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The Effectiveness of Neuroscience to Improve Teacher Pedagogic Competence: Systematic Literature Review

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ABSTRAK

Guru merupakan sebuah profesi, sehingga dituntut untuk profesional. Maknanya adalah bahwa guru harus memiliki kualitas khusus yang sudah ditentukan. Meskipun demikian, tidak dapat dipungkiri bahwa masih banyak guru, tidak memenuhi kualifikasi tersebut. Oleh karena itu, guru perlu meningkatkan kualitas atau kompetensinya dengan mengikuti pelatihan neuroscience. Pembelajaran terjadi di otak sehingga baik, apabila guru memahami pusat pembelajaran tersebut. Tujuan penelitian ini adalah untuk mengetahui apakah pelatihan pendidikan neuroscience dapat meningkatkan kompetensi guru, khususnya kompetensi pedagogik. Jenis penelitian ini adalah SLR. Data dalam penelitian ini adalah jurnal-jurnal baik internasional maupun nasional. Hasil penelitian ini mengatakan bahwa: pelatihan neuroscience dapat membantu guru memahami karakteristik peserta didik dalam berbagai aspek. Dengan memahami neuroscience guru menjadi menguasai teori belajar dan prinsip-prinsip pembelajaran yang mendidik. Dengan memahami neuroscience, guru menjadi mampu memfasilitasi pengembangan potensi peserta didik. Berdasarkan dari hasil tersebut maka dapat disimpulkan bahwa pelatihan pendidikan neuroscience dapat meningkatkan kompetensi pedagogik guru.

ABSTRACT

Teaching is a profession, so it is required to be professional. The meaning is that the teacher must have a special quality that has been determined. Even so, it cannot be denied that there are still many teachers who do not meet these qualifications. Therefore, teachers need to improve their quality or competence by participating in neuroscience training. The purpose of this study was to analyze neuroscience education training can improve teacher competence, especially pedagogical competence. This type of research is SLR. The data in this study are from both international and national journals. The results of this study say that: neuroscience training can help teachers understand the characteristics of students in various aspects. By understanding neuroscience, teachers become masters of learning theory and educational principles of learning. By understanding neuroscience, teachers become able to facilitate the development of student's potential. Based on these results, it can be concluded that neuroscience education training can improve teacher pedagogical competence.

1. INTRODUCTION

The teaching profession is a challenging job. Every teacher must meet national academic qualification and competency standards. Competence is a set of knowledge, skills, and behaviors that must be possessed, internalized, and mastered by teachers in carrying out professional tasks (Arifa & Prayitno, 2019; Hermawan et al., 2020). One of the competencies that teachers must have is pedagogical competence. Tacher pedagogic competence, including; mastering the characteristics of students from the physical, moral, and social, cultural, emotional, and intellectual aspects (Norahmi, 2017; Yetti & Jakarta, 2021). Mastering learning theory and educational learning principles. Facilitating the development of the potential of students to actualize their various potentials. Then describes the 21st-century teacher pedagogic competencies as follows: Competence to identify student learning characteristics, as well as competence to manage classroom management with different characteristics (Sobarningsih, 2022; Somantri, 2021). Professional teachers are teachers who always master the material or subject matter

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that will be taught in teaching and learning interactions and always develop their abilities on an ongoing basis, both in terms of their knowledge and experience (Hamid, 2020; Illahi, 2020; Sutiono, 2021). An educator must always develop himself and not only be satisfied with the skills and knowledge he currently has. This means that developing the potential of a teacher is lifelong learning. Competence is the ability to carry out a set of tasks that require the integration of knowledge, skills, and attitudes (Febrianna, 2019; Hermawan et al., 2020). The experts, in their opinion, reinforce that teachers must have reliable competence to be able to maintain their professionalism. But in reality, there are still many teachers who have low-quality competence (Hoesny & Darmayanti, 2021; Mulyati, 2022).

To improve these competencies, teachers can learn self-taught or attend training (Syafiq et al., 2022; Utiarahman, 2020). According to previous study training is a structured activity in a short period of time with the aim of increasing certain competencies (Djajadi, 2020; Gustiana et al., 2022; Haki, 2021; Iswan, 2021; Mon & Mulyadi, 2021). Teacher competence needs to be developed, bearing in mind that this affects teacher performance. The more competent a teacher is, the higher the quality of his performance results. This is in line with research conducted state that professional competence has a significant effect on teacher performance (Rosyada et al., 2021; Supriyanto, 2019). Based on these experts, then, the better the teacher's performance, the better the world of education will be because the main goal of increasing teacher competence is to improve the world of education. The teacher is the facilitator and driving force in learning activities, so it is a commonplace that the teacher is always the object of training and development (Cahyani et al., 2019; Sutisna, 2020; Tedjawati, 2011). Training - Interesting teacher training, many are offered, one of which is neuroscience education training. Neuroscience is an innovative education system that studies the nervous system of the human brain (Happé & Frith, 2014; Hengki, 2018; Nurasiah, 2016). This neuroscience training is starting to be in demand by education practitioners. The concept of this training is in demand because it is felt that it will be able to provide a powerful method for better learning activities, considering that learning is related to the brain (Ahmad, 2019; Privitera, 2021; Teti Sumiati & Septi Gumiandari, 2022). Other research said that neuroscience is an interdisciplinary research that seeks to translate neuroscience research findings into educational practices and policies, to understand the effects of education on the brain (Thomas et al., 2019). It is important for teachers to understand brain performance. Therefore, neuroscience education training is certainly the most appropriate choice for teachers to join, especially in the context of developing their pedagogical competence.

Several previous studies stated that neuroscience training enables teachers to determine learning methodologies that are appropriate to the biological development of their students so that learning becomes more fun and effective (Batubara & Supena, 2018; de Carvalho & Villas Boas, 2018; Petersen et al., 2020). Furthermore, it is said that neuroscience training will be very useful in the future; namely, it will have a very positive impact on the world of education (Coch, 2018; Melnyk et al., 2022; Thomas et al., 2019). As well as research conducted that said by participating in neuroscience training, teachers were able to find learning methods that were appropriate to the physical conditions of students with certain disabilities (Chen, 2020; Whiting et al., 2021). Based on the results of previous research, it can be said that neuroscience is very useful for teachers in determining effective learning models. Therefore, through this research, the researcher wants to know more about how effective neuroscience education training is in increasing teacher pedagogic competence. So the purpose of this research is analyze neuroscience education training help teachers understand the characteristics of students from various aspects. Moreover to obtain understanding neuroscience help teachers master learning theory and educational learning principles. And provide information neuroscience capable of helping teachers to be able to facilitate the potential development of students.

