Finnish ECEC teachers´ and leaders' conceptions of educational neuroscience

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Master's Thesis in Education
Spring Term 2022
Department of Education
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ACKNOWLEDGEMENT

First and foremost, I would like to express my gratitude to my supervisor, Tuulikki Ukkonen-Mikkola, for her guidance, patience, and endless support since the outset of the research process. I would like to warmly thank her for creating a friendly, supporting, encouraging, and comforting environment in all our thesis advising meetings. Her expertise and rich, detailed advice were invaluable in formulating the research.

I would like to thank Anduena Ballo for providing her expertise regarding phenomenography (as the adopted research approach), and for her time and efforts in explaining, contributing, and guiding through the pehomenographic data analysis process.

A warm thanks to the brave and beautiful Finnish participants who agreed to participate in the study and its conversations, although not in their native language. Their contributions and valuable insights are the foundation of what has been learned through the study.

I would like to acknowledge David M. Hoffman for his ideas, comments, suggestions, and conversation. And also acknowledge Jan Wikgren for his contribution in reviewing the educational neuroscience article to ensure the accuracy of neuroscience information.

I am grateful to Alaa Badran and Kostantza Avgoustinaki for their valuable comments regarding the research.

I would also like to thank my manager at work, Ahmed Abdo, for his understanding and being flexible and supportive regarding my studies.

Finally, I would like to thank my family and friends for their ongoing encouragement and support.

ABSTRACT

Khidr, Alaa. 2022. Finnish ECEC teachers´ and leaders' conceptions of educational neuroscience. Master's Thesis in Education. University of Jyväskylä. Department of Education. 109 pages

Somewhere between education and neuroscience lies the interdisciplinary field of educational neuroscience (EN). Since its emergence, a debate has been ongoing about its ability to transform educational practices by science. The brain is central to learning, therefore, EN has the potential to inform educational theories, practice, and policy. As important as the literature indicates, no studies were found that investigated Finnish educators' perceptions of EN in developing teachers' training. Aiming to cover this gap in research, this study aimed to examine Finnish early childhood education and care (ECEC) teachers' and leaders' conceptions of EN and delineate the various ways of conceptualizing it.

The study constitutes a phenomenographic investigation of EN by conducting semi-structured interviews with 10 Finnish ECEC teachers and leaders who were recruited by snowball and purposeful sampling. The qualitative data collected from transcribing the interviews revealed four categories in which EN is conceived to be 1-useful to the learning process 2-improves the learning process 3-significant to the learning process 4-the whole basis of learning.

The study found that EN is significant in informing education, having the potential to improve teachers' competence, professionalism, and professional agency. Moreover, weaving EN into teachers' formal education is important and valuable. Furthermore, teachers are interested in learning about EN and prefer it to be presented to them in a simplified way that is directly related to their practices. Findings have practical implications for improving the curriculum of Finnish ECEC teachers, and future research is suggested.

Key Words: Educational neuroscience, Finnish ECEC, Finland, Teachers training, phenomenography

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1 INTRODUCTION

As a communication engineer (my bachelor's studies and working background), I experienced the context of formal (Logic, Mathematics, Statistics, and Computer science) and natural (Physics, Chemistry, and Engineering) sciences worlds frequently; worlds where numbers and equations dominate. In the context of studying, for example, all problems we had to study and solve were of only one distinctive correct answer nature, such as 1+1= 2, wherein there is no other correct existing answer except 2. We, students, had to reach the same result for these answers to be accepted. However, since starting my study in the social science world (educational sciences) in Jyväskylä, I discovered a different world. It is where we, as students, could answer different answers to the same question, and these answers are gratefully acknowledged and accepted. This diversity in our backgrounds, ways of thinking, and producing answers is encouraged and considered a merit. It is a world where 1+1 could equal 2, 7, 100, or even 1000. As at the final steps of finishing my master's degree, I consider myself a hybrid person who has learned about and experienced the characteristics of both worlds.

When exploring my first article about the subject of educational neuroscience, a strong thought provoked my mind; this is a place where these two worlds magically intertwine. The first is the world of neuroscience, where "pure" science dominates; a world of natural science, where it uses tools from formal sciences to convert information about nature into precise measurements. It investigates the brain by employing restricted numbers and measurements to unveil sophisticated brain mechanisms such as action, emotion, sensation, thought, perception, and attention, as well as how these mechanisms influence the brain (Spitzer, 2012). And the second is the world of education, where applying knowledge to individual cases is an art. A world where there could be many answers to the same question, for example, applying acquired knowledge about children's development and the function and development of children's brains may be different when dealing with different children (Spitzer, 2012).

I developed a profound interest in the interdisciplinary discipline of Educational Neuroscience (EN) and decided to further learn about, explore, and investigate this interesting field.

1.1 Background of the Study

Brain-based research has long been of interest to scholars. Hence, an abundance of neuroscience research work has been and is still being conducted, providing useful insights into a wide range of domains. One important area that captured educators' attention focuses on how the brain learns. This new aim of research has resulted in the emergence of a relatively new interdisciplinary field (Bruer, 2016; Jamaludin et al., 2019; Luzzatto & Rusu, 2020) that predominantly integrates education and neuroscience (Dubinsky et al., 2019; Janati Idrissi et al., 2020) in order to improve the teaching-learning process (Ching et al., 2020; Han et al., 2019; Twardosz & Bell, 2012). It is called "educational neuroscience" (EN).

Although this is still an emerging field (Bruer, 2016; Tan & Amiel, 2019), its actual and potential contributions to the field of education were acknowledged and promoted in many pieces of the literature (Blakemore & Frith, 2005; Gabrieli, 2016; Goswami, 2004; Howard-Jones et al., 2016; OECD, 2007; Wilcox et al., 2021). Moreover, several studies even suggested that it is vital (Grospietsch & Mayer, 2019; Jamaludin et al., 2019) for teachers to learn basic knowledge about how the brain works. The logic is simple: the more the brain is understood by teachers, the more effectively they can promote learning in their learners (Tan & Amiel, 2019). In general, EN can be useful in areas such as attention, memory, emotion regulation, and reasoning. Specifically, it may improve teachers' competence in designing learning environments and strategies to use inside their classrooms, such as ones related to reading and mathematics (Han et al., 2019).

Owing to the aforementioned importance of learning about how the brain learns for teachers, studies were conducted to investigate in-service and pre-service teachers' knowledge in this area in many countries such as the United States, Canada, Turkey, Morocco, United Kingdom, Switzerland, Netherlands, Spain, France, and Greece (Janati Idrissi et al., 2020). A common result of these studies was that

teachers lack sufficient knowledge in this area. Moreover, many teachers fall prey to neuromyths (neuro-educational false beliefs) (Grospietsch & Mayer, 2019; Luiz et al., 2020; Luzzatto & Rusu, 2020). Additionally, studies reported that, internationally, teachers of all subjects were eager to be educated in this area (Dekker et al., 2012; Luiz et al., 2020). Other studies were conducted to suggest a model or a framework to facilitate the cooperation between educators and neuroscientists (Han et al., 2019).

It was recommended that current and future teachers have sufficient formal training in EN (Ching et al., 2020), with particular importance given to refuting neuromyths and how teachers could critically evaluate promoted classroom practices that stem from brain-based research. In short, it was highly recommended "to improve teachers' neuroscience literacy" (Luiz et al., 2020, p. 1).

"To understand learning is to understand the brain" (Spitzer, 2012, p. 1). After delving into knowledge in the area of neuroscience and EN, I developed a firm conviction of the potential of the field of EN in positively influencing and improving education. I decided to start my investigations with Finnish early childhood education and care (ECEC) teachers and leaders to investigate their conceptions of EN and whether they value integrating it into initial teacher training. Investigating teachers' conceptions about a certain subject is one recommended way to start modifying their formal education curriculum by integrating this subject into it (Ching et al., 2020). Teachers are one critical pillar of education as they are the ones who implement teaching theories and strategies, and they directly face learners, deal with different, challenging, and unexpected teaching and learning situations, and have to timely make critical decisions that would influence the whole life of their learners.

1.2 Research Problem, Purpose, and Questions

Despite the previously indicated importance of enhancing teachers' EN literacy to improve their competencies and therefore, classroom practices, EN is not yet integrated into Finnish teachers' professional teacher education programs (PTEPs). Investigating teachers' conceptions of the neuroscience of learning in informing education is recommended when aiming at integrating neuroscience into teacher training

as it is instrumental to planning and developing teachers' preparation programs (Ching et al., 2020).

To my knowledge, it seems that no study about Finnish teachers' perspectives regarding EN, their needs and wishes about integrating neuroscience knowledge into teachers' PTEPs, nor about the spread of neuromyths among them was conducted in Finland. This conclusion was reached by searching through several research databases, using keywords like "Finland" or "Finnish" and several combinations of EN-related keywords. It is, therefore, I believe, important to investigate the previously mentioned aspects in Finland as one way to begin understanding and promoting the significance of the process of integrating EN in PTEPs.

The primary aim of this research is to explore the conceptions of Finnish ECEC teachers and leaders of the phenomenon of *educational neuroscience* and the *aspects* that differentiate the diverse ways of conceptualizing it. It has a secondary aim of utilizing its results for future pedagogical purposes, particularly in improving the curricula of ECEC Finnish teachers' PTEPs to improve their competence, professionalism, and professional agency, which will eventually lead to improving their teaching practices. Therefore, it aims to inform those responsible for planning, designing, and updating the curricula of programs of ECEC Finnish teachers' PTEPs.

In this study, leaders refer to Finnish ECEC leaders who had previous experience as ECEC teachers and now are leading in the ECEC context. Leaders are often interested in improving teacher training, therefore, having previous teaching background and being responsible for leading teachers justifies the reason for recruiting these leaders to the study. Not only can they provide us with their own insights about EN, but they also can give some insights of the perspectives of the teachers they lead. The sample substitutes 5 Finnish ECEC teachers and 5 Finnish ECEC leaders. Four of these leaders are leaders of ECEC centers, and one is a head director of the ECEC in a city in Finland.

A phenomenographic approach was chosen to explore the different qualitative ways of understanding how EN is conceived by administering semi-structured interviews with Finnish ECEC teachers and leaders. The research is intended to answer the following research questions:

- What are the Finnish ECEC teachers' and leaders' conceptions of educational neuroscience?
- What are the aspects that differentiate qualitatively diverse ways of conceptualizing educational neuroscience?

I predict that participants will most probably be interested in learning EN knowledge and its applications in the educational context like their counterparts in other parts of the world.

It is worth noting that I could have done this research by exploring ECEC and non ECEC teachers' and leaders' conceptions; however, I have chosen ECEC for the following reason. From the neuroscience perspective, although humans' brains indeed are able to learn throughout their lives, the most critical period of developing the brain is the early childhood stage. In neuroscience terms, Purves and colleagues (2018) explain:

> "[g]ray matter grows throughout the cortex [brain] during early life, then declines slightly over a protracted period of late childhood and early adolescence…analysis of the increase and decrease of cortical gray matter volumes...indicate that a full range of human behaviors may be shaped by activity- and experience-dependent addition and subsequent elimination of synaptic connections during critical periods that begin at birth and end in early adulthood" (p. 591, 593).

This means, in educational terms, that learning at the stage of early childhood is critical in shaping humans' experiences and behavior. This reason is why I decided to focus my research on ECEC teachers and leaders, aiming at, first, to improve ECEC teachers' preparation programs, although I hope this improvement reaches formal education of teachers of all levels of education.

The current research is organized as follows. It constitutes four main chapters after the introduction. The second chapter is the theoretical background and literature review of some of the significant bodies of work published in this area. I start in the first section by presenting a historical overview of the emergence of the field of EN. I follow by presenting an overview of EN's definition, aim, and thematic perspectives. As the limited space of this work does not permit a comprehensive overview of all relevant EN thematic perspectives, I focus my discussion on the interdisciplinary nature of EN, translating neuroscience language into education language,

EN applications into the education context, and finally, EN's role in debunking neuromyths. In the third section of the same chapter, I outline the subject of improving teachers' neuroscience literacy. In this section, I focus on the potential of EN knowledge in improving teaching practices, weaving EN into teachers' formal preparation courses, and providing concrete successful research-based examples of established EN teachers' teaching training. In the final section, I briefly describe some aspects of Finland's current formal ECEC education and teacher training system.

The third is the methodology chapter. It consists of two main sections. The first is the research approach, where I provide an overview of the chosen research approach for the current research (phenomenography), then I address my ontological, epistemological, and methodological perspectives regarding the study, and finally, I touch on the notion of using phenomenography in developing learning. The second section of this chapter addresses the research implementation. It consists of two relevant subsections. The first is about research design, where I discuss the recruitment and sampling processes, the pre-task given to the participants to perform before the interviews, data collection (interviews) and transcriptions, and the data analysis. The second is about the ethics, confidentiality, and integrity issues.

The fourth chapter is where I present the results of the current study. In the first section, I present the four categories of description derived from the study's data. Then I dedicate a section to discussing the relationships between the categories.

The fifth chapter is where I examine the research results by presenting the findings and the final discussion regarding the study. I follow with evaluating the research and presenting the research strengths and limitations, further research and possible implementations, and the summary and conclusion.

2 EDUCATIONAL NEUROSCIENCE – A NEW PERSPECTIVE ON INFORMING EDUCATION

In the following subsections, I highlight the theoretical background regarding several aspects related to educational neuroscience. The goal is to lay out the theoretical foundation of the current study and inform the reader of the basics of EN and its significant thematic perspectives and previous research. I believe that an effective way of introducing a research field is by reviewing its historical overview, therefore, I start with the historical overview of EN's emergence as a distinctive research field. I follow with an overview of EN's definition, aim, and thematic perspectives. Regarding the thematic perspectives, I focus on central EN themes: the interdisciplinary nature of EN, translating neuroscience-specific language into educational-related language, EN's applications in the education context, and, finally, EN's role `in debunking neuromyths. In the third section, I address the subject of improving teachers' neuroscience literacy. In this section, I focus on the potential of EN knowledge in improving teaching practices, weaving EN into teachers' formal preparation courses, and providing concrete research-based examples of established EN teachers' training. In the final section, I briefly describe some aspects of the current formal ECEC and teacher training system in Finland as it is the context of the study.

2.1 The Emergence of Educational Neuroscience: Historical overview

The interest in learning about "how the brain/mind works" and its significance to learning is well documented in scientific literature. One of the earliest acts of pursuing this knowledge was the formation of the cognitive science society in the mid-1970s, and the appearance of its journal "Cognitive Science" in 1977 cemented this act (Schoenfeld, 1987). Schoenfeld (1987) stated that "A basic assumption underlying work in cognitive science is that mental structures and cognitive processes (loosely

speaking, 'the things that take place in your head') are extremely rich and complex-but that such structures can be understood, and understanding them will yield significant insights into the ways that thinking and learning take place" (p. 2).

Another interdisciplinary discipline that aims at understanding how our brain learns is cognitive neuroscience; it mainly investigates the genetic neurological bases of cognition (Dundar & Ayvaz, 2016). Cognition is thought to be quite comprehensive as it investigates an extensive range of psychological processes such as emotion, motivation, intelligence, personality, and, of course, cognition (Atherton, 2005). It also includes, among others, acquiring and using the knowledge that involves attention, perception, learning, memory, reasoning, and thinking. Moreover, it encompasses skills such as making decisions, problem-solving, concept formation, language acquisition, and creativity; furthermore, it covers all mental processes related to the previously mentioned skills, such as learning and understanding (Dundar & Ayvaz, 2016).

The previously mentioned disciplines paved the way for expanding the neuroscience perspective to be included in the educational domain. Consequently, a more recent interdisciplinary discipline emerged that is also concerned with how the brain learns, and in which an educational dimension was added; it is educational neuroscience (EN). Its goal is more directed at having a deeper understanding of educational theories, policy and practice, approaches and attitudes (Caragea et al., 2017; Hruby, 2012; Mareschal et al., 2013). Although EN started to flourish only recently, its roots can be found several decades ago.

Theodoridou and Triarhou (2009) reported two of the earliest attempts of scientists to link neuroscience with education. The neurologist Henry Herbert Donaldson (1857-1938) and the educator Reuben Halleck (1859-1936) are considered pioneers in this field. In 1895, Donaldson published his work titled "The Growth of the Brain: A Study of the Nervous System in Relation to Education", and Halleck followed him by publishing "The Education of the Central Nervous System: A Study of Foundations, Especially of Sensory and Motor Training" in 1896 (Théodoridou & Triarhou, 2009). In 1926, the pioneer in educational research and psychologist Edward L. Thorndike recognized and called out for brain physiology knowledge to be included

in educational psychology. He wrote, "Intellect, character and skill have their physiological basis in the structure and activities of the neurons and accessory organs which compose the nervous system" (Thorndike, 1926, p. 209). Near the end of the 20th century, more interests were oriented to EN, and the relation between education and neuroscience was more deeply realized.

Jocelyn Fuller and James Glendening (1985) commented in their study that "The literature is filled with reports of successful applications of brain function to learning" (p. 136). They mentioned that, although several studies have investigated educational inputs and outputs, the processes that happen inside our brains have not been paid much attention to. They emphasized that understanding the brain can undoubtedly improve the teaching-learning process. In addition, they discussed a future needed profession of a "neuroeducator," someone who should be trained in both domains of neuroscience and education. A neuroeducator, as they proposed, should be working in schools to support teachers' understanding of the neuropsychological side of students' learning processes. In their view, this interdisciplinary integration and cooperation of disciplines will eventually be translated into more effective teaching strategies and interventions. In 1988, the "Brain, Neurosciences, and Education" special interest group of the American national research society, the "American Educational Research Association (AERA)" provided a forum for scientists to submit their research papers that are focused on the subject of neuroscience and education (Atherton, 2005).

Although recognized early, it was not until the 1990s (Decade of the Brain) (Bush, 1990) that educational neuroscience became more popular. That was parallel with the advances in the field of medicine and neuroscience (Hruby, 2012) and, in particular, with the evolutions pertaining to non-invasive brain imaging techniques (Ching et al., 2020; Thomas al., 2019; Tibke, 2019; Torrijos-Muelas et al., 2021), such as electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI), (Caragea et al., 2017; Tham et al., 2019) which allowed scientists to use imaging techniques to study the developing brain and utilize neural processes to inform their work on behavior analysis (Atherton, 2005).

