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Research paper

Neuroscience literacy in educators' training programs in Asia: A call to action

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ABSTRACT

The center of learning is the brain and the disciplinary science that examines its structure and functioning, and the nervous system as a whole, is called neuroscience. The assimilation of essential neuroscience-related content by educational systems has gained global interest, given the relevance of learning to education. Recognizing the significance of frontline workers, several governmental agencies and educational institutions have launched initiatives to foster the inclusion of neuroscience literacy in educators' training programs. Their success, however, has depended on collaborative efforts among educators, researchers, and other educational stakeholders, and the process has involved considerable debate. Here, we aim to articulate a rationale to promote neuroscience literacy for educators. In doing so, we revisit prior arguments on the importance of training educators and build up on other reasons to advocate for this kind of endeavor considering cutting-edge research. Following this, we discuss critical elements to advance neuroscience literacy for educators and examine the most important challenges to execute successful initiatives. Finally, we appraise the significance for Asia, reviewing the scholarly literature on educators' prior experiences, and highlight the case of Singapore as an exemplar initiative that catalizes human capital, infrastructure, and strategies to advance neuroscience literacy. We conclude by arguing that governmental agencies and educational institutions should strengthen their efforts to accommodate their programmatic plans and agendas to embrace neuroscience literacy in educators' training programs. This global trend has arrived to stay.

1. Introduction

In 2002, the Organisation for Economic Co-operation and Development (OECD) published the book 'Understanding the Brain' to increase awareness among the public and political sectors on how our ever-increasing understanding of brain functioning could benefit educational systems implement more effective programs, practices, and policies for teaching and learning through research-based evidence (OECD, 2002). Twenty years later, we revise some of the arguments raised by the OECD considering cutting-edge research and examine other reasons that have emerged during the last two decades to advocate for neuroscience literacy in educators' training programs.

2. Why is neuroscience literacy in educators' training important?

2.1. The center of learning: the brain

Neuroscience—a basic science—deals with brain function and structure, including learning; education—a social and more applied science—refers to the process of teaching and learning, which in turns shapes brain function and structure. Neuroscience and education have always been naturally intertwined through learning, but it was not until the emergence of the field of educational neuroscience that a more direct dialogue between these two disciplines intensified (Thomas et al., 2019). Before that, it was predominantly psychology—another social and more applied science involving the study of the mind—the discipline that for many years served the education sector on teaching and learning matters (Walberg and Haertel, 1992).

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The advent of educational neuroscience makes the connection between brain functioning and pedagogy more visible and provides genuine opportunities to directly interrogate the neurobiology of learning, examine the teaching and learning process, hypothesize about human potential, and translate findings into practice and policy. Equally important, the field offers possibilities to foster neuroscience literacy as it provides a platform for educators, researchers, and other educational stakeholders (e.g., students, parents, and policymakers) to come together and learn collaboratively.

Educators are curious about brain functioning, and there is now an extensive literature demonstrating that this knowledge can indeed help them make theoretical connections with pedagogy, improve their instructional practices, and enhance students' learning (Dubinsky et al., 2019; Hook and Farah, 2013a; MacNabb et al., 2006; Privitera, 2021; Serpati and Loughan, 2012; Tan et al., 2019). The data illustrate that, for example, educators exposed to neuroscience literacy optimized lessons' planning and delivery and attempted new teaching strategies (Chang et al., 2021; Schwartz et al., 2019; Tan et al., 2019), moved away from direct instruction to implement more student-centered activities (Anderson et al., 2018; Roehrig et al., 2012), improved classrooms' climate and students' engagement and motivation (Roehrig et al., 2012), became more aware of students' needs and negative behavior (Bana and Cranmore, 2019; Chang et al., 2021; Hook and Farah, 2013a), were better able to design instruction that aligned with principles of brain functioning (Tan et al., 2019), applied neuroscience concepts in their classrooms and developed better relationships with students (Hachem et al., 2022), and changed their understandings on the utility of scientific concepts on learning (A. Howard-Jones et al., 2020). Moreover, educators have manifested greater professional satisfaction and self-image after being exposed to neuroscience literacy (Hook and Farah, 2013a).

