

Pre-service early childhood education teachers' views and competency levels regarding neurolinguistic-based STEAM applications in phonemic skills instruction

Yeldana K. Otegenova¹ , Assem I. Bulshekbayeva^{1*} , Gulbanu T. Abitova¹ ,
Lazzat M. Madenova² , Salima S. Seitenova² 

¹ Department of Pre-school Education and Social Pedagogy, Abai Kazakh National Pedagogical University, Almaty, KAZAKHSTAN

² Department of Pre-school and Primary Education Pedagogy, Makhambet Utemisov West Kazakhstan University, Uralsk, KAZAKHSTAN

Received 04 May 2026 ▪ Accepted 19 October 2026

Abstract

The purpose of this study is to determine pre-service early childhood teachers' views and perceived competency levels regarding neurolinguistic-based science, technology, engineering, arts, and mathematics (STEAM) applications in phonemic skills instruction, and to examine whether these perceptions differ significantly according to demographic (gender, age, and grade level) and professional/experiential (having received phonemic awareness training, STEAM experience, and familiarity with the concept of neurolinguistic programming [NLP]) variables. Adopting a descriptive survey design, one of the quantitative research methods, the study group consisted of 179 pre-service teachers enrolled in an early childhood education undergraduate program at one university in Kazakhstan. The research data were collected through a demographic information form, a structured views questionnaire, and a data collection tool measuring pre-service teachers' perceived competency. The findings show that participants' overall perceived competency was high. However, 36.9% of participants regarded phonemic awareness as a naturally developing process and 31.3% viewed STEAM as unrelated to language skills, which may indicate conceptual gaps; and although 41.9% stated that the art component made phoneme discrimination more concrete, 53.6% considered art either unrelated to phonemic awareness or merely entertaining. Perceived competency did not differ significantly by gender or age, whereas third-year pre-service teachers reported lower perceived competency than first- and second-year students; a "reality shock" after practicum is a possible but untested explanation, as practicum was not measured. In addition, pre-service teachers who had previously received phonemic awareness training, who had STEAM experience, and who were familiar with the concept of NLP reported significantly higher perceived competency. The findings suggest that teacher educators may consider adding applied, STEAM-integrated phonemic awareness modules supported by microteaching, including a critical examination of the evidence on NLP and learning-styles claims. The findings are limited by self-report data and a single-university convenience sample.

Keywords: early childhood education, phonemic skills, STEAM education, neurolinguistics, perceived competency, pre-service teachers

INTRODUCTION

The early childhood period is a critical developmental stage in which children make their most

rapid progress in language, cognitive, motor, and social-emotional development, and in which fundamental life skills take shape. Language and early literacy skills acquired during the early childhood years are

Contribution to the literature

- This study addresses a gap in early childhood education research by examining pre-service teachers' views and perceived competency regarding the integration of neurolinguistic-based science, technology, engineering, arts, and mathematics (STEAM) applications into phonemic skills instruction, bringing together three areas that have largely been investigated separately.
- The findings reveal a discrepancy between pre-service teachers' high perceived competency and their conceptual understanding of phonemic awareness and the role of STEAM in language instruction, highlighting the need for more practice-oriented and interdisciplinary teacher education.
- This study identifies prior phonemic awareness training, previous STEAM experience, and differences across year of study as factors associated with pre-service teachers' perceived competency. These findings provide practical guidance for designing teacher education programs that strengthen early literacy instruction through interdisciplinary, hands-on, and developmentally appropriate STEAM activities.

considered among the strongest predictors of later academic reading and writing achievement, academic self-confidence, and reading comprehension capacity (Parpucu & Güler Yıldız, 2022). Within this process, phonemic awareness, defined as the ability to discriminate, analyze, and mentally manipulate phonemes, the smallest sound units of spoken language, constitutes an indispensable precondition for successful reading acquisition (Degé & Schwarzer, 2011). In contemporary early childhood education pedagogy, rather than treating language as a one-dimensional, rule-based object of instruction, interdisciplinary approaches that activate children's natural curiosity and exploratory drive have come to the fore. Along these lines, the STEAM approach, which integrates the disciplines of science, technology, engineering, arts, and mathematics, incorporates music, rhythm, movement, and visual elements into language pedagogy through its Arts component, thereby making learning more concrete (Alghamdi, 2023; Cabero-Almenara et al., 2026; Walshe et al., 2025). At the same time, there is growing interest in bringing insights from neurolinguistics, the scientific study of how the brain represents, processes, and acquires language (Paradis, 2004), into language pedagogy. In some applied language-teaching literature this interest is accompanied by neurolinguistic programming (NLP) techniques. The two should not be conflated: neurolinguistics is an established scientific field, whereas NLP is a set of practitioner-oriented techniques whose theoretical basis and empirical support remain contested (Witkowski, 2010). Studies conducted mostly with adolescent and adult English as a foreign language (EFL) learners report that multisensory, NLP-informed teaching is associated with lower language-learning anxiety and higher motivation (Merkviladze, 2023; Zhang et al., 2023); evidence concerning young children's phonemic development, however, is lacking.

Even though the importance of phonemic awareness and phonemic skills is stressed in the early literacy literature, it seems that both pre-service and in-service early childhood teachers have very little knowledge

about them in terms of theory and methodology (Forgie et al., 2022). The research done in the field shows that teachers mix phonemic awareness with articulation, auditory perception, or even letter learning, and in practice, they ignore the other aspects of phonemic awareness, such as awareness of syllables, words, and rhymes and limit themselves only to the identification of the initial sounds in words (Parpucu & Güler Yıldız, 2022). However, pre-service early childhood teachers acknowledge the value of STEAM for cognitive and socio-emotional development but face self-efficacy problems when trying to plan and implement this interdisciplinary approach in the classroom (Alghamdi, 2023; Veziroglu-Celik et al., 2026; Wang & Lin, 2026). The uncertainty surrounding how neurolinguistic strategies and brain-based learning principles might be blended with the STEAM disciplines at the early childhood level, together with the fact that pre-service teachers' views and competency perceptions regarding this innovative pedagogical combination have not yet been clarified qualitatively or quantitatively, constitutes the core problem addressed by this study.

Review of the existing literature suggests that experimental studies on the impact of musical and rhythmic work on phonemic awareness (Degé & Schwarzer, 2011), descriptive studies on the attitudes and beliefs of pre-service early childhood teachers about STEAM education (Alghamdi, 2023; Veziroglu-Celik et al., 2026), as well as studies of neurolinguistic and NLP-informed strategies in language education and their reported links with learners' motivation and anxiety (Keezhatta, 2019; Merkviladze, 2023; Sgueglia, 2024) have mainly been studied independently from each other. However, there is a lack of empirical studies on how pre-service early childhood teachers, who are at the most important point before going to work, perceive the application of neuro-linguistically-based STEAM approaches in phonemic skills training, as well as how their self-perceived competency level is regarding those applications, within a holistic approach. Understanding how pre-service teachers' competency perceptions differ by demographic characteristics, as well as by

professional and experiential factors such as prior phonemic awareness training, STEAM experience, and knowledge of NLP, is equally important. In this respect, the study offers a novel perspective, as it examines pre-service teachers' views and perceived competency regarding the integration of neurolinguistic-based STEAM applications into early literacy instruction in early childhood teacher education. The results of the study may inform the enhancement of course content such as 'early literacy education', 'child language development', 'music education', and 'preparation for primary education' within the curriculum of the early childhood education undergraduate program considering the interdisciplinary approach to STEAM and neurolinguistics. On the other hand, the knowledge about the demographic and experiential factors that influence the professional self-efficacy beliefs of pre-service teachers will help develop high-quality workshops and microteaching activities in faculties in a way that supports equitable opportunities for early language development through multisensory approaches to phonemic awareness instruction in early childhood. Thus, the purpose of the study is to reveal the perceptions of pre-service early childhood education teachers concerning neurolinguistic approaches (NLAs) to STEAM in phonemic skills education, and if these perceptions are different according to any demographic or experiential variable. In this study, "neurolinguistic-based STEAM applications" refers to STEAM-integrated phonemic awareness activities (e.g., sound-color matching, rhythmic and movement-based activities, technology-supported sound discrimination tasks, and exploratory sound-source experiments) designed in line with brain-based, multisensory learning principles drawn from the neurolinguistic and NLP-informed language-teaching literature. The term is used as a descriptive label for this cluster of practices and does not imply that each component has been empirically validated for young children's phonemic development. The study concerns pre-service teachers' views and perceived competency regarding such applications, not their effectiveness.

