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Research Article

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Visualizing Learning: Evolution of Styles and Pedagogical Strategies in Teacher Education

Pablo Rosser[1*] and Seila Soler[2]

[1]*International University of La Rioja (Spain)*

[2]*University of Isabel I*

[*]Corresponding Author
Pablo Rosser, International University of La Rioja.

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Abstract

This study investigates the relationship between learning styles and the teaching-learning process in university students of Primary Education, utilizing the Felder and Silverman model. A descriptive and statistical analysis of learning styles (visual, auditory, and kinesthetic) among 157 students was conducted using Google Forms surveys and SPSS analysis. The results show a predominance of the visual style, suggesting that teaching methods commonly used by faculty may have influenced the modification of students' Learning Styles to include more visual resources. The absence of the kinesthetic style is discussed, thus raising the hypothesis to be tested in ongoing studies that traditional educational methodology may influence the evolution of learning styles. This study highlights the importance of recognizing and adapting teaching strategies to predominant learning styles to enhance the effectiveness of the educational process. The findings suggest the need to integrate more visual resources into teaching while considering the variability and potential evolution of learning styles due to the educational methodology employed.

1. Introduction

Much has been theorized about the importance of learning styles in teaching [2]. It has been emphasized how the diverse learning styles of students in the teaching and learning process in the classroom underscore the importance of educators understanding and adapting their teaching methodologies to students' learning styles [2]. Indeed, it has been argued that understanding how students learn and what factors influence academic performance is essential for lesson planning and assessment, as well as enabling better utilization of students' learning potential [3]. In this regard, the importance of aligning teaching methods with individual learning styles to improve the educational experience has been highlighted [4].

Learning styles are of great importance for pedagogical theory and practice: the knowledge acquired contributes to a better understanding of students, their learning style, the quality of teacher-student interaction, but also sheds light on the causes of learning difficulties and prevents school failure [5]. In this sense, it has been investigated whether students' awareness of their learning styles influences, for example, the acquisition of a second language. The results show that, after becoming aware of their own learning styles, students can learn English better and without obstacles [6]. Focused on Arabic learning, the association between students' thinking style and their performance in Arabic learning has also been verified. The Sternberg-Wagner Thinking Style Inventory is used to determine students' thinking styles and analyze how these styles influence Arabic learning [7]. Efforts have also been made to identify, analyze, and facilitate the alignment of these styles to improve the quality of postgraduate education [8]. Through a bibliometric study of systematic review, which summarizes findings on the role and importance of learning styles in scientific education at the university level from 2007 to 2023, it is confirmed that learning styles have a positive effect on both cognitive and affective factors [9].

2. Objectives

2.1 General Objectives

• To investigate the relationship between the learning styles of university students training to be teachers and the teaching-learning process.

• To assess the prevalence of visual, auditory, and kinesthetic learning styles among Primary Education Degree students.

• Specific Objectives

• To determine the distribution of learning styles among Primary Education Degree students at the beginning of the educational course.

• To analyze the influence of traditional educational methodology on the evolution of students' learning styles.

• To examine differences in learning style preference according to

demographic variables such as age and gender.
• To identify the pedagogical implications of predominant learning styles for the design of more effective educational strategies.

3. Methodology

3.1 Research Design

To address these objectives, a case study was conducted among university students training to be teachers.

• Participants

The sample consisted of 157 students aged 18 to 45, of both genders, enrolled in the subject of History Didactics of the Education Degree. Participant selection was comprehensive, including all enrolled in the subject.

• Instruments

At the beginning of classes, all students were given a survey via Google Form on Felder and Silverman's learning styles [10]. The SPSS Statistics software, version 29.0.1.0, was used to analyze participants' survey responses.

• Procedure

The study was conducted in two phases, at the beginning and end of the subject, although only the initial phase will be analyzed here.

• Data Analysis

The data were analyzed statistically. Patterns and trends in the results were identified, providing a deep understanding of the relationship between learning styles and the teaching-learning process of students.

• Ethical Considerations

The study adhered to the ethical principles of scientific research, obtaining informed consent from participants and ensuring data confidentiality.