There is also evidence indicating that educators' exposure to neuroscience literacy can impact students' achievement. For instance, several studies have shown that students of neuroscience-trained educators, when compared with those of untrained ones, have improved their competencies in reading, mathematics, and empathy (Caballero and Llorent, 2022), and neuroscience (Ellingson et al., 2021; Hachem et al., 2022). Similarly, students' opinions about mathematics and respective test scores have improved (Anderson et al., 2018).

The effectiveness of neuroscience-based training for educators has been evidenced in several studies. Neuroscience literacy can empower educators holistically, complementing or supplementing their understanding of the teaching and learning process and own performance. Crucially, all these findings have emerged from short-term continuing professional initiatives, suggesting that more sustained, long-term training (e.g., bachelors, master's and doctorate's programs) may lead to overall better outcomes.

2.2. Neuromyths in education, curricula design, and other educational policies

The OECD defined the term *neuromyth* as "a misconception generated by a misunderstanding, a misreading or a misquoting of facts scientifically established (by brain research) to make a case for the use of brain research in education and other contexts" (OECD, 2002, p.111). The list of neuromyths circulating these days that are taken for granted in society is extensive: "We use 10% of our brain," "When we sleep, the brain shuts down," and so forth.

Over the past years, several studies have consistently reported a high prevalence of neuromyths among pre-service and in-service educators, including developed and developing countries across the five continents—America, Europe, Asia, and Australia (Torrijos-Muelas et al., 2021) and Africa (Janati Idrissi et al., 2020). Currently, there is lack of research assessing the direct impact of beliefs in neuromyths on educators' teaching practices and students' learning (Hughes et al., 2022; Rousseau, 2021). Endorsing neuromyths, for example, may not necessarily imply deficits in teaching effectiveness (Horvath et al., 2018). This, however, does not prevent their use in classrooms, which could be problematic. Educators who believe that "differences in hemispheric dominance (right brain, left brain) can help explain individual differences amongst learners," for instance, may adopt misleading practices (https://www.oecd.org/education/ceri/neuromyth6.htm). They may rely on drawings to stimulate students' creative and emotional abilities (allegedly connected to the right brain) and on problem solving assignments in mathematics to develop students' analytic and logical competencies (supposedly attributed to the left brain). Educators may even believe that students with damage on either the left or right hemisphere are incapable of acquiring the skills incorrectly assigned to these parts of the brain. Yet, there are reported cases of hemispherectomized children whose brain compensated for cognitive skills to surprising levels (for example, Immordino-Yang, 2007, 2008). Neuroscience literacy can help educators to deal with false assumptions on brain structure and functioning. Converging evidence indicate that, while not entirely, neuroscience literacy reduces educators' beliefs in neuromyths (Im et al., 2018; Macdonald et al., 2017; McMahon et al., 2019).

The belief in neuromyths can also persuade school leaders and educators to utilize products in their classrooms with insufficient or complete lack of scientific evidence. A typical example constitutes the so-called 'Brain gym' programs that prescribe a series of simple exercises "to integrate all areas of the brain to enhance learning" (e.g., https://integratedlearningacademy.com/brain-gym/). The data, however, have failed to validate such claim (Hyatt, 2007; Spaulding et al., 2010), meaning that these are ineffective interventions for learning. Preventing counterproductive actions in curricula innovations is critical. Furthermore, neuromyths may also be deep-rooted in large scale educational policies. In the United States, for instance, future educators from several states need to pass licensing exams based on state-provided study materials that incorporate the neuromyth of learning styles (Furey, 2020). Neuroscience literacy can also assist school leaders and educators become critical consumers of research to better allocate their resources and capacities on trainings and practices that truly enrich learning experiences.

Educational systems regularly introduce curriculum reforms to achieve students' intended learning outcomes. These reforms depend on several factors, including short- and long-term programmatic plans, local priorities, budget cuts, standardized tests performance, and international recommendations. Deciding what to cut, what to keep, and what to adapt is a challenging process in curricula design that may not always align with research-based evidence. During the last decades, for instance, students' exposure to music (Aróstegui, 2016) and art (Helton, 2021) has been progressively reduced or eliminated. However, these reforms are counterproductive because there is an extensive body of research linking these subjects to numerous aspects of cognitive development. They favor students' learning trajectories by promoting motivation, attention, memory, and many other cognitive domains (Gazzaniga, 2008). Greater exposure to neuroscience literacy can empower educators to intervene in curricula design to ensure that these meet the criteria of scientific validity and practical relevance for learning.

