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Neurodidactic teacher training program for educational dropouts in vulnerable groups

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Neurodidactic is presented as an effective teaching tool for creating an equitable society, regardless of the population. This educational methodology, which has recently been introduced in teacher training, supports students with functional diversity, special educational needs, sensory diversity (visual or auditory), and those belonging to the Gypsy ethnic group. Neurodidactics emphasizes that the teacher's role is to create synapses in the neuronal structures through activities that a student finds innovative, attractive, and motivating. To achieve this, it is necessary to identify the aspects that should be included in the training of teachers to work with students who belong to vulnerable groups and to develop effective intervention programs based on neurodidactics. The study population comprises professors of higher education at the University of Jaen (UJA) who responded to a Likert scale survey using an operationalization table. The survey was conducted to determine the professors' knowledge of neuroscience, particularly neurodidactics.

KEYWORDS

neurodidactics, vulnerable groups, ethnic, Roma, functional diversity

1. Introduction

1.1. Neuroscience

Neuroscience is a field of study that focuses on the biological functioning of living organisms, with a particular emphasis on the brain and its responses to various experiences (Campuzano et al., 2019). Neuroscience has allowed the linking of different areas, so it is considered interdisciplinary. If the term neuroscience is referred in terms of the cognitive level, we mean the scientific field of cognitive neuroscience, which is relatively new and has emerged from the union between neuroscience and cognitive psychology, covering brain function from a multidisciplinary and human performance perspective (Redolar, 2014). In addition, neuroscience refers to the study of the nervous system and its functioning, thus the relationship between the brain and behavior has been established (Campuzano et al., 2019).

The neuroscientific basis can be defined across the four following dimensions: synaptogenesis, myelinogenesis, neurogenesis, and epigenesis (Siegel, 2012). Synaptogenesis refers to the creation of new neural connections and the hardening and strengthening of the existing connections. Myelinogenesis involves the process of enveloping interconnected axons with an insulating sheath to increase neural processing speed. Neurogenesis is the term used to describe the distinction between stem cells and fully mature cells; finally, epigenesis refers to the process of changing genes according to the environment (Miller, 2016).

The study of neurons and their role in daily activities has been made possible by technological advancements and the interdisciplinary nature of cognitive psychology, biology, and evolutionary psychology (Payarés, 2016).

Neuroscience has driven advances in knowledge concerning the treatment of psychiatric diseases and disorders, leading to the deceleration of cognitive decline and cellular aging (McMahon, 2016; Stroustrup et al., 2016) and, in turn, improving the cognitive functions of healthy individuals in non-clinical settings (Sahakian and LaBuzetta, 2015). Techniques such as neuroimaging have been instrumental in the primary measurement of the neural activity associated with a mood state, as was the case for behaviors in the human species. In addition, novel neuromodulation interventions such as neurofeedback, non-invasive brain stimulation, and cognitive training can induce changes in the brain's plasticity, leading to improved learning (Trenado et al., 2021). Thus, neuroscience must be included in teacher training to provide quality education and dispel neuromyths related to education (Hernández, 2022).

Although criticized by many (Salles, 2013), neuroscience has introduced significant scientific importance and normativity into the study of the social sciences.

1.2. Neurodiversity, neuroeducation, and neurodidactics

The concept of neurodiversity was coined by people with autism, and it was later embraced by other groups with functional diversity upon reconceptualization. This idea proposes a wide spectrum of neurological differences, and autism is one of many (Tonatiuh and Anguiano, 2019). The term "neurodiversity" was first used by the autism community in 1998, with Asperger's syndrome being another term created by the Australian activist Judy Singer (Armstrong, 2005). Consequently, most researchers interested in neurodiversity study autism. However, at present, neurodiversity has evolved beyond its original conception and has become a movement that offers a new approach to understanding atypical neurological developments in behavior (Moreno, 2021). Thus, neurodiversity refers to the diversity of the brains and minds among people, encompassing the infinite changes in neurocognitive functioning that are associated with psychological development (Silberman, 2015; Vidal and Diaz, 2016).

By applying the strategies of neuroscience, neuroeducation, neurolearning, neurodidactics, and neuroassessment, students' academic results can improve. The reason for this improvement is that the teacher better understands how the brain and its mechanisms work (Pherez et al., 2018).