THEORETICAL FRAMEWORK

The Development of Phonemic Skills in Early Childhood and Their Role in Early Literacy

The term phonemic awareness describes the ability to distinguish the sounds called phonemes, the basic building blocks of speech, and the mental processing of these sounds through manipulation, blending, and segmentation (Degé & Schwarzer, 2011; Parpucu & Güler Yıldız, 2022). As the ultimate form of phonological awareness, which corresponds to the most refined level within the early literacy concept, phonemic awareness is required by children to understand the letter-sound connection (grapheme-phoneme correspondence) and to

break the code of reading and writing (Ehri et al., 2001; Whitehurst & Lonigan, 1998). Based on studies, those children who have phonemic awareness abilities in their early childhood period learn how to read faster when starting primary education, become fluent readers and exhibit excellent reading comprehension levels (Kjeldsen et al., 2014; Rakhlin et al., 2014). It is essential to support the development of this ability through scientifically based practices during the preschool period because this is a protective factor for avoiding possible reading disorders, such as dyslexia (Parpucu & Güler Yıldız, 2022).

Phonemic and phonological awareness is a process which occurs hierarchically and vertically. At first, children learn word and sentence awareness and proceed to syllable segmentation/blending and rhyme awareness, eventually developing their ability to decode the single sound elements (phonemes) in words (Degé & Schwarzer, 2011; Gillon, 2007). However, it is stated by literature that the activities conducted in preschools are not aligned with the hierarchical development process and are limited to a certain scope (Forgie et al., 2022; Parpucu & Güler Yıldız, 2022). Teachers tend to conduct phonemic awareness activities related only to the identification of the first sound in words and teaching vowels, leaving aside more advanced phonemic awareness activities, such as syllable blending, rhyme generation, distinguishing between the final sounds of words, and deleting/substituting sound elements (Parpucu & Güler Yıldız, 2022). Music, rhythm, and art-based activities have been proposed as promising ways of supporting phonemic awareness, although the evidence base is still limited and should be interpreted cautiously. The 'shared sound category learning mechanism' theory by Patel (2008) states that the human brain uses similar neurological structures and auditory processes in analyzing sounds of music (notes, melody, rhythm, and pitch) and linguistic sounds (phonemes, syllables, and stress) (Degé & Schwarzer, 2011). In one experimental study with preschool children, those who received a music program showed gains in phonological awareness compared to those of children who received phonological training (Degé & Schwarzer, 2011). Musical rhythm and song-based activities may help children perceive syllable boundaries and phonemic changes in words through the auditory channel, and rhythm sensitivity has been linked to phonological segmentation skills (Gromko, 2005; Moritz et al., 2013). Such activities can also make language processing a more enjoyable experience (Barg, 2021).

Phonemic skills instruction quality depends directly on the content pedagogical knowledge and self-efficacy perceptions of preschool teachers and pre-service teachers responsible for delivering such an instruction (Forgie et al., 2022; Mather et al., 2001). Still, research has found out that pre-service teachers and in-service teachers alike demonstrate great conceptual confusion

and lack of knowledge related to the nature of phonemic awareness instruction, its scope and methods of instruction (Forgie et al., 2022; Parpuću & Güler Yıldız, 2022). The low practical focus of early literacy and language pedagogy courses offered in pre-service teacher education programs results in self-efficacy problems of pre-service teachers related to their ability to plan and assess phonemic skills of children (Altun & Tantekin Erden, 2016; Bezcioglu-Göktolga, 2013). Hence, it becomes necessary to look into pre-service teachers' perspectives and self-perceptions of competencies needed for innovative, multi-disciplinary, and theory-based phonemic skills instruction.

The STEAM Approach in Early Childhood Education and Its Integration into Language Pedagogy

The STEAM approach is an interdisciplinary method of teaching which attempts to combine the domains of science, technology, engineering, arts, and mathematics into one process (Alghamdi, 2023; Veziroglu-Celik et al., 2026; Yakman, 2010). As the name of this approach implies, it is constructed by adding the 'Arts' domain to the classical STEM structure, where the main idea is to develop logical-mathematical thinking and creativity of children, their divergent thinking, aesthetic perception and communication skills (Sousa & Pilecki, 2013; Walshe et al., 2025). The principle of STEAM learning in early childhood education is based on the curiosity of children who explore their environment, ask questions, perform experiments, make mistakes, and come up with unique solutions to real-life problems (DeJarnette, 2018; ElSayary et al., 2022). Early childhood STEAM education equips children with necessary competencies for the future by providing them with a framework to turn the abstract into something tangible through play, design, and experience (Stepanović Ilić et al., 2025; Wang & Lin, 2026).

'The arts' aspect is important in bringing together STEAM approach and language learning and teaching as well as early literacy. In the words of Yakman (2010) and ElSayary et al. (2022), the notion of 'Arts' in the STEAM paradigm includes not only visual arts, but a wide spectrum of art including language arts, literature, drama, music and movement. When children explore a scientific question or engineering problem at early ages through play, they use their language skills when describing their observations, making up stories, keeping beat using songs and rhymes, and saying sounds in particular order (Veziroglu-Celik et al., 2026). The integration of arts in science and math lessons turns language learning into practical multi-sensory experience for kids helping them increase vocabulary and develop phonemic awareness (DeJarnette, 2018; Sousa & Pilecki, 2013).

The ability of teachers and pre-service teachers to implement STEAM applications in classrooms is directly

connected with STEAM curriculum design thinking competencies of teachers and with implementation self-efficacy. Pre-service teachers with a high level of competence in implementing STEAM applications using the steps of understanding need, lesson planning, idea generation, validation, and problem definition demonstrate higher self-confidence in their ability to implement STEAM-related activities (Wang & Lin, 2026). The international research reveals that, while preschool teachers believe in the importance of STEAM-based approach, they face significant issues with implementation of these disciplines into practice and application of the mentioned disciplines in the classroom (Alghamdi, 2023; Jamil et al., 2018). This fact highlights the significance of letting pre-service teachers experience, prior to becoming teachers, how philosophy of STEAM may be combined with such specific subject like language teaching. The main barriers for implementation of STEAM disciplines into early childhood education are usually connected with teachers' low level of theoretical knowledge, lack of materials and resources, time limitation, and content limitation of pre-service education (Alghamdi, 2023; Veziroglu-Celik et al., 2026; Walshe et al., 2025). The fact that pre-service teachers are not advised on how to integrate STEAM subjects into interdisciplinary pedagogy implies that they usually view the STEAM fields as separate subjects (Simoncini & Lasen, 2018). The 'STEAM from the start' concept introduced by Walshe et al. (2025) suggests that successful implementation of any ideas is associated with encouraging teachers in willingness and competence. In this case, integration of the selected language field and STEAM can be considered as an approach that helps to consolidate the interdisciplinary competencies of pre-service teachers.

Neurolinguistics, NLP, and Brain-Based Approaches in Language Teaching: Perceived Competency of Pre-Service Teachers

Neurolinguistics is the scientific field concerned with the neural basis of language comprehension, production, and acquisition (Paradis, 2004), and the NLA in language teaching draws on this field (Elleuch, 2024; Sgueglia, 2024). NLP, by contrast, is not a branch of neurolinguistics. It emerged in the 1970s as a set of communication and personal-change techniques and has been adopted in some language-teaching contexts (Keezhatta, 2019; Zeb & Hameed, 2020), but its theoretical assumptions have been criticized and reviews have found little empirical support for them (Sharpley, 1987; Witkowski, 2010). The two are therefore treated as distinct in this paper. In accordance with neurolinguistic theory (Paradis, 2004; Sgueglia, 2024), fluency in using language is possible if procedural memory is used in the brain, as opposed to declarative memory, and if implicit learning takes place. Prioritizing communicative interaction and sensory experience in

the classroom over the memorization of rules and grammar is likely to result in the activation of procedural memory (Sgueglia, 2024). According to the multi-stratal model of language processing proposed by Elleuch (2024), language acquisition involves not only grammatical elements but also social, cultural, emotional, and sensory (gestural) aspects.

NLP-based language teaching draws on techniques such as representational systems (visual, auditory, kinesthetic [VAK]), anchoring, reframing, modeling, and Milton model language patterns (Keezhatta, 2019; Perumal & Shanmuhavelu, 2026; Zeb & Hameed, 2020). NLP-based approaches propose matching instruction to learners' preferred representational system. However, the notion that tailoring teaching to individuals' preferred sensory modality improves learning is not supported by controlled evidence (Pashler et al., 2008) and is widely regarded as a neuromyth (Dekker et al., 2012; Howard-Jones, 2014). A separate and less contested idea is that presenting information through several modalities (e.g., sound, image, and movement) may benefit learners in general. "Multisensory" is understood in this sense in the present study, not as matching instruction to children's individual sensory preferences. It has been argued that combining auditory, visual, and kinesthetic input around a phoneme (e.g., hearing it, seeing an associated image, and moving to its rhythm) may support memory and engagement. Studies with EFL learners report lower speaking anxiety and higher motivation after NLP-informed instruction (Merkviladze, 2023; Zhang et al., 2023), and NLP-informed teaching has been described as fostering an emotionally safe and motivating classroom climate (Perumal & Shanmuhavelu, 2026). These findings, however, come from older foreign-language learners and rely largely on self-reports. They do not demonstrate that such procedures strengthen neural connections or improve phonemic development in preschool children.