Several reputable international educational organizations and universities established further interest in EN and started to promote the possible advantages of the cooperation of these two fields in favor of improving the quality of education. For example, the Organization for Economic Co-operation and Development (OECD) launched its "Brain and Learning" Project in 1999, which aimed at exploring the possibility of the partnership between education and neuroscience research (OECD, 2021) to be directed toward a common objective of informing education practice and policies. They led conferences, publications, and meetings jointly with three different networks to fulfill this aim, namely educational researchers, neuroscientists, and policymakers (OECD, 2021).

Furthermore, in 2004, the "International Mind, Brain and Education Society (IMBES)" organization was formed, and it is still operating today. Its mission is to facilitate the collaboration between education, biology, and cognitive and developmental sciences (IMBES, 2021). Moreover, the Harvard Graduate School of Education dedicated a separate degree program in 2002 related to EN called "Mind, Brain, & Education" (HGSE, 2007). One of the main beliefs of the founders of the mind, brain, and education program is that education practice and policy should be grounded in scientific research. In 2007, the Mind, Brain, and Education journal was founded by the Harvard graduate school of education professor Kurt Fischer (HGSE, 2008). Another example is forming the university-led research center "Centre for Educational Neuroscience (CEN)" in London in 2008. It combines experts in child development, education, and neuroscience to develop the discipline of EN and investigates how biological and neuronal processes contribute to our understanding of learning. Its mission is also to establish a dialog between educationalists and science researchers. It is a joint venture between the University College London and Birkbeck University of London (Mareschal et al., 2013).

In addition to the aforementioned international organizations, initiations, and reputable universities, an abundance of publications discussing and debating neuronal functions to learning have been published in the last decade (Spitzer, 2012). The field is not now only inhabited by educators who are interested in neuroscience or by cognitive scientists/neuroscientists who are interested in education, as was the

case until recently. A few years ago, a new generation of researchers identified themselves as educational neuroscientists; several research groups and EN laboratories were established; moreover, master's and doctoral students are completing their training and thesis in EN (Pincham et al., 2014). This new community profoundly believes in the significant role neuroscience knowledge and findings can have in improving education.

To this point, I have presented a historical overview of the emergence of the field of EN. In the following, I briefly discuss what EN is, its definition, aims, and a few related thematic perspectives.

2.2 The Interdisciplinary discipline of Educational Neuroscience - Definition, Aims, and Thematic Perspectives

Drawing on the rich EN literature, I endeavor to present a clear preview of the definition of EN and the aim of this discipline. Moreover, I present an overview of four of its significant thematic perspectives. They are the interdisciplinary nature of EN, EN's mission in translating the neuroscience language into the educational language, EN's applications in the educational contexts, and EN's role in debunking neuromyths (false beliefs of neuroscience concepts that are related to education).

2.2.1 What is Educational Neuroscience?

'Educational Neuroscience,' 'Neuroeducation,' or 'Brain, Mind and Education' is acknowledged by researchers to be an interdisciplinary, (Jamaludin et al., 2019; Palghat et al., 2017; Thomas et al., 2019) emerging (Bruer, 2016; Caragea et al., 2017; Ching et al., 2020; Feiler & Stabio, 2018; Howard-Jones, 2014; Morris & Sah, 2016; Tan & Amiel, 2019; Thomas, 2013; Tibke, 2019) field that draws on a wide range of disciplines. Researchers used the previously mentioned terms interchangeably (Howard-Jones, 2014) when referring to this field, although in some pieces of the literature, researchers have used these terms separately. In this paper, I will mainly adopt the term Educational Neuroscience (EN) to refer to this discipline.

Despite being defined in several ways, the primary purpose of this field is to create joint research endeavors for encouraging and facilitating the integration of theories and methodologies of mainly education and neuroscience (mainly related to cognitive learning processes research) in order to *eventually* inform education (Dubinsky et al., 2019). Fields that are involved are, among others, neuroscience, cognitive neuroscience, cognitive psychology, neurobiology, psychology, and education (research and practice). EN makes links between behaviors and neuronal bases of mental processes related to learning (Howard-Jones et al., 2016). Therefore, researchers consider it to be a *bridge* between neuroscience findings and education research and practice to facilitate better learning (Caragea et al., 2017), although some doubt its potential in informing education and view it to be a *bridge too far* (Bruer, 1997; Cubelli, 2009). EN advocates claim that educators' knowledge about learning may improve when educating them regarding the scientific processes underpinning learning, and this additional scientific understanding of the brain may inform teaching practice on a daily basis (Howard-Jones et al., 2016).

It is worth noting that EN differs from the field of cognitive neuroscience as EN's impact is not only in discoveries made but in its promises to improve educational practices (Feiler & Stabio, 2018). Therefore, EN "extends beyond the basic sciences and into the social and applied sciences" (Feiler & Stabio, 2018, p.18). It is also worth adding that EN is not only concerned with the neural substrates of mental processes. Indeed, a significant part of its research interest is regarding factors that influence brain function, such as nutrition, stress, energy supply, and environmental pollution. Therefore, although psychology is at EN's core, it is also involved in investigating non-psychological factors that influence outcomes of the educational process, such as sleep, diet, aerobic fitness, exercise, and music (Carew & Magsamen, 2010; Thomas et al., 2019). In Table 1, I provide several definitions and insights of EN coined by researchers to view EN from different perspectives.

Table 1

Educational Neuroscience definitions

Definition of EN	Reference
"EN is a collaborative attempt to build methodological and theoretical bridges between cognitive neuroscience, cognitive psychology, and educational practice without imposing a knowledge hierarchy."	(Howard-Jones et al., 2016, p. 625)
"Educational neuroscience is an emerging research field aiming to bridge the neuroscientific knowledge and methodology with those of more consecrated research disciplines investigating learning and education, like psychology, sociology or education."	(Caragea et al., 2018, p. 7)
"The integration of education, psychology, and neuroscience into an interdisciplinary field that is devoted to helping students learn. Educational Neuroscience communicates the language of multiple disciplines and applies methods from multiple disciplines to translate discoveries about the brain and its networks into educationally relevant outcomes."	(Feiler & Stabio, 2018, p.23)
"Education is about enhancing learning, and neuroscience is about understanding the mental processes involved in learning. This common ground suggests a future in which educational practice can be transformed by science, just as medical practice was transformed by science about a century ago."	(Royal Society UK, 2011, p. v)
"Educational neuroscience is seen as a bridge to connect the significant differences between knowledge of the neuronal function and how these functions operate and actuate in teacher/learners."	(Patten 2011, p. 94)
"[EN is about] understanding the very general physiological aspects that influence human learning as sleep, nutrition or exercise, [and] comprehending brain architectures explaining fundamental processes such as language or reading, and the innovative tools allowing us an early detection of the cognitive deficits in children."	(Caragea et al., 2017, p. 98)
"Educational neuroscience is an interdisciplinary research field that seeks to translate research findings on neural mechanisms of learning to educational practice and policy and to understand the effects of education on the brain.	(Thomas et al., 2019, p.1)

Definition of EN	Reference
Neuroscience and education can interact directly, by virtue of considering the brain as a biological organ that needs to be in the optimal condition to learn ('brain health'); or indirectly, as neuroscience shapes psychological theory and psychology influences education."	

When exploring the field of EN, one should consider its complexity and diversity. Therefore, one could detect several related thematic perspectives when delving through its related literature. I have chosen a few central themes to shed some light on in the following sections. The first three were derived from the systematic review of the EN related literature for 30 years (1985–2017) from 38 different peer-reviewed journals conducted by Feiler and Stabio (2018); these themes are about the interdisciplinary nature of the field, translation of neuroscience language to educators, and applications of EN in educational contexts. I added neuromyths as another theme I consider critical when exploring EN from the focus of improving teachers' neuroscience literacy because many teachers shape their pedagogies based on neuromyths (Tan & Amiel, 2019).

2.2.2 The interdisciplinary nature of EN – Collaborative, not competitive

One of the reasons educators remain suspicious of EN's effect on informing education is the assumed characterization of the relation between the disciplines of education, psychology, and neuroscience to be of a competitive nature rather than a collaborative one (Thomas et al., 2019). Howard-Jones and his colleagues (2016) clarified this by explaining that EN does not rely only on neural explanations nor suggests that education should be evaluated only based on neuronal functions. In fact, EN argues that brain studies complement behavior studies to understand what underlies the learning processes, and this understanding has the potential to lead to the improvement of the teaching-learning process.

Palghat and his colleagues described this interdisciplinary relation to be of an "epistemological pluralism" nature (2017, p. 205). They complimented that researchers of different epistemological backgrounds accommodate their methodological and

theoretical knowledge to contribute to EN's body of knowledge to reach the same goals, for example, informing our choices of educational context design and classroom practices.

Feiler and Stabio (2018) described the interdisciplinary collaboration to be such that "the whole is greater than the sum of parts" (p. 19). And because scholars believe that the distance between education and neuroscience is considerable (Torrijos-Muelas et al., 2021), the interdisciplinary work is critical for smooth collaboration, and it should include multilevel analysis to find the answers to the complex EN questions and conduct research involving methodologies of several well-established fields (Stein & Fischer, 2011). Feiler and Stabio (2018) cited an example of a successful interdisciplinary cooperative research conducted by Neville et al. (2013), in which not only experts from fields of education, neuroscience, psychology, and social work were involved, but also teachers, parents, and students. Researchers of this study designed a family-based training program to aid developing attention skills for at-risk preschool pupils using principles of neuroplasticity (the capacity of our brains to change functionally and structurally through learning).

In sum, both neuroscience and behavior science can inform our understanding of teaching and learning. The usefulness of EN findings and their contribution to education are not achievable without the joint efforts of the previously mentioned involved disciplines. Each discipline collects data and theorizes learning at their distinct levels with the possibility of informing each other (Howard-Jones et al., 2016). And therefore, it is recommended that for EN to flourish, a suitable medium should be created to facilitate conducting joint research projects in this area. This is assumed to be the natural relation between disciplines in an interdisciplinary field. Although several disciplines indeed contribute to the EN field, in this study, I will mainly refer to neuroscience and education.

2.2.3 Translation of language and filling up gaps

As previously noted, the distance between education and neuroscience fields is indeed considerable. There are several obvious differences between their theories, methodologies, and language. Thus, one of the main missions of EN is to act as a

mid-way translator between these two fields (Feiler & Stabio, 2018). This mission is both difficult and important (Feiler & Stabio, 2018; Goswami, 2006). There are three reasons I will mention to support the imperativeness of this role. The first is, although a part of neuroscience or cognitive neuroscience's research goal is to investigate the mental processes related to learning, it is not ever likely that research from these fields will result in outputting classroom-ready knowledge for teachers (Howard-Jones, 2010) (as cited in Thomas et al., 2019, p. 1). The second is that neuroscience concepts and terminologies are not in the familiar lexicon of educators. There is more complicated technical jargon in the neuroscience literature; therefore, directly reading the neuro literature is very likely to be a hard challenging reading not only for educators but also for all of those who are outside of the scientific community. Therefore, there is a need to facilitate the accessibility to the neuroscience technical literature for educators and educational policymakers (Feiler & Stabio, 2018). The third is because of the difference in methods used and how scientists of these two disciplines differently view and study the process of learning. While neuroscientists deem the primary component of learning to be the brain, educators have a broader perspective on learning and consider the influence of other aspects on learning, such as educational settings and environments (Feiler & Stabio, 2018).

Therefore, the role of educational neuroscientists is to plug the previously mentioned gaps. For example, these researchers should be trained and thus knowledgeable in both fields of education and neuroscience, and firstly work as "professional interpreters" (Feiler & Stabio, 2018, p. 20) of the neuroscience literature by simplifying it and abstracting (in a way that does not affect the meaning) some of the challenging scientific neuroscience jargon, and present this new translated writing to educators in a way that is easy for them to comprehend. Secondly, I consider that they are responsible for exploring the neuroscience literature of teaching and learning, then, by referring to their knowledge of education theories, methodologies, and practices, they make these neuroscience findings applicable in classrooms, test them, get feedback from teachers, and further improve these neuroscience dependent practices. They should do this by considering the impact of the different environments and settings on students' learning.

Finally, EN researchers consider the bridge between education and neuroscience to be bi-directional; that is, education can certainly inform cognitive neuroscience studies, just like how neuroscience research can inform education research and practices. However, the direction of translating neuroscience research for educators is emphasized more in the literature (Feiler & Stabio, 2018).

2.2.4 EN's applications in the educational contexts

As an educator, I could argue that probably the most interesting part of EN for teachers is the practical applications of brain-related discoveries that can be directly used in the classroom to improve teaching approaches or, in general, the teaching-learning processes. Teachers usually do not have the time or scientific knowledge to explore research papers of neuroscience or EN, look for findings related to their personal teaching needs, and turn them into applicable classroom practice. Instead, they are more likely to look for the final product of EN work that is simply ready written concrete practical approaches and practices related to improving their teaching process. Examples of neuroscience themes that could be applied to classrooms are studies about the effect of sleep, emotions, and stress on learning, as well as studies related to attention, memory, language, reading, and numeracy (Feiler & Stabio, 2018).

One concrete application mentioned in (Feiler & Stabio, 2018) was the work done by Rivera and colleagues (2005). This study found that younger students utilize more attention areas and working memory of their brains when learning arithmetic subjects than older students to reach the same arithmetic competence. The study concluded that teachers could improve young students' arithmetic learning by providing training to develop their attention and working memory skills before or along with teaching students arithmetic lessons. There are numerous examples of neuroscience concepts that could be utilized in education by practitioners, researchers, and policymakers in the field of education. I will discuss three of these neuroscience concepts that I take to be of interest to educators.

Neuroscience concept 1 – Exercising and brain development

Much of the discourse about regularly exercising addresses its positive influence on our body's general health. However, it was not until recently that researchers started to reveal scientific evidence on how regularly exercising affects our brains (Hansen, 2017). Hansen (2017) explains that even spending a few minutes jogging could improve our brains; however, regularly exercising does give an individual a better chance to improve his brain and memory.

Regarding learning in particular, neuroscience findings suggested that physical training improves our learning and memory (Hillman et al., 2008; Suzuki, W. 2017): instantly during the training, just after the training, and for a long term after the training (Hansen, 2017). For example, one could raise the number of learned words by 20% by being physically active prior to or during learning the words if compared to learning at rest. What is more, one could probably acquire better skills if he is physically active before practicing to learn a particular skill, such as practicing piano or golf (Hansen, 2017).

When it comes to children, research has shown that more fit children had a larger and better functioning hippocampus (part of the brain strongly related to memory) and therefore had better academic abilities and better cognitive faculties when compared with their less-fit peers. For example, they became better at mathematical and logical reasoning, remembering facts, vocabulary comprehension, reading, and performed better in memory and IQ tests, and they got better grades than their less active peers. The improvement did not only happen in their pure academic development, but it seems like these children were more able to stay focused and remain undistracted while taking their lessons. Moreover, they were better at solving problems, multitasking, regulating their emotions, controlling emotional impulses, and became less sensitive to stress arousal. In addition, children showed improvement in executive control abilities; that is, making more sound decisions, showing initiative, having the ability to plan, and being organized (Hansen, 2017). These non-direct academic abilities certainly influence children's academic performance. According to Hansen (2017), children's type of activity is not of major importance; what is important is raising the heart rate and constantly being active. In

practical terms, it is recommended that children jog or run in place for at least four minutes between school sessions to utilize some of the previously mentioned benefits.

Neuroscience concept 2 – Sleep and memory

A robust, efficient, and long-lasting memory is one critical aspect in terms of better learning abilities. Sleep scientists do stress the advantages of sleeping to our body and brain. It was found that the adult brain needs approximately 8+ daily hours of night sleep to work at its full potential (Walker, 2017). But how exactly does sleep affect our memory? It was found that sleep is certainly beneficial for the retention of memory. Moreover, studies uncovered that sleeping provides the optimal circumstances for consolidating our memory (Rasch & Born, 2013). "Consolidation refers to a process that transforms new and initially labile memories encoded in the awake state into more stable representations that become integrated into the network of pre-existing long-term memories" (Diekelmann & Born, 2010, P. 1). While sleeping, we typically go through several complete cycles of REM-NREM sleep stages, which last for 90-min per cycle. A considerable amount of evidence suggests that these stages are essential in memory consolidation (Stickgold et al., 2001). In practical terms, the previously mentioned studies reveal evidence that if one would like to enhance his learning, he is encouraged to have a period (90+ minutes) of post-learning sleep within 24 hours after learning.

Furthermore, A body of research promoted the role of sleep in "off-line memory reprocessing" (Rasch & Born, 2013; Stickgold et al., 2001). In their paper, Diekelmann and Born (2010) referred to an important breakthrough study (performed on rats) that found that the patterns of neuronal firing (the way neurons communicate to convey information) that happened in rats' brains when they were awake and having a new learning experience were reactivated in the same order in their brains while sleeping. The same research pointed out a study conducted regarding the reactivation of neuronal firing patterns in human learning. Participants of the mentioned study were involved in a learning experience about spatial locations and were doing so in the presence of a certain odor. Then, a few of them were

re-exposed to the same odor in the Slow Wave Sleep period (the deepest phase of NREM stage) of a post-learning sleep. Those who were exposed to the odor while sleeping remembered what they had learned better than the others.

Neuroscience concept 3 – The Neuroscience of Music

Historically, it has been known that music is a universal source of enjoyment and well-being for humans in several different cultures. However, it was not until recently known that the impact of music on our brains in terms of the neural level is significant. Researchers were asking questions such as: What exactly is going in our brains when we listen to or produce music? Does music affect learning? Is there a difference in the brain development and structure of students who are regularly subjected to music than their peers who are not? Does music change certain brain functions and areas? And does music change our brains in a way that improves our abilities in several domains? (Iversen, 2015).

To answer these questions and more, research in the neuroscience of music has been growing in the past decades. Scientists provided findings regarding the various neural mechanisms, such as the cognitive processing and emotional experience of music in our brains (Särkämö & Sihvonen, 2018). It was found that,

> "music arguably ranks among the most complex and multi domain stimuli engaging a large-scale bilateral network of temporal, frontal, parietal, cerebellar, and limbic and paralimbic brain areas associated with multiple parallel cognitive, verbal, motor, and emotional processes…[T]he neural processing of songs is a combination linguistic (syntactic, semantic), musical (melodic, rhythmic), domain-general cognitive (attention, memory), vocal-motor, and emotional processing" (Särkämö & Sihvonen, 2018, p.105-106).