Originally, the relationship between neuroscience and education was viewed as conflicting. However, the subject has since been consolidated and integrated across the fields of neurology, psychology, and educational research, giving rise to the emergence of educational neuroscience or neuroeducation (Parra-Díaz et al., 2019). The neuroscientific contributions to education have made it essential to reorganize pedagogical practices to better align with how the brain works, leading to the emergence of education with scientific connotations in the 20th century (Hernández, 2022).

Neuroeducation is a recent field of study that connects neuroscience with education (Hernández and De Barros, 2021). Neuroeducation is a branch of education linked by knowledge based on neuroimaging to the way in which the brain interacts with its environment (Hernández, 2022). Regarding neuroeducation, it is fundamental to highlight the importance of emotional management and control. Emotion plays an essential role in the decisions made on a daily basis, which means that the quality of our decisions can be affected by our mood. This highlights the importance of neuroeducation for teachers (Logan et al., 2014). Neuroeducation attempts to provide education professionals with educational strategies and technologies based on the brain's functions to make teaching more effective (Battro, 2016).

Similarly, neurodidactics is known for providing various efficient strategies that promote neuronal development, which, in turn, enhances learning. When working with vulnerable groups or students with specific learning difficulties, teachers must possess knowledge of brain structures to adapt their strategies and promote meaningful activities (Paniagua, 2013). This is directly linked to the study objective of this research, which is to analyze teachers' need to study neuroeducation to promote the learning of vulnerable groups. Currently, neurodidactics is considered a part of pedagogy with a scientific basis that guides innovative education. It involves a method of teaching and learning based on neuroscience. In other words, it is an extension of neuroeducation since it studies the application of neuroeducation in the classroom (De Barros and Hernández, 2022).

1.3. Culture, ethnicity, and diversity

Culture is constantly evolving, which is why it is essential for teachers to remain active in their learning. In the classroom, activities and methodological strategies should be designed to approach Gypsy culture not as something exotic or picturesque but as scientific knowledge that is part of our history and as values for democratic coexistence (García, 2017).

Two of the main problems observed in relation to ethnic differences are that attention to diversity in schools is associated with the conception that each teacher has regarding the different cultures that exist and that can be found; thus, it will depend on the conception and morality of the teacher, as well as their recognition of the ethnicities, territories, and ideologies that can be presented in their classrooms. Another problem is the tension involved in resolving these differences (Campoflor et al., 2016).

In the school context for Gypsy students, it is necessary to emphasize the importance of an inclusive school climate and teachers who stimulate and promote high expectations for these students to enhance their performance and socialization (Abajo and Carrasco, 2004). To increase the expectations and motivation of students, it is necessary to work on emotional intelligence, including improving empathy and collaboration between students (Mayer and Salovey, 1997; Goleman, 2011).

"We are emotional brains. Therefore, the role of the teacher is to foster spaces of pleasure and security... that allow participants to give their best" (Vega, 2022, p. 17).

On the basis of the above, the present investigation aimed to assess the neurodidactic knowledge of future teachers to address cultural differences stemming from ethnicity and functional diversity that may arise in their classrooms.

The problem addressed in this research is the inadequacy of teacher training in neurodidactic aspects as a tool to support educational dropouts in vulnerable student groups.

The main objective of this research was to evaluate the level of knowledge of teachers in neurodidactics and its application to vulnerable groups.

2. Method

2.1. Context of the research

This research was carried out in Jaén, which is a small city in northern Andalusia, Spain. Approximately 42% of the Gypsy population is registered in Andalusia. Specifically, in Jaén, according to the sociodemographic data of the Gypsy Secretariat, there are more than 10,000 people of Gypsy ethnicity. With regard to education, according to the Gypsy Secretariat, an educational gap is beginning to appear, especially in primary education.

In addition, according to the Observatorio de la Infancia en Andalucía (2020), 7,762 students with functional diversity have been enrolled in Andalusian primary education. In Andalusia, 0.3% of the foreign students enrolled in school have disabilities.

2.2. Hypothesis

The following null hypothesis is defined as follows: H_0- Teachers are trained to apply neurodidactics to students from vulnerable groups.

2.3. Population and sample

To investigate the training of teachers in neurodidactic knowledge to prevent school dropout in the vulnerable student groups, the population of interest was undergraduate students at the University of Jaén during the academic years 2022–2023. A convenience sample of 67 participants from the Primary Education department was selected for this study.