• Limitations

It is acknowledged that the study has limitations, including the sample size and representativeness, the focus solely on the pre-test, and the failure to address other aspects as interesting as emotions. These limitations are important when considering the generalization of results but are supplemented and complemented by those published here, in other works on the topic [11].

• Results

Descriptive analysis of the predominant learning style, as well as its distribution by age and gender. With the survey data, a descriptive analysis was performed, obtaining valuable information regarding age and gender, as well as the predominant learning styles in each student and overall (Table 1).

Age	Gender	% Visual	% Auditory	% Kinesthetic	Predominant Style
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	50	50	0	Visual
18 to 25	Male	61,36364	38,63636	0	Visual
26 to 35	Female	65,90909	34,09091	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Male	52,27273	47,72727	0	Visual
18 to 25	Male	77,27273	22,72727	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	54,54545	45,45455	0	Visual
18 to 25	Female	36,36364	63,63636	0	Auditory
18 to 25	Female	56,81818	43,18182	0	Visual
18 to 25	Female	68,18182	31,81818	0	Visual
18 to 25	Female	68,18182	31,81818	0	Visual
18 to 25	Male	56,81818	43,18182	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Male	63,63636	36,36364	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual

18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	43,18182	56,81818	0	Auditory
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Female	56,81818	43,18182	0	Visual
18 to 25	Female	54,54545	45,45455	0	Visual
18 to 25	Female	68,18182	31,81818	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Male	72,72727	27,27273	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	68,18182	31,81818	0	Visual
18 to 25	Female	47,72727	52,27273	0	Auditory
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	52,27273	47,72727	0	Visual
18 to 25	Female	56,81818	43,18182	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Male	65,90909	34,09091	0	Visual
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Male	63,63636	36,36364	0	Visual
18 to 25	Female	75	25	0	Visual
18 to 25	Male	54,54545	45,45455	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	77,27273	22,72727	0	Visual
18 to 25	Female	56,81818	43,18182	0	Visual
18 to 25	Female	50	50	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Female	52,27273	47,72727	0	Visual
18 to 25	Male	65,90909	34,09091	0	Visual
18 to 25	Female	50	50	0	Visual
36 to 45	Female	75	25	0	Visual
18 to 25	Male	52,27273	47,72727	0	Visual
18 to 25	Female	47,72727	52,27273	0	Auditory
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	75	25	0	Visual
18 to 25	Male	72,72727	27,27273	0	Visual
18 to 25	Female	75	25	0	Visual
18 to 25	Male	70,45455	29,54545	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual

18 to 25	Male	70,45455	29,54545	0	Visual
18 to 25	Female	34,09091	65,90909	0	Auditory
18 to 25	Female	70,45455	29,54545	0	Visual
18 to 25	Female	52,27273	47,72727	0	Visual
18 to 25	Female	61,36364	38,63636	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Male	52,27273	47,72727	0	Visual
18 to 25	Female	68,18182	31,81818	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	50	50	0	Visual
18 to 25	Male	54,54545	45,45455	0	Visual
18 to 25	Female	68,18182	31,81818	0	Visual
18 to 25	Male	59,09091	40,90909	0	Visual
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Male	63,63636	36,36364	0	Visual
18 to 25	Female	77,27273	22,72727	0	Visual
18 to 25	Male	68,18182	31,81818	0	Visual
18 to 25	Male	68,18182	31,81818	0	Visual
18 to 25	Female	54,54545	45,45455	0	Visual
18 to 25	Female	50	50	0	Visual
18 to 25	Female	54,54545	45,45455	0	Visual
18 to 25	Male	63,63636	36,36364	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Male	56,81818	43,18182	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	68,18182	31,81818	0	Visual
18 to 25	Female	75	25	0	Visual
18 to 25	Male	61,36364	38,63636	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	56,81818	43,18182	0	Visual
18 to 25	Female	43,18182	56,81818	0	Auditory
18 to 25	Male	56,81818	43,18182	0	Visual
18 to 25	Female	43,18182	56,81818	0	Auditory
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Male	50	50	0	Visual
18 to 25	Female	47,72727	52,27273	0	Auditory
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Male	61,36364	38,63636	0	Visual
36 to 45	Male	72,72727	27,27273	0	Visual
18 to 25	Male	52,27273	47,72727	0	Visual
18 to 25	Male	59,09091	40,90909	0	Visual