Regarding the effects of music on children's brains, research revealed that music helps certain brain areas to develop. It also can improve math skills, reading, school attendance, confidence, attention (Iversen, 2015), and language (Linnavalli et al., 2018). In their study, Linnavalli and colleagues (2018) conducted an experiment to investigate the impact of music on the linguistic abilities of 5 to 6 year old children.

They found that implementing regular music lessons for children in kindergarten improves the development of children's vocabulary skills.

In her book, Harris (2009) presented several research findings that supported the positive influence of music on children's brains. She pointed out evidence that exposing students to music and teaching them to produce music enhances higher brain functions and improves their language, math, reading, communication, concentration, motor skills and movement, creativity, self-esteem, and social skills. Harris stressed that these positive effects are more effective and profound if children are exposed to music in an earlier period of their lives as their brains are more plastic for development and change.

2.2.5 EN's role in debunking neuromyths

The final EN theme is related to EN's role in debunking neuromyths. EN training is regarded the main safeguard against believing in neuromyths. I added this section because it is suggested that teaching educators to be aware of neuromyths is important for enriching their neuro-educational literacy and dispelling neuromyths.

A myth is defined as "a commonly believed but false idea" (Oxford University Press, 2010). The neurosurgeon Alan Crockard first coined the term neuromyth in the 1980s in the context of medical discipline when referring to unscientific concepts regarding the brain (Torrijos-Muelas et al., 2021). It was then used in the educational context to refer to the commonly believed false neuroscience concepts related to learning and education. It gained more traction after the OECD started to discuss it in their reports promoting EN (Hughes et al., 2020; OECD, 2002).

Neuromyths often originate from the oversimplification of the language of neuroscience literature (Grospietsch & Mayer, 2019; Howard-Jones, 2014), overgeneralizations of the empirical neuroscience research (Macdonald et al., 2017), misunderstandings, misinterpretations, and distortions of scientific facts relating to different brain mechanisms (Howard-Jones et al., 2016; Pasquinelli, 2012). Therefore, although some neuromyths emerged due to a lack of scientific concepts, most of them spawn from accurate neuroscience findings (Grospietsch & Mayer, 2019). Others

suggested that the challenges in communication between different disciplines in EN (Feiler & Stabio, 2018) are another reason for neuromyths emergence.

One problem concerning the existence and prevalence of neuromyths among educators is that educational practices stemming from neuromyths are prevalent in different educational settings (Tan & Amiel, 2019). Therefore, it threatens educational (e.g., pedagogical) practices. It negatively influences the pedagogical choices of teachers as it is used to justify ineffective teaching practices (Howard-Jones, 2014) and stands as a barrier to benefiting from scientific-based pedagogical practices (Janati Idrissi et al., 2020); this threatens to hinder learning (Feiler & Stabio, 2018).

Another problem is that teachers are specifically susceptible to the allure of neuromyths due to the high interest and lack of neuroscience knowledge (Ching et al., 2020). Therefore, educators endorse neuromyths, and neuromyths are prevalent among educators (Hughes et al., 2020). Teachers face difficulties identifying and distinguishing accurate, evidence-based brain-related information from neuromyths (Grospietsch & Mayer, 2019). Moreover, teachers are prone to consume and promote products that claim to be brain-based, and media and advertisements further increase this tendency (Torrijos-Muelas et al., 2021). Furthermore, the scientifically supported neuro-educational knowledge and findings are published in a way that is challenging to read by educators, and it is thus difficult for them to interpret and understand.

What is more worrying is that this unrealistic neuro-educational information found its way into teachers' training programs (Luiz et al., 2020). Moreover, teachers are not prepared to be critical to knowledge that claims to be scientifically supported (Howard-Jones, 2014). Additionally, some studies show that even going through EN teachers' training leaves teachers still believing in neuromyths; therefore, it was recommended that teachers are encouraged to explicitly discuss neuromyths and refute them (Hughes et al., 2020).

In studies addressing neuromyths, the call for integrating EN courses in teachers' training programs has been suggested and highly recommended as a possible solution for dispelling and debunking these false beliefs (Feiler & Stabio, 2018; Grospietsch & Mayer, 2019; Howard-Jones et al., 2020; Torrijos-Muelas et al., 2021).

This integration would improve teachers' neuroscience literacy and train them to be critical consumers of brain-based materials and products (Grospietsch & Mayer, 2019). Additionally, scholars emphasize the direct refutation of neuromyths by learning and comparing it to the actual neuroscientific facts as one effective means of fighting its existence and prevalence among educators (Coch, 2018; Grospietsch & Mayer, 2019).

This section has highlighted the history of EN's emergence and its definition, aims, and popular thematic perspectives. The following deals specifically with the subject of teachers' EN knowledge and training.

2.3 Improving Teachers' EN Literacy

To illustrate the importance of improving teachers' EN literacy, I review studies that focus on addressing the effect of EN knowledge on informing teaching. I then specifically review the goals of weaving EN training in teachers' preparation programs. I also address what studies have concluded about teachers' wishes of how they want EN to be presented to them, and I address existing concerns about the subject of improving teachers' neuroscience literacy. I end with three evidence-based examples of established teacher training programs.

2.3.1 Neuro-educational knowledge for more effective teaching

Recently, several studies reported on the usefulness of neuro-educational related research (particularly neuro-cognition) in informing education and in improving teachers' teaching strategies (Grospietsch & Mayer, 2019; Howard-Jones, 2014; Jamaludin et al., 2019; Papadatou-Pastou et al., 2017; Tan & Amiel, 2019). Therefore, it was recommended that teachers learn about this neuro-educational-related information in their professional teaching training courses and implement these neuro-related findings into classroom teaching and pedagogy (Coch, 2018; Dubinsky et al., 2019; Friedman et al., 2019). In this regard, calls are being made among researchers for new generations of teachers who are interested in and moti-

vated to learn about how the brain learns besides learning about what they teach to be able to face today's challenges of teaching (Curtis & Fallin 2014).

It is proposed that this neuro-educational knowledge aids teachers in fulfilling their pupils' individual needs (Papadatou-Pastou et al., 2017) and has the potential to make their teaching more effective. “Teachers’ awareness about the nervous system of the brain helps them comprehend their students’ behavior and learning ability” (Ramganesh & Hariharan, 2020, p.2696). Sripongwiwat and colleagues (2016) and Sasikumar and colleagues (2016) reported the effectiveness of Neurocognitive-Based Teaching and Neurocognitive Intervention Strategies in enhancing teachers’ teaching practices. Not only researchers but also educators themselves believe in the potential of neuro-educational knowledge in helping them to make more informed choices with regard to their teaching approaches (Edelenbosch et al., 2015). Moreover, it was described how teachers are eager to learn about neuroscience findings related to education and how these findings could contribute to improving their teaching practices (Luiz et al., 2020).

Howard-Jones and his colleagues (2020) concluded that teaching teachers about the "science of learning" advanced teachers' evidence-based/scientific understanding of learning and supported them in making more informed decisions, along with making them rely less on unscientific information related to teaching and learning. Howard-Jones and colleagues’ (2020) philosophy regarding this issue is that "science cannot tell the teacher what should be done, but provides insight that, alongside other evidence, supports the teacher in making decisions” (p. 274). Therefore, it is worth emphasizing that integrating neuro-educational knowledge into teachers’ preparation courses offers an additional perspective on teaching and learning (Coch, 2018), such as understanding more about the brain mechanisms of learning (Luzzatto & Rusu, 2020).

Although studies reported the importance of enriching the neuro-educational literacy, both for in-service and pre-service teachers, some emphasized that it may be more beneficial for teachers to gain this knowledge before graduating (Ching et al., 2020). In this regard, Ching and colleagues (2020) explained that the scientific knowledge learned in high school is more likely to be retained by pre-service teach-

ers, and they are also more likely to be willing to adopt scientific-based teaching practices. On the other hand, in-service teachers could be more resistant to change. Therefore, calls were made to conduct more research that would output course recommendations for universities to utilize to improve pre-service teachers' knowledge about basic brain understanding that is education-related and that may positively influence classroom practices (Luzzatto & Rusu, 2020).

2.3.2 Weaving neuroscience into teachers' universities programs

In the remainder of this chapter, I present the goals of weaving EN into teachers' programs. I also address what teachers reported in other studies regarding how they want this knowledge to be presented to them. I end by elaborating on some of the current concerns regarding this subject.

The goals of educating teachers about EN

One major goal for educating teachers about EN is to help them improve their teaching practices by advancing their knowledge about the brain in neuroscience areas related to learning, such as emotion, attention, language processing, memory, reasoning, and basic and higher functioning (Tommerdahl, 2010). Another goal is to explicitly debunk neuromyths (Ching et al., 2020). The third goal is to give them the basic knowledge and train them to critically evaluate neuro-educational related readings that contain neuro-educational related claims and findings (Dubinsky et al., 2019). This would prevent teachers from falling prey to neuromyths or marketers of non-scientific "brain-based" teaching programs. One more goal is to teach teachers how to critically evaluate educational products (toys, apps, electronic games…) that claim to be brain-based. An example could be a guideline such as what Sylvan and Christodoulou (2010) have presented in their study for teachers to educate them about making this evaluation and being critical consumers of this type of product.

What do teachers want from the neuroscience literature?

Although some pre and in-service teachers are curious about knowing how EN can be useful for their knowledge and expertise (Tibke, 2019), the majority already con-

sider it beneficial for their professional work (Dekker et al., 2012; McMahon et al., 2019) and are convinced with the promising implications of EN (Della Chiesa et al., 2009). And as previously described, teachers are genuinely interested in the brain (Feiler & Stabio, 2018) and feel that their knowledge lack information regarding how students' brains work (Schwartz et al., 2019). However, when asked how they would prefer this knowledge to be presented to them, they answered that they needed the brain-related knowledge to be accessible and education-related (Dubinsky et al., 2019; Pickering & Howard-Jones, 2007). Additionally, teachers were asking for neuroscience reading material that is simplified and of straightforward language that improves their current teaching practices (Goswami, 2006) and provides new teaching strategies for them to utilize (Tham et al., 2019). The reason is that, as already mentioned, the neuroscience literature is full of technical jargon that is challenging for teachers to understand and is full of excess knowledge for teachers. Moreover, neuroscientists are not particularly interested in neuro-educational findings that may directly improve classroom practices; therefore, their research findings and recommendations are most probably not written in a way that interest and benefit teachers. Scholars suggested that one possible way to produce materials to read and use in courses is the cooperation and partnership between educators and neuroscientists, as neuroscience experts could easily and accurately evaluate neuro-related materials used to educate teachers (Hughes et al., 2020).

Concerns regarding the issue of improving teachers' neuroscience literacy

Several concerns were reported when it comes to the subject of improving teachers' neuroscience literacy. One of them is that, although the previously mentioned potential benefit of implementing neuroscience knowledge in education and the genuine interest of teachers and educators to learn more regarding this domain, EN is seldomly featured in teacher education (Ching et al., 2020; Coch, 2018; Dubinsky et al., 2019; Luzzatto & Rusu, 2020; Tibke, 2019). Moreover, there are limited suggested actual teacher training programs that fulfill teachers' and educational needs in this area, therefore, researchers have been calling for the need of constructing a reliable

neuro-educational curriculum to be added to teacher training programs (Luzzatto & Rusu, 2020)

Another concern, also previously emphasized in this paper, is the large gap between neuroscience and education fields and that it is certainly challenging to start with cellular level research until we reach the classroom research level (Schwartz et al., 2019). Furthermore, the aforementioned language difference between neuroscience and education and the gap in research between these two disciplines lead to a third problem, that is, educators find it complex to understand and use EN concepts in a correct and meaningful way, and this also leads to misunderstanding these scientific concepts and for them to be easily taken out of context (Schwartz et al., 2019). If we add teachers' enthusiasm towards EN and its applications in education in addition to their lack of EN knowledge, the result is the prevalence of neuromyths among teachers (Ching et al., 2020). Ching and colleagues warned that when EN courses are missing from pre-service college teachers' courses, the teachers' orientation will be towards looking for information from non-accredited sources and blindly accepting these oversimplified and misrepresented EN information.

The calls for the potential benefit of training teachers about EN encouraged researchers to start such programs to empirically investigate and evaluate its outcomes. In the following, I present an example of three different programs.

2.3.3 Examples of established EN teachers' training programs

This section aims to present evaluated research-based successful programs conducted for educating teachers of EN knowledge. I would suggest that these programs and others be utilized if it is decided to update the Finnish ECEC curricula to include EN training.

Applying neuroscience knowledge in formal education

A recent study conducted by Tan and Amiel (2019) aimed to investigate the result of applying neuroscience knowledge in formal education is one fruitful example of improving teachers' neuroscience literacy. More specifically, they looked into neuroscience's potential in supporting teachers' professional development and enriching

classroom instruction. They aimed to explore their participants' engagement with neuroscience and how they integrate neuroscience knowledge into their teaching instructions after going through such training. The study was conducted with elementary school teachers in British Columbia in Canada, and the training allowed them to collaborate in designing, implementing, and evaluating neuroscience-framed lessons.

The study's findings highlighted the potential neuroscience has to support developing teachers' understanding of pedagogy and learning and its profound influence on educators' pedagogical decision-making. Moreover, it emphasized the usefulness of using analogies to bridge neuroscience knowledge to teachers. Finally, the study concluded that improving teachers' neuroscience literacy helps them recognize and confront teaching practices stemming from neuromyths (Tan & Amiel, 2019).

Professional development experimental course

Schwartz and his colleagues (2019) conducted a study to investigate the impact of a 36-hour neuroscience experimental course (in a professional development setting) on the basic neuroscience understanding of non-science teachers and how it reflects their pedagogical decisions, especially their use of student-centered pedagogies. A three-week course, "Neuroscience for Educators," was offered for students in the college of education. They used ten EN concepts as a framework for developing the course, and the course included several activities to help participants develop an individual personal meaning of the taught EN concepts. The training focused on brain function, development and structure, and synaptic plasticity. Moreover, it covered relating neuroscience to learning and memory and how stress and emotions impact learning.

By exploring the relationship between teachers' EN understanding and their teaching decisions and choices, the study found that teachers grew their neuroscience understanding significantly by the end of attending this course. Moreover, they realized its possible implications in the teaching-learning process. Finally, they applied what they learned to their lesson plans and were motivated to enact active

learning. The study concluded that teaching teachers about EN in formal education might benefit teachers of all disciplines (pre-k to grade12), namely by offering them the basics to understand the usefulness of student-centered pedagogy. It suggested the benefit of teaching EN to teachers in both formal education and professional development settings. It further concluded that teachers are eager to know practical classroom teaching strategies stemming from neuroscience, why they are worth implementing, and the reasons behind the effectiveness of these strategies (Schwartz et al., 2019).

Brain-U professional development program for teachers

Brain-U is another professional development program for teaching neuroscience knowledge to pre- and in-service, science, and non-science teachers. This multilayer (from 36 to160 hours) training course was a part of a master's degree in the "Mind, Brain, and Education" master's program. Similar to the previous study, this study examined neuroscience knowledge's impact on influencing teaching practices. The program was developed through a partnership between educators and neuroscientists, and the study examined eight programs offered from 2000 to 2018 (Dubinsky et al., 2019).

The study concluded that attendees of this professional development workshop learned about neuroscience concepts, gaining the ability to teach these concepts to their students. This new knowledge affected how participants viewed learning and their understanding of their students' potential to learn. They realized the benefit of active-learning strategies, learner-centered pedagogies, and inquiry-based practices in promoting deeper learning. The acquired knowledge contributed to self-knowledge awareness (metacognition). Moreover, the resulting modified teaching practices improved classroom engagement, promoted higher-order thinking, and encouraged teachers to support their learners' needs and expand their learning. Importantly, this training proved to have a continuing effect on teachers and their teaching practices many years after they attended the course (Dubinsky et al., 2019).

Teachers who attended this course expressed their willingness to learn about neuroscience and expressed how it transformed their teaching practices. Researchers

of the study recommended the collaboration between neuroscientists and educators in offering such high-quality neuroscience training for pre- and in-service teachers. However, some challenges to offering this sort of course remain, such as ensuring that the information presented is accurate and is taught in a learner-centered way (Dubinsky et al., 2019)`.

This section summarized aspects regarding improving teachers' EN literacy, such as the significance of weaving EN knowledge into initial teacher training in the international context. The following provides a brief overview of the ECEC teacher training in Finland as a background of the context of interest of the current study.

2.4 ECEC and Teacher Training in Finland

In this section, I shortly review the values and guidelines of the Finnish ECEC and the corresponding needed teachers' competency to fulfill the quality demands of ECEC. I argue that integrating EN knowledge into teacher preparation programs has the potential to improve teachers' competency. I then describe the ECEC teachers' training in Finland and argue that it does not include sufficient EN training.

2.4.1 Finnish quality ECEC and the corresponding needed teachers' competency

The Finnish ECEC is guided by the Act on Early Childhood Education and Care (540/2018) and the regulation of the National core curriculum for ECEC (2018), issued by the Finnish National Agency for Education. The national core curriculum has several underlying values, such as the substantial value of childhood, equity, equality, diversity, children's rights, and the value of healthy living. The newly reformed curriculum was formulated to address the latest research findings and the society and ECEC operating environment change. The national core curriculum promotes children's learning and growth and puts much emphasis on pedagogy. Moreover, it advocates the child's right to high-quality education and care, individual ECEC plan, play, and participation. Furthermore, it establishes transversal competencies such as developing knowledge and skills in thinking and learning, self-

expression, taking care of oneself, involvement, interaction, participation, and cultural, ICT, and multiliteracy competencies (Finnish National Agency for Education, 2022).

For teachers to fulfill the high-quality demands of the ECEC profession, it is evident that they are challenged to acquire sufficient professional competencies. Research proposes that teachers' professional competence encompasses contextual knowledge, pedagogical competencies, and interaction and cooperation skills. It moreover includes teachers' enthusiasm, reflection practices, and self-conception. Initial teachers' training is considered one critical aspect for improving the professional competence level of ECEC teachers. The quality of this training ensures teachers' acquisition of quality pedagogical skills and therefore reaching teachers' professionalism (Fonsén & Ukkonen-Mikkola, 2019).

