of clinical training (practical experience) grounded in neuropedagogy.
4. Organize symposiums for educators to present new and applied research in instructional practices.

Channel 2: encourage neuropedagogical research among teacher educators

Neuropedagogy is based on and fosters a strong mutual dialog between findings from neuroscientific research and educational practice. The next step is to conduct neuropedagogical research that enables the development and evaluation of innovative educational practices and leads educators to greater pedagogical understanding. The following recommendations are intended to facilitate this goal:

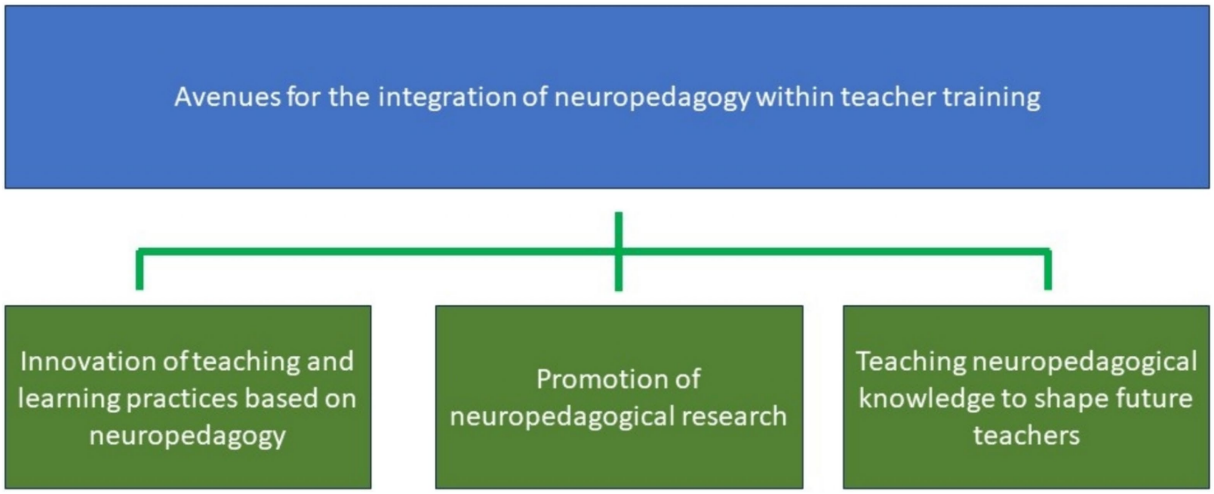

FIGURE 2
Three avenues for the integration of educational neuroscience within institutes of teacher training.

1. Recruit interested faculty members to form research teams to explore avenues for neuropedagogical research (i.e., motivation, learning and memory, SEL), including the use of available brain research technologies (i.e., eye tracker, EEG) to evaluate pedagogical practices.
2. Encourage teacher educators, together with teachers and teachers-in-training to engage in Action Research and Design Research to study emerging insights, tools and neuropedagogical applications in the context of their educational practices.
3. Initiate research collaborations with neuroscientists and brain research labs to systematically address issues that emerge from the field.

Channel 3: teach neuropedagogical knowledge explicitly, to train pre-service teachers as shapers of the future educational system

Teachers teach the way they are taught and therefore it is very important for teacher educators to teach, use and model neuropedagogical knowledge and innovative practices (Dubinsky et al., 2019; Jolles and Jolles, 2021; Hachem et al., 2022). Future teachers should be explicitly exposed to neuropedagogical principles while they are still being trained, both in their courses and in their clinical practice. We propose the following ideas:

1. Teach a course on neuropedagogy and develop independent study modules in neuropedagogy across all the fields of education to all teachers in training.
2. Develop an outline for writing lesson plans which take neuropedagogical considerations into account and encourage students to use these in their clinical practice.
3. Integrate the field in academic, classroom, and community programs, especially with a focus on equity and diversity.
4. Equip future teachers with the neuropedagogical knowledge and tools needed to teach in diverse classrooms.

Conclusion

Neuroeducational research shows the invaluable contribution of neuroscientific knowledge to education. This is especially relevant in the field of teacher education, for both pre-service and in-service teachers. This paper described a number of examples of the application of neuropedagogical principles in educational settings and gave a brief summary of the major platforms, centers and programs in the field. We end our paper with a call for the integration of neuropedagogical knowledge in pre-service teacher training. We recommended three avenues for action in teacher training: the promotion of innovative teaching and learning practices based on neuropedagogical principles, encouraging teacher educators to conduct neuropedagogical research, and the explicit teaching of neuropedagogical knowledge to train pre-service teachers as shapers of the education of the future.