18 to 25	Male	54,54545	45,45455	0	Visual
18 to 25	Female	59,09091	40,90909	0	Visual
18 to 25	Male	65,90909	34,09091	0	Visual
18 to 25	Female	50	50	0	Visual
18 to 25	Female	54,54545	45,45455	0	Visual
18 to 25	Male	65,90909	34,09091	0	Visual
18 to 25	Female	61,36364	38,63636	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	61,36364	38,63636	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	79,54545	20,45455	0	Visual
18 to 25	Male	61,36364	38,63636	0	Visual
18 to 25	Female	61,36364	38,63636	0	Visual
18 to 25	Female	54,54545	45,45455	0	Visual
18 to 25	Male	79,54545	20,45455	0	Visual
18 to 25	Male	68,18182	31,81818	0	Visual
18 to 25	Female	70,45455	29,54545	0	Visual
18 to 25	Male	52,27273	47,72727	0	Visual
26 to 35	Male	70,45455	29,54545	0	Visual
18 to 25	Female	43,18182	56,81818	0	Auditory
18 to 25	Male	63,63636	36,36364	0	Visual
18 to 25	Female	43,18182	56,81818	0	Auditory
18 to 25	Male	45,45455	54,54545	0	Auditory
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	75	25	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	54,54545	45,45455	0	Visual
18 to 25	Male	65,90909	34,09091	0	Visual
18 to 25	Male	50	50	0	Visual
18 to 25	Female	65,90909	34,09091	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Male	54,54545	45,45455	0	Visual
18 to 25	Female	70,45455	29,54545	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
26 to 35	Male	59,09091	40,90909	0	Visual
18 to 25	Female	50	50	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Female	63,63636	36,36364	0	Visual
18 to 25	Male	36,36364	63,63636	0	Auditory
18 to 25	Female	72,72727	27,27273	0	Visual
18 to 25	Male	22,72727	77,27273	0	Auditory
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18 to 25	Female	47,72727	52,27273	0	Auditory
18 to 25	Female	50	50	0	Visual
18 to 25	Female	52,27273	47,72727	0	Visual

Table 1: Descriptive Analysis.

• Learning Style Analysis

The predominant learning style analysis shows a clear dominance of the Visual style, with 91.03% of participants identifying it as their primary learning method. The Auditory style is preferred by 8.97% of participants, while the Kinesthetic style does not appear as predominant in this sample (Figure 1).