The foremost determinant of how pre-service teachers translate innovative teaching techniques into practice is self-efficacy, a notion introduced by Bandura (1977). In the present study, self-efficacy serves as the theoretical background, whereas the construct actually measured is referred to throughout as "perceived competency". That is, participants' self-reported judgment of their own capability to carry out the listed instructional tasks. Four major factors influence pre-service teachers' self-efficacy perceptions: mastery experiences, vicarious experiences, persuasion and physiological/emotional states (Bandura, 1977). Pre-service early childhood teachers' self-efficacy perceptions about NLP-based STEAM approach to phonemic skills teaching will determine their willingness to employ the approach in practice, their resilience, and lesson planning (Stepanović Ilić et al., 2025; Wang & Lin, 2026). Pre-service teachers' self-efficacy perceptions and pedagogical beliefs may greatly

vary depending on demographic and experiential variables (gender, year of study, age, receiving phonemic teaching, STEAM experience, awareness of the concept of NLP) (Alghamdi, 2023; Forgie et al., 2022; Walshe et al., 2025). From the literature, it is evident that teachers who have had some previous experience with the practical aspects of STEAM or language teaching demonstrate significantly higher levels of professional beliefs and perception of competence (Alghamdi, 2023; Chen et al., 2021). In addition, some studies report that NLP-trained teachers perceive themselves as better able to manage communication and classroom anxiety (Ginting & Hartati, 2023; Keezhatta, 2019), although these are self-reported perceptions. Integrating phonemic awareness, STEAM teaching approaches, and neurolinguistic perspectives may offer a useful conceptual lens for examining pre-service early childhood teachers' professional development and perceived competency in early literacy teaching (Ginting & Hartati, 2023; Keezhatta, 2019).

The research problem investigated in this study was: What are the views and perception levels of pre-service early childhood teachers on NLAs for applying STEAM in teaching phonemic skills and do these levels vary based on different factors? This is why this study tried to answer the following questions:

1. What are pre-service early childhood teachers' views regarding neurolinguistic-based STEAM applications in phonemic skills instruction?
2. What are pre-service early childhood teachers' competency perception levels regarding phonemic skills instruction practices?
3. Do pre-service early childhood teachers' competency perception levels regarding phonemic skills instruction practices differ significantly according to demographic variables (gender, grade/year of study, and age range)?
4. Does having previously received phonemic awareness training significantly differentiate competency perception?
5. Does STEAM education experience create a significant difference in competency perception?
6. Does familiarity with the concept of NLP create a significant difference in competency perception?

METHOD

Research Design

As this study aimed to describe, as they currently exist, pre-service early childhood teachers' views and competency perceptions regarding neurolinguistic-based STEAM applications in phonemic skills instruction, it was designed according to the descriptive survey model, one of the quantitative research approaches. Survey models aim to describe an existing

Table 1. Frequency and percentage distributions of participants' demographic characteristics (N = 179)

Variable	Category	n	Percentage (%)
Gender	Female	155	86.6
	Male	24	13.4
Grade/year of study	1 st year	27	15.1
	2 nd year	63	35.2
	3 rd year	66	36.9
	4 th year	23	12.8
Age range	18-20	139	77.7
	21-23	33	18.4
	24-26	1	0.6
	27 and above	6	3.4
Phonemic awareness training	None	53	29.6
	Yes, as a seminar/workshop	64	35.8
	Yes, as a course	62	34.6
STEAM experience	No	55	30.7
	Yes, within a course	73	40.8
	Yes, through a project/event	51	28.5
Familiarity with NLP	Never heard of it	51	28.5
	Heard of it but don't know it	60	33.5
	Somewhat familiar	44	24.6
	Very familiar	24	13.4

situation regarding the views, attitudes, or competency perceptions of individuals within a population on a given subject, without attempting to change or manipulate these variables in any way (Creswell, 2024).

Population and Sample

The population of the study consists of pre-service teachers enrolled in the early childhood education undergraduate program at a university in Kazakhstan. Because participants were reached through an online form, a convenience sampling method was used in determining the sample. The data were collected during the spring semester of the 2025-2026 academic year, between 9 May 2026 and 11 June 2026, and valid responses were obtained from a total of 179 pre-service teachers. Information regarding participants' demographic characteristics is presented in [Table 1](#).

The majority of participants were female (86.6%), and students in their second and third years made up 72.1% of the sample. Most participants were in the 18-20 age range (77.7%); because the number of participants in some of the original age subcategories (particularly the 24-26 range, $n = 1$) was very small, the age variable was recoded into two categories for comparative analyses (see data analysis).

Data Collection Tool

The data were collected using the "neurolinguistic-based STEAM applications data collection form" developed by the researchers. The form consists of three sections. The first section contains six personal information items designed to determine participants' gender, grade/year of study, age range, phonemic

awareness training status, STEAM education experience, and level of familiarity with the concept of NLP. The second section is a structured views questionnaire consisting of seven items, each with four options, designed to determine views regarding neurolinguistic-based STEAM applications in phonemic skills instruction; in constructing the options, distractors were designed to reflect common misconceptions or incomplete views reported in the field alongside an appropriate view. Items 1, 2, 5, and 7 were treated as keyed items (appropriate options: item 1, "systematically fostered through structured activities"; item 2, "indirectly supports" and "effective instructional tools"; item 5, "multisensory setting"; item 7, "make phoneme discrimination more concrete"), based on the sources listed below. Items 3, 4, and 6 are attitude/preference items without a correct answer and are reported descriptively only. Response options were not designed to be mutually exclusive in item 3 and item 6, and respondents chose the option closest to their view. The third section is a 10-item competency scale in 5-point Likert format (1 = strongly disagree, 5 = strongly agree) designed to measure pre-service teachers' perceived competency regarding neurolinguistic-based phonemic skills instruction.

In creating the items and options for the views questionnaire in the second section, there were several sources used from the literature review. In creating the option structures regarding the instruction of phonemic awareness, the explicit and systematic instruction principles that were stated in the national reading panel report of the National Institute of Child Health and Human Development [NICHD] (2000) were considered, along with the principle that phonemic awareness

should be taught through direct and structured instructions as stressed in the Australian national inquiry into the teaching of literacy report by Rowe (2005). In representing the views, beliefs, and attitudes of teachers towards STEM/STEAM integration in the creation of the items, the study by Çiftçi et al. (2022) on the views of pre-service early childhood teachers about STEM, the study by Dare et al. (2019) on the conception of STEM education by teachers, and the study by Jamil et al. (2018) on the beliefs of preschool teachers about STEAM education were considered. While developing the items that related to the interdisciplinary STEAM models, especially the items associated with arts and phonemic awareness, the research conducted by Bassachs et al. (2020) on critical thinking by STEAM methods in elementary education served as the foundation for the study. In order to reflect the brain-based learning and NLA within the content of the items, Duman's (2010) research was consulted. Two field experts (special education and STEAM education) reviewed the draft. No expert in early literacy or phonological awareness was included, which is acknowledged as a limitation. According to the feedback of the experts, two items underwent changes regarding the content to exclude overlapping in the structure of options, and the stem and the options of another item were changed to increase its clarity and discrimination. Then, the experts re-assessed the revised version of the test. Content validity was therefore supported only qualitatively (independent evaluation followed by consensus); no quantitative validity index was computed, and no psychometric properties are reported for this questionnaire, which is used for descriptive purposes only. Both instruments are provided in Appendices A and B.

For developing the item pool of the competency scale in the third part of the scale, the pedagogical self-efficacy and content self-efficacy subscales of the STEM teaching self-efficacy scale by Yang et al. (2023) that were designed for early childhood teachers, as well as Carroll et al.'s (2012) and Purvis et al.'s (2016) research about teachers' phonological awareness knowledge and STEAM teacher self-efficacy scale by Stepanović Ilić et al. (2025) were used. New items dedicated to teaching phonemic skills according to neurolinguistic principles were added to those by the authors. The items initially written in English were translated into Russian by a translation professional and then back-translated into English. Back-translated items were compared with the original English version of the items line-by-line to see if there is semantic and expressive equivalence. The 12-item draft form that was created was evaluated in terms of content validity by three experts, including an early childhood education expert, an early childhood educator working in the field of STEAM, and a measurement and evaluation specialist. The inter-rater agreement was higher than 80%. Following the expert assessment of the

first round, the content of three questions was modified, two questions were combined into one question, and one question was eliminated. In the second round, the item wording and option structure were checked jointly with the experts, and the final form of the scale was prepared. Thus, following these steps, the competency scale is comprised of 10 items. The questionnaire was conducted online in Russian.