Finally, it is becoming increasingly possible to apply neuroscience-related innovations in education. While these innovations have mainly involved drugs (e.g., Adderall), there are other approaches, such as brain imaging techniques and brain stimulation procedures, that are being developed and show great potential for describing, measuring, modulating, and/or predicting learning (Schmied, 2017). The use of these innovations in education raises a range of ethical concerns, given that academic performance can or could be enhanced (Lalancette and Campbell, 2012). In the future, educational systems will need to determine what innovations to incorporate, as well as when, how, for how long, and under what circumstances to use these. Educators will play a key role in integrating and deciding their potential application on all students or only on those that present academic disadvantages, either due to low performance or learning difficulty, and their rationale may be more prudent with regards to researchers' judgements (Schmied et al., 2021). Neuroscience literacy can prepare educators to appraise the advantages and disadvantages, risks, and impact regarding the use of these neuroscience-related innovations to make informed decisions.

In recent years, several innovations on neuroscience literacy for educators, school staff, and educational policymakers have been developed, spanning from multi-year programs, such as BrainU (Dubinsky et al., 2019) to specialized conferences (Learning & the Brain, http://www.learningandthebrain.com/), and scientific societies (e.g., the International Mind, Brain and Education Society, https://imbes.org/). All these efforts have surfaced the need to debunk neuromyths in education and align curricula design and other educational practices and policies with evidence-based research.

2.3. Media coverage of neuroscience information

Successful dissemination strategies involve reducing complexity in scientific explanations while preserving accuracy when mobilizing certain knowledge (Ravinetto and Singh, 2022). Referencing all supporting research, recognizing the respective limitations, issues, and gaps, is also required. The number of neuroscience articles published in the popular press has increased during the last years (O'Connor et al., 2012). Several reports indicate that, when covering neuroscience-related research, journalists often face difficulties when translating the scientific and technical aspects in a comprehensive manner. Racine et al. (2006) evaluated the media coverage of a brain imaging technique (functional magnetic resonance imaging) that regularly appears in dissemination pieces intended for the general public, and found an overly enthusiastic tone and lack of technical explanations in most articles. When conducting similar analysis on other common neuroscience-related technologies (e.g., electroencephalography and neurostimulation), the authors observed similar results (Racine et al., 2010). After evaluating the types of explanations and the tone in several articles, they noted that—irrespective of the technology—the characteristics and limitations were rarely or poorly explained, and the tone was predominantly uncritical. While accuracy in translational research is generally a flaw, it also varies depending on publication tendencies, neuroscience theme, and newspaper type (Van Atteveldt et al., 2014). The media coverage commonly fails to ponder important factors, such as sample size, population, and context for generalizability, and even alters explanations provided by researchers (O'Connell et al., 2011). Omissions of critical information and potential reductionism represent unsuccessful research translation. Among the adverse consequences of neuroscience-related misinformation, there is an audience whose perceptions might be influenced to raise unrealistic expectations and create overenthusiasm. During the last decades, there has been a rise of words using the "neuro-" prefix, which may be decontextualized (Muzur and Rincic, 2013). Educators are active media consumers; neuroscience literacy can equip them with sufficient knowledge to evaluate the accuracy and interpretations of knowledge that is translated through the popular press.

2.4. Seductive allure of neuroscience information

Neuroscience-related information seems to be particularly appealing to the public (Beck, 2010). McCabe and Castel (2008) assessed participants' credibility on neuroscience research while presenting the information through different formats. They noticed that disseminating research with brain images resulted in higher ratings than either only texts (no images), bar graphs or topographical maps of brain activation. The sole presence of brain images, therefore, resulted more influential on participants' credibility than plain text and other kinds of diagrams, even if these were pointless in terms of content. Similar results were observed by Weisberg et al. (2008) when using explanations of psychological phenomena via text, instead of brain images. Participants' satisfaction increased after reading explanations with neuroscience information, versus those without it, which presented irrelevant context. Thus, neuroscience information has the potential to interfere with the public's critical thinking capabilities when it comes to evaluating explanations logically. While some studies have failed to replicate some of these results (e.g., Gruber and Dickerson, 2012; Hook and Farah, 2013b; Michael et al., 2013), others continue to point to the seductive allure of neuroscience information (Rhodes et al., 2014; Weisberg et al., 2015). Exposure to neuroscience literacy can provide educators with the knowledge to refrain from adding extra value to irrelevant information, interpret scientific information properly, and avoid the compelling effect neuroscience-related content may have on judgements.