2. METHOD

This study uses the Systematic Literature Review (SLR) method. SLR is a research summary of the literature focused on a question, which is done by identifying, selecting, assessing, and synthesizing all relevant, high-quality research evidence (Triandini et al., 2019). While the research design or the steps in the systematic literature review research consist of planning, conducting, and reporting (Wahono, 2015). The object of this research is neuroscience training to improve teacher pedagogic competence. In this SLR, the data obtained is filtered based on questions of quality screening criteria. Thus, the inclusion and exclusion criteria used in screening this SLR are shown in Table 1.

In an effort to find journals/data related to neuroscience training to increase teacher competence, researchers visited the Google Scholar digital library, Mendeley.com, Sciendirect.com, Emerald Journal, Genesis Library, Francis & Taylor, Wiley, Springer, Oxford Academic, and ProQuest. The technique used in sampling is purposive sampling. Purposive sampling is a sampling technique with certain considerations.

The samples in this study were journals or proceedings related to neuroscience education training. The number of samples used in this study were 20 journals and or proceedings published from 2018 to 28 February 2023, both national and international journals. Referring to the inclusion and exclusion criteria shown in Table 1, in this search, 260 journals were identified. The identified journals are then processed using certain criteria that have been determined by the researcher to get the final number of journals. The process is depicted in Figure 1.

Table 1. Inclusion and Exclusion Criteria

Criteria	Description
Inclusion	1. The data used are journals/proceedings published in the last 5 years, namely between 2018 to 28 February 2023. 2. The data show that neuroscience improves teachers' pedagogical competence. 3. Journal data, both international and national.
Exclusion	1. Data discusses neuroscience that helps teachers understand students 2. The data discuss neuroscience that helps teachers master learning theory 3. Data discusses neuroscience that facilitates teachers in developing potential

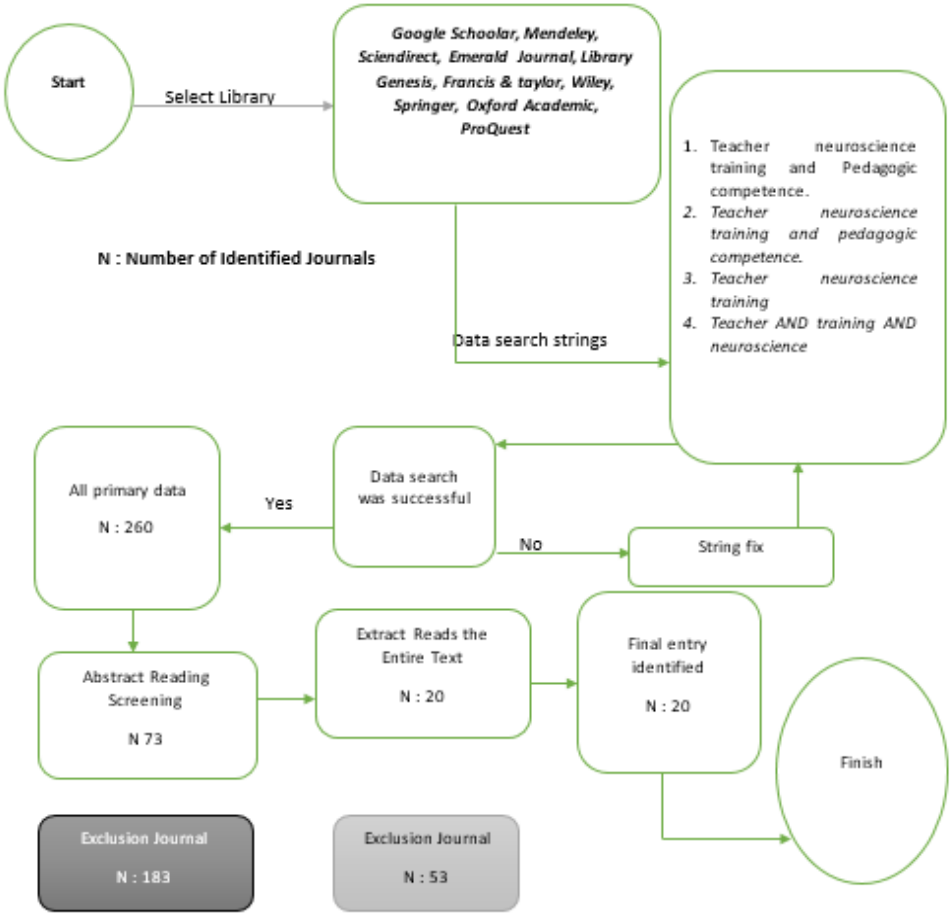

Figure 1. Searching & Filtering Articles

3. RESULT AND DISCUSSION

Result

To find out the novelty of this study, the researcher conducted a research trend search on the openknowledgemaps.id portal and was shown the following visualization, as classed in Figure 2.