The dimensionality of the scale was examined with principal component analysis (PCA) (without rotation) on the study sample ($N = 179$). This is a preliminary check rather than a full validation of the scale. First of all, before conducting the analysis, the suitability of the dataset for performing factor analysis was evaluated with the help of Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. Specifically, the value of KMO was determined as .96 which is indicative of the "marvelous" level of sampling adequacy by Kaiser's standards. Also, Bartlett's test of sphericity was found to be significant ($\chi^2[45] = 1,957.91$, $p < .001$); thus, the dataset was considered very suitable for factor analysis. In the process of the analysis (performed with the principal components method without rotation), the eigenvalue of the first factor was determined as 7.79, while the eigenvalue of the second factor (0.43) stayed far below 1; the scree plot confirmed the same result. These criteria are consistent with a single dominant component. The proportion accounted by this one factor alone amounted to 77.9%, exceeding the widely accepted 60% level for measurement tools. Factor loadings of the items varied between .82 and .91, all of which were clearly beyond the .40 lower limit of acceptance; the lowest factor loading was recorded for item 1 (.82) while the highest loadings were recorded for item 8 (.91) and items 3, 5, 7, and 10 (.90). All items loaded highly on the single component, which supports the scale's uni-dimensionality in this sample; further validation (e.g., confirmatory analysis in an independent sample) is needed. Cronbach's alpha internal consistency coefficient was used to test the reliability of the scale, yielding $\alpha = .97$. Such a high value, together with item-total correlations of .78-.89 and a first eigenvalue of 7.79, suggests substantial item redundancy rather than only high reliability. The item-total correlation was between .78 and .89, clearly above the acceptability level of .30; removing any of the items from the scale will result into a reliability coefficient of .96-.97, and none of the items can be removed to increase overall reliability. This means that it is appropriate to keep all 10 items of the scale. No correction for multiple comparisons was applied across the several tests; p values close to .05 should therefore be interpreted cautiously. Some cells were small ($n = 23-24$).

Data Analysis

Data were analyzed with the help of IBM SPSS and Python (libraries pandas, scipy, pingouin, and

factor_analyzer). Results with respect to the first research question (the views questionnaire) are provided through descriptive statistics (frequency and percentage). With respect to the second research question (competency scale), the mean and standard deviation of item and scale scores were computed. Competency scores can be interpreted according to the following scale, which is based on the interval of $(5-1)/5 = 0.80$: 1.00-1.80 very low, 1.81-2.60 low, 2.61-3.40 moderate, 3.41-4.20 high, 4.21-5.00 very high.

In testing for the homogeneity of variances of each grouping variable that corresponds to the third, fourth, fifth, and sixth research questions, the Levene's test was conducted first. If the variances were homogeneous (phonemic awareness training, STEAM experience), one-way ANOVA for independent samples was performed, along with the Tukey's honestly significant difference (HSD) post hoc test, which would pinpoint the sources of the difference. However, if the variances were heterogeneous (grade level, NLP familiarity), then the Welch's ANOVA test was utilized, and the post hoc test chosen was the Games-Howell test.

In the case of the two-levels gender variable, the Welch's t-test was conducted, regardless of whether the variances are homogeneous or not. Due to the insufficient number of participants in some of the original age categories (especially ages 24-26, $n = 1$), this variable was recoded into only two levels, i.e., 18-20 years old and 21 years and older. This comparison was conducted using Welch's t-test, same as in the case of the gender variable. Effect size was reported as Cohen's d in t-tests and eta squared (η^2) in ANOVAs. The significance level was .05 for all tests.

Ethical Procedures

All procedures for gathering data were conducted online and voluntarily. First of all, before answering any questions, the participants were made aware of the aims of the study, that their answers would be used exclusively for scientific purposes, that participation was voluntary, and that they had the right to withdraw from answering at any moment. Answering the form served as an indication of electronic consent of the participants. All answers were gathered anonymously and could not be traced back to particular people.

RESULTS

This section presents the findings regarding the research questions in turn.

Findings Regarding the First Research Question

Pre-service teachers' opinions on neurolinguistic-based STEAM integration in phonemic skills teaching were analyzed in terms of frequency and percentage

distribution of their responses to the seven items of the views questionnaire. The results are shown in **Table 2**.

Analysis of the results shows that the attitude of pre-service teachers reveals a rather scattered picture among items. For instance, in item 1, the largest share of participants (36.9%) is convinced that phonemic skills emerge naturally in early childhood without special instructions, while only 28.5% support, which is also confirmed by the literature review, the idea that such skills must be systematically developed through certain activities. Regarding item 2, the relation between STEAM and phonemic skills teaching, three answers reveal almost equal number of participants (31.3%, 30.7%, and 30.7%, respectively); nearly a third of them think that STEAM is not relevant to teaching language skills. Conversely, regarding item 3, the relations between attitudes to using neurolinguistic-based STEAM applications, the largest share (42.5%) represents those participants who want to learn and apply these applications due to the fact that they can contribute to professional development, while 22.9% rely on traditional approaches. Finally, in item 4, concerning the most effective STEAM element, technology prevails (41.9%), followed by art (21.8%), nature/science activities (21.2%), and music and movement (15.1%). For item 7 that evaluated the arts aspect, the largest percentage (41.9%) was of the individuals who agreed that sound-visual matching and rhythmic drawings made phoneme discrimination concrete; however, a significant number of respondents were of the opinion that art could only be used for entertainment (28.5%), while others believed that art cannot be directly linked to phoneme awareness (25.1%). For item 5, relating to the most appropriate environment in which phoneme discrimination should take place, almost half of the participants (49.7%) picked a multisensory environment where stimuli appear at the same time, while 27.9% preferred a quiet and calm classroom environment. Finally, for item 6, regarding the incorporation of neurolinguistic perspectives into teacher education programs, 37.4% of respondents felt that all pre-service early childhood teachers should receive mandatory training on this topic, while 34.6% felt that it can be an elective course.

Findings Regarding the Second Research Question

Concerning the second research question, the levels of competency perception of pre-service teachers in the context of phonemic skills instructions practices were investigated using descriptive statistics for the 10 competency scale items. The results are summarized in **Table 3**.

A scrutiny of **Table 3** reveals that pre-service teachers expressed high levels of perceived competency along the whole scale (mean $[M] = 4.10$, standard deviation $[SD] = 0.96$).

Table 2. Frequency and percentage distributions for the views questionnaire items (N = 179)

Item and options	n	P (%)
1. Acquisition of phonemic skills in early childhood		
Should be taught in primary school	43	24.0
Develops naturally; no instruction needed	66	36.9
Should be systematically fostered through structured activities	51	28.5
Falls exclusively within specialists' domain	19	10.6
2. Relationship between the STEAM approach and phonemic skills instruction		
STEAM is related only to mathematics and science, not to language skills	56	31.3
STEAM activities indirectly support phonemic awareness but do not provide direct instruction	55	30.7
STEAM activities combining art, music, and technology are effective instructional tools	55	30.7
STEAM focuses primarily on developing motor skills rather than academic competencies	13	7.3
3. Attitude toward using neurolinguistic-based STEAM applications		
I do not want to use them; traditional methods are sufficient	41	22.9
I find it interesting, but I hesitate because I do not know how to apply it	42	23.5
I want to learn and use them because I think they will contribute to my professional development	76	42.5
Applying them in instruction is overly complex and time-consuming	20	11.2
4. The most effective STEAM component in phonemic skills instruction		
Technology (speech recognition applications, digital tools)	75	41.9
Art (sound-color matching, rhythmic visual activities)	39	21.8
Music and movement (sound-rhythm-body coordination)	27	15.1
Nature/science-based activities (exploring sound sources, experiments)	38	21.2
5. The most appropriate setting for developing phoneme discrimination, according to brain-based learning principles		
A quiet, calm classroom setting	50	27.9
A multisensory setting with simultaneously presented stimuli (auditory + visual + kinesthetic)	89	49.7
Structured, repetition-based question-and-answer sessions only	15	8.4
A free-play setting in which children make entirely autonomous, free choices	25	14.0
6. Inclusion of neurolinguistic approaches in teacher education programs		
No; it unnecessarily complicates the curriculum	31	17.3
Could be offered as an elective course but should not be mandatory	62	34.6
Yes; all pre-service early childhood teachers should have mandatory access to it	67	37.4
Should be addressed only for graduate and final-year students	19	10.6
7. The value of the STEAM arts component in phonemic awareness activities		
Art activities cannot be directly linked to phonemic awareness	45	25.1
Can only be used for entertainment; its educational contribution is limited	51	28.5
Sound-visual matching and rhythmic drawings make phoneme discrimination more concrete	75	41.9
The arts component is effective only for children aged 5 and above	8	4.5

Note. Percentages are calculated based on N = 179 and totals may differ from 100% due to rounding; P: Percentage

Table 3. Descriptive statistics for the competency scale items (N = 179)