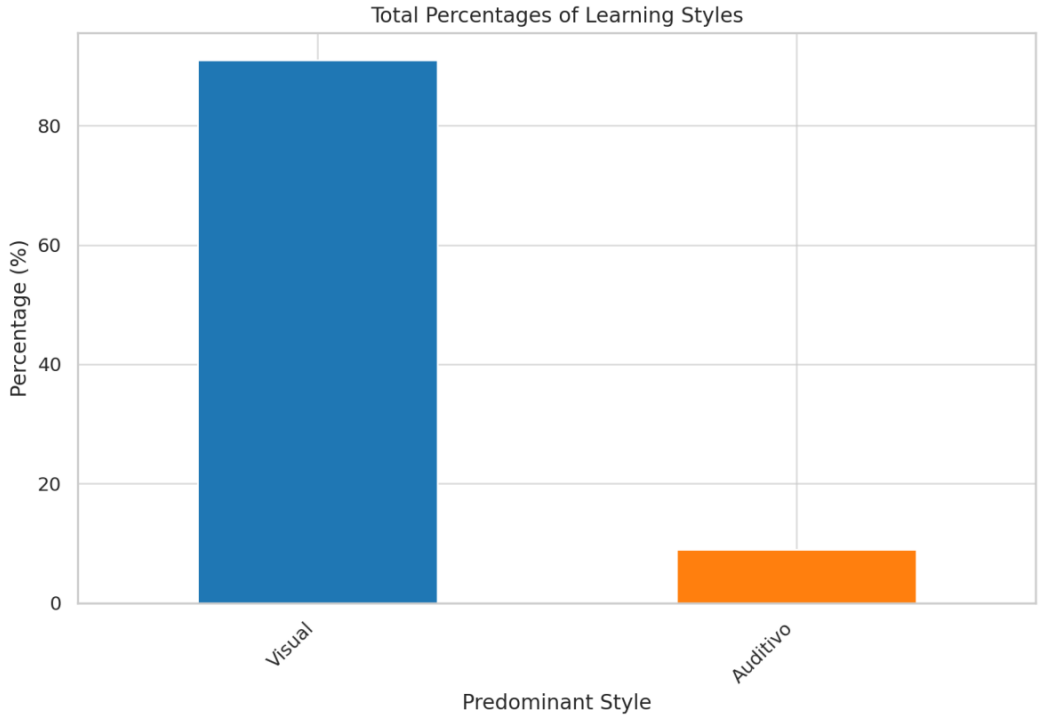

Figure 1: Total Percentage of Learning Styles.

• Distribution by Gender

The Visual style is predominant in 93.48% of males, while 6.52% show a preference for the Auditory style. As for females, 90.00% show a preference for the Visual style and 10.00% for the Auditory (Figure 2).

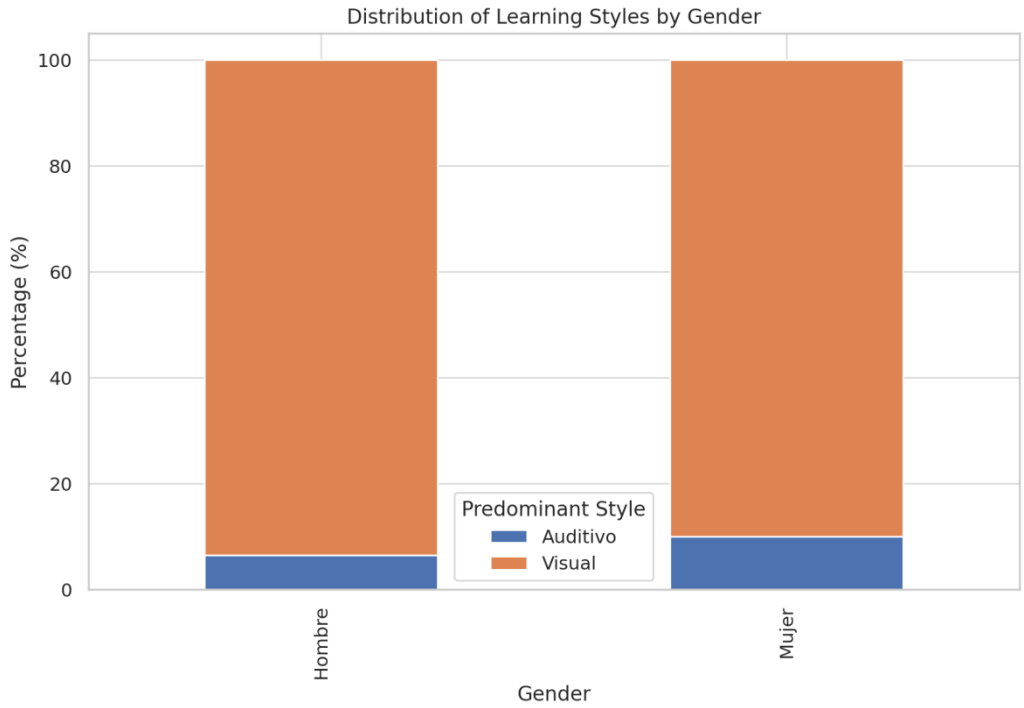

Figure 2: Distribution of Learning Styles by gender.

Distribution by Age

Among 18-25-year-olds, the Visual style is predominant in 90.67% of this age group, with the Auditory style at 9.33%. Among 26-35-year-olds, 100% of participants in this age range prefer the Visual style. Lastly, among 36-45-year-olds, also 100% of this age group prefers the Visual style (Figure 3).