2.4. Research design

This research was characterized by an experimental design that is exploratory, descriptive, and correlative, and it was carried out through a quantitative methodology. The software used was the SPSS v.25 statistical package.

2.5. Research instrument

According to Mejía (2005), an operationalization matrix must be developed to create the research instrument. This matrix establishes the variables, items, and units of measurement.

This scale was composed of 24 items, grouped into four dimensions: A (teaching performance), B (vulnerable groups), C (beliefs), and D (inclusion). These theoretical items were based on a review of the scientific literature (Hernández and De Barros, 2016; De Barros and Hernández, 2018; Sims et al., 2021; Pinto and Flores, 2022).

The transition from the Likert scale to the aforementioned sample was made using both in-person and online questionnaires. The questionnaire was anonymous and voluntary for all participants, indicating that they could withdraw from the investigation at any time. Prior to completing the questionnaire, participants were informed of the research objectives and the commitment to publishing the results in the article once the study was completed.

2.6. Validity of content

To ensure content validity, a content validity evaluation was carried out by university professionals who agreed to participate in the study (Malla and Zabala, 1978). The knowledge or information coefficient (Kc) and the argument coefficient (Ka) were determined for these professionals, and based on these values, the value of the Competence Coefficient (K) was determined to determine which experts should be included for this research. Based on the results, 15 specialists were selected with an average K of 0.9, which shows a high level of competence (Mengual, 2011). After analyzing the validation questionnaires, some questions were modified without affecting the substance of the issue. In addition, a pilot test was carried out on a subgroup of the sample to review comprehension difficulties and identify problematic questions, and the corresponding checklist was used (Iraosi, 2006). The pilot test results were satisfactory, and the instrument was validated.

2.7. Construct validity (exploratory factor analysis)

The factor analysis technique used in this research follows the stages marked (García Ferrando, 2015).

2.8. Study of the correlation matrix

It was important to analyze the correlation matrix to determine if our data were suitable for factor analysis. To do this, this matrix must have a certain structure. The Kaiser-Meyer-Olkin sampling adequacy measure (KMO coefficient) was used to verify this. In this case, the value was 0.671. According to Kaiser (1974), this value is acceptable; Bartlett's sphericity test is significant (0.000), and the determinant had a value of $7.540E^{-6}$. Based on these results, we proceeded with the factor analysis.

TABLE 1 Total variance explained.

Component	Initial eigenvalues			Sums of squared loading from extraction			Sums of squared loadings from rotation		
	Total	% variance	% cumulati-ve	Total	% de varian-ce	% acumula-tive	Total	% de varian-ce	% acumula-tive
1	4,787	19,948	19,948	4,787	19,948	19,948	3,331	13,879	13,879
2	3,357	13,987	33,935	3,357	13,987	33,935	2,885	12,021	25,900
3	2,394	9,976	43,911	2,394	9,976	43,911	2,677	11,154	37,054
4	1,907	7,946	51,857	1,907	7,946	51,857	2,272	9,466	46,520
5	1,260	5,249	57,106	1,260	5,249	57,106	1,691	7,048	53,567
6	1,129	4,704	61,810	1,129	4,704	61,810	1,634	6,809	60,376
7	1,058	4,409	66,219	1,058	4,409	66,219	1,402	5,843	66,219
8	,987	4,114	70,333						

Extraction method: principal component analysis. Source: own elaboration.

2.9. Extraction of commonalities

The extraction of the commonalities obtained shows that these factors have a value >0.349, so we decided that there was no need to delete any item.

The best-represented items are as follows:

B9.-All students with auditory and/or visual functional diversity are considered vulnerable groups. (0.923)
B10.-All students with intellectual and functional diversity are considered to be from vulnerable groups.

The worst-represented items are as follows:

B11.-All students from vulnerable groups have problems with adaptation in different areas. (0.471)

This item leads to the reflection that the teacher considers that curricular adaptation is needed at some of its levels for any student belonging to one of the vulnerable groups.

B12.-Students from vulnerable groups may have access to the curriculum on a daily basis. (0.376)
D19.-You consider yourself an inclusive person. (0.349)

2.10. Total variance explained

There are specific rules to determine the most appropriate number of factors to retain. In this case, the commonly used Kaiser (1974) criterion suggests retaining the first seven factors, which explain 66.219% of the accumulated variance, as presented in Table 1.