Item	M	SD	Level
1. I can design brain-based activities that support phoneme discrimination	4.18	1.04	High
2. I know how to relate NLP techniques to phoneme instruction	4.02	1.17	High
3. I can foster phonemic awareness using STEAM materials	4.10	1.05	High
4. I can explain how sound is processed in the brain using age-appropriate methods	4.08	1.06	High
5. I can integrate phoneme instruction with art/music activities	4.13	1.06	High
6. I can prepare materials that support the phoneme-grapheme relationship	4.05	1.09	High
7. I can effectively use technology-supported STEAM tools	4.12	1.06	High
8. I can plan differentiated instruction for different developmental levels	4.04	1.14	High
9. I can adapt activities according to sensory channel preferences	4.09	1.11	High
10. I can prepare observation forms/checklists for assessment purposes	4.16	1.06	High
Overall scale	4.10	0.96	High

Note. Measured on a 5-point Likert scale ranging from 1 to 5; Level classification: 3.41-4.20 = High; Item 9 refers to "sensory channel preferences", a notion associated with the contested learning-styles idea; it was interpreted here only as perceived ability to adapt activities across modalities

Mean item scores were tightly clustered from 4.02 to 4.18; high perceived competency was found for designing brain-based activities (item 1, M = 4.18) and preparing observation forms/checklists (item 10, M = 4.16), whereas low was for applying NLP techniques to phoneme instruction (item 2, M = 4.02) and

differentiated instruction (item 8, M = 4.04). Small disparities between individual items are in line with the results of analysis of construct validity that demonstrated the scale's uni-dimensionality and internal consistency (see method, data collection tool).

Table 4. Comparison of competency perception scores by gender

Gender	n	M	SD	t	df	p	d
Female	155	4.11	0.95	0.23	29.62	.818	0.05
Male	24	4.05	1.01				

Note. Welch's t-test was applied under the assumption of unequal variances

Table 5. Comparison of competency perception scores by grade/year of study

Grade	n	M	SD	F	df1, df2	p	η^2
1 st year	27	4.38	0.79	3.48	3, 70.16	.020*	0.06
2 nd year	63	4.29	0.81				
3 rd year	66	3.81	1.13				
4 th year	23	4.07	0.76				

Note. * $p < .05$ because Levene's test was significant ($p = .003$); Welch's ANOVA was applied; post hoc comparisons were conducted using the Games-Howell test

Table 6. Comparison of competency perception scores by age

Age group	n	M	SD	t	df	p	d
18-20 years	139	4.09	1.02	-0.41	93.86	.683	0.06
21 years and above	40	4.14	0.69				

Note. Because participant numbers in some of the original four age categories were insufficient (particularly the 24-26 range, $n = 1$), the age variable was recoded into two categories: 18-20 years and 21 years and above; Because Levene's test was significant ($p = .020$), Welch's t-test was applied

Table 7. Comparison of competency perception scores by phonemic awareness training status

Group	n	M	SD	F	df1, df2	p	η^2
None (A)	53	3.39	0.98	26.56	2, 176	< .001**	0.23
Seminar/workshop (B)	64	4.36	0.80				
Course (C)	62	4.43	0.75				

Note. ** $p < .01$; because Levene's test was not significant ($p = .167$), standard ANOVA and Tukey's HSD post hoc test were applied; Tukey's HSD: $A < B$, $p < .001$; $A < C$, $p < .001$; $B < C$, $p = .878$

Findings Regarding the Third Research Question

Within the scope of the third research question, whether competency perception scores differed according to gender, grade/year of study, and age range was examined.

Findings by gender

Table 4 shows the comparison of competency perception scores by gender.

It is evident that competency perception scores were equally distributed among both genders, $t(29.62) = 0.23$, $p = .818$. Moreover, the effect size was found to be insignificant ($d = 0.05$). This means that even though the gender distribution was imbalanced (female participants comprised 86.6% while male participants represented 13.4%), there was no difference in competency perception.

Findings by grade/year of study

Table 5 shows the comparison of competency perception scores by grade/year of study.

However, Levene's test indicated that variances were heterogeneous across different grades ($p = .003$); thus, Welch's ANOVA was employed. It showed that there was a statistically significant difference in competency perception score by grades, Welch's $F(3, 70.16) = 3.48$, $p = .020$, $\eta^2 = .06$ (small to moderate effect size). According

to the results of the Games-Howell post hoc test, the competency perception score of first-year pre-service teachers ($M = 4.38$) was significantly greater than the competency perception score of third-year students ($M = 3.81$, $p = .034$). Also, competency perception score of second-year students ($M = 4.29$) was significantly higher than that of third-year students ($p = .028$). There were no other statistically significant differences. This pattern implies that, instead of a linear effect, there is a pronounced lower competency perception of third-year students, who demonstrated much greater variability ($SD = 1.13$) in comparison with other grades.

Findings by age range

Table 6 shows the comparison of competency perception scores by age.

Scores on perceived competencies were not significantly different across age groups, $t(93.86) = -0.41$, $p = .683$, $d = 0.06$ (negligible effect). The two age groups did not differ in perceived competency.

Findings Regarding the Fourth Research Question

Table 7 shows the comparison of competency perception scores by phonemic awareness training status.

The results indicate that there were significant differences in competency perception based on

Table 8. Comparison of competency perception scores by STEAM experience

Group	n	M	SD	F	df1, df2	p	η^2
None (A)	55	3.48	0.92	20.63	2, 176	< .001	0.19
Within a course (B)	73	4.33	0.94				
Project/event (C)	51	4.44	0.67				

Note. Because Levene's test was not significant ($p = .217$), standard ANOVA and Tukey's HSD post hoc test were applied; Tukey's HSD: A < B, $p < .001$; A < C, $p < .001$; B = C, $p = .783$

Table 9. Comparison of competency perception scores by familiarity with NLP

Group	n	M	SD	F	df1, df2	p	η^2
Never heard of it (A)	51	3.67	1.06	15.24	3, 91.12	< .001	0.15
Heard of it, doesn't know it (B)	60	3.97	0.95				
Somewhat familiar (C)	44	4.44	0.74				
Very familiar (D)	24	4.72	0.47				

Note. Because Levene's test was significant ($p < .001$), Welch's ANOVA and the Games-Howell post hoc test were applied

phonemic awareness training experience, $F(2, 176) = 26.56$, $p < .001$, $\eta^2 = .23$ (large effect). As per the post hoc analysis conducted using the Tukey HSD test, participants who had no experience of phonemic awareness training ($M = 3.39$) scored significantly lower as compared to those who have had phonemic awareness training in seminar/workshop mode ($M = 4.36$, $p < .001$) and those who had it as a course ($M = 4.43$, $p < .001$). There were no significant differences between participants having undergone seminar / workshop and course mode training ($p = .878$).

Findings Regarding the Fifth Research Question

Table 8 shows the comparison of competency perception scores by STEAM experience.

Scores on the competency perception scale were significantly different based on the STEAM experience variable, $F(2, 176) = 20.63$, $p < .001$, $\eta^2 = .19$ (large effect). Tukey's HSD post hoc test indicated that participants who did not have any experience in STEAM ($M = 3.48$) performed significantly worse compared to those who acquired their STEAM experience from taking a course ($M = 4.33$, $p < .001$), as well as those who had STEAM experience from working on a project/event ($M = 4.44$, $p < .001$). There was no significant difference between these two latter groups ($p = .783$). Similar to phonemic awareness training, STEAM experience (course, project) is highly associated with competency perception.

Findings Regarding the Sixth Research Question

Table 9 shows the comparison of competency perception scores by familiarity with NLP.

Perception of competency scores varied significantly based on the participants' familiarity with NLP concept, Welch's $F(3, 91.12) = 15.24$, $p < .001$, $\eta^2 = .15$ (large effect). Based on Games-Howell post hoc test, the participants who had never heard of NLP concept had significantly low perception of competency ($M = 3.67$) compared to those who were somewhat familiar with the concept ($M = 4.44$, $p < .001$) and those who were very familiar with the concept ($M = 4.72$, $p < .001$). However, no significant

difference was noted between the first group and those who had heard about the concept but had no knowledge of its contents ($M = 3.97$, $p = .423$). In contrast, those who were somewhat familiar with the concept scored significantly higher than those who had only heard of it ($p = .027$), and those who were very familiar scored significantly higher than both those who had never heard of it ($p < .001$) and those who had only heard of it ($p < .001$). There was no significant difference between the very familiar and somewhat familiar groups ($p = .221$).