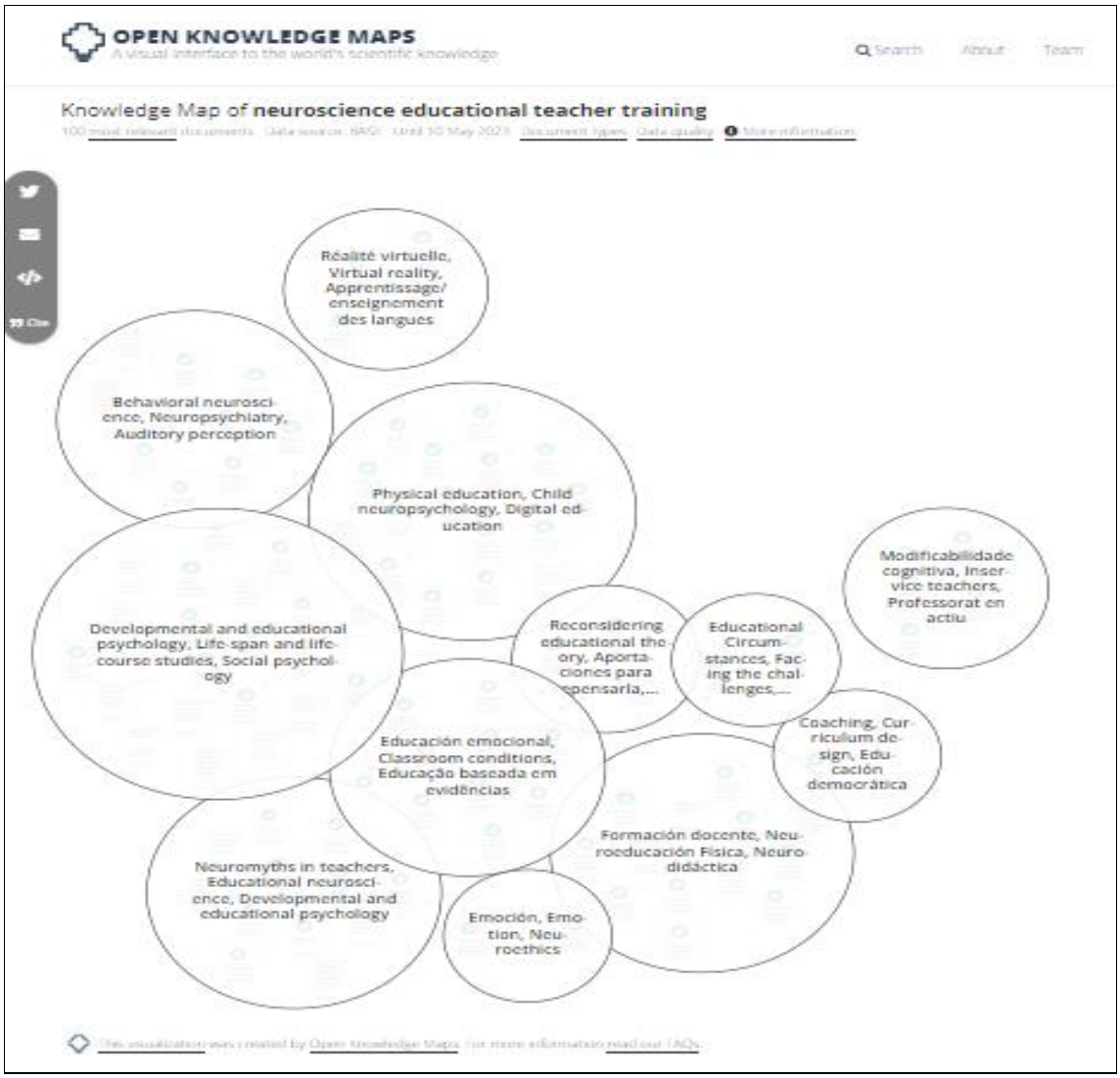

Figure 2. Visualization of Neuroscience Educational Research

Based on Figure 2, it can be seen that research on neuroscience education training to improve teacher pedagogical competence is still interesting for study or research. This is reasonable because, based on the visualization results, research on neuroscience training for teacher training is still rare. Referring to Figure 1 previously obtained a number of 20 journals that are very relevant to describe research on neuroscience education training to improve teacher pedagogic competence, where the results of the identification process are presented in Table 2.

Table 2. Summary of Neuroscience Findings to Improve Teacher Pedagogical Competence

No.	Author (Year)	Research methods	Pedagogic Competency indicators used	How to Bring Up Pedagogic Competence
1	(Dubinsky et al., 2019)	R&D	• Teachers plan and embrace pedagogies that involve modeling, experimentation, discussion, analysis, and synthesis, increasing the cognitive engagement of the class. • Provide opportunities for students to actively engage with content.	A neuroscience course for preservice and in-service teachers called BrainU

No.	Author (Year)	Research methods	Pedagogic Competency indicators used	How to Bring Up Pedagogic Competence
2	(Ching et al., 2020)	Quantitative descriptive research	• Increasing teacher professionalism, patience, and self-confidence in applying neuroscience in classrooms	Surveys related to neuroscience literacy and perceptions in education: general brain knowledge (19 items), neuromyths (17 items), perceptions of the importance of understanding how the brain works in educational activities (9 items), and perceptions of the importance of different issues in the application of neuroscience for education (14 items).
3	(Caballero & Llorent, 2022)	quasi-experimental study	• There are two experimental groups and one control group • looking for similarities and differences; make generalizations; consider decisions and apply principles; give a reason; and identify problems	Teacher training on neuroscience to improve reading, mathematics, social, emotional, and moral competence of secondary school students.
4	(Rato et al., 2022)	SLR	The main contribution of this research is to present complete curriculum overview in Education teacher training. Early Childhood and Basic Education in the Future and books brain outreach published in Portugal.	Teacher preparation programs should be seen as a sound investment, and here, neuroscience can play a modest but encouraging role in building an educational culture of evidence-based learning.
5	(Amran et al., 2019)	SLR	Student achievement can not only be determined by environmental factors but also by biological factors because they play a very important role in understanding student abilities.	Neuroscience and education are one of the efforts to improve the delivery system in education and improve student achievement.
6	(Tan & Amiel, 2022)	Qualitative research	learning study(LS). LS creates opportunities for teachers to engage with new theories while working collaboratively to design, enact, and reflect on theory-framed lessons	A small-scale study called learning study (LS).
7	(Gkintoni & Dimakos, 2022)	Conceptual review/critical literature review	understanding fundamental neuroscience research on learning and its underlying components is as important as studying child development, educational psychology, or any other aspect of teacher education.	take cues from the relationship between biology and medicine, which have faced the same challenges as neuroscience and education
8	(Goldberg, 2022)	Literature review	educational practices must be human-brain friendly and "ride" a wave of	The broad period of human development is thought to facilitate the learning processes