Author contributions

IS-S: Writing – original draft, Writing – review & editing. GB-Y: Writing – original draft, Writing – review & editing. OE-H: Writing – original draft, Writing – review & editing. EG: Writing – original draft, Writing – review & editing. AK: Writing – original draft, Writing – review & editing. EL: Writing – original draft, Writing – review & editing. MS: Writing – original draft, Writing – review & editing. TZ-H: Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Ackermann, S., and Rasch, B. (2014). Differential effects of non-REM and REM sleep on memory consolidation? *Curr. Neurol. Neurosci. Rep.* 14:430. doi: 10.1007/s11910-013-0430-8

Akther, J. (2020). Influence of UNESCO in the development of lifelong learning. *Open J. Soc. Sci.* 8, 103–112. doi: 10.4236/jss.2020.83010

Alfonsi, V., Scarpelli, S., D'Atri, A., Stella, G., and De Gennaro, L. (2020). Later school start time: the impact of sleep on academic performance and health in the adolescent population. *Int. J. Environ. Res. Public Health* 17:2574. doi: 10.3390/ijerph17072574

Bassett, D. S., Wymbs, N. F., Porter, M. A., Mucha, P. J., Carlson, J. M., and Grafton, S. T. (2011). Dynamic reconfiguration of human brain networks during learning. *Proc. Natl. Acad. Sci. U.S.A.* 108, 7641–7646. doi: 10.1073/pnas.1018985108

Blakemore, S. J., and Frith, U. (2005). *The learning brain: Lessons for education*. Oxford, United Kingdom: Blackwell Publishing.

Bueno, D. (2021). Epigenetics and learning. How the environment shapes gene expression, and the possible consequences for learning and behaviour. *Epigenetics*.

Busso, D. S., and Pollack, C. (2015). No brain left behind: consequences of neuroscience discourse for education. *Learn. Media Technol.* 40, 168–186. doi: 10.1080/17439884.2014.908908

Carew, T. J., and Magsamen, S. H. (2010). Neuroscience and education: an ideal partnership for producing evidence-based solutions to guide 21st century learning. *Neuron* 67, 685–688. doi: 10.1016/j.neuron.2010.08.028

Cochran-Smith, M., Keefe, E., and Carney, M. (2018). Teacher educators as reformers: competing agendas. *Eur. J. Teach. Educ.* 41, 572–590. doi: 10.1080/02619768.2018.1523391

Dawson, P., and Guare, R. (2018). *Executive skills in children and adolescents: A practical guide to assessment and intervention*. New York: Guilford Publications.

Devonshire, I. M., and Dommett, E. J. (2010). Neuroscience: Viable application in education? *Neurosci. Soc.* 16, 349–356. doi: 10.1177/1073858410370900

Diamond, A. (2016). "Why improving and assessing executive functions early in life is critical" in *Executive function in preschool-age children: Integrating measurement, neurodevelopment and translational research*. eds. J. A. Griffin, P. McCardle and L. S. Freund (Washington: American Psychological Association).

Dubinsky, J. M., Guzey, S. S., Schwartz, M. S., Roehrig, G., MacNabb, C., Schmied, A., et al. (2019). Contributions of neuroscience knowledge to teachers and their practice. *Neuroscientist* 25, 394–407. doi: 10.1177/1073858419835447

Elgavi - Hershler, O. (2023). Neuropedagogia: keshemoach ve'chinuch nifgashim [Neuropedagogy: when brain science meets education]. Mofet

Friedman, I. A., Grobgeld, E., and Teichman-Weinberg, A. (2019). Imbuing education with brain research can improve teaching and enhance productive learning. *Psychology* 10, 122–311. doi: 10.4236/psych.2019.102010

Grossberg, S. (1999). The link between brain learning, attention, and consciousness. *Conscious. Cogn.* 8, 1–44. doi: 10.1006/ccog.1998.0372

Hachem, M., Daignault, K., and Wilcox, G. (2022). Impact of educational neuroscience teacher professional development: perceptions of school personnel. *Front. Educ.* 7:912827. doi: 10.3389/feduc.2022.912827

Hardiman, M. (2012). Informing pedagogy through the brain-targeted teaching model. *J. Microbiol. Biol. Educ.* 13, 11–16. doi: 10.1128/jmbe.v13i1.354

Immordino-Yang, M. H., Darling-Hammond, L., and Krone, C. R. (2019). Nurturing nature: how brain development is inherently social and emotional, and what this means for education. *Educ. Psychol.* 54, 185–204. doi: 10.1080/00461520.2019.1633924