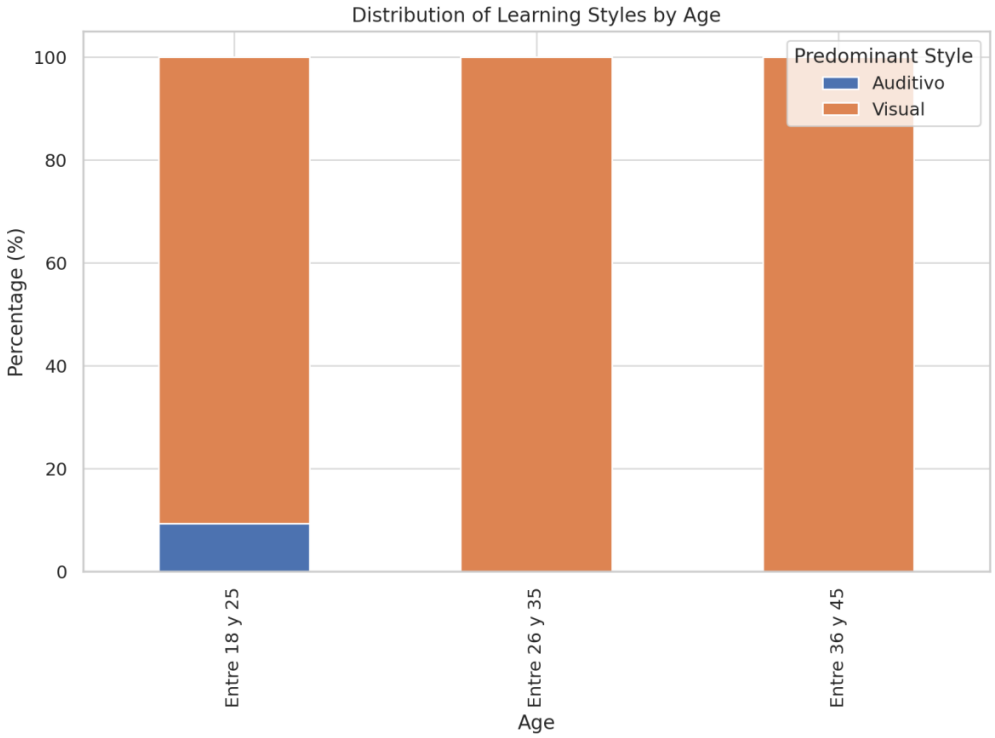

Figure 3: Distribution of Learning Styles by age.

• Scientific Conclusions

The results of this study highlight the predominance of the Visual learning style among participants, regardless of their gender or age group. This trend indicates that educational and pedagogical strategies emphasizing visual elements could be more effective for a vast majority of the studied population. The marked preference for the Visual style over Auditory and Kinesthetic styles suggests the need to review and potentially adapt traditional teaching methods to incorporate more visual resources, such as diagrams, videos, and infographics, which may facilitate the learning process. The gender distribution shows a slight variation in preference for learning style, with males slightly more inclined towards the Visual style compared to females. However, this difference is not significantly pronounced, indicating that visual learning strategies remain effective for both genders.

The uniformity in preference for the Visual style across different age ranges suggests that intrinsic characteristics of visual learning are attractive and effective for a wide range of ages. This could be due to the ability of visual material to simplify complex concepts, maintain interest, and facilitate long-term information retention. In educational terms, these findings emphasize the importance of integrating technologies and methodologies that prioritize visual learning. This not only supports the learning preferences of the majority but may also contribute to improving understanding and academic performance. Although it is crucial not to neglect minority learning styles, such as Auditory and Kinesthetic, this study reinforces the idea that a visual-centered approach can benefit most students, suggesting a path towards more inclusive and effective educational practices.

• Age and Gender Distribution by Learning Styles from the Box Plot:

This graph shows the distribution of ages within each prioritized learning style and allows for comparing the distributions of percentages of different learning styles between different age groups or genders. If significant differences are observed in the median or dispersion between males and females, this could indicate a gender inclination towards a visual learning style.