No.	Author (Year)	Research methods	Pedagogic Competency indicators used	How to Bring Up Pedagogic Competence
			neuroplasticity.	necessary for the growth and maturation of the complex human brain.
9	(Menezes, 2022)	cross-sectional study	Lack of knowledge about the brain, linked to a greater spread of neuromyths	a digital questionnaire containing 32 questions about brain function and the use of this knowledge in teaching, 16 of which are neuromyths
10	(Luzzatto & Rusu, 2020)	R&D	focuses on the need to build a neuroeducational curriculum, particularly when dealing with learning disabilities.	Neuroscience Teacher-Based Teacher Training Program (NMTTP)for Special Education Pre-Services (PST) Teachers
11	(Brault Foisy et al., 2020)	literature narrative review	Student behavior results are often used by researchers and teachers to evaluate the effectiveness of pedagogical interventions.	Provide insight into how teachers regulate neural plasticity through different pedagogical choices.
12	(Martín-Aragoneses et al., 2021)	Qualitative research	increases the interest of teachers in building their educational practice based on neuroscience.	There is a need for an initial and ongoing teacher training plan for the effective use of available neuroscientific knowledge in educational practice.
13	(Lima et al., 2020)	R&D	Basic knowledge of neuroscience is important in many aspects of life, as it enables understanding of the neural processes present in our everyday lives, such as cognition and learning.	"Applied Neuroscience Course for Education." In total, twenty-eight professors participate in the course, covering a variety of themes: neuroscience and education, neuroanatomy, neurophysiology, neurobiology of learning and memory, factors that interfere with learning, and pedagogical innovation.
14	(Brick et al., 2021b)	R&D	*Neuroscience with mental health literacy content can increase teachers' awareness of students' mental health issues and result in changes in teacher attitudes and classroom practices.*	A tiered Training-of-Trainers approach is used
15	(Dubinsky et al., 2022)	Literature review	From a teacher's perspective, the academic distinctions between cognitive science, developmental science, educational psychology, and neuroscience—plus related subfields—are still confusing and perhaps irrelevant.	Neuroscience professional development provides neuroscience principles that teachers can learn and apply to differentiate between pedagogical choices, plan lessons, guide current classroom decisions, and inform student views.
16	(Brick et al., 2021c)	R&D	Neuroscience learning influences teacher self-efficacy, belief in their ability to teach effectively, self-responsibility, and other components of teacher	The pilot training-of-trainers program designed and delivered in Liberia combines basic neuroscience with information on the social, emotional, behavioral, and

No.	Author (Year)	Research methods	Pedagogic Competency indicators used	How to Bring Up Pedagogic Competence
			motivation.	mental health issues faced by students
17	(Tan et al., 2019)	R&D	Teachers develop an understanding of the cognitive architecture that underlies functions such as learning and memory, which enables them to identify pedagogical actions consistent with human biology and understand why these actions are effective in promoting learning.	LS is proving to be an effective professional development (PD) model where theoretical knowledge, such as neuroscience, can be used and tested in the classroom to provide depth to support teacher praxis.
18	(Chang et al., 2021)	Qualitative Research	Advances in neuroscience reveal how individual brains change as learning occurs.	Ten Educational Neuroconcepts (ENCs) are built for an audience of educators in areas such as memory, learning, and emotion. These neuro concepts represent a synthesis of neuroscientific research that offers insight into the basic or general principles of how the brain creates behavior
19	(Schwartz et al., 2019)	qualitative and quantitative methods	Although student-centered activities are emphasized as important for student learning, motivating teachers to engage in active learning is difficult.	*Neuroscienceinfluencing non-science teachers' understanding of basic neuroscience; and, in turn, how that knowledge influences their reflections on pedagogy.*
20	(Gutshall, 2020)	R&D	teacher mindset, teaching efficacy, teacher approach to learning, and grit. Specifically, the teacher's mindset beliefs increased significantly	*BrainBuilders- Teachers are taught introductory neuroscience concepts related to how the brain learns. Session topics include basic neurodevelopment, neural plasticity, sleep, and the brain, stress and the brain, exercise and the brain, growth mindset, growth mindset feedback, self-control, and fortitude.*

Discussion

Neuroscience helps teachers understand the characteristics of students from various aspects.

Neuroscience education training is able to help teachers understand the characteristics of students from various aspects. This statement is supported by research that said that neuroscience is a promising field in teaching students about their brains and teaching them in a brain-friendly way to support them to become lifelong learners (Goldberg, 2022). Research shows that neuroscience training helps teachers understand students' characteristics from an intellectual aspect. Teachers who understand the theory of child brain development will teach by paying attention to the capacity and growth of the child's brain in receiving learning material. In other words, the teacher is no longer forcing the performance of the child's brain. Another implication of understanding the brain is that teachers have the awareness that learning takes place over a long period of time, even for a lifetime; this is what is called lifelong learning (Jannah, 2013; Yurdakul, 2017). Therefore, teachers who carry out the learning process by paying attention to brain development, support brain-friendly learning towards lifelong learning. The teacher's understanding of children's brain development also results in increased teacher creativity in creating creative and interesting learning methods so that student achievement in class also increases (Amran et al., 2019; Mahmud, 2019). The brain is the center of emotions; teachers who

understand this will certainly make learning methods based on the emotional situations and conditions of students. In this case, neuroscience assists teachers in understanding the characteristics of students on the emotional aspect. In line with previous research, said that learning is created in situations that involve environmental, emotional, social, physical, and psychological aspects, and it is important to contextualize education that allows students to build their own knowledge (Lima et al., 2020).

Teacher understanding of children's brain development is very useful for teachers, especially in the early detection of learning problems. Problems in learning, for example, high school students have difficulty reading or reading haltingly, difficulty distinguishing letters, etc. With teachers able to detect problems early on, problems will be resolved quickly too. In addition to detecting learning problems, knowledge of neuroscience also helps teachers to know that students have their own way of learning and thinking range, from low-level automatic skills to abstraction and creativity in problem-solving (Martín-Aragoneses et al., 2021; Schwartz et al., 2019). So that the teacher can design learning that is adapted to the character of the student's learning; besides that, it is necessary to design learning that is more student-centered. According to previous study neuroscience and education are "the ideal partnership to generate evidence-based solutions (Gutshall, 2020). In other words, neuroscience brings a mechanistic, biologically based approach that can explain why a practice occurs. For example, the discovery of the mirror neuron system helps explain why mimicry and social interaction are so influential on learning, especially for language acquisition and related cognitive processes (Dubinsky et al., 2019; Rato et al., 2022).The teacher's understanding of student characteristics in the intellectual and emotional aspects is also seen in the research conducted which says that students are unique, meaning that students have their own learning character (Chang et al., 2021). Neuroscience concepts influence teachers' views of how physiological and emotional needs influence learning. A comfortable and fun learning environment for students will increase student achievement. So it is important for teachers to create learning that is both brain-friendly and fun for students.