DISCUSSION

The study evaluated the views and competency perception levels of pre-service early childhood teachers on the application of neurolinguistic-based STEAM to phonemic skills training, and the differences in their levels in terms of different demographic and professional factors. The findings revealed that the most dominant view held by pre-service teachers (36.9%) is that phonemic skills will emerge spontaneously in early childhood without requiring any systematic training, whereas only 28.5% of them held the view consistent with the literature. By considering the number of those pre-service teachers who think that phonemic skills should be taught in primary education (24.0%) or are only the responsibility of specialists (10.6%), about 71.5% of participants did not agree on systematic preschool training. This finding implies that pre-service teachers might have conceptual gaps about early literacy and phonemic awareness training (Forgie et al., 2022; Parpucu & Güler Yıldız, 2022). In comparison with other existing studies in the literature, this finding reveals significant similarities with the literature revealing that preschool teachers and pre-service teachers overlook the nature of phonemic awareness training and consider it a natural part of linguistics (Cunningham et al., 2009; NICHD, 2000; Purvis et al., 2016). But this finding is limited to pre-service teachers' self-reported views and does not allow for observation of their actual classroom instructional behavior or direct pedagogical practice.

Analysis of results related to the relation of STEAM strategy to phonemic skills development demonstrates that about one-third of pre-service teachers (31.3%) claimed that STEAM is irrelevant to language skills, 30.7% stated that STEAM activities indirectly contribute to phonemic awareness development, and another 30.7% believed that such activities are useful as instructional means. As for the most effective component of STEAM, the majority of participants (41.9%) highlighted technology, while 21.8% pointed out art, 21.2% – nature/ science activities, and 15.1% – music and movement. In the case of item that assessed the art component, 41.9% of respondents claimed that sound-visual matching and rhythmic drawings help students discriminate against phonemes better, while 53.6% viewed art as either entertainment (28.5%) or irrelevant to phonemic awareness (25.1%). It should be noted that the fact that pre-service teachers mainly focus on technology when they refer to STEAM strategy and pay little attention to phonological aspect of art and music, in addition to considering STEAM separately from language education, may point to a tendency to treat STEAM components separately from language pedagogy (Veziroglu-Celik et al., 2026). Technology as the most frequent choice in item 4 cannot be read as fragmentation on its own, since that item has no keyed answer; the interpretation rests on item 2 and item 7. This conclusion corroborates the research conducted by Alghamdi (2023) and Wang and Lin (2026), which shows that teachers believe that STEAM is mainly confined to science and math education, whereas it contradicts the researches that prove the connection between musical and visual arts and the improvement of sound structure and phonological awareness (Barg, 2021; Degé & Schwarzer, 2011). Therefore, while some future teachers seem to realize that the arts have a potential to make concepts tangible, they lack the pedagogical framework that would turn this realization into an educational result.

With respect to attitudes towards neuro-linguistically-based applications of STEAM and the context of instruction, 42.5% of future educators indicated that they wished to learn and apply the approaches since they would develop professionally, while 49.7% indicated that in terms of the theory of brain-based learning, the most suitable context for phoneme discrimination would be multisensory learning where stimuli were presented simultaneously, whereas 8.4% chose structuring and repetition-based context. Moreover, 37.4% supported mandatory inclusion of NLAs in pre-service programs and a further 34.6% an elective course, while 17.3% rejected inclusion. The results show that future educators have professional curiosity and positive attitudes towards innovative NLAs and support the idea of multisensory learning (Ginting & Hartati, 2023; Merkviladze, 2023). On the other hand, 57.5% of the respondents did not choose the

positive attitude towards the strategy mentioned in the attitude item; 22.9% believed that traditional methods were enough, 23.5% were uncertain about applying these strategies because they did not know how to do it, and 11.2% thought they were too complicated and time-consuming. In fact, it was proven by research that even though teachers have positive attitudes towards NLP and brain-based strategies, they have insufficient methodological knowledge in the design of multisensory learning environments (Keezhatta, 2019; Zhang et al., 2023). It indicates the presence of clear differences between the willingness of pre-service teachers to accept innovative brain-based strategies and their competencies in doing so. On the other hand, due to the cross-sectional nature of the study, it is impossible to monitor changes in attitudes of the participants to the mentioned approach.

The results related to the second research question indicated that the perceived levels of competency of pre-service teachers in practices of phonemic skills instructions were quite high. All items were rated similarly high, and no item-level ranking is interpreted. High scores, which pre-service teachers reported as their competencies, in contrast to the diversity of opinions provided in relation to the first research question, could be explained by the overestimation of their self-confidence or, in other words, inflated self-efficacy typical for pre-service teachers. The latter opinion is supported by literature, which indicates that pre-service teachers usually tend to estimate their theoretical skills quite positively before having enough practical experience of teaching in classrooms (Alghamdi, 2023; Forgie et al., 2022; Stepanović Ilić et al., 2025). It is believed that pre-service teachers are able to use interdisciplinary approaches in their work, but this is more related to their professional optimism rather than knowledge and practice (ElSayary et al., 2022; Walshe et al., 2025). Indeed, an important limitation is that the high scores obtained from the scale reflect pre-service teachers' self-perceptions rather than their objective performance.

Comparing data for the third research question showed that pre-service teachers' scores on competency perception were similar regardless of their gender or age category. Such result implies that pre-service teachers' competency perceptions in relation to neurolinguistic-based STEAM and phonemic skills teaching is influenced more by the training procedures than by demographic characteristics like gender and age. Literature review also proves that most studies exploring the issue of self-efficacy of teachers in early childhood education and STEAM classes find no significant differences in competency perceptions depending on gender and age (Alghamdi, 2023; Lundberg et al., 2012; Stepanović Ilić et al., 2025). Thus, the similarity of training procedures that undergraduates are exposed to and shared content of

courses seems to compensate for possible individual differences due to gender and age. On the other hand, the prevalence of female respondents (86.6%) and those from the 18-20 age category (77.7%) among participants can be considered as the limitation of the study. As far as the results concerning the grade/year of study variable go, on the contrary, there was an established significant difference in competency perception, where the first and second year pre-service teachers had much higher competency perception compared to the third-year students. This non-linear difference may be explained by the fact that pre-service early childhood teachers, after starting to make school placements and to have the practicum experience during their third year of study, face the reality of the class, which makes their initially highly-idealized self-perception of their competency lower and become more real, experiencing what can be called "reality shock." These findings are in full conformity with the professional development literature, where it is established that the pre-service teachers realize their pedagogical incompetence during practicum and field experience, so their perception of their competency becomes much more critical (Bezcioglu-Göktolga, 2013; Tschannen-Moran & Hoy, 2007; Veziroglu-Celik et al., 2026). However, since this result was found using cross-sectional study design, the inability to follow up on the same students' professional development throughout their stay at the school is one of its limitations.

Results obtained for the fourth research question demonstrated that the previous presence of phonemic awareness training made a significant difference in the perceived competence with a large effect size. It becomes clear from the results that participants who received either seminar/workshop-based or course-based training scored higher than those who did not receive any training. This means that specific training in the area of early literacy skills development develops the professional confidence of pre-service teachers. This conclusion is supported by findings stating that the participation in the course devoted to phonemic awareness and language instruction increases teacher self-efficacy (Cheesman et al., 2009; Forgie et al., 2022; Schachter et al., 2016). The lack of a significant difference between the two types of training proves that short but good-quality training seminars are able to develop the same level of competence as a full-length course.

Analysis pertaining to another research question indicated that having STEAM education experience greatly increased competency perceptions with a large effect size. Since the competency perceptions of participants without STEAM experience were significantly lower than those of participants who acquired such experience either from courses or events, it becomes clear that practical experience in an interdisciplinary setting is an essential source of competency perceptions. This conclusion is consistent

with the findings of studies that have demonstrated that STEAM education through practice and project experience enhance the curriculum design thinking and implementation self-efficacy of pre-service teachers (Alghamdi, 2023; ElSayary et al., 2022; Walshe et al., 2025; Wang & Lin, 2026). The equality of the levels of competencies achieved through course-based experience and project-based experience emphasizes the importance of any kind of practical experience where interdisciplinary integration is possible in reducing the implementation anxiety of pre-service teachers. Regarding the answer to the sixth research question, we can state that the familiarity with the NLP concept made a big difference in the competency perception with a high effect size. The fact that those participants who did not know about NLP or just heard the term perceived significantly lower levels of competency compared to those who knew something about NLP indicates the importance of conceptual knowledge of neurolinguistic concepts. This result is consistent with findings that show how NLP approaches, VAK representational systems, and neurolinguistic communication techniques in language teaching increase teachers' professional identity, communication, and instructional self-efficacy (Ginting & Hartati, 2023; Keezhatta, 2019; Merkviladze, 2023; Zhang et al., 2023). The mere exposure to the concept of NLP at a basic level did not bring about any increase in perceived competency, suggesting that in order for self-efficacy to increase, understanding is needed beyond mere exposure.