3. What is needed to advance neuroscience literacy for educators?

Implementing pre- and in-service educators' training programs—both short- and long-term—in neuroscience-related contents across all educational levels, from K-12 to tertiary, is key. By promoting the incorporation of core courses in pre-service education curriculum, certain standards in terms of knowledge and skills can be achieved since early stages in educators' professional careers. Establishing continuing professional development training for in-service educators is particularly relevant for those who were never exposed to neuroscience-related content during their formation. While short-term continuing professional initiatives are beneficial for educators who prefer a relatively quick training given time, monetary, and other constraints, long-term trainings (e.g., bachelors, master's and doctorate's programs) are suitable for those who hope to become experts.

Not only educators' training is needed to advance neuroscience literacy, however. It is also essential to promote more context- and audience-dependent research on the impact of neuroscience literacy on educators' training and practices and students' learning through alliances among different educational stakeholders, such as educators, researchers, school staff, students, and ministries of education.

4. What are some of the challenges in advancing neuroscience literacy for educators?

Overall, stronger infrastructure for introducing neuroscience literacy and related research needs to be created. Sufficient human capital to drive growth and innovation is what, today, remains as perhaps the most challenging aspect to advance this endeavor. Not too long ago, Sheridan et al. (2004) envisioned a new profession— known as 'Neuro-educators'— who, after mastering the fields of neuroscience and education, should be equipped to critically and ethically mobilize knowledge between disciplines. While there has been good progress in formation, the limited number of these experts (also called "educational engineers" by Fischer et al., 2010) and others, including neuroscientists familiarized with educational systems, practices, and issues, is still a flaw.

To advocate for neuroscience literacy for educators, implementing inter- or transdisciplinary training programs and establishing partnerships among different educational stakeholders (such as policymakers and school administrators) are needed actions. These, however, represent a challenge for faculties, departments, or institutes of education as they need to introduce important modifications to their traditional administration systems and ways of design, development, and delivery of instructional materials (Mcgregor and Volckmann, 2013), as well as emphasize research translation (Aymerich et al., 2014). The introduction of 'Research Schools' as models, where practice, research, and policy coexist, has been argued to be an example of infrastructure that promotes neuroscience literacy for educators and supports sustainable and lasting collaborations among different educational sectors (Hinton and Fischer, 2008). Examples of successful initiatives include the

Brainwave Learning Center, which is a research-practice partnership between Stanford University and Synapse School (https://www.synapseschool.org/innovation/blc) and the fellowship program within the Institute's Center for Innovation and Leadership in Special Education at the pediatric hospital Kennedy Krieger Institute, where fellow educators are trained on neurodevelopmental disabilities by clinical faculty (Carey et al., 2020).

Moreover, changes in educational systems are largely determined by politics and policymaking. These changes are continuously shaped by the needs and demands of contemporary society and normally respond to practical problems that are essentially context- and audience-dependent. The implementation of continuous examinations of students' achievement in preparation for standardized testing is a systemic priority in many countries, for example, and the value and implications of 'Neuroeducators' training may not be part of their culture and mindset yet. For progress to be made, financial resources need to be secured and properly allocated across educational systems, from preschools to ministries.

5. Why is neuroscience literacy relevant for educators in Asia?

Salient differences in education contexts in Asia and the West arise from varying cultural, economic, and political contexts that influence the educational systems and their goals. Studies (e.g., Dahlin and Watkins, 2000; Kim et al., 1999; Muench et al., 2022) have found that Asian countries, such as China, Japan, and Korea, place emphasis on memorization and repetition as the primary means of learning. This can be attributed to a number of factors, including the desire for academic excellence and the large class sizes that make it difficult for educators to provide individualized attention to students. In contrast, the Western approach to education emphasizes critical thinking, creativity, and problem-solving skills.