What makes it even more challenging for teachers are the rapid and complex changes that happen in the world which create challenging demands on teachers to keep up with these changes in terms of delivering quality teaching and, therefore, the need to continually improve their professional competence. Certain aspects are recommended to be improved to meet these increasing challenges: teachers' pedagogical professionalism and competency, and professional agency (PA) (Ukkonen-Mikkola & Varpanen, 2020), as one aspect of PA is the teachers' ability to develop their professional practices (Ukkonen-Mikkola, 2018). One way to improve these aspects is by updating and improving pre-service teachers' teaching programs, as teachers' initial education is crucial for the quality of ECEC pedagogy (Fonsén & Ukkonen-Mikkola, 2019) and for developing teachers' PA (Ukkonen-Mikkola & Varpanen, 2020).

Finland, indeed, is one of the leading countries interested in and has undertaken several pedagogical reforms to develop early childhood education and care practices (Ukkonen-Mikkola, 2018). However, due to the expected high quality research-based initial teacher training outcome, there are high national expectations regarding teachers' teaching practices, decisions, and pedagogical competence (Fonsén & Ukkonen-Mikkola, 2019; Ukkonen-Mikkola, 2018). Although, and as previously mentioned, well known for its high-quality initial teaching training, some criticized

it for failing to provide teachers with sufficient pedagogical competence and PA support (Ukkonen-Mikkola & Varpanen, 2020).

Drawing on the previously stated evidence regarding EN, I could argue that integrating EN knowledge into the Finnish ECEC teacher preparation program has a great potential for improving teachers' pedagogical professionalism and competency and professional agency (PA).

2.4.2 ECEC teacher training in Finland

The Finnish initial teacher education is of a high-quality standard and is known to graduate highly educated professional teachers, who are given a great deal of autonomy. It aims at educating experts in education, teaching, and care who are able to support children's learning and well-being. To become an accredited ECEC teacher, Finnish students study either to reach a bachelor's degree (180 credits – three years) or a master's level (300 credits – five years) at a Finnish university level. They also could become ECEC teachers by studying at universities of applied sciences for a bachelor's degree (Fonsén & Ukkonen-Mikkola 2019). At the bachelor's level, students have both research-based theoretical courses and practical training periods (work placements). These courses comprise professional studies in preschool and early childhood education subjects, basic and intermediate studies in education, and some other elective studies. Moreover, students study some general learning skills such as language studies. ECEC student teachers are trained in approaches to areas such as pedagogy, childhood, play, sociology, general and developmental psychology, and arts (Ukkonen-Mikkola, 2018). In the following, I provide a more detailed description of ECEC teachers' training in Finland. Details regarding theoretical courses are taken from the Tuku bachelor's degree program in early childhood teacher education, faculty of education of the University of Turku (University of Turku, 2022).

I start with the general studies (12 ECTS). These studies aim to orient students around university studies and the community. It trains students to work in multicultural learning environments and competently teach and deal with children of different backgrounds. Moreover, it develops students' ability to utilize information tech-

nology resources as learners and teachers. Then, there are the language studies (14 ECTS), in which students develop their general communication and language skills by improving their academic reading, writing, and communication skills. Another group of studies are the basic studies in education (25 ECTS). In these studies, students develop the competence to relate the theories of education and empirical research with teaching practices and interventions and, therefore, become able to translate theoretical knowledge into actions in authentic teaching and learning context. Students are educated about several aspects of education, such as psychology, sociology, philosophy, and ethics. They learn about the complex nature of learning from the individual level to the social and cultural levels. Moreover, students learn about the learning process, diversity of learning, and children's development. Students learn to plan and evaluate curricula, and support children's holistic development, growth, and well-being by themselves and in cooperation with other educators (University of Turku, 2022).

In addition, students go through intermediate studies in education (35 ECTS). They aim to train students in constructing scientific knowledge and conducting scientific research. Moreover, students learn to be competent as teachers, learn about pedagogical support, children's development, and how to reflect on their development and experiences as educators. Additionally, students learn how to plan, implement, and evaluate the learning of mainstream and special needs children according to the national core curriculum. A Bachelor's Thesis is written as part of these studies. Then, there are the professional studies in early childhood and pre-primary education (60 ECTS). Students in these studies are led to become skilled in leading children's education from infancy to their entry into primary school. They apply what they learned in early childhood and pre-primary contexts among various children's groups. Students develop their co-working skills, learn to improve pedagogy from several perspectives, such as cultural learning and children's development, and learn about the significance of physical education, craft, art, interaction, and play. Finally, students can choose additional studies according to their preferences and future personal plans in the group of studies called minor studies and elective studies (34 ECTS) (University of Turku, 2022).

Turku University's bachelor's also includes supervised practice periods. Ukkonen-Mikkola (2018) explains that these periods are considered a pedagogical strategy for bridging theory and practice and are critical for developing students' expertise and professionalism in early childhood education work. In workplaces, students first experience the actual demands of their profession, and they experience different fundamental roles. In practicum periods, students are guided by a university lecturer (tutor) and an ECEC teacher (mentor). The practicum training has three phases, the preparation (selecting ECEC centers and meeting mentors), actual practicum training (do reflective tasks and meetings), and after the practicum training (evaluating and reflecting on learning) phases. In the bachelor's years, students go through three practicum training. The first (4 credits) is related to observing young learners and the learning environment and learning about ECEC teachers' ethics and professional identity. The second (5 credits) is concerned with the ECEC pedagogy and curriculum work. The third (6 credits) focuses on the ECEC teachers' holistic responsibility (pedagogy, interaction with parents and other co-workers, and organizing the development process of the center) (Ukkonen-Mikkola, 2018).

Through exploring the Finnish ECEC teachers' initial training program, it can be assumed that EN is not explicitly taught. Teachers in their elective studies may choose some courses that contain some brain-related information, however, I assume that the EN knowledge will be scattered and not effectively taught. Therefore, although the training could contain some scattered knowledge about how the brain learns in course subjects such as general and developmental psychology, there is no explicit, organized, systemized neuro-educational information taught. Here what I mean by neuro-educational information is the brain knowledge related to education in the context recommended by educational neuroscientists, such as written in simple (but not oversimplified) jargon, free of unnecessary neuro technical terms, and that are relating recent neuro findings to classroom practices (see APPENDIX 1, Pre-Task to read 2 for an example).

3 METHODOLOGY

This study aimed to investigate Finnish ECEC teachers' and leaders' conceptions of educational neuroscience as a phenomenon in the context of education and explore the aspects that differentiate the various ways of conceptualizing it. Its secondary aim was to utilize its results for future pedagogical purposes, that is, to improve the curricula of ECEC Finnish teachers' PTEPs.

A phenomenographic approach was chosen to investigate various qualitative ways of understanding how EN is conceived. The research is intended to answer the following research questions:

- What are the Finnish ECEC teachers' and leaders' conceptions of educational neuroscience?
- What are the aspects that differentiate qualitatively diverse ways of conceptualizing educational neuroscience?

This chapter focuses on the research approach utilized in the current study, wherein it touches on significant aspects related to the phenomenographic approach in regard to the current study. Moreover, it addresses the research design details and ethics, confidentiality, and integrity issues.

3.1 Research Approach

3.1.1 Phenomenography

Originating within the field of educational research (Hajar, 2020), it has become a widely valued research approach since its emergence in the 1970s (Ashworth & Lucas, 2000). Ference Marton and his colleagues originally developed it at Gothenburg University in Sweden to get descriptions of knowledge (Svensson, 1997) by experimentally investigating students' experiences of learning (Hasselgren & Beach, 1997).

Emerging from an empirical base rather than a philosophical or theoretical one (Åkerlind, 2005b; Hajar, 2020), the aim of this empirical content-oriented research approach (Marton, 1986) is to understand and describe (Svensson, 1997) different ways of people's conceptions, experiences, understandings, interpretations and perceptions about a specific phenomenon/aspect of reality that is shared by members of a particular society (Marton, 1981). The current study is regarding how Finnish ECEC teachers and leaders (subjects of the study) conceptualize EN (the object of research).

Marton (1981) explains the main foundation which phenomenography is built upon by distinguishing between two (complementary) perspectives, the first-order perspective (statement about reality) and second-order perspectives (statement about the perceived reality). The first describes diverse aspects of the world, while the second (the foundation of phenomenography) describes an individual's conceptions/experiences of diverse aspects of the world. An example of differentiating between these two perspectives in our case could be by asking either "What is the value of integrating neuro-educational knowledge to teachers' university courses?" or "What do Finnish ECEC teachers and leaders think about the value of integrating neuro-educational knowledge to teachers' university courses?". Answering the first question constitutes a statement about reality; however, answering the second will be a statement concerning educators' conception of reality. Therefore, in phenomenography, as researchers, we orient ourselves toward our participants' ideas of the world instead of orienting ourselves toward the world (Marton, 1981).

3.1.2 Ontological, Epistemological, and Methodological Perspectives

Within the world of scientific research, paradigms are regarded as the guiding belief system or worldviews of any scientific inquiry or inquirer (Dieronitou, 2014). These paradigms can vary according to the ontology (nature of reality) and epistemology (nature of knowledge) views (Hajar, 2020; Slevitch, 2011; Tracy, 2019).

In the spectrum of social science research, particularly when investigating the improvement of the teaching-learning process by exploring teachers' and leaders' conceptions, I believe that there is no one absolute truth. The process of teaching and

learning constitutes an extensive range of complex aspects, spectrums, and possibilities. This variety could be considered an indication for us researchers to open our minds to the existence of multiple realities. Consequently, I lean toward the relativist ontology and subjective epistemology. Relativism entails that the social entity to be studied is constructed from social actors, and it may have multiple subjective realities according to the different perspectives of these social actors. The subjective epistemology resonates with the relativism ontology. And in most cases, researchers relying on the relativist ontology and subjective epistemology adopt qualitative research approaches (Dieronitou, 2014). Therefore I adopted (for the sake of this particular study) a qualitative research approach. I also chose phenomenography (Marton, 1981) as my particular qualitative research approach as I find it fit my ontological and epistemological beliefs and my study's objectives. In the following, I elaborate on phenomenography's ontological and epistemological underpinning to justify the approach's fit for the study.

Phenomenography holds a non-dualistic view of nature, and that reality is how subjects of the study conceive it. The ontological underpinning of phenomenography entails the existence of multiple realities (conceptions) that are socially constructed and characterized as context-sensitive and dynamic (not fixed in space and time). Regarding the epistemological underpinning of phenomenography, knowledge is constructed from individuals' descriptions of how they conceptualize or experience reality (Hajar, 2020). As I aimed to explore informants' conceptions of EN for the sake of improving the ECEC formal teacher education by integrating EN into teachers' in-service curriculum, I sought to find the answer to the question posed by gathering pieces of the reality from the perspectives of the social actors (Finnish ECEC teachers and leaders) and try to put the pieces of the puzzle together to constitute a bigger picture and comprehensive depiction of the phenomenon of EN to reach a satisfactory valid point of view concerning it (Hajar, 2020). It will not be the only existing reality, however.

The origin of phenomenography was in higher education, and it aimed at improving education. In the following, I elaborate on this thought and further support the appropriateness of this approach in fulfilling the aim of the current study.

3.1.3 Using the study in developing learning

The ultimate aim of this thesis study is to illustrate the importance of integrating EN knowledge into the Finnish ECEC teacher training programs as an attempt to improve these programs for the sake of improving teachers' competence, professionalism, and professional agency, which will eventually lead to improving their teaching practices. Therefore, after exploring various research approaches, I chose phenomenography.

As previously noted, phenomenography emerged within the discipline of education and evolved from an empirical educational framework (Larsson & Holmström, 2007) to understand the world from a second-order perspective, that is, in the time of its emergence, understanding student's perspectives. Researchers sought to enter into the students' world while trying to understand their perspectives to improve the quality of (their) learning outcomes (Åkerlind, 2005a ; Ashworth & Lucas, 2000). Similarly, I sought to explore teachers' and leaders' perspectives to improve their training programs to better their learning outcomes and, therefore, their competencies and teaching practices. In their study in the health care sector, Jan Larsson and Inger Holmström (2007) have illuminated that phenomenographic study results can be used in studies aimed at developing learning and competence development. They argued that the role of phenomenography studies has advanced beyond describing conceptions to using the outcome space in educational interventions.

3.2 Research Implementation

In the following, I mainly discuss the research design, including recruitment and sampling procedures, the pre-task given for participants to perform prior to the interviews, and collecting, transcribing, and analyzing the data.

3.2.1 Research Design

Recruitment and sampling procedure

In order to obtain maximum variations of the conceptions of the phenomenon to ensure sufficient data to be able to derive the optimal set of categories and applicability of findings, and to avoid superficiality in the data, the number and diversity of participants in the study are important factors to consider (Kettunen & Tynjälä, 2018).

As previously noted, I have chosen to interview Finnish ECEC teachers and leaders. Specifically, leaders who had previous experience as ECEC teachers and are now leading in the ECEC context. The rationale for this choice is that not only can these leaders provide us with their own insights about EN, but they also can give some insights regarding the perspectives of the teachers they lead. The sample substitutes 5 Finnish ECEC teachers and 5 Finnish ECEC leaders. Four of these leaders are ECEC center leaders, and one is a head director of ECEC in a city in Finland.

One of the challenges I faced in the research process was recruiting participants. The reason is that I have been studying for my master's degree fully online because of the Covid-19 situation. Therefore I never visited Finland and have a very limited network of Finnish persons. Purposeful sampling is the recommended method in phenomenography to maximize diversity (Kettunen & Tynjälä, 2018). However, for this study, I used both snowballing and purposeful sampling (Tracy, 2019). At the beginning of the research process, I did not have the luxury of selecting certain participants from a pool of prospective ones. Therefore, my supervisor and I first aimed to use the snowball sampling method. And indeed, six of the participants were recruited from my supervisors' network and my limited network of Finnish ECEC teachers and leaders. Participants from my network are mainly fellow students whom I knew from attending my master's courses. I asked these six participants to recruit other participants from their network, however, all potential participants they reached out to refused to participate in the study mainly because they were not comfortable being interviewed in the English language or because they were not comfortable with the subject of the interview. Regarding the latter reason, they assumed that they had to have sufficient knowledge in neuroscience to be able to answer the questions of the interview, although this was not the case.

Then, (after several unsuccessful attempts to recruit more participants), I thought of using my LinkedIn profile as a possible solution to recruiting the rest of the needed participants. I used LinkedIn as a way to enact purposeful (Åkerlind et al., 2005) sampling as I could look for participants of different backgrounds to try to ensure the diversity of chosen participants (Tracy, 2019). I tried to select heterogeneous informants; that is, they are intuitively likely to seem to have different worlds in terms of interacting with the object of the study. This is because the core premise of phenomenography is to gather a wide range of conceptualizations/experiences (Ashworth & Lucas, 2000). Therefore, in my search through the platform, I considered the diversity from the aspects of age, gender, the city lived in, the university graduated from, the school worked in, the scope of interest, and professional and academic backgrounds.

Regarding the adequate number of participants in the study, some researchers suggested that the sample size should be between 15 – 20 (Hajar, 2020); however, others suggested that 10 – 15 participants would be an adequate sample number to capture the range of variations of understanding the concept in question (Åkerlind, 2008; Kettunen & Tynjälä, 2018; Trem, 2017; Trigwell, 2006). The sample size of this study is 10. Although a sample size of 10 was the minimum recommendation, some researchers reported data saturation from only seven participants. It is also worth noting that, in a recent study that had a sample size of 1622, the researchers reported that the large sample size did not provide value for the search results as the same result would have been found with a very much smaller number of participants (Kettunen & Tynjälä, 2018). I intended to recruit at least nine more in addition to the 6 participants recruited by the snowballing sampling, so the sum would be 15 participants. To do so, I dedicated a considerable amount of time for several weeks, searching through LinkedIn profiles of the prospective participants and choosing whom I would contact. I had to find and individually contact around 130+ persons; however, the result was getting the confirmation to participate from only four. Although my original plan was to recruit more participants than the actual ones, I am satisfied that I succeeded in recruiting the minimum number of participants recommended for phenomenographic studies.

I could say that the spread of the characteristics of interviewees has bettered the findings and applicability of these findings. However, due to the limitation of not being in Finland and having a limited network of Finnish people, I must say that the spread of the characteristics of the interviewees could have been better. I will elaborate on this point in the research limitation section.

Regarding participants' characteristics, one participant's level of education is a Bachelor's level, one is of a Ph.D. level, and the rest are of Master's level. They have done their studies at the universities of Helsinki, Jyväskylä, Eastern Finland, Oulu, and Tampere. I present an overview of the participants' characteristics in Table 2.

Table 2

Participants' characteristics (F= Female, M= Male) (work experience in years)

Informant	Bachelor	Masters	Teachers' work experience	Leadership experience	Other roles with children	Current Role	Age	Gender
1	X	X	24	1		Leading & Stuying	48	F
2	X	X	Less than a year		Nurse (2.5y)	Studying	36	F
3	X	X	4			PhD Researcher	34	M
4	X	X	6,5			Studying	30	F
5	X	X	8	5	Nurse (3y)	Leading	39	M
6	X		2,5		Nurse	Teaching	30	M
7	X	X	5,5	2,5		Teaching & leading	31	F
8	X	X	10	1		Leading	33	F
9	X	X	17	0.5		Teaching & leading	40	F
10	X	X			Teacher assistant (4y)	Studying	29	F

Pre-task before interviews

A pre-task was given to participants to perform before the interviews to orient them towards the study, and provide an example of how neuroscience could be related to education. Moreover, I aimed to collect background data to support suggesting a structure of presenting EN knowledge to teachers. The task contained two texts to read and then a reflection on each after reading, and a third reflection on a comparison between them. Surveys were adopted from (Tham et al., 2019, p. 170). The first text was an abstract of a neuroscience study discussing the subject of the influence of physical activity on the brain and learning. One may find this usual neuroscience abstract when searching for one of the neuroscience findings related to education (see APPENDIX 1, Pre-Task to read 1). The other text is an article I produced discussing the same concept, however, written in a way that is, I predicted, to be more understandable and acceptable for teachers who do not have a neuroscience background as I used a simplified language and content that is more related to educators. This article constitutes a suggested structure for presenting EN knowledge to teachers. The first part contains an introduction to the neuroscience concepts to be discussed in the article. The second part introduces the EN concepts. The third explains, in particular, how these EN concepts are related to learning performance. The final part includes concrete suggestions of applications for utilizing the explained EN concepts that could be easily applied in schools by teachers and leaders alike (see APPENDIX 1, Pre-Task to read 2).