Table 1 shows the seven components statistically extracted from the data provided by the participants, showing that these factors can explain more than half the variance in the responses.

2.11. Component matrix

Then, the component matrix was calculated, which is shown in Table 2. The matrix corresponding to Table 2 shows the scores that we had to study to obtain the reduced final scale.

TABLE 2 Study of factor scores.

Factors	
1	A2
	B7, B8, B9, B10, B11
	C13, C17, C18
	D19, D20, D21
2	A1, A3, A4, A5, A6
	D22, D23, D24
3	C14, C16
4	B12
5	
6	C15
7	

Source: own elaboration.

2.12. Study of factor scores

Having already calculated the factorial scores, the analysis of the explained and accumulated variance, and the determination of factors and distribution of items according to the highest level of factor saturation, we constructed the table of items integrated into each factor.

Within the exploratory analysis, it is relevant to examine the grouping of the items of the original questionnaire prior to the reduction and creation of the final proposal.

After calculating the factorial scores, analyzing the explained and accumulated variance, and determining the factors and distributed elements according to the highest level of factor saturation, we constructed the table of elements integrated into each factor. Within the exploratory analysis, it is pertinent to examine the grouping of the points of the original questionnaire before the reduction and creation of the final proposal.

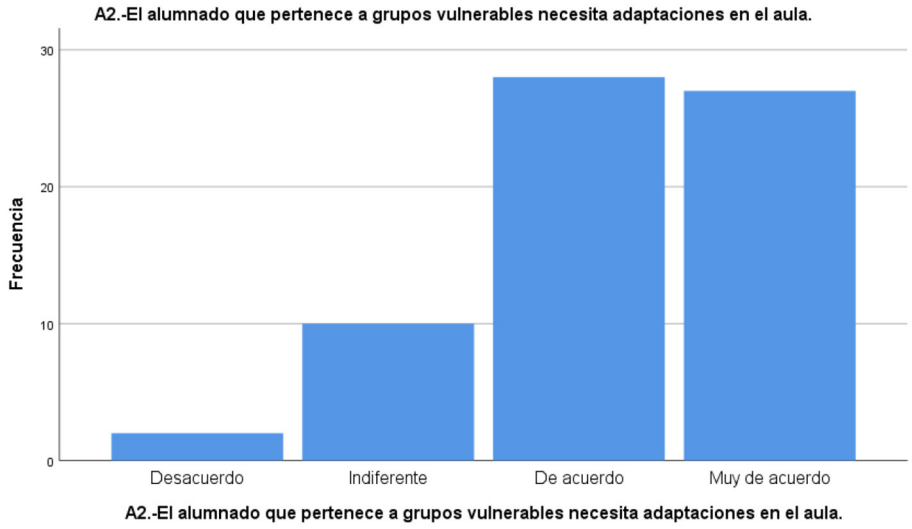

FIGURE 1
Dimension A (teaching performance): the participants agree (x = 4.19) that students belonging to vulnerable groups need curricular adaptations in the classrooms.

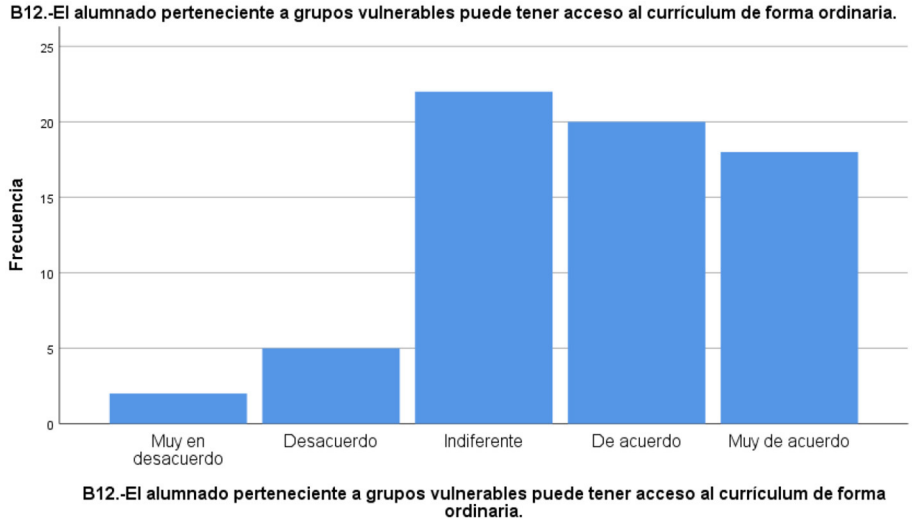

FIGURE 2
Dimension B (vulnerable groups): respondents respond in agreement (x = 3.75) that students belonging to vulnerable groups can access the curriculum on an ordinary basis.