• Prioritized Style Box Plot

Regarding the Visual Style, the box is relatively shorter, indicating that preferences for the visual style are more consistent among participants identifying visual as their prioritized style. The median is above 60%, suggesting that the majority has a significant preference towards visual learning. There are no outliers, reinforcing the idea of coherence in the group (Figure 4a).

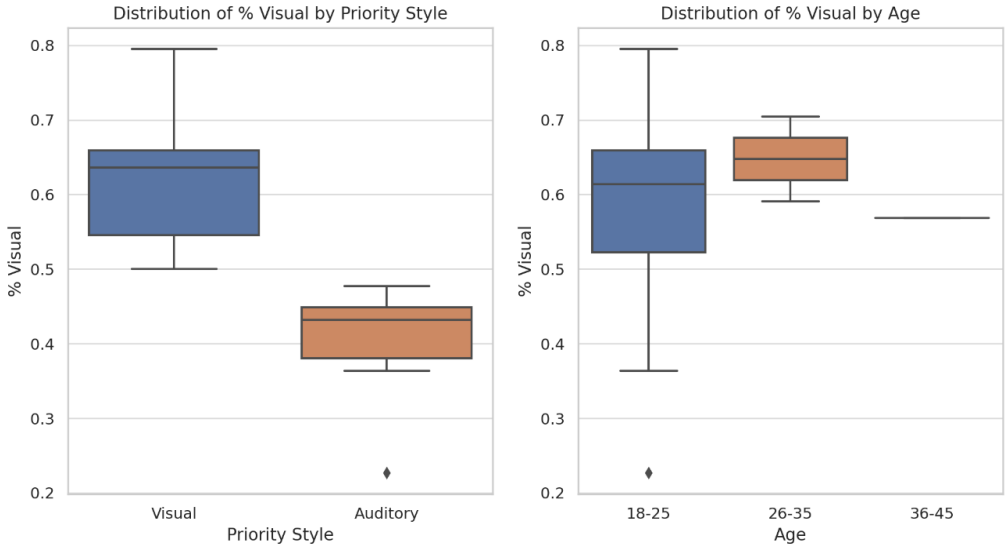

Figure 4: Box plots by distribution of percentages of Learning Styles (a), or by age (b).

In contrast, the box for the Auditory style is longer and located lower, indicating greater variability in preference for the visual style among those prioritizing auditory learning. Additionally, the median is lower than in the visual group, suggesting that, although auditory is their prioritized style, their preference for the visual is not as low. There are outliers present, indicating individuals within the auditory group with unusually high or low preferences for visual learning (Figure 4a).

• Box Plot by Age

Regarding the distribution of Learning Styles by Age, the Box Plot provides interesting information (Figure 4b).

The box for the age group between 18-25 years has a narrower Interquartile Range (IQR) and a high median, similar to the group with a visual prioritized style, indicating a strong and consistent preference for visual learning in this age group. No outliers are observed, suggesting uniformity in preference for visual style. On the other hand, for the age group between 26-35 years, the box is longer, and the median is slightly lower than in the 18-25

age group. This indicates greater variability in visual preference and a lower median, suggesting that this age group may have a less pronounced preference for visual learning compared to the younger group. An outlier is observed, indicating the presence of at least one person with a considerably different visual preference from the majority of their age group. Finally, students between 36-45 years old have the narrowest Interquartile Range of the three, with the lowest median, indicating a consistent but more moderate preference for visual learning. The presence of longer whiskers and the absence of outliers suggest that, although there is variability, there are no extremely different cases in terms of visual preference.

• Educational and Pedagogical Conclusions

The data conclude that educators can confidently adopt visually rich teaching strategies with younger students (18-25 years old), given their marked and consistent preference for visual learning. As the age of the students increases, it seems important to incorporate a broader range of pedagogical strategies to accommodate greater variability in learning preferences. The presence of outliers in the auditory group and in the age group of 26-35 years emphasizes the importance of not overlooking the needs of those whose preferences may significantly deviate from the group norm.

Therefore, in a student profile as described, educators should be prepared to interpret and apply this data in their teaching practice, seeking continuous training and professional development in multimodal teaching techniques and learning style assessment.