All in all, the results indicate that even though pre-service teachers exhibit a high level of competence perception regarding neurolinguistic based STEAM application, their perceptions regarding phonemic skill development and the role of STEAM in language teaching seem rather dispersed and may contain misconceptions which contradict the scientific literature. It indicates a potential gap between the level of self-efficacy perception and conceptual knowledge; the fact that the vast majority of pre-service teachers favor the use of such teaching approaches in the teacher education programs (72.1%) highlights the importance of integration of brain-based learning principles, multisensory methods, and STEAM subjects in early literacy teaching by means of holistic approach (Elleuch, 2024). The evidence that the three factors of phonemic awareness, STEAM, and NLP training, conducted during the pre-service phase, are strong predictors of competency perception, individually, further proves the necessity for designing an innovative curriculum which will combine all three factors. The positive attitude of the pre-service early childhood teachers towards the application of the above tools proves to be an excellent starting point for designing educational interventions. The study was conducted solely with pre-service teachers from one university, limits generalizability of results to other cultures and countries.

This study has several limitations. Participants came from a single university and were selected by convenience sampling; 86.6% were female. All data were self-reported, so scores reflect perceptions rather than performance, and the high scores may be affected by acquiescence and social desirability. The cross-sectional design and self-selected experience groups do not allow causal inference. Some cells were small ($n = 23-24$), and several tests were run without correction for multiple comparisons. The views questionnaire has no psychometric evidence beyond a qualitative expert review, and its expert panel lacked early literacy expertise. The competency scale was examined with PCA on the same sample, shows signs of item redundancy, and item 9 is framed around the contested notion of sensory preferences. Practicum experience was not measured.

CONCLUSION AND RECOMMENDATIONS

From the results found in this study, it can be concluded that the perception of competence of the pre-service early childhood teachers regarding the use of neurolinguistic-based STEAM applications in teaching phonemic skills is rather high, and the positive attitude towards learning and application of these applications is the largest one among the participants. It should be noted that the pre-service teachers' perception concerning the development of phonemic skills and the relationship between STEAM and language pedagogy was varied and included views that did not completely correspond to the existing literature. Moreover, another important conclusion from this study is that previous phonemic awareness training, STEAM experience, and having a higher level of knowledge about NLP were associated with higher perceived competency among the pre-service teachers. Moreover, the finding of the lower perception of competence of the third-year students than the first- and second-year ones may reflect, among other possible explanations, a more critical self-assessment as the program progresses. Thus, in order to develop sustainable high pedagogical competence among pre-service teachers, who are highly motivated and self-confident, holistic modules may be worth considering in undergraduate education.

The following recommendation is made for teacher education institutions and practitioners in relation to this topic: *The findings suggest that teacher educators may consider adding applied, STEAM-integrated phonemic awareness modules to early literacy and language development courses, including a critical examination of the evidence on NLP, learning styles, and brain-based claims.* Teacher trainees should not be offered only the theoretical aspects of knowledge in such classes during their undergraduate studies, but they should be offered the opportunity to create multisensory materials

incorporating music, art, and technology and to do microteaching.

In terms of future research, besides the use of survey designs that include quantifiable methods, it is advised that research designs that would include observation of the teaching practices and material preparation processes of the pre-service teachers should be carried out. It would be valuable for experimental and longitudinal designs to be developed to see the impact of neurolinguistic based STEAM education applications on phonological awareness and literacy development of the children. The use of longitudinal design on how the pre-service teachers' perception of their competency and a possible "reality shock" effect would change throughout their years from their first year to their graduation would be a valuable contribution to the literature.

Author contributions: **YKO:** conceptualization, investigation, methodology, writing – original draft; **AIB:** project administration, supervision, validation, writing – review & editing; **GTA:** data curation, formal analysis, resources; **LMM:** methodology, software, visualization; **SSS:** investigation, validation, writing – review & editing. All authors agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: This study was conducted in accordance with the ethical principles and procedures set out in the Declaration of Helsinki. Prior to data collection, all participants were informed about the purpose and scope of the study, and online informed consent was obtained on a voluntary basis. Participants were assured that their participation was entirely voluntary and that they could withdraw at any stage without any consequences. All data were collected anonymously, and no personal identifiable information was recorded. The data were stored securely and used solely for the purposes of this research, in full compliance with relevant data protection regulations.

AI statement: No generative AI or AI-based tools were used in this study.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

- Alghamdi, A. A. (2023). Exploring early childhood teachers' beliefs about STEAM education in Saudi Arabia. *Early Childhood Education Journal*, 51(2), 247-256. <https://doi.org/10.1007/s10643-021-01303-0>
- Altun, D., & Tantekin Erden, F. (2016). Pre-service preschool teachers' opinions and school practices on early literacy. *Ahi Evran University Kırşehir Faculty of Education Journal*, 17(1), 241-261.
- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191-215. <https://doi.org/10.1037/0033-295X.84.2.191>
- Barg, J. (2021). *Music integration in childhood education* [Master's thesis, Roberts Wesleyan College].

- Bassachs, M., Cañabate, D., Nogué, L., Serra, T., Bubnys, R., & Colomer, J. (2020). Fostering critical reflection in primary education through STEAM approaches. *Education Sciences*, 10(12), Article 384. <https://doi.org/10.3390/educsci10120384>
- Bezcioglu-Göktolga, İ. (2013). *Self-reports of preschool foreign language teachers on early childhood foreign language teaching and related challenges* [Master's thesis, Middle East Technical University].
- Cabero-Almenara, J., Llorente-Cejudo, C., Ballesteros-Regaña, C., & Fernández-Scagliusi, M. V. (2026). Teachers' perceptions of the challenges in integrating augmented reality, virtual reality, and extended reality into higher education. *Contemporary Educational Technology*, 18(4), Article ep690. <https://doi.org/10.30935/cedtech/19274>
- Carroll, J., Gillon, G., & McNeill, B. (2012). Explicit phonological knowledge of educational professionals. *Asia Pacific Journal of Speech, Language and Hearing*, 15(4), 231-244. <https://doi.org/10.1179/136132812804731820>
- Cheesman, E. A., McGuire, J. M., Shankweiler, D., & Coyne, M. (2009). First-year teacher knowledge of phonemic awareness and its instruction. *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children*, 32(3), 270-289. <https://doi.org/10.1177/0888406409339685>
- Chen, Y.-L., Huang, L.-F., & Wu, P.-C. (2021). Preservice preschool teachers' self-efficacy in and need for STEM education professional development: STEM pedagogical belief as a mediator. *Early Childhood Education Journal*, 49, 137-147. <https://doi.org/10.1007/s10643-020-01055-3>
- Çiftçi, A., Topçu, M. S., & Foulk, J. A. (2022). Pre-service early childhood teachers' views on STEM education and their STEM teaching practices. *Research in Science & Technological Education*, 40(2), 207-233. <https://doi.org/10.1080/02635143.2020.1784125>
- Creswell, J. W. (2024). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (7th ed.). Pearson.
- Cunningham, A. E., Zibulsky, J., & Callahan, M. D. (2009). Starting small: Building preschool teacher knowledge that supports early literacy development. *Reading and Writing*, 22(4), 487-510. <https://doi.org/10.1007/s11145-009-9164-z>
- Dare, E. A., Ring-Whalen, E. A., & Roehrig, G. H. (2019). Creating a continuum of STEM models: Exploring how K-12 science teachers conceptualize STEM education. *International Journal of Science Education*, 41(12), 1701-1720. <https://doi.org/10.1080/09500693.2019.1638531>
- Degé, F., & Schwarzer, G. (2011). The effect of a music program on phonological awareness in preschoolers. *Frontiers in Psychology*, 2. <https://doi.org/10.3389/fpsyg.2011.00124>
- DeJarnette, N. K. (2018). Implementing STEAM in the early childhood classroom. *European Journal of STEM Education*, 3(3), Article 18. <https://doi.org/10.20897/ejsteme/3878>
- Dekker, S., Lee, N. C., Howard-Jones, P., & Jolles, J. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology*, 3. <https://doi.org/10.3389/fpsyg.2012.00429>
- Duman, B. (2010). The effects of brain-based learning on the academic achievement of students with different learning styles. *Educational Sciences: Theory & Practice*, 10(4), 2077-2103.
- Ehri, L. C., Nunes, S. R., Stahl, S. A., & Willows, D. M. (2001). Systematic phonics instruction helps students learn to read: Evidence from the national reading panel's meta-analysis. *Review of Educational Research*, 71(3), 393-447. <https://doi.org/10.3102/00346543071003393>
- Elleuch, D. (2024). Applying the MSMLP model in advancing language teaching and learning: A longitudinal case study on soft skills development. *Frontiers in Education*, 9. <https://doi.org/10.3389/feduc.2024.1355952>
- ElSayary, A., Zein, R., & San Antonio, L. (2022). Using interactive technology to develop preservice teachers' steam competencies in early childhood education program. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(2), Article em2079. <https://doi.org/10.29333/ejmste/11649>
- Forgie, J. C., Hu, J., & Boccalon, M. (2022). Pre-service and in-service early childhood educators' self-efficacy and knowledge for early literacy instruction. *Cogent Education*, 9(1), Article 2151246. <https://doi.org/10.1080/2331186X.2022.2151246>
- Gillon, G. T. (2007). *Phonological awareness: From research to practice*. Guilford Press.
- Ginting, S. A., & Hartati, R. (2023). Neuro-linguistic programming in the English classroom: Perceptions and applications among teachers. *Voices of English Language Education Society*, 7(2), 355-363. <https://doi.org/10.29408/veles.v7i2.22549>
- Gromko, J. E. (2005). The effect of music instruction on phonemic awareness in beginning readers. *Journal of Research in Music Education*, 53(3), 199-209. <https://doi.org/10.1177/002242940505300302>
- Howard-Jones, P. A. (2014). Neuroscience and education: Myths and messages. *Nature Reviews Neuroscience*, 15(12), 817-824. <https://doi.org/10.1038/nrn3817>