Along with orienting participants to the subject of the study, this pre-task aimed to investigate how participants perceived the two pieces of texts discussing the same EN concept. Moreover, I wanted to capture my participants' evaluation of the appropriateness of the second article to be further used in teaching teachers about EN knowledge. Some participants were reluctant to participate until they reviewed the text written in the pre-task, then, they realized how neuroscience could be closely related to education and their teaching practices and therefore were motivated to further participate in the study.

Data collection (interviews) and transcription

Collecting data through interviews

I used the recommended and most common data collection method in phenomenography, which is oral, in-depth, semi-structured interviews using open-ended questions (Marton, 1986, 1994). I conducted interviews with the 10 participants via Zoom application, and they lasted an average of 60 minutes. Interview questions were emailed to the participants to review before we met for the interview. Overall, the focus of the interviews was on the relationship between the phenomenon in question and the informants and how the phenomenon is conceptualized by interviewees rather than focusing on the phenomenon or the interviewees themselves (Hajar, 2020).

Regarding interview questions, I have carefully prepared them to fit phenomenographic research (Hajar, 2020) (See APPENDIX 3). I then consulted four other researchers about these questions, and I edited and modified them after we collectively discussed how to make questions better fit, given the study's goals and approach. The first researcher I consulted was my supervisor. Regarding the other three, two of them were master's level fellow researchers, and the last was a Ph.D. level phenomenographer researcher.

I conducted one pilot interview (Sin, 2010) before starting with the actual ones; of course, the data from this pilot study was not used in the analysis of the study. Given that the number of interviewees was limited, I conducted the pilot interview with my supervisor as a participant. She could be considered as an eligible participant as she is a Finnish university teacher and researcher in early childhood education with extensive experience in this field. As this is my first research in academia and, therefore, the first time for me to conduct such an interview, the pilot interview with my supervisor was indeed beneficial and fruitful. It helped me to improve my interview techniques in practice. Moreover, it made me aware of all aspects of conducting an online interview, including technical, time management, and clearly communicating my questions and thoughts to interviewees.

During the interviews, I gave participants the space to speak freely and gave enough time to comfortably talk, express themselves, and reflect (Ashworth & Lucas,

2000) by continually telling them to take their time in expressing their thoughts and that we always had enough remaining time. Moreover, I noticed that the interviewees felt stressed as they were sometimes struggling to articulate and communicate their thoughts in English, and this is normal as they are not communicating in their native language. To alleviate their stress and make them more comfortable, I consistently said at the beginning of the interview session that we are both (me and the participant) non-English natives, and I understand how one can sometimes struggle to articulate their thoughts, as I have experienced the same situation. I told them that they could use the simplest words to articulate their answers, and they could use any translator to translate words from Finnish to English if they needed to, and I would wait for them to do so. After hearing this, I received a relieving smile from my participants, and several of them used the translator during the interview to translate some words they wanted to communicate.

Moreover, at the beginning of each interview, I briefly explained my study and re-ensured that it did not require them to have any neuroscience background. Furthermore, I explained shortly the approach I am using, which is phenomenography, and I cleared that this approach requires that I ask probing questions to confirm my understanding of their responses and to understand their deep understanding of the phenomenon. I did this so they become prepared and expect these questions and understand why I am asking these follow-up questions that were not in the interview file questions I sent them before the interview. Finally, I remained present and empathically and attentively listened to their talk with welcoming, understanding, smiling, and encouraging facial expressions (Sin, 2010).

In phenomenography, the researcher should interact and engage with the study's participants without influencing or leading them (Hajar, 2020). During the interview, I used the intentional-expressive approach (see Anderberg, 2000) as a strategy to clarify and confirm participants' expressions and the intended meanings they wanted to communicate. I will elaborate on this approach later, however, to follow this approach, participants were asked questions about the phenomenon, and then follow-up, prompting, and clarifying questions were asked to encourage them to clarify and reflect on the expressions and thoughts they have said. Examples of

general follow-up questions asked are: what do you mean by that? Could you give me an example that illustrates your response? Would you please explain your response further? And is there anything else you would like to say regarding this subject? Examples of specific follow-up questions that have been asked in specific parts of the interviews are:

EX1:

Interviewee: "I think nowadays, you, you combine, these two things, education, neuroscience, they are combined together."

Interviewer: why do you think that they are combined? Or should be combined?

EX2:

Interviewer: What do teachers want from the neuroscience literature? From your point of view as a teacher?

Interviewee: "I think they want not just the theory, of course, it is important, but the practical ways to do or ideas or, or, like curriculum, or some learning plan. How, how to do and, and what to do. And then and of course, teachers need to know why they are doing it."

Interviewer: Is it important for the teacher to understand "Why" they are doing a certain practice that stems from neuroscience? Does it make a difference?

Transcribing the interviews

I solely transcribed the audio recording of the interviews verbatim (Larsson & Holmström, 2007) in 130 pages. Transcribing is an important stage in the research process, and to ensure the quality of transcribing and the validity and reliability of the transcribed data, I did the following. As phenomenographic research investigates participants' intended meanings and expressions, data was transcribed without any restatement or interpretation to ensure reliability. Since oral meanings are usually contextual and more complex than text, a careful intention was paid to keep the meaning without change when transforming the oral data into written text.

In the following, I present my documentation of the transcribing process, wherein I elaborate more on how I tried to keep faithful to my participants' conceptions and interpret their thoughts within the context of the transcripts.

In order to avoid the risk of misunderstanding and misinterpreting the data in the analysis process, I tried to address the limitations of transcription. First, I am the sole interviewer for all interviews, and conducting all interviews ensured, to a great extent, understanding of the context of the conversation and therefore remembering the context of the conversation when reading the transcribed text and relating this context to the text. In order to not lose touch with the context of the oral data and keep mental awareness of contextual features of the conducted interviews, I did the following: I transcribed the interviews shortly after they were conducted, listened several times to the recordings before and after transcribing them as a whole entity, started the analysis immediately after finishing the interviews, and also listened to parts of the recordings during the process of analysis to refresh my memory of the context of the particular part I was analyzing (Sin, 2010). I deliberately took short breaks during the analysis process, as Åkerlind and colleagues (2005) advised, to return to the data and the whole process with a refreshed and open mind.

Data Analysis

One aspect of phenomenography is that variation in its practices is accepted. Of course, there are standard core practices and clear guidelines that a phenomenographer should follow, and there are several commonalities within its practices; however, there are some accepted variations in its methodological approaches and methods (Åkerlind, 2005b). In this regard, Hasselgren and Beach (1997) commented that there is no one agreed-upon method of phenomenography; consequently, phenomenographic analysis could be conducted in several ways. The focus could be on the whole transcripts, on large pieces of each transcript, or on quotations pulled out from the transcripts (Kettunen & Tynjälä, 2018). The researcher is to determine the way of proceeding (Kettunen & Tynjälä, 2018). In analyzing my data, I used the selected quotations approach (Marton, 1986). Phenomenographers argue that this approach helps the researcher in interpreting the data and in focusing on the collective

meanings rather than the individual ones (Åkerlind et al., 2005). For Åkerlind and colleagues (2005), phenomenography is differentiated from other qualitative approaches as it focuses on awareness rather than beliefs, context-sensitivity rather than stable awareness, interpretive rather than explanatory foci, connected rather than distinct meanings, and collective rather than individual understanding and experiences.

I aimed at developing categories of description (grouping of different aspects of the phenomena) that describe the meanings discovered from the data (Marton & Booth, 1997). Generally, there are two phases of the analysis process in phenomenography. The first includes identifying and depicting participants' understanding or experience in terms of its meaning. The second involves distinguishing the structural relationships among the identified meanings; these meanings are comprehended from the utterances in context (Kettunen & Tynjälä, 2018). The following described steps of my analysis follow examples and guidelines presented by Åkerlind (2005), Kettunen and Tynjälä (2018), Marton (1986), and Marton and Booth (1997).

I started the analysis just after collecting and transcribing the data. In the pre-analysis phase, I first read the whole set of transcripts as one entity wherein I initially looked for meanings, aspects, themes, or domains commonly mentioned in the transcripts (Kettunen & Tynjälä, 2018). Then, in the first phase of analysis, I listened to the recording of each participant and read through the transcripts several times, and while doing so, I pulled out any quotation or piece of text that seemed to address a particular aspect or theme related to the phenomenon in question. Thereafter, I kept adding meanings extracted from all transcripts and ended with a "decontextualized pool of meanings" (Marton, 1986; Marton & Booth, 1997). Then, I read and reread these emerged meanings to identify similarities and the differences in the meanings expressed by the informants and grouped those that appeared similar or addressed the same theme together (See APPENDIX 4 for a sample). These themes are called (dimensions of variations) as they indicate the aspects or elements differentiating the categories (Kettunen & Tynjälä, 2018). I eventually derived a set of first draft categories from the identified collective meanings. This process required several iterations of going through the quotations and going back and forth between the

original transcripts and the analytic outcome to check the context related to a specific quotation (Hasselgren & Beach, 1997). The reason for this repeated checking is first to compare and contrast differences and similarities of meanings and secondly to assure the accuracy of developing these meaning statements. By accuracy here, I mean how accurate the developed meaning reflects how participants experience and understand the aspect in question and what the participant intended to say.

In the second phase, I precisely identified the themes (dimensions of variation). And I went through the created categories trying to find the key structural, logical relation between the categories of the same theme. Participants expressed their understanding of these commonly mentioned aspects in different ways, and these ways of thinking could be arranged from the least complex to the most complete and complex. I focused on one theme at a time and sought different levels of understanding from the participants (Marton & Booth, 1997). With reference to the data, categories of description in this phase were accurately defined and labeled in accordance with the categories' most characteristic features (Kettunen & Tynjälä, 2018).

Throughout the analysis, I was oriented toward phenomenography's common standard core practices. I maintained an open mind for the emergence of new perspectives and for discovering new insights of meanings (Åkerlind et al., 2005); I did not pre categorized the categories in advance; I was aware of and tried to bracket out (Richardson, 1999) my predetermined views regarding the phenomenon and therefore allowed the logical and relational structure of the outcome to be evolved from the data directly with minimum reflection from my judgment (Åkerlind, 2005b; Kettunen & Tynjälä, 2018).

Moreover, I was directed towards the collective experience rather than the individual by focusing on the whole transcript and the developing categories as a set. In particular, when a meaning emerged from a transcript of one participant, I utilized this meaning in the process of identifying the similarities and differences among other meanings and identifying the relationships among the categories of the whole set of transcripts (Åkerlind, 2005b). Finally, I tried to ensure that the output follows the criteria of a quality outcome space suggested in (Marton and Booth,

1997). Namely, each category holds a distinctive aspect of the phenomenon, categories should be parsimonious, and the relation between them should be clearly stated.

Through exploring phenomenographic research studies, I found that researchers have several ways of developing the data into outcome space. And the outcome space itself is represented by phenomenographers in different ways. I intended to analyze the data for the current study to develop the outcome space portrayed in Table 3, which looks like a "multidimensional jigsaw puzzle" (Marton & Booth, 1997, P. 153). Results were presented holistically, containing the defined categories arranged from the least to the most complete or complex. These results are directly developed from the data, and the table contains the categories of description and dimensions of variations. Moreover, the table portrays the logical and structural relationship among categories describing qualitative differences in subjects' understanding of the investigated phenomenon (Åkerlind, 2005b; Åkerlind et al., 2005).

Conceptions in the table are backed up with quotations presented in the study's results section. Although in this approach, participants' conceptions are explored, the researcher's voice in reporting the findings is inevitable. I carefully selected and included a rich set of quotations from the interviews to support and clarify that the reported conceptions and categories are conveyed directly from the participants. This is necessary evidence for the reader that the researcher's voice in reporting the findings did not influence the participants' conceptions of the phenomenon.

In sum, I sought to develop logically related but qualitatively (Svensson, 1997) different categories of description (outcome space) that are of a hierarchical nature (Åkerlind, 2005b, Hajar, 2020). These categories indicate various ways of understanding EN expressed by the subjects of the study. From these categories, a "collective mind" map or a collective intellect was produced (Hasselgren & Beach, 1997). Of course, ideally, the results should represent the full range of conceptualizing the aspect of reality, however, the study is limited by the collective understanding of the sample group of Finnish teachers and leaders.

This process was demanding and complex for me as a new researcher and a first-time phenomenographer. Therefore, I reached for advice and regular discussions with an experienced phenomenographer for guidance and quality assurance.

We met several times during the analysis process via zoom for 60 to 90 minutes sessions, and we were involved in deep discussions about phenomenography in general and about the data of my study in particular. Her vision, comments, directions, and advice were of invaluable help to me as a novice researcher and for ensuring the quality of data from the perspective of the phenomenography research approach.

3.2.2 Ethics, confidentiality, and the integrity issues

A critical attribute to the quality of any research is the ethical conduct of the researcher. The research was conducted based on the principles of research integrity of the European Code of Conduct for Research Integrity published by (All European Academies, 2017). These principles are reliability in assuring research quality, honesty in processing and delivering the research, respect for all who are related to the study, and accountability for the research. Additionally, the study was administered in compliance with the guidelines of responsible conduct and ethical principles of research (Finnish Advisory Board on Research Integrity, 2012). Namely, by following principles of meticulousness, integrity, and accuracy. Moreover, data acquisition and research evaluation methods were ethically sustainable and complied with scientific criteria. The results were accurately recorded, presented, evaluated, and communicated in a responsible and open manner.

A proper course of action and research ethics were implemented by maintaining the confidentiality of the study's participants. This was done by preserving their anonymity by withholding their names and other details, such as schools or institutions they are currently working at, to prevent the recognition of their identities. Moreover, published quotations were anonymized.

Using the university U-drive to store the interviews' recordings and personal data was another measure I used to ensure the security of the data and, therefore, confidentiality. Measures to ensure participants' voluntary participation in the study were taken, and I explicitly cleared that they were free to withdraw from participating in the study without any consequences. Moreover, I received consent from participants before participating, and I informed them of the nature of the study and explained its purpose and implementation.

As a researcher, I ensured following the standards of scientific knowledge in the process of planning and administrating the research. I moreover ensured the accurateness, integrity, and truthfulness of the data findings and that they were presented in a complete, accurate, and honest fashion.

4 FINNISH ECEC TEACHERS' AND LEADERS' CONCEPTIONS OF EDUCATIONAL NEUROSCIENCE

Analyzing the data revealed four categories of description that reflect participants' conceptions of educational neuroscience (See Table 3). Educational neuroscience is conceived to be 1-useful to the learning process 2- improves the learning process 3-significant to the learning process 4-the whole basis of learning.

Moreover, the data illuminated eight "dimensions of variation" that are the aspects that differentiate the diverse ways participants conceptualize the phenomenon of educational neuroscience. These different ways of understanding are arranged in a hierarchy of inclusiveness, therefore, some conceptions are more complex and complete than others. They are organized so that participants' understanding of the phenomena expands from the least to the most complex and complete understanding (Åkerlind, 2005b; Hajar, 2020; Marton & Booth, 1997). Dimensions of variation are: what is educational neuroscience about, teachers' understanding, teachers' attitudes, teachers' agency, teachers' current EN knowledge, EN in teachers' formal education, adding EN to teachers' formal education, and finally, how EN should be presented to teachers.

In the following, I first elaborate on and describe each of the four categories of description, utilizing quotes extracted from the transcripts. Providing quotations is critical to support the trustworthiness of a phenomenographic study as they are the evidence of the link between the phenomenographer's interpretation and data collected from the participants (Åkerlind et al., 2005). Quotations of the current study may be richer than other studies as I aimed at providing illustrative quotations relevant to each conception. Then, I address the aspects (dimensions) of variation through explaining the heretical relationship between the categories.

Table 3

Final Outcome space – Conceptions of Finnish ECEC teachers and leaders of Educational Neuroscience

Dimensions of Variations	*Categories*			
	Useful to the learning process	**Improves the learning process**	**Significant to the learning process**	**The whole basis of learning**
What is Educational Neuroscience (EN) About	Limitations of learners' brain	Possibilities of learners' brain	Connection between learners' emotions and brains	Learners holistic development
Teachers' Understanding	Effects of external influences on brain	Behaviors and emotions of learners	Reasons behind own practices	Expand practices repertoire
Teachers' Attitudes	Coping with situations	Adapting with situations	Affecting teachers' teaching styles	Affecting teachers' behavior
Teachers' Agency	Less doubtful	More confidence	More self-aware	More power
Teachers' (Current) EN Knowledge	Quite bad	Basic	Not cohesive	Not deep enough
EN in Teachers' Formal Education	Not taught in formal education	Rarely taught in formal education	Should be added to professional development courses	Should be lobbied more to be taught in universities
Adding EN to Teachers' Formal Education	Useful	Helpful	Important	Valuable
How EN Should be Presented to Teachers	Easy without excess information	Translated to the education language	Connecting theory and practice	Related to teaching and life

4.1 Categories of description

4.1.1 Educational Neuroscience is useful to the learning process

Participants of the study conceived EN to be *useful to the learning process*. Informants described the usefulness from several angles. One angle mentioned

was that learning about how the brain learns, develops, and works supports children's learning, and are needed knowledge to learn better as a teacher and to teach and educate children easier. Another angle was that EN knowledge helps teachers understand their learners' individual needs. A third angle concerned how EN knowledge is useful, particularly for teaching and dealing with children of special needs. Another angle was that learning about how the brain works allows teachers to better design the learning environment to be more brain-friendly.

> "I think that knowing the basic findings from neuroscience is very important when trying to support learning process. Because if you do not know how to support brain work, you cannot effectively support children's learning"

> "I think it is very important to know how brain works. And why, it is because I think that it is the way how you know how to teach, and raise and educate children"

> "when you understand how your brain works, you can learn easier by yourself. And that is that is the way you can teach easier"

> "I think that when you understand this kind of things you can focus on different kinds of the learning process...[and] understand the child's individual needs"

> "I think there is also like, things that you can use if a child has some like a special needs, like maybe like, autistic or like ad ADHD… then you can you can know how these kids brains are like functioning because they are not maybe like normally functioning brains."