The extent of parental involvement in Asian and Western countries differ significantly too. In many Asian countries, parents are highly involved in their children's education, often attending parent-teacher conferences and monitoring their progress closely. This is partly due to the importance placed on education in Asian cultures, as well as the belief that parental involvement is essential for academic success. In the West, while parental involvement is still important, it tends to be less intensive and focused more on providing emotional support to children (Chan et al., 2009).

Moreover, as Asian and Western cultural values place more importance on conformity and discipline versus individuality and creativity respectively, prevalent teaching methods and assessments are observed to be enacted differently (Chao, 1994, 2001). In Asian contexts, exams are often the primary mode of assessments, with students expected to perform well on standardized tests. This reflects the emphasis on academic achievement and the competition for limited spaces in high-ranking educational institutions in many Asian countries. In the West, prevalent modes of teaching and learning include formative assessment, and critical, collaborative and problem-solving skills developed through project-based assessments rather than standardized tests. Importantly, these differences reflect the cultural, economic, and political contexts in which the educational systems operate, as well as the goals and priorities of the respective societies (Bell, 2020).

Given the unique education phenomena in East Asian contexts, it is envisaged that predominant challenges, such as culture of high stakes assessments, fear of academic failure, and fervid meritocracy (Avvisati et al., 2019; OECD, 2019), can be optimally addressed through scientifically validated evidence. For example, in thinking about maximizing learning, educators and parents can benefit from scientific insights on the combination of good cognitive and socio-emotional development coupled with optimal lifestyles, including appropriate sleep, diet, and exercise. Specifically, while these three factors have been evidenced to impact the structure and function of the brain (Wickham et al., 2020), it is uncommon to witness Asian parents placing high priorities on academic performance, at the expense of children's adequate sleep and well-being development. Fundamentally, in an Asian parental context where children are driven hard to academically succeed against a culture of high-stake assessments, such scientific understandings of the neuroscience of learning can afford a tempering of parental expectations and practices on fervid meritocracy.

Additionally, against a backdrop of Asian individualistic culture in schools, scientific insights into the neuroscience can inform the kinds of social interactions that can catalyse learning, including the implications on our major learning organ, the brain. Social encounters, for instance, can affect the activation of a network of subcortical (amygdala, hippocampus, striatum) and cortical (insula, cingulate) limbic areas (Vrtička and Vuilleumier, 2012).

Fundamentally, given that the brain is key for learning, neuroscientific evidence can address contextual learning challenges, unique to Asian contexts, in more targeted ways. For it is when educators are equipped with neuroscience literacy and understand key concepts on the neurobiology of learning, such as neuroplasticity and neurodiversity, coupled with understandings of cultural nuances, are they then empowered to design the most effective settings and lessons for their students to learn (Jamaludin, Wei Loong, et al., 2019).

6. Neuroscience literacy: what do educators in Asia think?

In Asia, few studies have focused on understanding the implications of neuroscience literacy in educators' training programs. In South Korea, for instance, Im et al. (2018) evaluated the impact of an educational psychology course on pre-service educators' neuroscience literacy ($N = 59$) through a pre- and post-testing. After the course, educators scored comparatively higher than a control group on items that addressed brain function, development, and structure, neuroimaging, and applications of neuroscience. The belief in neuromyths, however, remained unchanged. In Singapore, Tham et al. (2019) conducted focus group discussions on eight primary school educators—who had varying teaching experience in different subjects—to ponder their opinions on reading tasks that contained translated abstracts of neuroscience research. On the one hand, educators manifested enthusiasm in knowledge about learning disorders, classroom applications (e.g., teaching strategies), and straightforward information with relevant content. On the other hand, educators expressed disinterest in learning general and technical information, as well as neuroscience knowledge in excess. Lastly in Hong-Kong, Ching et al. (2020) studied pre-service educators' perceptions ($N = 968$) towards applying neuroscience-related content in a range of educational activities by using survey items. From considerations for 'the design of educational programs' to 'the role of the teacher in student learning,' the majority of educators rated this kind of content as highly important across the various educational activities. When asked to assess different issues in applying such content, however, most of them also rated as highly important items such as 'information is easily accessible to educators' and 'avoiding misinterpretation of science.' While limited, all these findings mirror data collected in other countries outside Asia (Bana and Cranmore, 2019; Hook and Farah, 2013a; Serpati and Loughan, 2012).