Using Histograms for the distribution of percentages of each learning style across the student population:

We will use histograms to visualize the distribution of percentages of each learning style across the student population, which can help identify if most students tend towards a specific style or if there is an equitable distribution (Figure 5).

The presented histograms illustrate the distribution of learning style preferences (visual, auditory, and kinesthetic) among a population of students.

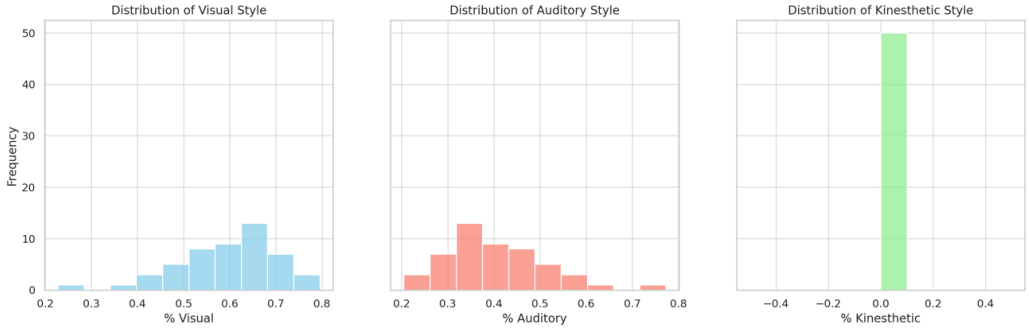

Figure 5: Bar charts with distribution of Learning Style percentages: visual (a), Auditory (b), and Kinesthetic (c).

• Distribution of Visual Style

The visual style histogram shows a distribution with a clear tendency towards higher percentages. Most students have a high preference for visual learning, with the highest frequency around 60-70%. This suggests that visual learning is the predominant style in this population (Figure 5a).

• Distribution of Auditory Style

On the other hand, the auditory style histogram shows a more uniform distribution with a tendency towards lower percentages, although there are some students with a moderate preference for this style. The highest frequency is observed around 30-40%, indicating that the auditory style is less predominant than the visual (Figure 5b).

• Distribution of Kinesthetic Style

The kinesthetic style histogram shows a concentration at 0%, indicating no preference for this learning style in the analyzed student population (Figure 5c).

• Educational and Pedagogical Conclusions

The clear preference for visual learning suggests that, for a classroom with these characteristics, educators, as we have already pointed out, should integrate visual resources into their teaching, such as graphics, videos, and demonstrations, to align with the preferences of the majority of students. Although less common, the presence of a moderate auditory preference indicates that teaching strategies should also include auditory components, such as discussions, narrations, and the use of music or sounds, to support students who benefit from this approach. The absence of representation of the kinesthetic style reinforces the need not to ignore the needs of students who might prefer this style. Educators should seek creative ways to incorporate hands-on and experiential activities into their lessons. In conclusion, the variety in learning preferences justifies the use of multimodal teaching strategies to address the needs of all students, regardless of their predominant style. Likewise, the findings underscore the importance of teacher training in designing inclusive learning experiences that recognize and value the diversity of learning styles.

Density Plot for Analyzing Learning Style Distributions:

Similar to the histogram, the density plot helps us understand the distribution of learning styles, in this case, the visual style being prioritized, but with a smoother curve that may make it easier to identify density peaks. The peaks in this graph represent the most common values of preference for the visual style, which can give

us an idea of how pronounced the preference for this style is in the studied population (Figure 6).