3. Results

3.1. Correlation analysis

To perform the correlation, we submitted the questionnaire to the K-S test, which resulted in the rejection of the null hypothesis. This indicates that the data followed an abnormal distribution; thus, we used the Spearman-Rho correlation.

Significant correlations are given.

A (teaching performance) <> D (inclusion): According to the data obtained, the variable A of teaching performance correlates significantly with variable D on inclusion in 0.427, more specifically in the following items A2. Students belonging to vulnerable groups need to adapt to the classroom and D20. Students from vulnerable groups have difficulties with educational inclusion. It was considered that the most vulnerable students with the problems of inclusion would need curricular adaptations in the classroom. Llorent and López-González (2010) highlighted in their study that society has not yet facilitated the inclusion of people with diversity since, in many studies, these people prefer to be in the same environment as other people with the same abilities.

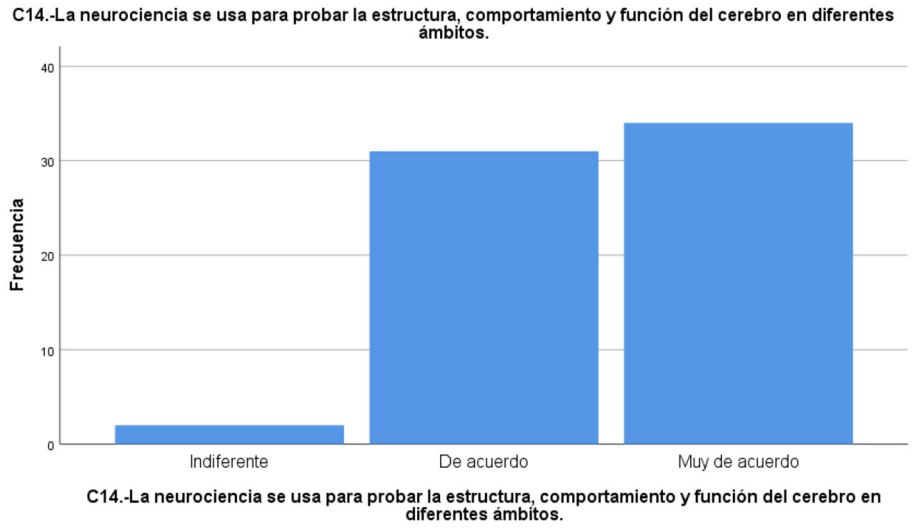

FIGURE 3
Dimension C (beliefs): subjects strongly agree that neuroscience is used to test brain structure, behavior, and function in different domains (x = 4.48). In the event of learning difficulties, teachers need to have knowledge of brain structures to change strategies and promote meaningful activities for their students (Paniagua, 2013).

B (vulnerable groups) <> B (vulnerable groups) the following items B8. All students with functional motor diversity are considered a vulnerable group and B9. All students with auditory and/or visual functional diversity are considered part of the vulnerable groups, and the correlation between them is 0.898.

C (beliefs) <> B (vulnerable groups): According to the data obtained, variable C of beliefs correlates with variable B on vulnerable groups in 0.366, more specifically in items B7. All Gypsy students are considered a part of vulnerable groups and C15. Learning styles are considered a neuromyth. With this correlation, it can be concluded that those who consider Gypsies vulnerable groups also consider that learning in one way or another is a neuromyth, which makes us believe that they may consider that being students belonging to the Gypsy race does not mean having different learning styles than ordinary ones.

D (inclusion) <> A (teaching performance): According to the data obtained, variable D on inclusion correlates significantly with variable A of teaching performance in 0.289, more specifically in items D24. Students with functional diversity feel included in the educational sphere and A1. Students belonging to vulnerable groups achieve the objectives of the primary education curriculum. Teachers who hold the belief that students from vulnerable groups feel included also believe that they are able to achieve their curricular goals. This highlights the significant impact a teacher's beliefs and perspectives can have on the attainment of educational objectives.