7. Advancing neuroscience literacy in educators in Asia: the case of Singapore

In recent years, there has been increased efforts to acquaint educators around the world with neuroscience literacy (Privitera, 2021). In Singapore, the National Institute of Education launched the Science of Learning in Education Centre (SoLEC) in 2021. While it is not a new concept, the science of learning is fundamentally oriented towards integrating evidence from scientific findings, in domains such as neuroscience, psychology, and technology into education (Horvath and Lodge, 2016). Specifically, the center seeks to identify, investigate, and cohere scientific education. Through effective interventions and pedagogical innovations, the aim is not only to study students' individual differences, but to also provide scientific explanations for why some learning strategies work better for some, while worse for others (Jamaludin and So, 2021). Strategically, SoLEC also initiated different alternatives to promote neuroscience literacy for educators. Currently, it offers a minor (undergraduate) and master program in science of learning.

At the broader national level, the Singapore government has also included science of learning research as one of the strategic areas for Research, Innovation and Enterprise 2021 – 2025 (RIE2025) under the human health and potential ambit. About 1% of Singapore's Gross Domestic Product (~SGD25B) is allocated for RIE2025, where research funding is made available towards advancing related initiatives and neurocognitive science research to support programs that improve learning outcomes for students and re-skilling in adult workers (National Research Foundation, 2020).

8. Discussion

Twenty years ago, the OECD published the book 'Understanding the Brain' (OECD, 2002). Since then, neuroscience literacy has gradually joined the conversation at the intersection of education, mental health, and wellbeing. By implementing more effective programs, practices, and policies for teaching and learning through research-based evidence, it has been shown that neuroscience literacy can be successfully integrated into educators' training programs (Dubinsky et al., 2019; Privitera, 2021). The contributions that the field of neuroscience has made to education were emphasized on the 50th anniversary of the Society for Neuroscience and even more progress is expected to occur during the next years (Altimus et al., 2020). Recently, and exactly 20 years after the OECD's book, another international organization—the United Nations Educational Scientific and Cultural Organization, UNESCO—has reaffirmed the growing international movement to promote neuroscience literacy for human flourishing, after embarking on the first-ever large-scale evaluation of education-related knowledge (Joldersma and Herwegen, 2022).

In Asia, where educational systems are diverse and rapidly evolving, there is parallel augmented interest in integrating neuroscience principles into educational practices to optimize learning and teaching strategies, as exemplified by prioritizations of health and human potential research programs, including investigating neuroscientific insights of learning and its implications to education (Jamaludin et al., 2019). Asia's unique educational landscape is poised to contribute to this movement, driving advancements and innovations to benefit students and educators across the region. To accelerate this process, researchers need to increase awareness among the political and public sectors on how our ever-increasing understanding of brain functioning benefits education. While neuroscience-related research has advanced forward enough to influence global reforms that can improve the quality and equity of educational systems, investigations that are context- and audience-dependent are particularly needed to better serve the local communities. As for educational policymakers, they should elaborate on strategies to successfully allocate tangible and intangible assets to propel ad hoc research, as well as neuroscience literacy for educators. Promoting curriculum and instruction changes to incorporate core and elective courses within their training programs at undergraduate and graduate levels is essential.

9. Conclusion

Neuroscience literacy in education continues to gain prominence globally. This is because neuroscience research continues to unravel the mysteries of the brain and its learning mechanisms. It is crucial to emphasize the role of ongoing professional development for educators. In Asia, innovations are needed to foster a culture of continuous learning and accessible opportunities for educators to deepen their understanding of neuroscience in relation to education, and vice versa.

To advance neuroscience literacy, collaborative efforts among educators, researchers, and other educational stakeholders become increasingly vital to shape practices for teaching and learning that are not only informed by rigorous scientific research, but are also compassionate, inclusive, and attuned to individual differences. Maximizing every student's potential must remain as the only actionable goal of this endeavor, regardless of life-course trajectories and societal distinctiveness. These collaborations hold the promise of transforming education into a more empowering and enriching experience, setting the stage for a brighter and more intellectually enriched society.

Conflicts of interest

The authors declare that there is no conflict of interest.

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