- Jamil, F. M., Linder, S. M., & Stegeline, D. A. (2018). Early childhood teacher beliefs about STEAM education after a professional development conference. *Early Childhood Education Journal*, 46(4), 409-417. <https://doi.org/10.1007/s10643-017-0875-5>
- Keezhatta, M. S. (2019). The impact of neuro-linguistic programming on English language teaching: Perceptions of NLP-trained English teachers. *International Journal of English Linguistics*, 9(6), 454-465. <https://doi.org/10.5539/ijel.v9n6p454>
- Kjeldsen, A. C., Kärnä, A., Niemi, P., Olofsson, Å., & Witting, K. (2014). Gains from training in phonological awareness in kindergarten predict reading comprehension in grade 9. *Scientific Studies of Reading*, 18(6), 452-467. <https://doi.org/10.1080/10888438.2014.940080>
- Lundberg, I., Larsman, P., & Strid, A. (2012). Development of phonological awareness during the preschool year: The influence of gender and socio-economic status. *Reading and Writing*, 25(2), 305-320. <https://doi.org/10.1007/s11145-010-9269-4>
- Mather, N., Bos, C. S., & Babur, N. (2001). Perceptions and knowledge of preservice and inservice teachers about early literacy instruction. *Journal of Learning Disabilities*, 34(5), 472-482. <https://doi.org/10.1177/002221940103400508>
- Merkviladze, M. (2023). Teachers' perspective on the applicability of neuro-linguistic programming to address EFL learners' speaking anxiety (case of the universities in Georgia). *Journal of Education in Black Sea Region*, 9(1), 106-124. <https://doi.org/10.31578/jebs.v9i1.311>
- Moritz, C., Yampolsky, S., Papadelis, G., Thomson, J., & Wolf, M. (2013). Links between early rhythm skills, musical training, and phonological awareness. *Reading and Writing*, 26(5), 739-769. <https://doi.org/10.1007/s11145-012-9389-0>
- NICHD. (2000). Report of the national reading panel. Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction. U.S. Government Printing Office. <https://www1.nichd.nih.gov/publications/pubs/nrp/documents/report.pdf>
- Paradis, M. (2004). *A neurolinguistic theory of bilingualism*. John Benjamins Publishing.
- Parpucu, N., & Güler Yıldız, T. (2022). What do preschool teachers know about phonological awareness education, what are they doing at practice and what do they need? *Hacettepe University Journal of Education*, 37(2), 684-700. <https://doi.org/10.16986/HUJE.2020062664>
- Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest*, 9(3), 105-119. <https://doi.org/10.1111/j.1539-6053.2009.01038.x>
- Patel, A. D. (2008). *Music, language, and the brain*. Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780195123753.001.0001>
- Perumal, N., & Shanmuhavelu, G. S. N. (2026). Examining neuro-linguistic programming practice in English language teaching: A systematic review and qualitative meta-synthesis. *Digital Technologies Research and Applications*, 5(1), 219-244. <https://doi.org/10.54963/dtra.v5i1.2095>
- Purvis, C. J., McNeill, B. C., & Everatt, J. (2016). Enhancing the metalinguistic abilities of pre-service teachers via coursework targeting language structure knowledge. *Annals of Dyslexia*, 66(1), 55-70. <https://doi.org/10.1007/s11881-015-0108-9>
- Rakhlin, N., Cardoso-Martins, C., & Grigorenko, E. (2014). Phonemic awareness is a more important predictor of orthographic processing than rapid serial naming: Evidence from Russian. *Scientific Studies of Reading*, 18(6), 395-414. <https://doi.org/10.1080/10888438.2014.918981>
- Rowe, K. (2005). Teaching reading: Report and recommendations. Australian Government Department of Education, Science and Training. https://research.acer.edu.au/tll_misc/5
- Schachter, R. E., Spear, C. F., Piasta, S. B., Justice, L. M., & Logan, J. A. R. (2016). Early childhood educators' knowledge, beliefs, education, experiences, and children's language- and literacy-learning opportunities: What is the connection? *Early Childhood Research Quarterly*, 36, 281-294. <https://doi.org/10.1016/j.jecresq.2016.01.008>
- Sgueglia, V. E. (2024). The neurolinguistic approach (NLA) to second or foreign language acquisition: An attempt to adapt this method to DELF exam preparation. *McGill Journal of Education/Revue des Sciences de l'éducation de McGill*, 58(3), 315-324. <https://doi.org/10.26443/mje/rsem.v58i3.10236>
- Sharpley, C. F. (1987). Research findings on neurolinguistic programming: Nonsupportive data or an untestable theory? *Journal of Counseling Psychology*, 34(1), 103-107. <https://doi.org/10.1037/0022-0167.34.1.103>
- Simoncini, K., & Lasen, M. (2018). Ideas about STEM among Australian early childhood professionals: How important is STEM in early childhood education? *International Journal of Early Childhood*, 50(3), 353-369. <https://doi.org/10.1007/s13158-018-0229-5>

- Sousa, D. A., & Pilecki, T. (2013). *From STEM to STEAM: Using brain-compatible strategies to integrate the arts*. Corwin Press.
- Stepanović Ilić, I., Peixoto, F., Dabić Boričić, M., Videnović, M., Castro Silva, J., Ferreira, N., & Monteiro, V. (2025). Construction of a scale measuring primary teachers' self-efficacy to teach STEAM: The STEAM-TSES. *Frontiers in Education*, 9. <https://doi.org/10.3389/feduc.2024.1519327>
- Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education*, 23(6), 944-956. <https://doi.org/10.1016/j.tate.2006.05.003>
- Veziroglu-Celik, M., Ozkaya, S., Kacar, G., & Senturk, Z. E. (2026). STEAM in early childhood: An analysis towards teachers' and children's perspectives. *Early Childhood Education Journal*, 54(2), 1027-1039. <https://doi.org/10.1007/s10643-025-01897-9>
- Walshe, P., Commins, A., McDonnell, C., & Kelly, B. G. (2025). 'STEAM from the start': Proposing a conceptual framework for the development and implementation of a STEAM training intervention for early childhood educators. *European Journal of STEM Education*, 10(1), Article 11. <https://doi.org/10.20897/ejsteme/17156>
- Wang, C.-Y., & Lin, Y.-H. (2026). STEAM in early childhood education: Teachers' curriculum design thinking and implementation self-efficacy. *Teachers and Teaching*, 32(5), 874-888. <https://doi.org/10.1080/13540602.2025.2490833>
- Whitehurst, G. J., & Lonigan, C. J. (1998). Child development and emergent literacy. *Child Development*, 69(3), 848-872. <https://doi.org/10.1111/j.1467-8624.1998.tb06247.x>
- Witkowski, T. (2010). Thirty-five years of research on neuro-linguistic programming. NLP research data base. State of the art or pseudoscientific decoration? *Polish Psychological Bulletin*, 41(2), 58-66. <https://doi.org/10.2478/v10059-010-0008-0>
- Yakman, G. (2010). STEAM: A framework for teaching across the disciplines. *Virginia Polytechnic and State University*. https://www.researchgate.net/figure/A-framework-for-STEAM-education-C-Yakman-G-2010-used-with-permission_fig2_333908373
- Yang, W., Wu, R., & Li, J. (2023). Development and validation of the STEM teaching self-efficacy scale (STSS) for early childhood teachers. *Current Psychology*, 42(9), 7275-7283. <https://doi.org/10.1007/s12144-021-02074-y>
- Zeb, F., & Hameed, A. (2020). Neurolinguistic programming and English language teaching: An exploration of linguistic variants in NLP for its connection to ELT. *SJESR*, 3(4), 96-105. [https://doi.org/10.36902/sjesr-vol3-iss4-2020\(96-105\)](https://doi.org/10.36902/sjesr-vol3-iss4-2020(96-105))
- Zhang, X., Davarpanah, N., & Izadpanah, S. (2023). The effect of neurolinguistic programming on academic achievement, emotional intelligence, and critical thinking of EFL learners. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.888797>

<https://www.ejmste.com>