3.2. Descriptive analysis

As initially proposed in Hypothesis 0, teachers recognize the importance of applying neurodidactics to students belonging to vulnerable groups, as can be viewed in the descriptive analysis shown in Figures 1–4.

The importance of teacher training is deduced from the inclusion of students belonging to vulnerable groups. The inclusion of Gypsy students must begin with the teacher. It should be shown as an example to the rest of the pupils, and its training should be adequate and capable of making the most relevant adaptations for each pupil so as not to exclude the vulnerable pupil (Navas Luque and Cuadrado Guirado, 2003).

Teachers consider that the disability in question does not matter. They are part of a vulnerable group. To some extent, this can be considered advantageous for its better curricular adaptation within the classroom. Teachers often attempt to label students, but some are against this practice. However, of the purpose of classifying students according to their characteristics aims to adapt and propose appropriate learning methodologies for personal development. Let us look at the main characteristics of a person with disabilities (Soro Camat et al., 2012).

Finally, a more in-depth statistical analysis has been carried out to obtain more concrete answers to the research problem.

Using a linear regression model, we verified the importance of the different items, with a focus on the vulnerable groups (which can be seen in item B12), and the objective of neuropedagogy, which is observed in item C17, states that neurodidactic helps learners establish appropriate methodologies for vulnerable groups, which is the central object of this research.

The result can be seen in Figure 5, where we can see that the regression is effective; however, to determine the items that are classed to achieve the objective of the study, we resorted to automatic regression modeling, obtaining the following Figure 6.

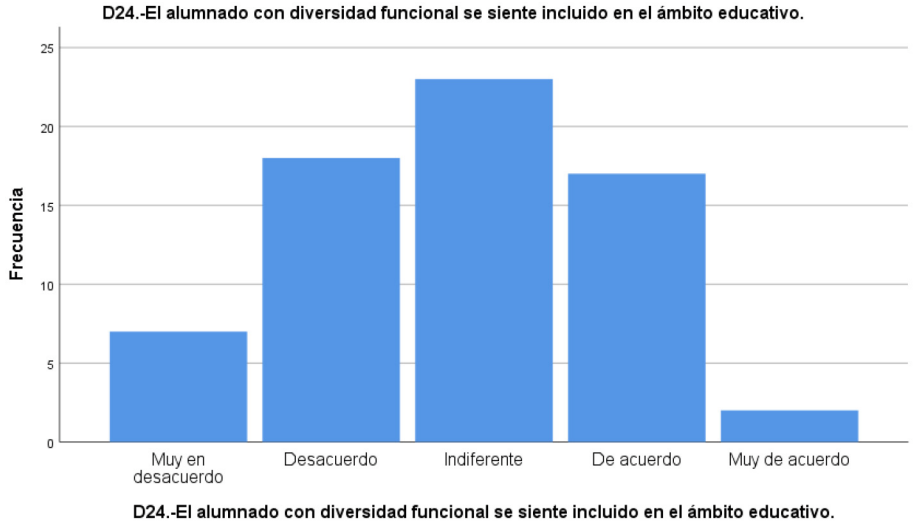

FIGURE 4
Dimension D (inclusion): the respondents show very little agreement (x = 2.85) that students of Roma ethnicity and students with functional diversity feel included in the educational sphere. We deduced from these data that it is believed that the students of the vulnerable group (in general) do not feel part of the group; that is, they feel excluded (Manota and Melendro, 2016).