> "the surroundings must be brain friendly also...so it is not that only the physical surroundings but then brain friendly surroundings"

Under this category, informants perceived EN to be about limitations of learners' brains. Participants explained that learning about and further understanding brain mechanisms and how the brain develops and functions will help them recognize the biological limitations of the brain in general and the limitations of young children's not fully developed brains. They expressed the usefulness of learning about these limitations when teaching in several ways and mentioned

that they should consider them in different aspects when teaching young learners.

> "we know something about how the brain usually works, but we also have certain limitations that we have to consider when we are asking someone to do something or when we are talking about small children that that are still developing regarding the the brain brain"

> "but it's really important that you understand that children do not have every mechanism that adults have"

Regarding teachers' understanding, participants expressed how learning about the effects of external influences (such as sleep, nutrition, and exercise) on the brain is useful to the learning process. They mostly used the example of sleep; however, a few mentioned external influences such as nutrition and exercise. They explained that learning about how these factors influence the brain is useful in improving their understanding and, therefore, practices. Moreover, it is useful in justifying their practices to learners' parents and coworkers.

> "And I think neuroscience is one good starting point, where you can think…has [the child] rested enough…So does he have any energy?... because that all affects your brain"

> "I think all of us, we know how it is going to affect you if you do not sleep or you do not eat. But when you have also the knowledge of the how it affects the brain…at least for me, it works. So that I started to think more about how I act as a teacher. How I plan my own work to be ready for those children who have not slept, because they cannot concentrate"

> "because when you understand that, you can also tell the parents and everyone else why we do that [put children to sleep in the day time]. That is very important"

Educational neuroscience's usefulness to education is manifested in its influence on teachers' attitudes. In this category, participants explained how learning about educational neuroscience helps them cope with different situations within the context of teaching and learning.

> "And you have to understand how the brain functions when the kid is like a hyper active or how to cope with the hyperactivity or like these kind of a thing"

In this category, teachers expressed that learning about the neuroscience of learning and teaching affects their agency by making them less doubtful and less worried when choosing the right strategy to apply to their learners in certain situations.

> "but I did doubt myself. If I had deeper understanding about about these things, I do not think I would have doubted myself and I am worried myself...Instead of if I if I had enough knowledge I would not doubt myself and I probably would do the right thing"

Concerning the teachers' current knowledge in EN, they expressed that their knowledge is quite bad. They also mentioned that, as far as they remember, EN is not at all taught in teachers' formal preparation programs. On the other hand, their opinion was that adding EN to teachers' formal education is useful to their knowledge as teachers and, therefore, the learning process. Finally, they expressed that it is preferable if EN content be presented to them in an easy way without excess information.

> "Well, my, my, my neuroscience literacy. It is quite bad. It is, it is, I think it is all that I learned in high school. And it is like, million years ago"

> "we did not talk about like how the brain actually works. We only talk about how the children are learning. But we did not talk about how they are related to the brains"

> "in university, we did not have any kind of studies that was about that"

> "I think that it would be very useful if that kind of information was taught in teacher preparation"

> "but then you make [a specific] book where you don't have to write write everything so ya maybe not methodology or difficult things in the book so it is it is different but easier to read."

4.1.2 Educational Neuroscience improves the learning process

In our second category, participants' understanding started to go one step further. All ten informants conceived EN and neuroscience's findings related to education to have the potential to improve *the learning process*. Participants explained that EN is about learning, recognizing, and acknowledging the evidence-based biological possibilities of the human brain.

> "[applying EN findings in education is] definitely important…[and it] is vital in improving, improving learning"

> "But I think for me, it is then a way of, of appreciating the knowledge that we have about the also the possibilities…that a human brain has regarding of learning"

In the dimension of teachers' understanding, participants explained that EN improves the learning process in the sense that it improves and deepens teachers' understanding of the behaviors and emotions of their learners and the biological underpinning of them. They explained the difference between learning about learners' behaviors and emotions from only the behavior science side and if they add to their knowledge the neuroscience side. They emphasized how the neuroscience side adds an important perspective, deepens their understanding, and teaches them the "*Why*" behind what is happening, such as why a child is behaving in a certain way or why he is feeling this way "brain-wise."

> "I think it is very important to know how brain works. And why it is because…you know, what to do with them, why they are behaving the way they are behaving and how you can impact to their behaviour and your own behaviour"

> "And we understand that the children can be behaving and doing things because of the neuroscience. And not just because they want to be bad or they want they just do not want to listen"

> "I maybe maybe could manage without knowing [about behavior from the neuroscience side] but I think it deepens the understanding of the behavior and what is going on. And I think it is important to know"

> "I think these these kind of things was quite important like how emotions and how feelings are related to your brains. And I think this kind of like brain kind of like knowledge is important also for the teachers"

In terms of how improving the neuroscience literacy of teachers affects their attitudes in a way that improves the learning process, participants mentioned that this knowledge helps them understand and adapt to different situations that they continually face when teaching young children and adapt to learners' needs. Regarding teachers' agency, they mentioned in this category that this knowledge gives them more confidence in choosing and applying the appropriate strategy or intervention to their students.

> "I think you have to have some kind of knowledge of how the brain works…because that you can adapt your key theme to the, like child needs…And you know about how the brain works, and how that kid can learn, and what kind of ways there is to adapt your teaching"

> "deeper knowledge of how the brain works helps me understand the different situation of children better"

> "But if I had like deeper understanding I think I would have had even more confidence that this is the right strategy to take with our with this child"

In this category, teachers described their EN knowledge to be at a basic level, and they pointed out that EN is rarely taught in the formal education of preparing teachers. They believed that adding EN to teachers' formal education is helpful as it provides them with different tools and explanations of how brains learn, which helps them understand their job better and makes their job easier. They suggested that EN be presented to teachers after translating the information into the educational language.

> "I think that I have some basic knowledge about neuroscience. But not very detailed information."

"At the moment there is not that much in the university degree program when we talk about bachelor or master degree about this kind of like a neuroscience brain function kind of like information."

"I think it is very important because it really gives you different tools and explanations and, and ways to be with with children and understand your your job better. And also, it will probably make make the work a little bit easier, because you kind of understand the basic principles that come from how [our brains] work"

"I think [adding EN to teachers' formal education is] valuable and it will help you"

"when you think about just a plain teacher, it might be easier if somebody like translates the neuroscience studies to the education language"

4.1.3 Educational Neuroscience is significant to the learning process

Participants expressed a deeper understanding than in previous categories regarding all specified dimensions in the third category. They acknowledged that EN is *significant* and is a big part of education and learning. Moreover, they perceived EN to be about the connection between learners' emotions and brains.

"Knowing how the brain works is big a big part of education…because a lot of important things happen in the brain…I realized that it is a very, very big part of learning [and] about education"

"it has a significant meaning to education and I think nowadays, you, you combined, those two things, education, neuroscience, they are combined together"

"we have been talking a lot about children's self-regulation…and how it is affecting their ways to learn things…And I connect that also to neuroscience"

"[in EN] we learn about there is different sections in your brain and how they will effect on behaving. And I think these these kind of things was quite important, like, how emotions and how feelings are related to your brains"

Regarding the dimension of teachers' understanding, the significance of EN to the learning process is manifested in the way that EN improves teachers' un-

derstanding of the reasons behind their practices. Almost all informants expressed their desire for and asserted the importance of teachers understanding "*Why*" they do what they do and the theoretical, science-based and brain-based principles underpinning their practices.

> "Yes, definitely [applying neuroscience knowledge and findings in the education setting is important] because it brings your understanding in what you are doing with children, it goes way deeper, it is not just doing stuff with kids"

> "because I am a teacher, and that is my profession. I need to know why I am doing something. And what is the theory behind it"

> "I also believe that it is quite important to understand why we are doing certain things. Why do we why do we value…day naps? Or why do we value about like, movement activities or these kinds of things?"

In terms of how EN affects teachers' attitudes in a way that improves the learning process, participants' perceptions developed to be broader and deeper in this category than the ones before it. They illustrated that improving their neuroscience literacy positively affects their teaching styles. On the other hand, in terms of the domain of how learning about EN affects teachers' agency, participants stated that they were more self-aware when practicing teaching after learning about knowledge inspired from neuroscience findings.

> "understanding how the brain works…I think will affect your teaching style and…will affect how do you do your work? So I think it is really important as well"

> "I was more self-aware when we had the practice in the day care…And I think I was more calm and and and I was studying children more in a different way than before"

When moving to dimensions concerning teachers' EN knowledge and weaving it into their teacher preparation programs in this category, participants pointed out that their current EN knowledge is not cohesive. Moreover, regarding integrating this knowledge into teachers' formal education, they confirmed that it is important to do this integration, and they expressed their interest, desire, and

need for learning EN and therefore adding it to teachers' professional development courses. Regarding the dimension of how EN should be presented to teachers, they argued that it would be more beneficial for teachers if the knowledge is presented in a way that connects both theories behind brain-based learning mechanisms and practical strategies and approaches that are inspired from these brain theories. Additionally, they showed their desire to combine both behavior science and neuroscience with the educational material they would be learning from as teachers.

> "it is not that cohesive, the understanding [of EN and] it is there…between the lines…So it is there in my in in the way that I think about things and the way that I act, but it is not a cohesive conception"

> "I think the value is, it is a great value. I think it is, it is very important that you you learn learn about brain, when you are studying to become a teacher."

> "I think they want not just the theory...but the practical ways to do or ideas or, or, like curriculum, that or some learning plan how, how to do and, and what to do and then and of course, need to know why they are doing it"

> "the reality is so different. So, so maybe the connection between theory and practice should be better"

> "I think this combining…like the behavioural science, and then the neuroscience, how do they, like, talk together, use the same language. I think that is very important"

4.1.4 Educational Neuroscience is the whole basis of learning

In the final category, participants expressed the most complex understanding regarding each of our dimensions of variation. Participants' thoughts about what EN is about were more profound and holistic. They illustrated that how the brain is structured, developed, and functions are considered *the whole biases of learning*. Moreover, they described their understanding of EN to be related to the overall holistic development of students.

> "I think [knowing about how the brain works is] important because the whole basis of learning is actually in brain brain working, and how those brain cells are functioning"

> "like when they talk about children's holistic, or the overall growth or, or and development and health and well-being. Those things are, I think they are connected to the basis of neuroscience"

> "so the neuroscience is there, even though maybe the word neuroscience is not used as much, but it is like [about] that basic knowledge about children's overall holistic development"

In terms of teachers' understanding, participants explained that improving their EN knowledge helps in generally expanding their knowledge and practices' repertoire. Participants' understanding of how EN affects teachers' attitudes was expressed such that it affects teachers' overall behaviors in the teaching and learning settings. Regarding teachers' agency, participants described that EN knowledge empowers them as teachers.

> "you can expand your your repertoire, you can do a lot more things and and concentrate also on little things, which you might have not not knowledge before or noticed before"

> "I also change my behavior. I listen more, I do not try to make them do things that they are objecting"

> "[learning about EN] gives you more, I think, power when you have that info, information, how the brain works"

Moving on to the dimension of teachers' EN knowledge, participants described their knowledge as not deep enough in this category. Regarding EN in current formal education, they asserted that it should be lobbied more to be taught in universities. Concerning adding EN to teachers' formal education, participants stated that it would be valuable for teachers. Finally, they stated that the EN material should be related to teaching and life.

> "[in college] we did not go too deep in, in brain stuff "

"[EN] should be a lobbied more in the university"

"I think it is valuable to learn…when you are starting to like educate yourself as a teacher...They are, they are like a valuable kind of like information"

"it was easier to understand that it is explained in the way that you can relate it to your own life, like you do not have to…try to first understand that, then you are thinking, well, how this is related to my teaching, how do I implement it to my teaching"

"give you examples that you can actually relate to your own life. And then you can think that how this would actually relate to the children's life also"

4.2 Aspects of Variation and Relationship between the categories

The current study's data emerged from the transcription of the interviews conducted with 10 Finnish ECEC teachers and leaders. Through continually reading and going back and forth through these transcripts, eight main dimensions of variation (themes/aspects) have emerged. Participants' conceptions and understandings are arranged hierarchically (Åkerlind, 2005b). Their conceptions and understandings of each dimension are presented in a range, starting from the least complex, expanding, and reaching the more developed, complex, and/or complete ones across the four categories.

In the first dimension of variation, what is educational neuroscience about, participants first described it as the *limitation of the learners' brain* in the first category. Then, their perception bout EN expanded to be about *the possibilities of learners' brain*. Going further, their understanding of EN developed to be about the *connection between learners' emotions and their brains* where they illustrated how different behaviors are being practiced as a result of certain feelings and emotional states of students, and these emotions and emotion changes have a biological underpinning in the brain. Finally, participants' understanding of EN expanded in the final category to be about *learners' holistic development*.

The second dimension is the effect of EN on teachers' understanding. In the first two categories, where EN is conceived to be useful to the learning pro-

cess and improves the learning process, participants concentrated their thoughts around the learners. They first illustrated that EN improves teachers' understanding of the *effect of external influencers* on their students' brains, such as sleep and nutrition. Then, in the following category, they expressed a more deep perspective: EN knowledge improves teachers' understanding of the *behaviors and emotions of their learners*. A shift in their conceptions happens in the third and fourth categories, where their focus shifted on teachers instead of students. In the third category, they thought that EN develops teachers' understanding of the *reasons behind their practices*. In the most complex category, they believed that EN knowledge does *expand teachers' understanding and practices repertoires*.

In the third dimension, the effect of EN on teachers' attitudes, participants' understanding of the first two categories focused on the situations they face in an education setting. In the first category, they perceived EN knowledge to help teachers *cope with difficult situations* in the teaching and learning setting. In the following category, they noted that EN knowledge helps teachers *adapt with different situations*. A shift happened in the third and fourth categories where their thoughts leaned towards teachers themselves. In the third category, they conceived that EN knowledge affects teachers' *teaching styles,* and in the final most complex category, they perceived EN knowledge to affect generally *how teachers behave* in educating settings.

In the fourth dimension, EN's effect on teachers' agency, in the least complex category, participants believed that EN knowledge makes them *less doubtful* of decisions they take when, for example, applying a specific strategy or intervention to their students. In the following category, they believed that EN knowledge makes them *more confident* when making pedagogical and other educational decisions. Then, in the third category, their thoughts developed, and they expressed the belief that EN knowledge makes them *more self-aware* when teaching their learners. In the fourth and final category, they expressed that EN knowledge *empowers* them as educators.

The following aspects are more focused on teachers' EN current knowledge and integrating it into formal education. In the fifth dimension, teachers' current EN knowledge, participants evaluated their knowledge to be *quite bad, basic, not cohesive*, and finally, *not deep enough* in the final category. When describing and evaluating their own EN knowledge, they mostly talked negatively, that is, they had very little information in this area, and they expressed their excitement, interest, and eagerness to learn more about this field. Only one teacher expressed this domain positively, mentioning that her knowledge is quite well in this area, but still she complained that she does not have the appropriate EN vocabulary to use when discussing and explaining EN aspects with colleagues and parents.

In the sixth dimension, EN knowledge in teachers' formal education, in the first category, participants reported that EN is *not at all taught in formal education*. In the following category, they mentioned that EN is *rarely taught in formal education*. Moving to the third category, participants expressed their desire, need, and interest in adding EN knowledge to teachers' *professional development* courses. They illustrated that new neuroscience findings continually appear and develop, and it is beneficial for teachers to be updated by learning about these new findings even after they graduate through professional development courses. Participants emphasized that EN knowledge should be *lobbied more* to be taught in universities in the final category. They also asserted that this knowledge is even more important in the future.

In the seventh dimension adding EN to teachers' formal education, across the categories, participants believed this addition is *useful, helpful, important,* and *valuable* for teachers, learners, and for the teaching-learning process. All participants' responses were in the positive perspective, that is, all of them perceived the integration of EN into teacher programs to be beneficial.

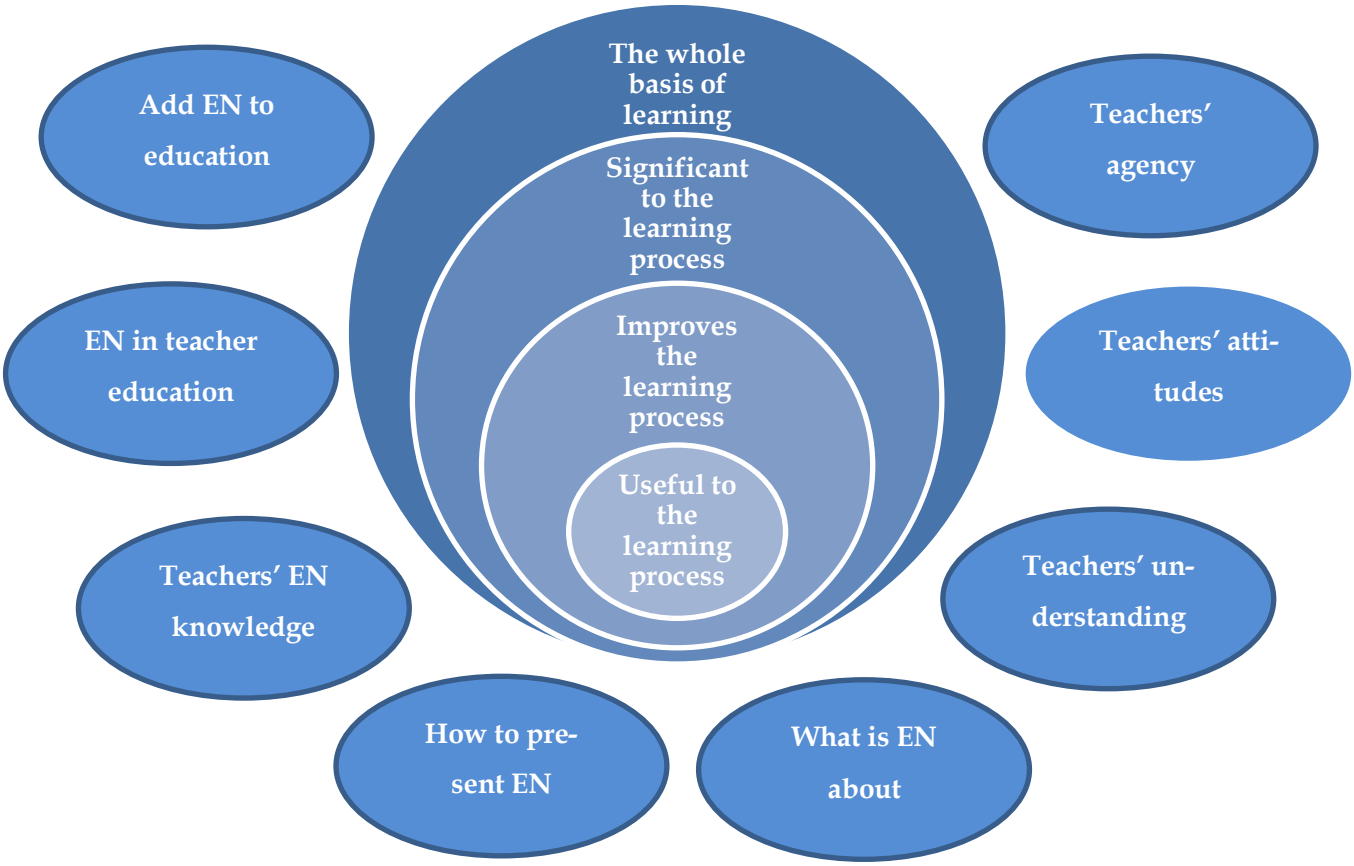
In the final dimension, how EN should be presented to teachers, participants firstly thought that EN information and knowledge should be *easy and without excess information* when presented to teachers. Moving to the next category, they mentioned that EN knowledge should be *translated to the education*

language. In the third category, they mentioned that EN knowledge should be in a form where the *connection between theory and practice* is clear. They also added that they would prefer that the material they study to combine both the behavior side and the neuroscience side. In the most complex and complete category, participants preferred that EN knowledge be presented in a way that *relates neuroscience knowledge to teaching in general and life*.