Neuroscience also assists teachers in understanding the characteristics of students in social aspects. The teachers attended neuroscience training, they understood better mental Health students, as well as its efforts to build positive relationships with students. Helping behavior and overall social and emotional support appeared to increase for both mental health problems and normal learning (Brick et al., 2021c; Dubinsky et al., 2022).

Neuroscience Helps Teachers Master Learning Theory and Educational Learning Principles

Neuroscience helps teachers master learning theory and educational learning principles; this statement is supported by studies conducted by the following Neuroscience experts. The first research said that after the teacher understands human learning, he also changes his teaching practices (Dubinsky et al., 2019). Neuroscience training can encourage teachers to pay more attention to the needs and broaden the range of student learning. Second, research results show that studying neuroscience can increase teacher professionalism, patience, and confidence when implementing neuroscience in class (Ching et al., 2020). Then neuroscience knowledge can help protect teacher candidates from neuromyths. Neuromyths are misunderstandings about brain function that result from misunderstanding, misreading, or misquoting scientifically established facts (Coch, 2018; Jolles & Jolles, 2021). Then research which said that Neuroscience helps teachers to understand the brain as circuits that are interconnected and work together in a network (Caballero & Llorent, 2022). Knowledge about the brain assist teachers in designing more appropriate learning contexts for students because understanding neuroscience increases teachers' understanding of thoughts, feelings, memories, etc. Other study say that neuroscience gives teachers a unique perspective on the importance of learning as connecting and broadening neural connections, akin to 'deepening the trenches (Tan & Amiel, 2022). This means that when the teacher does the learning and does it repeatedly, the learning will be increasingly understood by students. So it is good to repeat learning that is difficult for students so that their understanding is deeper.

Next research results say that neuroscience has uncovered the complexity of interactions in different brain areas and uncovered the many pathways that contribute to learning (Gkintoni & Dimakos, 2022). The point is, to explain a subject, the teacher can use thousands of ways, not just one way, or the teacher can plan learning based on the field of view. Research that state neuroscience training increases teacher motivation towards their responsibilities in increasing the success of their students; besides that, the training is also able to increase teachers' understanding of how humans learn (Brick et al., 2021a). The training is named pilot training-of-trainers; after attending the training, the teacher thought more about how to design meaningful and brain-friendly learning. The last training said that after teachers understand neuroscience, they are more confident to teach difficult science topics (Tan et al., 2019). Studying neuroscience helps teachers consider what material needs to be focused on to be given to students in their learning. The focus of the learning material is based on the teacher's strong

understanding of brain function. One of the goals of teachers participating in neuroscience training is to develop students' potential. With the teacher understanding the characteristics of students and mastering the theory and principles of learning, the teacher has facilitated the development of student potential. Teachers need to understand how information is obtained; as said it is incorrect to assume that only one sensory modality is involved in information processing (Jolles & Jolles, 2021; Menezes, 2022). What this means is that the brain does not process information only visually, auditory, or kinesthetically. The understanding that students have a visual, auditory, or kinesthetic learning style is a neuromyth. When the teacher is trapped in this understanding, the development of the child's potential will be hampered. The importance of knowing about neuroscience in order to develop children's potential is also reinforced by previous research who said that neuroscience impact on teachers' views of their students' lessons and potential (Luzzatto & Rusu, 2020).

4. CONCLUSION

Neuroscience training is useful for increasing teacher pedagogic competence, namely in terms of; First, neuroscience helps teachers understand the characteristics of students from various aspects, as evidenced by the fact that teachers are able to build positive relationships with students. Second, neuroscience helps teachers master learning theory and educational learning principles; for example, after a teacher understands neuroscience, he becomes aware of how humans learn, and this opens his horizons to design broad-based learning. Third, neuroscience helps teachers to be able to facilitate the development of student potential, with teachers understanding student character and trying to develop themselves; this is part of facilitating the development of student potential.

5. REFERENCES

Ahmad, D. N. (2019). Pembelajaran dengan Pendekatan Neurosains dalam Perkembangan Teknologi 4.0. *Diskusi Panel Nasional Pendidikan Matematika*, *1*(1), 497–502. http://www.proceeding.unindra.ac.id/index.php/DPNPMunindra/article/view/619.

Amran, M. S., Rahman, S., Surat, S., & Bakar, A. Y. A. (2019). Connecting neuroscience and education: Insight from neuroscience findings for better instructional learning. *Journal for the Education of Gifted Young Scientists*, *7*(2), 341–352. https://doi.org/10.17478/JEGYS.559933.

Arifa, F. N., & Prayitno, U. S. (2019). Peningkatan Kualitas Pendidikan: Program Pendidikan Profesi Guru Prajabatan dalam Pemenuhan Kebutuhan Guru Profesional di Indonesia. *Aspirasi: Jurnal Masalah-Masalah Sosial*, *10*(1), 1–17. https://doi.org/10.22212/aspirasi.v7il.1084.

Batubara, H. H., & Supena, A. (2018). Educational Neuroscience Dalam Pendidikan Dasar. *Jurnal Pendidikan Dasar*, *9*(2), 140–148. https://doi.org/doi.org/10.21009/JPD.092.013 EDUCATIONAL.

Brault Foisy, L. M., Matejko, A. A., Ansari, D., & Masson, S. (2020). Teachers as Orchestrators of Neuronal Plasticity: Effects of Teaching Practices on the Brain. *Mind, Brain, and Education*, *14*(4), 415–428. https://doi.org/10.1111/mbe.12257.