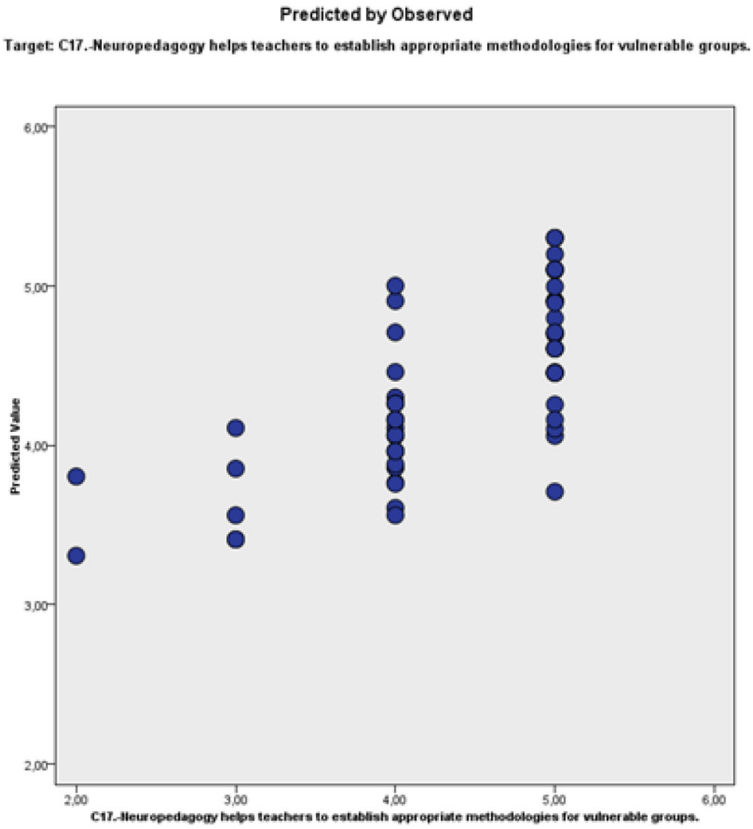

FIGURE 5
Linear regression analysis.