Figure 1 summarizes the results where it includes: Categories describing participants' conceptions of EN, the hierarchical logical relation between categories, and the aspects that differentiate the diverse ways of conceptualizing EN.

Figure 1

Categories, hierarchical relation between categories and aspects of variations



5 DISCUSSION

This study aimed to investigate Finnish ECEC teachers' and leaders' conceptions of the phenomenon of educational neuroscience (EN) and the variations of how they conceptualize it. The study revealed four categories and eight dimensions of variation that describe participants' conceptions and understandings of EN.

The categories of description are: Educational neuroscience is conceived to be 1- useful to the learning process 2- improves the learning process 3- significant to the learning process 4- the whole basis of learning.

The dimensions (aspects) of variation are: what is educational neuroscience about, teachers' understanding, teachers' attitudes, teachers' agency, teachers' current EN knowledge, EN in teachers' formal education, adding EN to teachers' formal education, and finally how EN should be presented to teachers.

In the current section, I start with examining the main study findings and how it is related or not to the scientific literature presented in the study. Several findings align with the aforementioned literature of the international community; however, it provides new insights in general and regarding the Finnish context in particular. I follow with a section regarding evaluating the study, then I touch on the research strengths and limitations, suggest further research and possible implementations, and I end with the summary and conclusion.

5.1 Examination of the Main Findings

The study's findings showed both similarities with earlier studies and new insights in regard to the phenomenon of educational neuroscience. I start first with similarities. According to the study, findings showed that educational neuroscience is important in informing education. This notion gained the consensus of participants and aligned with the literature regarding the potential of

EN knowledge in improving the teaching-learning process (Grospietsch & Mayer, 2019; Howard-Jones, 2014; Jamaludin et al., 2019; Papadatou-Pastou et al., 2017; Tan & Amiel, 2019). To be more specific, findings showed how EN informs education in terms of teachers and learners.

In terms of teachers, findings showed that EN knowledge improves teaching practices and expands teachers' practices repertoire, which aligns with (Feiler & Stabio, 2018; Howard-Jones et al., 2016; Tommerdahl, 2010). In supporting the observations of (Coch, 2018), findings showed that EN knowledge affects teachers' behavior and can interpret for teachers the reasons behind their practices. In this regard, most participants agreed that EN provides them with the answer to "why" do they do what they already do as teachers, and this helps them do their job better. Consequently, it could be concluded that EN deepens teachers' pedagogical content knowledge. Additionally, the neuroscience of learning information makes teachers less doubtful and more confident when choosing the appropriate teaching approach or intervention, which is congruent with (Edelenbosch et al., 2015; Howard-Jones et al., 2020).

In terms of learners, and in line with (Caragea et al., 2017; Carew & Magsamen, 2010; Thomas et al., 2019), findings showed that EN knowledge enriches teachers' understanding of the effect of external influences on learners' brains. They also showed that this knowledge makes teachers aware of the brain underpinnings of behaviors which is consistent with (Ramganesh & Hariharan, 2020) and makes them aware of the emotions of learners, and teaches them how to support learners' emotion development, which is consistent with (Feiler & Stabio, 2018). Further, EN allows teachers to be more understanding of their learners' behaviors and reactions, which sustains the findings in (Ramganesh & Hariharan, 2020).

Findings also showed that the neuroscience knowledge related to education complements behavior science knowledge. This indeed aligns with what educational neuroscientists say regarding the collaborative nature of disciplines in this field, which helps understand the underlying learning processes. The literature emphasizes the importance of both sciences in informing each other

and informing education without imposing a knowledge hierarchy (Dubinsky et al., 2019; Howard-Jones et al., 2016).

The study showed that the neuroscience literature is hard to: understand, interpret, and directly relate to classroom practices. Although participants were interested in improving their EN literacy, they confirmed that they would certainly prefer to read EN materials after being translated into the educational language. This finding is congruent with the literature reporting how neuroscience terminologies and conceptions are not easy to comprehend by educators; therefore, researchers recommended facilitating educators' access to comprehendible neuroscience literature (Feiler & Stabio, 2018). Consequently, the following finding showed that it is preferred that EN knowledge be presented to teachers in a way that is directly related to their practices. This finding is consistent with other teachers' preferences mentioned in earlier studies where it was pointed out that they prefer the neuroscience knowledge to be education-related (Dubinsky et al., 2019; Pickering & Howard-Jones, 2007) and directly related to improving their teaching practices (Tham et al., 2019). These findings also align with what was mentioned regarding one of the primary missions of the field of EN, that is, to act as a mid-way translator between the two fields of neuroscience and education (Feiler & Stabio, 2018).

A significant finding showed that EN promotes a more individualistic perspective of teaching and dealing with learners. It seemed that participants value the importance of individuality in teaching and regard EN as providing helpful knowledge that helps them better realize and understand learners' developmental rates, preferences, and needs, and therefore provide better-individualized education and intervention to their learners. The literature indeed reported that EN knowledge helps teachers fulfill their students' individual needs (Papadatou-Pastou et al., 2017).

In the most complex category, it was shown that EN promotes a holistic view of learning and learners. This aligns with (Dubinsky et al., 2019; Howard-Jones et al., 2016) that adding the neuroscience perspective to the behavior per-

spective makes the picture for teachers more complete, and it helps them to view learning and learners from a more holistic view.

The study showed that teachers' neuroscience literacy is limited. Nine out of the ten participants evaluated their neuroscience literacy negatively, for example, describing it as being quite bad, basic, not cohesive, and not deep enough. This finding shows agreement with that strand of researchers reporting about teachers' feelings that they lack information regarding how students' brains work (Schwartz et al., 2019). Moreover, it aligns with research reporting that teachers lack sufficient knowledge in EN after measuring how much in-service and pre-service teachers know in this area (Janati Idrissi et al., 2020). Although it needs further research in the Finnish context, however, the literature indicated that this limited knowledge could be a reason for the prevalence of neuromyths among teachers (Grospietsch & Mayer, 2019).

Another finding showed that EN is rarely taught in the Finnish ECEC pre-service teachers' formal curriculum. This finding aligns with the literature mentioned previously concerning the scarcity of EN knowledge in teacher preparation programs (Ching et al., 2020; Coch, 2018; Luzzatto & Rusu, 2020; Tibke, 2019). Findings moreover showed that weaving EN into teachers' formal education is useful, helpful, important, and valuable. This is consistent with researchers' calls for the importance of integrating EN in teachers' pre-service formal education (Ching et al., 2020; Coch, 2018; Dubinsky et al., 2019; Friedman et al., 2019). Although seeing EN as valuable to be added in formal education, in-service teacher participants showed their interest and eagerness to learn the neuroscience knowledge and findings related to education theory and practice through professional development courses. This notion also gained the consensus among participants of the study. This is consistent with earlier mentioned studies that reported the eagerness of teachers from different parts of the world to learn about neuro-educational knowledge and their potential classroom practices (Dekker et al., 2012; Luiz et al., 2020).

New insights were revealed related to how EN improves teachers' agency in making them more self-aware as educators. Moreover, another new insight

was related to the dimension of how EN knowledge affects teachers' attitudes, where it helps them to cope and adapt with different situations they face while teaching. One more new insight was that EN literacy gives teachers and leaders tools and vocabulary to justify their practices to co-workers and parents. The example mentioned was about napping. Participants eagerly wanted to know the neuronal biological underpinning of napping to persuade parents that the practice has a positive influence on their children's learning.

In summary, according to the discussion in the aforementioned findings, I could argue that EN knowledge has the potential to improve teachers' pedagogical professionalism, competency, and professional agency, therefore helping them in facing the increased challenges they meet in the fast-changing world. In justifying improving teachers' professional agency (PA), the literature review indicated that teachers' ability to develop their professional practices is one aspect of PA (Ukkonen-Mikkola, 2018).

5.2 Evaluation of the Study

The study aimed to produce pedagogical insights to inform universities' decision-makers regarding updating the current curricula of Finnish ECEC teachers with knowledge related to the neuroscience of learning. This aimed to be realized by exploring the conceptions of Finnish ECEC teachers and leaders of the phenomenon of *educational neuroscience* within the educational context and the *aspects* that differentiate the diverse ways of conceptualizing it. The aim of the study was realized. Participants provided valuable insights regarding EN, which could be utilized to update teachers' formal education. Specific suggestions for educational implementations are addressed in later sections. The study's knowledge could be considered new in terms of the Finnish context. However, in regard to the international context, some knowledge aligned with previous research indicated in the literature review, and some knowledge provided new interpretations of how teachers conceptualize EN in developing teachers' training.

It is worth noting that, to ensure the accurateness of the neuroscience information in the article I wrote (see APPENDIX 1, Pre-Task to read 2) of the pre-task, I sent it to an adjunct professor of behavioral neuroscience at the University of Jyväskylä to review before using it in my study. This is one practical way of enacting the collaboration between neuroscientists and educationalists in providing accurate EN information to teachers. Both articles of the pre-task and reflective questions are included in the appendix section.

In the following, I elaborate further on ensuring the quality of the study, with referencing to related literature.

5.2.1 Ensuring Quality – Trustworthiness, Validity, and Reliability

Although reviewing several studies addressing validity and reliability in phenomenographic research such as (Åkerlind, 2005b; Åkerlind et al., 2005; Collier-Reed et al., 2009; Sin, 2010), in my consideration of phenomenographic quality and trustworthiness, I principally followed Sin (2010) and certain aspects from (Sandbergh, 1997). Sin's description of quality considerations in phenomenographic research is, in my estimation, comprehensive –including most aspects addressed in the other studies – and descriptive, clear, and practically applicable among the ones I explored for a single phenomenographic researcher. It is worth noting that other procedures should be taken into account if a team of researchers administrates the study.

To ensure the quality of the current phenomenographic research, careful and thoughtful procedures have been considered at each research stage to ensure its quality. Rigor (validity and reliability) ensures that the object of the study is reflected by its finding. However, the quality of the research includes rigor and extends further than it (Sin, 2010). To ensure the quality of a phenomenographic research, produce a valid study, and convince the research community when evaluating it against commonly developed and agreed criteria for quality, I tackle several aspects concerning the issue of quality. First, I discuss quality from the lens of qualitative research rigor and quality. Then I discuss it from the lens of conceptual underpinnings of phenomenography and finally

consider the quality on the micro-level by enhancing and advancing each stage's quality and rigor (Sin, 2010).

In the following subsections, I discuss validity, generalizability, objectivity, and reliability aspects from the perspective of qualitative research in general and the perspective of phenomenography in particular. I also show and refer to examples of how I applied these principles in the current study to ensure quality in different stages of the research process.

5.2.2 Validity of the study

Validity in research, in general, refers to the internal consistency of the object, data, and findings of the study (Sin, 2010). In order to ensure the internal consistency and, therefore, defensibility of my research design, I previously defined phenomenography as a research approach that investigates individuals' conceptions, perceptions, and experiences of a particular phenomenon and describes the collective variations of the participants' conceptions (Marton, 1986). I then justified my choice of this approach. I also confirmed – referring to previous literature – the suitability of this approach in investigating social phenomena and enhancing formal higher education (Larsson & Holmström, 2007) and, therefore, its appropriateness and ability to satisfy the stated purpose of the research. In the results, I provided insights into how educators understand EN and its nature and scope. Finally, I ensured the consistency of the object, data, and study findings.

One of the main phenomenographic research validity issues related to internal consistency is ensuring the correct interpretation of interviewees' intended meanings of their expressions (Sin, 2010). I was aware of this issue in my study, and I interpreted and drew conclusions from the interviews' data with great reservation (Hammersley, 2003).

5.2.3 Generalizability and transferability of the research findings

In qualitative studies, researchers interpret the analyzed data derived from observations or conversations of a specific context and explore diversity in the

meanings of different phenomena. Therefore, "[g]eneralizability may be more appropriately considered in terms of transferability, which is the extent in which findings can be used or applied in other contexts" (Sin, 2010, p. 309). To realize transferability, I provided rich and adequate information about the study for readers to be able to make transferability judgments of their own (Sin, 2010).

As previously noted, in terms of phenomenographic research, one of its well-known applications is to improve education. Therefore, if the researcher aims to make the findings transferable, it is advised that he considers it early when determining the scope, research design, and participants' selection (Sin, 2010). As the secondary aim of the current study was to produce findings that would contribute in improving the Finnish ECEC teacher preparation programs, I have considered this at the outset of this research. Putting this in mind has directed my choice when determining the scope, research design, and participants' selection.

5.2.4 Objectivity and reflexivity Issues of the study

Sin (2010) explained that objectivity deals with the researcher's influences on the study process. This includes: how the researcher interacts and engages with participants, the researchers' relation with the phenomenon, and the researchers' subjective judgment when interpreting the study's data. She further suggests that reflexivity is the way to tackle the issue of objectivity. I enacted reflexivity by identifying and recognizing my preconceptions of the phenomenon in question at the outset of the study and continually questioned and dealt with, and minimized my subjective influence on the study at all its stages. This was realized by trying to explicitly document the research process to allow the readers to make their judgments. I attempted to provide information about the study for readers (Sin, 2010) to be able to make judgments of their own, such as, for example, describing the characteristics of the participants in Table 2 to allow readers to give their judgment of the data's diversity and therefore validity.

In terms of phenomenographic research, using the intentional-expressive approach (previously mentioned in the data collection section) in the interviews is one way to collect the accurate intended meaning participants intended to communicate in order to minimize the researchers' influence on the data by minimizing his interpretations of participants' expressions mentioned in the interviews. I enacted this by encouraging participants to reflect on and confirm the meanings they intended to express throughout the interview. The intentional-expressive perspective is:

> "concerned with the identification of relations between content of thought and language used…[therefore it] focuses on the relationships between language meaning and personal knowledge. It looks at the relation between semantic meaning and intentional meaning, and at how this relation is experienced in the way the words are found to be useful in expressing an understanding of the specific objects referred to" (Anderberg, 2000, p. 91).

In the data collection section, I presented my documentation of the interviewing process, wherein I elaborated on how I clarified participants' intended meanings in the interviews in reference to the intentional-expressive perspective and other guidelines.

5.2.5 Reliability in the study

Sin (2010) explained that reliability is widely defined by the extent of the study's replicability. She argued that the replicability of qualitative studies is not easily realized because of the unstable nature of its context and the unstable and dynamic nature of the social worlds. She added that it is expected that qualitative evidence does change over time, and therefore, qualitative studies are not conducted to be reproduced by further studies. Therefore, regarding the current study, it is expected that if further research is done for making fresh appraisals of the phenomenon after a certain interval of time, there could be inconsistencies in outcomes, and this inconsistency should not be considered a reliability failure.

Marton (1986) argued that the outcome space is a discovery that does not have to be replicable in terms of phenomenography. And as previously noted,

phenomenography is of a dynamic nature as reality is not fixed in space and time. Therefore, even if I conduct the same study with the same participants and ask them the same questions sometime after conducting the current study, it is acceptable and expected that the results could be different. This is because the same participants may go through new life experiences that would lead them to change their understanding and conceptions of the questioned phenomenon.

In this regard, Sandbergh (1997) noted that reliability in phenomenography must correlate with the epistemology underpinning it, therefore, the "inter-judge reliability," for example, is not a reliable phenomenographic reliability criteria. Sandbergh added:

> "Reliability as interpretative awareness, maintained through the phenomenological reduction, was suggested as one way of establishing reliability of phenomenographic results. It both takes into account the researcher's procedures in the research process and accords with the epistemology of intentionality underlying the phenomenographic approach" (p. 211).

In practice, I enacted Sandberg's (1997) view of interpretative awareness by being faithful to participants' conceptions**,** namely by checking and controlling my interpretation during the research process. This was done by acknowledging and dealing with my biased subjectivity instead of overlooking it. Sandberg further explained that entering into phenomenological reduction is one way to maintain interpretative awareness. I enacted this by withholding my prejudices and background knowledge of EN theories and related aspects mentioned in the literature, for example, when interpreting participants' conceptions. Keeping the researchers' biases and presuppositions aside allows them to fully engage with interviewees' conceptions and experience and interpret it as is.

5.3 Research Strengths and Limitations

In previous sections, several strengths were touched on, such as that phenomenography studies provide a holistic description that includes the variations and

similarities of peoples' conceptions and experiences of a particular phenomenon. And that its results could be utilized in improving education. Therefore, in this section, I will focus on the study's limitations. To start with, one weakness of phenomenography is the possibility of the researcher misinterpreting what his participants say regarding their conceptualization and experience of the phenomenon of interest. Moreover, phenomenography is criticized regarding the validity of the developed outcome space as it only depends on the personal judgment of the researcher. This implies the possibility of imposing bias on the research and ignoring the participants' voices, which contradicts one of the main principles of phenomenography, that is, the aspect of reality should be investigated only from a second-order stance. As the process of fully detaching the researcher from the study is not realistic, it was suggested first to be aware that the outcome space represents both the data and the phenomenographer's opinion in interpreting this data (Hajar, 2020). Then, to overcome this weakness, a rich set of quotations were provided to prove that the results were directly driven from the data without imposing the researcher bias.