Brick, K., Cooper, J. L., Mason, L., Faeflen, S., Monmia, J., & Dubinsky, J. M. (2021a). *Tiered Neuroscience and Mental Health Professional Development in Liberia Improves Teacher Motivation*. *15*(May). https://doi.org/10.3389/fnhum.2021.664730.

Brick, K., Cooper, J. L., Mason, L., Faeflen, S., Monmia, J., & Dubinsky, J. M. (2021b). Tiered Neuroscience and Mental Health Professional Development in Liberia Improves Teacher Self-Efficacy, Self-Responsibility, and Motivation. *Frontiers in Human Neuroscience*, *15*(May). https://doi.org/10.3389/fnhum.2021.664730.

Brick, K., Cooper, J. L., Mason, L., Faeflen, S., Monmia, J., & Dubinsky, J. M. (2021c). Training-of-Trainers Neuroscience and Mental Health Teacher Education in Liberia Improves Self-Reported Support for Students. *Frontiers in Human Neuroscience*, *15*(June), 1–15. https://doi.org/10.3389/fnhum.2021.653069.

Caballero, M., & Llorent, V. J. (2022). The effects of a teacher training program on neuroeducation in improving reading, mathematical, social, emotional and moral competencies of secondary school students. A two-year quasi-experimental study. *Revista de Psicodidáctica (English Ed.)*, *27*(2), 158–167. https://doi.org/10.1016/j.psicoe.2022.04.002.

Cahyani, A., Manzilah, A., Nurfadilah, F. R., & Adawiyah, R. (2019). Kompetensi Pedagogik Guru Dengan Strategi Pembelajaran Kreatif Pada Mata Pelajaran Bahasa Indonesia. *Pgmi*, *11*(1), 353–360. https://doi.org/https://www.bing.com/search?pglt=41&q=KOMPETENSI+PEDAGOGIK+GURU+DENGAN+STRATEGI+PEMBELAJARAN+KREATIF+PADA+MATA+PELAJARAN+BAHASA+INDONESIA+Annisa+Cahyani1%2C+Asfi+Manzilah2%2C+Febriyanti+Rizki+Nurfadilah3%2C+Raabiah+Ada

wiyah4+Pendidikan&cvid=511db08489e548799a5928599ec79e18&aqs=edge.0.69i59.983j0j1&FORM=ANNTA1&PC=ASTS.

Chang, Z., Schwartz, M. S., Hinesley, V., & Dubinsky, J. M. (2021). Neuroscience Concepts Changed Teachers' Views of Pedagogy and Students. *Frontiers in Psychology*, *12*(August). https://doi.org/10.3389/fpsyg.2021.685856.

Chen, L. (2020). Education and visual neuroscience: A mini-review. *PsyCh Journal*, *9*(4), 524–532. https://doi.org/10.1002/pchj.335.

Ching, F. N. Y., So, W. W. M., Lo, S. K., & Wong, S. W. H. (2020). Preservice teachers' neuroscience literacy and perceptions of neuroscience in education: Implications for teacher education. *Trends in Neuroscience and Education*, *21*, 100144. https://doi.org/10.1016/j.tine.2020.100144.

Coch, D. (2018). Reflections on Neuroscience in Teacher Education. *Peabody Journal of Education*, *93*(3), 309–319. https://doi.org/10.1080/0161956X.2018.1449925.

de Carvalho, D., & Villas Boas, C. A. (2018). Neurociências e formação de professores: Reflexos na educação e economia. *Ensaio*, *26*(98), 231–247. https://doi.org/10.1590/S0104-40362018002601120.

Djajadi, M. (2020). Efektivitas Pendidikan dan Pelatihan Guru: Suatu Upaya Meningkatkan Kualitas Pengajaran Fisika. *Jurnal Sipatokkong BPSDM Sulsel*, *1*(1), 30–44. https://doi.org/http://ojs.bpsdmsulsel.id/index.php/sipatokkong/article/view/13.

Dubinsky, J. M., Guzey, S. S., Schwartz, M. S., Roehrig, G., MacNabb, C., Schmied, A., Hinesley, V., Hoelscher, M., Michlin, M., Schmitt, L., Ellingson, C., Chang, Z., & Cooper, J. L. (2019). Contributions of Neuroscience Knowledge to Teachers and Their Practice. *Neuroscientist*, *25*(5), 394–407. https://doi.org/10.1177/1073858419835447.

Dubinsky, J. M., Roehrig, G., & Varma, S. (2022). A Place for Neuroscience in Teacher Knowledge and Education. *Mind, Brain, and Education*, *16*(4), 267–276. https://doi.org/10.1111/mbe.12334.

Febrianna, R. (2019). *Kompetensi Guru* (B. S. Fatmawati (ed.); 1st ed.). Bumi Aksara.

Gkintoni, E., & Dimakos, I. (2022). an Overview of Cognitive Neuroscience in Education. *EDULEARN22 Proceedings*, *1*(July), 5698–5707. https://doi.org/10.21125/edulearn.2022.1343.

Goldberg, H. (2022). Growing Brains, Nurturing Minds—Neuroscience as an Educational Tool to Support Students' Development as Life-Long Learners. *Brain Sciences*, *12*(12). https://doi.org/10.3390/brainsci12121622.

Gustiana, R., Hidayat, T., & Fauzi, A. (2022). Pelatihan Dan Pengembangan Sumber Daya Manusia (Suatu Kajian Literatur Review Ilmu Manajemen Sumber Daya Manusia). *Jemsi*, *3*(6), 657–666. https://doi.org/https://doi.org/10.31933/jemsi.v3i6.

Gutshall, A. C. (2020). When Teachers Become Students: Impacts of Neuroscience Learning on Elementary Teachers' Mindset Beliefs, Approach to Learning, Teaching Efficacy, and Grit. *European Journal of Psychology and Educational Research*, *3*(1), 39–48. https://doi.org/10.12973/ejper.3.1.39.

Haki, U. (2021). Pengaruh Pelatihan Dan Kualitas Pelayanan Terhadap Kepuasan Konsumen Pada Giant Ekstra Sempu Kota Serang. *Jemasi: Jurnal Ekonomi Manajemen Dan Akuntansi*, *17*(1), 64–74. https://doi.org/10.35449/jemasi.v17i1.96.