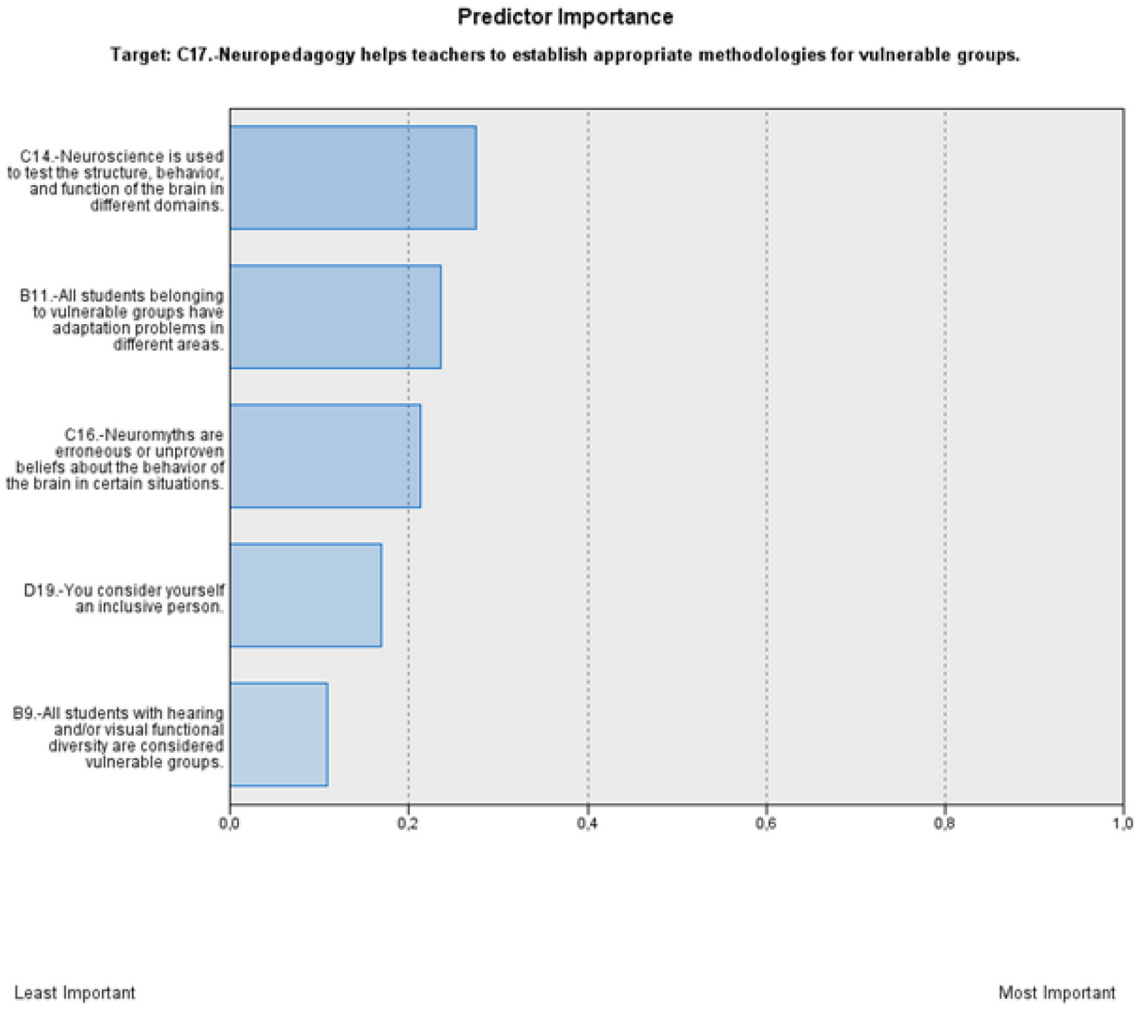

FIGURE 6
Importance of the predictor.

Figure 6 shows that neurodidactic helps the teacher establish appropriate methodologies for the vulnerable group. We must consider the students belonging to vulnerable groups in order of importance: C14, B11, C16, D19, and B9.

4. Discussion and conclusion

The presented research was conducted on a population of primary education graduates from the University of Jaén. In future research, it would be ideal to expand this research to university professors, as suggested by Castro et al. (2011), to assess their educational level and their interest in education and neurodidactics for improving the learning outcomes of vulnerable groups and promoting their inclusion. It would be useful to conduct similar research on education professionals in educational institutions to compare data between students and professionals in service, as mentioned by González and Zerpa (2007) in their study.

The descriptive analysis revealed that the participants strongly agreed (x=4.85) that students from vulnerable groups require, in most cases, curricular adaptations. However, there is little agreement (=2.85 and 2.83) that Gypsy students and students with functional diversity feel included in classroom settings (Carmona et al., 2019). Neurodidactics and its adaptation in the educational field make learning for students belonging to vulnerable groups more efficient, as proposed in the initial hypothesis of the study, by providing a scientific basis for innovative educational practices. This, in turn, can help promote the inclusion of such students (De Barros and Hernández, 2022).

Teachers recognize the importance of neurodidactic implementations for students belonging to vulnerable groups. In the fields of Navas Luque and Cuadrado Guirado (2003), the inclusion of Gypsy students should begin with the teacher and continue with the inclusion of classmates.

With regard to the problem for which this research **was** carried out, it can be concluded that future teachers do not have high expectations of students belonging to vulnerable groups and believe that they do not feel included in their peer groups at schools. They lack sufficient training and knowledge in neurodidactics to work with these students effectively,

although they recognize its importance and functionality in the educational field.

The discovery of brain structures in children from vulnerable groups allows professionals and families to take appropriate actions to promote the effectiveness of educational and social interventions (Gaya and Salomó, 2019).

Finally, to provide a comprehensive understanding that complements the central idea of this research, we resorted to the data expressed by the regression analysis. Thus, based on the vulnerability of students and the objective of educating teachers about neurodidactics, the most critical factors to consider are arranged in order of importance:

1. The importance of neuroscience in education.
2. All students belonging to vulnerable groups have adaptation problems in different areas.
3. Neuromyths must be eliminated from the educational system.
4. We must have inclusive teachers.

Students with functional diversity should also be considered a vulnerable group.

With all these factors in mind, we conclude that providing training on "neuro" aspects could help prevent student dropout among students belonging to vulnerable groups (López-García, 2020).

5. Limitations of the study

Performing data analysis for this study required individuals skilled in programming knowledge.

The time of the research was very high since it was necessary to review each stage of the processes: it was necessary to develop pilot tests and programming knowledge to elaborate on the equestrian, work design, etc.

The number of participants in the sample was small (although representative) due to their lack of collaboration.

As a quantitative study, the research had to overlook the context's qualitative aspects. The study's quantitative nature means that there could be errors in interpreting the data, which is inevitable given the researchers' human qualities and skills.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This research is under the authorization of the Ethics Committee of the University of Jaén, with reference JUL.22/4. The patients/participants provided their written informed consent to participate in this study.

Author contributions

CD has contributed to the development of research and methodology. CM has contributed in the compilation of data and finalization of the manuscript. CP has contributed in the development and application of instruments. CF has contributed to the development of the theoretical framework. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2023.1134732/full#supplementary-material

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