Despite being designed and conducted with great carefulness, certain constraints were inevitable, and certain limitations existed. The following limitations are discussed to be addressed in further studies.

First is the limited number of informants. As previously noted, I intended to recruit 15 (Hajar, 2020) participants for the study, however, I succeeded in recruiting 10 (Trigwell, 2006). The reason is my limited network of Finnish people in general and particularly those in the ECEC field, as I have been studying the two years of my master's degree entirely online because of the Corona situation. I assume that the research could have been richer in terms of collected conceptions about EN from Finnish ECEC teachers and leaders if more participants had been recruited. However, 10 participants are satisfactory for successfully conducting the study (Åkerlind, 2008; Kettunen & Tynjälä, 2018).

Another limitation closely related to the first is the sampling approach in phenomenography. As previously noted, purposeful sampling is the recommended approach in phenomenography (Kettunen & Tynjälä, 2018) because the

researcher selects participants of a broad range of different characteristics. This is because it is assumed that this differentiation leads to collecting more diverse meanings from these diverse participants, eventually reaching a more holistic meaning of the phenomenon. Due to the limited options for finding participants, the first six were recruited by snowballing sampling. Although from snowballing sampling, I believe that the six participants were of different characteristics, which significantly conveys the study's requirements. The other four participants were recruited using purposeful sampling using LinkedIn. The variety of these participants could have been wider; however, I was limited by accepting those who agreed to participate, and they were, indeed, very limited. In further research attempts, it would be interesting and valuable to recruit an audience of more spread out characteristics such as, for example, participants who graduated from universities of applied science, as none of the ones I contacted replied to my request for participation.

The final limitation I would like to elaborate on is the language barrier limitation. The study is conducted using the English language and aims to collect conceptions and understanding of Finnish teachers and leaders. Both the researcher and participants are not native to the English language. This, I believe, is considered one of the limitations of the current study. As a result of this language limitation, I am concerned with the possibility of missing aspects of experiences participants could not or did not express due to the language barrier. To obtain a wider variety of frames of thought of participants on EN, it would be useful to conduct future studies by Finnish researchers and mediated by the Finnish language.

5.4 Further research and Possible implementations

Further research is welcome to extend the scope of the current research findings. It could be useful if research similar to the current study is carried out on non ECEC Finnish teachers as I firmly believe in the importance of EN for teachers teaching at all levels of education, from ECEC to university teachers.

Moreover, as previously noted, studies in this area could be made using the Finnish language to overcome the limitations of the mentioned language barriers. Furthermore, quantitative research could be done on larger populations to measure/evaluate Finnish educators' neuroscience literacy. In these studies, EN survey items in previously conducted similar studies could be utilized. Otherwise, Finnish EN experts could create a new pool of questions.

Additionally, studies could be made to explore the actual current use of neuroscience findings in teaching strategies in classrooms in Finland. These studies could measure the degree or rate of using these teaching strategies and their impact on teaching. In the same regard, it might be useful to investigate whether there are different rates of using EN strategies among teachers, if there are any. Moreover, studies may investigate the degree to which Finnish educators believe in neuromyths, the predictors of these false beliefs, and possible protective factors. Such studies could contribute to developing an EN curriculum added to teachers' formal education. It is moreover interesting and valuable to investigate university lecturers' conceptions and thoughts regarding the necessity of teaching EN to teachers in universities and their opinions of how it could be taught. Then, detailed research could be done on developing an EN university curriculum that would be added to teachers' formal education in a way that is appropriate for teachers and test its effectiveness and influence

On the other hand and regarding implementations, I recognize several opportunities for implementations that emanate from this research. Firstly, although still needs further research, I present a primary suggestion for a structure of one way to present EN knowledge to teachers that gained the appeal of the study participants. The material is structured as follows: The first part contains an introduction to some of the neuroscience concepts to be talked about in the article. The second part introduces the EN concepts that are utilized in the article. The third explains, in particular, how these EN concepts are related to learning performance. The final part includes concrete suggestions of applications for utilizing the explained EN concepts that could be easily applied in schools by teachers and leaders alike (see APPENDIX 1, Pre-Task to read 2). The

suggestion is derived from the results of the surveys, presented in Table 4 (see APPENDIX 2), reflecting participants' thoughts about reading two texts. In the comparison survey, all ten participants preferred the second text, found it easier to understand, and more relevant to their teaching practice, and it empowered them more to take action as teachers.

Secondly, the results of the study proposed the importance and usefulness of EN in improving the teaching-learning process and the importance of integrating EN into teachers' preparation programs. Therefore, one way to realize producing accurate EN material that is appropriate for teachers could be facilitated by creating a joint medium between neuroscientists and educators. In this medium, educators and neuroscientists could meet and discuss possible ways of producing such knowledge. In particular, it seems that it would be of great benefit if the University of Jyväskylä mediates a suitable medium for researchers from the education discipline to meet and discuss the future EN curriculum with researchers from the Centre for Interdisciplinary Brain Research (CIBR) (CIBR, 2021). The CIBR provides research support and facilities containing state-of-the-art techniques for measuring and stimulating the brain and neuroscientific research across different disciplines, such as learning and development. They have already developed research themes such as learning and cognition, well-being and health, and development across the lifespan. These themes are directly or indirectly related to education. Therefore, I could see that the foundation and grounding of this partnership are easy to be done, and there is a need only to encourage and facilitate this partnership to be activated and enacted.

Thirdly, based on the study's results, it could be suggested that universities consider updating their curriculum of teacher preparation programs to include EN knowledge in the upcoming curriculum update. Although the curriculum is indeed compact and it is challenging to add new information to it, according to the findings, adding even concise EN knowledge to the curriculum seems to have a promising potential for improving teachers' pedagogical competency and professional agency.

Fourthly, the study's findings are not only valuable for the initial teacher-training of ECEC teachers but also significant for professionally developing all in-service teachers. Therefore, based on the study's findings and utilizing the aspects identified in the study, it seems beneficial if research is continued to develop an in-service educational neuroscience teacher-training manual and module that aims to deepen teachers' pedagogical knowledge and professional competency. Certain conceptions of the outcome space could serve as pedagogical guidance for training in-service teachers. This includes what to present to them in the training, such as subjects related to the limitations and possibilities of learners' brains, the connections between learners' emotions and brains, the effects of external influences on the brain, and the biological underpinning of behaviors and emotions. It also includes how to present the training materials for them, such as without the neuroscience complexities, connecting the behavior science with the neuroscience and related to teaching and life.

Finally, based on the study results, I would suggest that policymakers in Finland consider EN knowledge that includes neuroscience research underlying components of teaching and learning as one new addition to support the quality of education. EN has already started its momentum, therefore, I would suggest considering EN to be one of the future education policy issues.

I believe in the power of neuroscience as a teaching and learning base and very much hope that educators tap its potential, integrating EN into their policies and daily school instructions. As a pioneering country in quality education, I hope to see Finland become among the early adopters of neuro-educational innovations.

5.5 Summary and Conclusion

Improving teachers' competence and professional agency is one of the critical aims of the educational community. Integrating new useful knowledge in teachers' formal education is one way of achieving this aim. The extended purpose of the study was to inform curriculum development specialists of the po-

tential of integrating educational neuroscience knowledge in the formal education of Finnish ECEC teachers. To do so, this study aimed to investigate Finnish teachers' and leaders' (subject of the study) conceptions of EN (object of the study) and the various ways of conceptualizing it. In adopting a phenomenographic approach, the study revealed four categories of description and eight dimensions of variations that described participants' conceptions and understanding of the object of the study. Educational neuroscience is conceived to be 1-useful to the learning process 2-improves the learning process 3-significant to the learning process 4-the whole basis of learning.

The study found that educational neuroscience is complementary to behavior science knowledge and is significant in informing education and, therefore, potentially improving teachers' competence, professionalism, and professional agency. Particularly, EN improves teachers' teaching practices, positively affects their behaviors and attitudes, and enriches their understanding of the brain underpinnings of learners' emotions and behaviors. Moreover, it promotes a more individualistic teaching perspective and a holistic view of learning and learners. Additionally, EN is rarely taught in the Finnish ECEC formal curriculum, and that is one reason that teachers' neuroscience knowledge is limited. Consequently, weaving EN into teachers' formal education is important and valuable, and teachers are interested in learning about EN and prefer it to be presented to them in a simplified way that is directly related to their teaching practices.

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APPENDICES

Appendix 1 Pre-task for participants

Pre-Task to read 1 (Abstract)

1- *Long-term exercise is needed to enhance synaptic plasticity in the hippocampus*

"Exercise can have many benefits for the body, but it also benefits the brain by increasing neurogenesis, synaptic plasticity, and performance on learning and memory tasks. The period of exercise needed to realize the structural and functional benefits for the brain have not been well delineated, and previous studies have used periods of exercise exposure that range from as little as 3 d to up to 6 mo. In this study, we systematically evaluated the effects of differential running periods (3, 7, 14, 28, and 56 d) on both structural (cell proliferation and maturation) and functional (in vivo LTP) changes in the dentate gyrus of adult male Sprague-Dawley rats. We found that voluntary access to a running wheel for both short- and long-term periods can increase cell proliferation in the adult DG; however, increases in neurogenesis required longer term exposure to exercise. Increases in immature neurons were not observed until animals had been running for a minimum of 14 d. Similarly, short-term periods of wheel running did not facilitate LTP in the DG of adult animals, and reliable increases in LTP were only observed with 56 d of running. These results provide us with a greater understanding of the time course of wheel running access needed to enhance DG function. Furthermore, the results indicate that the new neurons produced in response to exercise in rats do not contribute significantly to synaptic plasticity until they mature" (Patten et al., 2013, p. 642).

Pre-Task to read 2 (Article: Physical Activity makes us Smarter)

2- *Physical Activity makes us Smarter (We Think Better on our Feet)*

We all know that exercising improves our health conditions, but are you aware that it also changes and improves our brains? One would ask, how does this happen? Let us first learn some facts about our brains. The basic functional units of the brain are brain cells (e.g., neurons). Our brains contain an enormous number of neurons that form clusters of neuron networks. These neurons have a complicated communication system; communication in the brain works through the passing or exchanging information between the neurons. Brain cells communicate by sending signals (messages) to each other; when one neuron sends a signal to another neuron, they become connected. Figuratively, they "hold hands" although they are not actually physically touching each other. But where is learning from all this? Learning and forming memories are the result of establishing/strengthening neuronal connections (synapses). This brain modification is called "neuroplasticity," that is, the capacity of our brains to change functionally and structurally through learning. If these connections are not strengthened, neurons "holding hands" will let go, and as a result, one will forget what they have learned. Neuroplasticity is one of the most essential lessons from neuroscience for educators. We are the ones who should always have the firm belief that people's brains are plastic to change and can change by learning.

Over the past decade, studies on both animals and humans proved that exercise and physical activity positively affect an individual's cognitive abilities and memory, including in both adults and children. That is because research proved that physical activity creates stronger connections between brain cells and different brain parts, and it improves the functionality of an essential part of our brain called the "hippocampus." The hippocampus is referred to as the memory center of the brain. It is not only critical for regulating our memory, but it is also responsible for our ability to control our emotions, make quicker

and better associations, and keep track of us spatially, similar to how a GPS works.

Exercising elevates the heart rate and improves both adults' and children's memory and cognitive abilities immediately and in the long run. Although physical exercise has immediate effects, the more regularly you exercise, the more positive impacts it has on the brain. Training stimulates the creation of new brain cells (neurogenesis), makes them more flexible to change, and reinforces the connection between them "hold hands harder." Moreover, it makes the hippocampus (memory center) grow larger and function better. All this leads to an improved short- and long-term memory and better learning. In other words, it makes adults and children smarter. Research shows that those who exercised right before a memory test did better than those who did not. A word recall test observed that compared to when people are at rest, if they were physically active before or while learning, they can learn up to 20 percent more words. But what about school performance?

Research has shown that more fit children had better academic abilities and better cognitive faculties when compared to their less fit peers. For example, they became better at mathematical and logical reasoning, remembering facts, vocabulary comprehension, and reading, performed better on memory and IQ tests and got better grades than their less active peers. The improvement did not only happen in their pure academic development, but it seems that these children remained more focused and undistracted while taking their lessons. Additionally, they were better at solving problems, multitasking, regulating their emotions, and controlling emotional impulses; moreover, they became less sensitive to stress arousals. In addition, children showed improvement in executive control abilities (making more sound decisions, showing initiative, and planning, and being organized). These non-direct academic abilities influence how children perform in their academics. According to Hansen (2017), the type of activity that children do is not of vital importance; what is important is raising the heart rate and constantly being active. Even four minutes of activity such as jogging improves children's immediate concentration.

Suggested applications in educational settings:

- Using standing desks. There was a direct correlation between performing better in school and standing/moving while learning.
- Plan 30 minutes exercise session at the beginning of the school day. For optimal benefits, children should be active for at least thirty minutes.
- Make children active (elevate their heart rate) for 4 minutes after each session (approximately 1 hour).

Table 4

Survey on Reading Tasks 1 and 2. Adopted from (Tham et al., 2019, p. 170)

Please read each item and express your scale of agreement with the statement, using the scale below (1 = strongly disagree to 5 = strongly agree).

	Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I understood the aim of the study.	1	2	3	4	5
2	The reading task was difficult to comprehend.	1	2	3	4	5
3	The language and tone used in the reading task was appropriate for teachers.	1	2	3	4	5
4	There was one or more technical term(s) used in the reading task, that I am not familiar with	1	2	3	4	5
5	The reading task was useful in helping me to understand the brain basis of the exercising	1	2	3	4	5
6	I can verbally explain what I have read to someone else whom has no knowledge in Neuroscience.	1	2	3	4	5
7	I can identify the key message(s) and takeaway(s) of the reading task	1	2	3	4	5
8	The content of the reading task is relevant to me as a teacher.	1	2	3	4	5

	Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
9	The reading task has helped me to feel better equipped as a teacher.	1	2	3	4	5
10	I could potentially apply what I have learnt from the reading task to my overall teaching practice.	1	2	3	4	5

Table 5

Survey after 2 Reading Tasks. Adopted from (Tham et al., 2019, p. 170)

R= reading task

	Questions	Response	
1	Which reading task do you prefer?	R1	R2
2	Which reading task was easier to understand?	R1	R2
3	Which reading task was more relevant to your teaching practice?	R1	R2
4	Which reading task made you feel more empowered to take action as a teacher?	R1	R2

Appendix 2 Survey Results

For the sake of simplicity, I use the "agree" answer to represent both the "strongly agree" and "agree." Moreover, I use the "disagree" answer to represent both the "strongly disagree" and "disagree." I do not mention the answers of "neutral" to the survey questions in the table. In the comparison survey, participants were asked four questions: Which reading task do you prefer, which reading task was easier to understand, which reading task was more relevant to your teaching practice, and which reading task made you feel more empowered to take action as a teacher? All the 10 participants preferred the second text, found it easier to understand, and more relevant to their teaching practice, and it empowered them more to take action as teachers.

Table 6

Surveys results reflecting participants' thoughts about the two pre-task texts- Survey Adopted from (Tham et al., 2019, p. 170)

Survey Question	Result of Text 1	Result of Text 2
I understood the aim of the study.	9 agreed	10 agreed
The reading task was difficult to comprehend.	4 agreed & 3 disagreed	10 disagreed
The language and tone used in the reading task was appropriate for teachers.	2 agreed & 5 disagreed	10 agreed
There was one or more technical term(s) used in the reading task, that I am not familiar with	10 agreed	7 disagreed
The reading task was useful in helping me to understand the brain basis of the exercising	6 agreed & 2 disagreed	10 agreed
I can verbally explain what I have read to someone else whom has no knowledge in Neuroscience.	6 agreed & 2 disagreed	10 agreed
I can identify the key message(s) and takeaway(s) of the reading task	6 agreed	9 agreed
The content of the reading task is relevant to me as a teacher.	7 agreed	10 agreed
The reading task has helped me to feel better equipped as a teacher.	1 agreed & 4 disagreed	9 agreed
I could potentially apply what I have learnt from the reading task to my overall teaching practice.	5 agreed and 1 disagreed	10 agreed

Appendix 3 Interview Questions Sample

- What is educational neuroscience to you? Do you think knowing about how the brain works is important when you learn about education? Why?

- What are your overall conceptions of brain-related (findings) as it relates to education?

- Do you consider applying it in education settings important for improving the learning process? Why?

- From where do you draw your information about the brain from? What are your references?

- Through your years of bachelor's and/or master's study, did you learn anything about how the brain works/functions in relation to education?

- How could you evaluate your neuroscience literacy? (your existing general knowledge and familiarity with the structure and function of the brain)

- Are you curious about learning about teaching strategies (that stem from neuro findings) that could be applied in your classrooms? Why?

- What do teachers want from the neuroscience literature? From your point of view as a teacher?

Appendix 4 Example of data analysis

Table 7 *Example of the grouping of meanings in the data analysis process (P=Participant)*

Dimension of variation	Conceptions derived from quotations	Quotations	P
How EN should be presented to teachers	Translated to the education language	it might be easier if somebody like translates the neuroscience studies to the education, language	P1
	Connection between theory and practice	the reality is so different. So, so maybe the connection between theory and practice should be better	P1
	Related to life and teaching	explained in the way that you can you can you can relate it to your own life... how this is related to my teaching	P2
		more like activities, or like something that you can relate it by doing in your, in your teaching or something like, so it is it is not just that you are reading something, I would like to have something that that I can do	P2
		I think when it has a lot of examples, when it's very relatable, you can actually think it through yourself...and I think it should be very practical for the students...be related, to the actual work	P9
	Material that combines both the behavioral and neuroscience	I think this combining difference, like the behavioral science, and then the neuroscience, how do they, like, talk together, use the same language	P9
	Easy to read without excess information	but then you make [a specific] book where you don't have to write write everything so ya maybe not methodology or difficult things in the book so it is it is different but easier to read.	P3