Hamid, A. (2020). Profesionalisme Guru Dalam Proses Pembelajaran. *AKTUALITA Jurnal Penelitian Sosial Dan Keagamaan*, *10*(Juni), 1–17. http://ejournal.an-nadwah.ac.id/index.php/aktualita/article/view/159.

Happé, F., & Frith, U. (2014). Annual research review: Towards a developmental neuroscience of atypical social cognition. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *55*(6), 553–577. https://doi.org/10.1111/jcpp.12162.

Hengki, W. (2018). Pendidikan Neurosains Dan Implikasinya Dalam Pendidikan Masa Kini. *Pendidikan Dasar*, *2*(March), 1–19. https://repository.sttjaffray.ac.id/pt/publications/269017/pendidikan-neurosains-dan-implikasinya-dalam-pendidikan-masa-kini.

Hermawan, I., Supiana, S., & Zakiah, Q. Y. (2020). Kebijakan Pengembangan Guru di Era Society 5.0. *JIEMAN: Journal of Islamic Educational Management*, *2*(2), 117–136. https://doi.org/10.35719/jieman.v2i2.33.

Hoesny, M. U., & Darmayanti, R. (2021). Permasalahan dan Solusi Untuk Meningkatkan Kompetensi dan Kualitas Guru : Sebuah Kajian Pustaka. *Scholaria : Jurnal Pendidikan Dan Kebudayaan*, *11*(2), 123–132. https://ejournal.uksw.edu/scholaria/article/view/3595.

Illahi, N. (2020). Peranan Guru Profesional Dalam Peningkatan Prestasi Siswa Dan Mutu Pendidikan Di Era Milenial. *Jurnal Asy-Syukriyyah*, *21*(1), 1–20. https://doi.org/10.36769/asy.v21i1.94.

Iswan. (2021). *Manajemen Pendidikan dan Pelatihan* (Mirsawati,). Rajawali Printing.

Jannah, F. (2013). Pendidikan Seumur Hidup dan Implikasinya. *Dinamika Ilmu*, *13*(1), 1–16. https://doi.org/10.21093/di.v13i1.19.

Jolles, J., & Jolles, D. D. (2021). On Neuroeducation: Why and How to Improve Neuroscientific Literacy in

Educational Professionals. *Frontiers in Psychology*, *12*(December), 1–18. https://doi.org/10.3389/fpsyg.2021.752151.

Lima, K. R., Lopes, L. F., Marks, N., Franco, R. M., Mello, E. M. B., & Mello-Carpes, P. B. (2020). Formação continuada em neurociência: percepções de professores da educação básica. *Revista Brasileira de Extensão Universitária*, *11*(3), 361–376. https://doi.org/10.36661/2358-0399.2020v11i3.11512.

Luzzatto, E., & Rusu, A. S. (2020). Development of a Neuroscience Motifs-based Teacher Training Program for Pre-Service Teachers in Special Education in Israel. *Educatia 21*, *19*, 180–191. https://doi.org/10.24193/ed21.2020.19.23.

Mahmud, B. (2019). Urgensi Stimulasi Kemampuan Motorik Kasar Pada Anak Usia Dini. *DIDAKTIKA : Jurnal Kependidikan*, *12*(1), 76–87. https://doi.org/10.30863/didaktika.v12i1.177.

Martín-Aragoneses, M. T., Expósito-Casas, E., López-Martín, E., & Nieto, D. A. (2021). Educator perceptions of the role of neuroscience in education: Evidence from Spain. *Bordon. Revista de Pedagogia*, *73*(3), 83–99. https://doi.org/10.13042/Bordon.2021.89143.

Melnyk, O., Petryk, O., Lysohor, L., Pavlyk, O., Boiaryn, L., & Tykhonova, S. (2022). Current Approaches to Organizing the Educational Process in Primary School: a Neuroscientific Approach. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, *13*(1Sup1), 01–21. https://doi.org/10.18662/brain/13.1sup1/299.

Menezes, J. P. C. de. (2022). Neurociência E Formação Docente: Prevalência De Mitos Em Licenciandos E Professores No Ensino De Ciências. Um Estudo De Caso No Distrito Federal. *Formação Docente – Revista Brasileira de Pesquisa Sobre Formação de Professores*, *14*(30), 181–195. https://doi.org/10.31639/rbpfp.v14i30.561.

Mon, M. D., & Mulyadi, S. (2021). Pengaruh Kompensasi, Pelatihan dan Pengembangan, Pemberdayaan Karyawan Terhadap Turnover Intention dan Kepuasan Kerja Sebagai Mediasi di Hotel Berbintang Kota Batam. *CoMBInES-Conference on Management, Business, Innovation, Education and Social Sciences*, *1*(1), 2165–2177. https://journal.uib.ac.id/index.php/combines/article/view/4752.

Mulyati. (2022). Kurangnya Kompetensi Pendidik Menjadi Masalah di Indonesia. *Seri Publikasi Pembelajaran*, *1*(1), 47–58. http://publikasipips.ulm.ac.id/index.php/tmkm/article/view/429.

Nasution, S., Afrianto, H., Safei, N. S., & Jamilah. (2017). Berbagai Pendekatan dalam Proses Belajar dan Mengajar. *Pendidikam*, *3*(1), 1–62. https://doi.org/10.1017/CBO9781107415324.004.

Norahmi, M. (2017). 21st-century teachers: The students' perspectives. *Journal on English as a Foreign Language*, *7*(1), 77. https://doi.org/10.23971/jefl.v7i1.538.

Nurasiah. (2016). Urgensi Neuroscience Dalam Pendidikan (Sebagai langkah inovasi Pembelajaran) Nurasiah (Dosen FTK IAIN Raden Intan Lampung). *Jurnal Pendidikan Islam*, *7*, 72–93. https://www.neliti.com/publications/57137/urgensi-neuroscience-dalam-pendidikan-sebagai-langkah-inovasi-pembelajaran.

Petersen, S. C., McMahon, J. M., McFarlane, H. G., Gillen, C. M., & Itagaki, H. (2020). Mini-Review - Teaching Writing in the Undergraduate Neuroscience Curriculum: Its Importance and Best Practices. *Neuroscience Letters*, *737*(August), 135302. https://doi.org/10.1016/j.neulet.2020.135302.