Immordino-Yang, M. H., and Gotlieb, R. (2017). Embodied brains, social minds, cultural meaning: integrating neuroscientific and educational research on social-affective development. *Am. Educ. Res. J.* 54, 344S–367S. doi: 10.3102/0002831216669780

Jansen, K., and Kiefer, S. M. (2020). Understanding brain development: investing in young adolescents' cognitive and social-emotional development. *Middle Sch. J.* 51, 18–25. doi: 10.1080/00940771.2020.1787749

Jolles, J., and Jolles, D. D. (2021). On neuroeducation: why and how to improve neuroscientific literacy in educational professionals. *Front. Psychol.* 12:752151. doi: 10.3389/fpsyg.2021.752151

Jones, S. M., and Kahn, J. (2017). *The evidence base for how we learn: Supporting Students' social, emotional, and academic development. Consensus Statements of Evidence from the Council of Distinguished Scientists*. Perumpilavu: Aspen Institute.

Kalyuga, S. (2010). "Schema acquisition and sources of cognitive load" in *Cognitive load theory*. eds. J. L. Plass, R. Moreno and R. Brünken (Cambridge: Cambridge University Press).

Kelley, P., and Whatson, T. (2013). Making long-term memories in minutes: a spaced learning pattern from memory research in education. *Front. Hum. Neurosci.* 7:589. doi: 10.3389/fnhum.2013.00589

Marchak, D., and Shvarts-Serebro, I. (2021). "The multidisciplinary learning grid: a conceptual space to develop Neuropedagogy-based, arts-integrated chemistry activities" in *The arts of the grid: Interdisciplinary insights on gridded modalities in conversation with the arts*. eds. L. Bigon and N. Shaked (Berlin: De Gruyter).

McKeever, P. M., and Clark, L. (2017). Delayed high school start times later than 8: 30 am and impact on graduation rates and attendance rates. *Sleep Health* 3, 119–125. doi: 10.1016/j.sleh.2017.01.002

Meltzer, L. (2018). *Executive function in education: From theory to practice*. New York: Guilford Publications.

Nouri, A. (2016). Exploring the nature and meaning of theory in the field of neuroeducation studies. *Int. J. Educ. Pedagogical Sci.* 10, 2733–2736.

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nat. Rev. Neurosci.* 9, 148–158. doi: 10.1038/nrn2317

Pessoa, L., Medina, L., Hof, P. R., and Desfilis, E. (2019). Neural architecture of the vertebrate brain: implications for the interaction between emotion and cognition. *Neurosci. Biobehav. Rev.* 107, 296–312. doi: 10.1016/j.neubiorev.2019.09.021

Privitera, A. J. (2021). A scoping review of research on neuroscience training for teachers. *Trends Neurosci. Educ.* 24:100157. doi: 10.1016/j.tine.2021.100157

Rees, P., Booth, R., and Jones, A. (2016). The emergence of neuroscientific evidence on brain plasticity: implications for educational practice. *Educ. Child Psychol.* 33, 8–19. doi: 10.53841/bpsecp.2016.33.1.8

Rodgers, D. L. (2015). The biological basis of learning: Neuroeducation through simulation. *Simul. Gaming* 46, 175–186. doi: 10.1177/1046878115590585

Rueda, C. (2020). Neuroeducation: teaching with the brain. *J. Neuroeduc.* 1, 108–113. doi: 10.1344/joned.v1i1.31657

Sousa, D. A. (2010). *Mind, brain, & education: neuroscience implications for the classroom*. Bloomington, Indiana: Solution Tree Press.

Spiegel, J. A., Goodrich, J. M., Morris, B. M., Osborne, C. M., and Lonigan, C. J. (2021). Relations between executive functions and academic outcomes in elementary school children: a meta-analysis. *Psychol. Bull.* 147, 329–351. doi: 10.1037/bul0000322

van Kesteren, M. T. R., Krabbendam, L., and Meeter, M. (2018). Integrating educational knowledge: reactivation of prior knowledge during educational learning enhances memory integration. *NPJ Sci. Learn.* 3:11. doi: 10.1038/s41539-018-0027-8

Wiebe, S. A., and Karbach, J. (2018). *Executive function: Development across the life span*. Taylor & Francis Group: Routledge.

Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., et al. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature* 573, 364–369. doi: 10.1038/s41586-019-1466-y

Ziporyn, T. D., Owens, J. A., Wahlstrom, K. L., Wolfson, A. R., Troxel, W. M., Saletin, J. M., et al. (2022). Adolescent sleep health and school start times: setting the research agenda for California and beyond: a research summit summary. *Sleep Health* 8, 11–22. doi: 10.1016/j.sleh.2021.10.008