Privitera, A. J. (2021). A scoping review of research on neuroscience training for teachers. *Trends in Neuroscience and Education*, *24*, 100157. https://doi.org/10.1016/j.tine.2021.100157.

Rato, J. R., Amorim, J., & Castro-Caldas, A. (2022). Looking for the Brain Inside the Initial Teacher Training and Outreach Books in Portugal. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.737136.

Rosyada, A., Harapan, E., & Rohana, R. (2021). Pengaruh Kompetensi Pedagogik Guru terhadap Kualitas Pembelajaran Sekolah Menengah Atas di Kota Sekayu, Sumatera Selatan. *Jurnal Manajemen Pendidikan: Jurnal Ilmiah Administrasi, Manajemen Dan Kepemimpinan Pendidikan*, *3*(1), 31–42. https://doi.org/10.21831/jump.v3i1.38295.

Schwartz, M. S., Hinesley, V., Chang, Z., & Dubinsky, J. M. (2019). Neuroscience knowledge enriches pedagogical choices. *Teaching and Teacher Education*, *83*, 87–98. https://doi.org/10.1016/j.tate.2019.04.002.

Sobarningsih, I. and T. M. (2022). Kompetensi Pedagogik Guru Abad Ke-21: Sebuah Tinjauan Peran Guru pada Generasi Z. *Jurnal Ilmiah Indonesia*, *7*(5), 5143–5155. https://doi.org/10.36418/syntax-literate.v7i5.6905.

Somantri, D. (2021). Pentingnya Kompetensi Pedagogik Guru. *Equilibrum: Jurnal Penelitian Pendidikan Dan Ekonomi*, *18*(2), 188–195. https://doi.org/10.25134/equi.v18i2.4154.

Supriyanto, S. (2019). Peran Kompetensi Pedagogik Dan Profesional Terhadap Kenerja Guru Ekonomi. *Perspektif Pendidikan Dan Keguruan*, *10*(2), 33–36. https://doi.org/10.25299/perspektif.2019.vol10(2).3988.

Sutiono. (2021). Profesionalisme Guru. *Tahdzib Al-Akhlaq: Jurnal Pendidikan Islam*, *4*(2), 16–25.

https://doi.org/10.34005/tahdzib.v4i2.1569.

Sutisna, D.; A. W. (2020). Peran Kompetensi Guru Sekolah Dasar Dalam Meningkatkan Efektivitas Pembelajaran Daring. *Jurnal Bahana Manajemen Pendidikan*, *9*(2), 58–64. https://doi.org/10.24036/jbmp.v9i2.110927.

Syafiq, Z. Z., Zaky, F. A., Erliani, S., Rahayu, P., Tanjung, W. K., Hasibuan, D. F., Fatwa, M., & Nasution, I. (2022). Upaya Meningkatkan Kompetensi Pedagogik Guru dalam Kurikulum Merdeka. *Jurnal Pendidikan Dan Konseling*, *4*(6), 4688–4695. https://doi.org/10.31004/jpdk.v4i6.9013.

Tan, Y. S. M., & Amiel, J. J. (2022). Teachers learning to apply neuroscience to classroom instruction: case of professional development in British Columbia. *Professional Development in Education*, *48*(1), 70–87. https://doi.org/10.1080/19415257.2019.1689522.

Tan, Y. S. M., Amiel, J. J., & Yaro, K. (2019). Developing theoretical coherence in teaching and learning: case of neuroscience-framed learning study. *International Journal for Lesson and Learning Studies*, *8*(3), 229–243. https://doi.org/10.1108/IJLLS-10-2018-0072.

Tedjawati, J. (2011). Peningkatan Kompetensi Guru Melalui Lesson Study: Kasus Di Kabupaten Bantul. *Jurnal Pendidikan Dan Kebudayaan*, *17*(4), 480–489. https://doi.org/10.24832/jpnk.v17i4.43.

Teti Sumiati, & Septi Gumiandari. (2022). Pendekatan Neurosains Dalam Strategi Pembelajaranuntuk Siswa Slow Learner. *Risâlah, Jurnal Pendidikan Dan Studi Islam*, *8*(3), 1050–1069. https://doi.org/10.31943/jurnalrisalah.v8i3.326.

Thomas, M. S. C., Ansari, D., & Knowland, V. C. P. (2019). Annual Research Review: Educational neuroscience: progress and prospects. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *60*(4), 477–492. https://doi.org/10.1111/jcpp.12973.

Triandini, E., Jayanatha, S., Indrawan, A., Werla Putra, G., & Iswara, B. (2019). Systematic Literature Review Method for Identifying Platforms and Methods for Information System Development in Indonesia. *Indonesian Journal of Information Systems*, *1*(2), 63. https://doi.org/10.24002/ijis.v1i2.1916.

Utiarahman, T. B. (2020). Meningkatkan Kompetensi Pedagogik Guru Melalui Pelatihan Berjenjang. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, *5*(3), 215–222. https://doi.org/10.37905/aksara.5.3.215-222.2019.

Wahono, R. S. (2015). A Systematic Literature Review of Software Defect Prediction: Research Trends, Datasets, Methods and Frameworks. *Journal of Software Engineering*, *1*(2356–3974), 1–16. https://romisatriawahono.net/lecture/rm/survey/software engineering/Software Fault Defect Prediction/Wahono - Systematic Literature Review of Software Defect Prediction - 2015.pdf.

Whiting, S. B., Wass, S. V., Green, S., & Thomas, M. S. C. (2021). Stress and Learning in Pupils: Neuroscience Evidence and its Relevance for Teachers. *Mind, Brain, and Education*, *15*(2), 177–188. https://doi.org/10.1111/mbe.12282.

Yetti, E., & Jakarta, U. N. (2021). The Influence of Dance Instructional Strategy and Teacher's Pedagogy Competence on Classroom Climate. *İlköğretim Online*, *20*(1), 642–650. https://doi.org/10.17051/ilkonline.2021.01.54.

Yurdakul, C. (2017). An Investigation of the Relationship between Autonomous Learning and Lifelong Learning. *International Journal of Educational Research Review*, *2*(1), 15–20. https://doi.org/10.24331/ijere.309968.