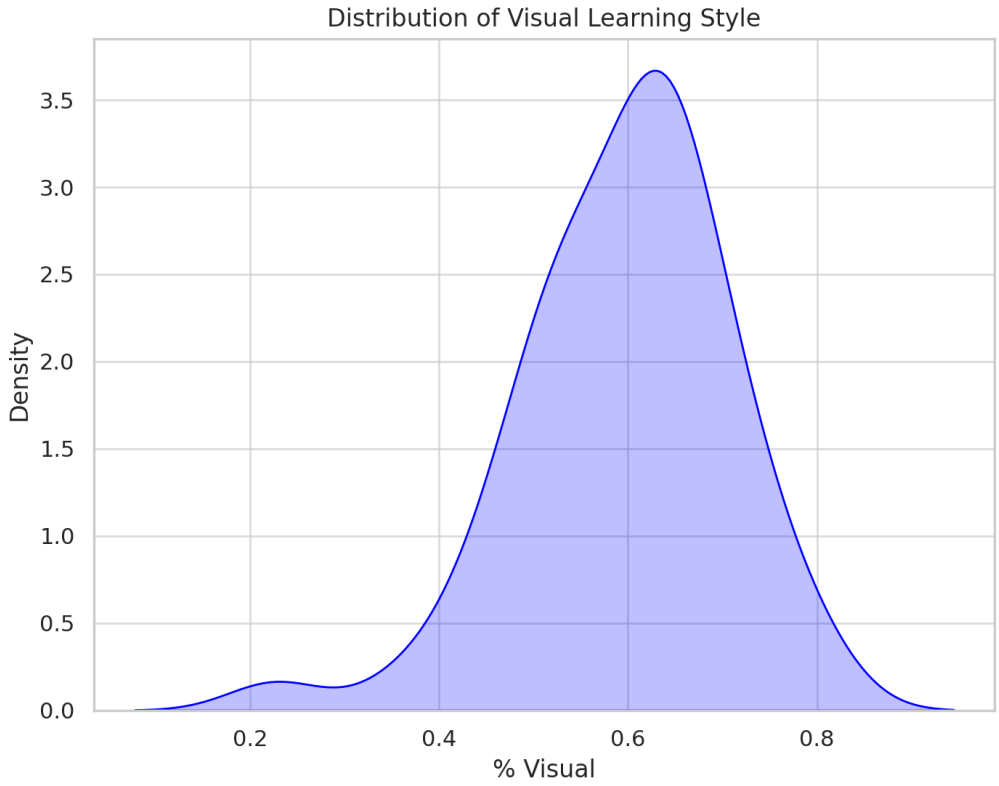

Figure 6: Density plot with the distribution of percentages of Visual Learning Styles.

• Observations from the Density Plot

There is a very pronounced central peak around 60-70%, indicating that a large proportion of the student population shows a strong preference for the visual learning style. This is the mode of the distribution and represents the most common value of preference for the visual style.

On the other hand, the curve is quite symmetrical around the peak, suggesting that the distribution of preferences for the visual style is relatively uniform, with a gradual decrease in density towards the lowest and highest visual percentage values. Lastly, the tails of the distribution (the left and right ends of the curve) fall towards 0 and 100%, respectively. This indicates that there are few students with extremely low or extremely high preferences for the visual style.

• Educational and Pedagogical Conclusions

To avoid repeating what was mentioned in the results of the previous analyses, as they are similar, we want to emphasize that despite the clear preference for visual learning, educators facing a spectrum of students like the one we are analyzing should not neglect those in the tails of the distribution who may prefer other learning styles. It is important to offer a variety of learning resources to address the entire student diversity. When designing the curriculum and teaching materials, the predominance of visual learning should be considered, but a balance should also be maintained with activities that involve other senses and learning styles for comprehensive education.

• Scatter Plots for Dispersion Analysis

This scatter plot compares the percentages of preference for visual and auditory styles among students. The relationship (or lack thereof) between these two styles can indicate whether they tend to be complementary or if students clearly prefer one over the other. A uniform distribution would suggest that there is no clear preference, while clustering would indicate a trend. The relationship between visual and auditory styles may vary, but a uniform dispersion would indicate that there is no exclusive preference for one over the other, allowing students to use both styles complementarily.

• Observations from the Scatter Plot

The points seem to be scattered across the graph without a clear linear trend or distinctive pattern. There is no evident correlation suggesting that a high preference for the visual style is consistently associated with a high or low preference for the auditory style. This could indicate that visual and auditory learning styles are independent of each other among students in this population (Figure 7). The points are colored according to age groups, but they do not seem to cluster in a way that indicates significant differences in

learning style preferences among different age groups. Each age group is represented across the entire range of percentages for both visual and auditory styles (Figure 7).

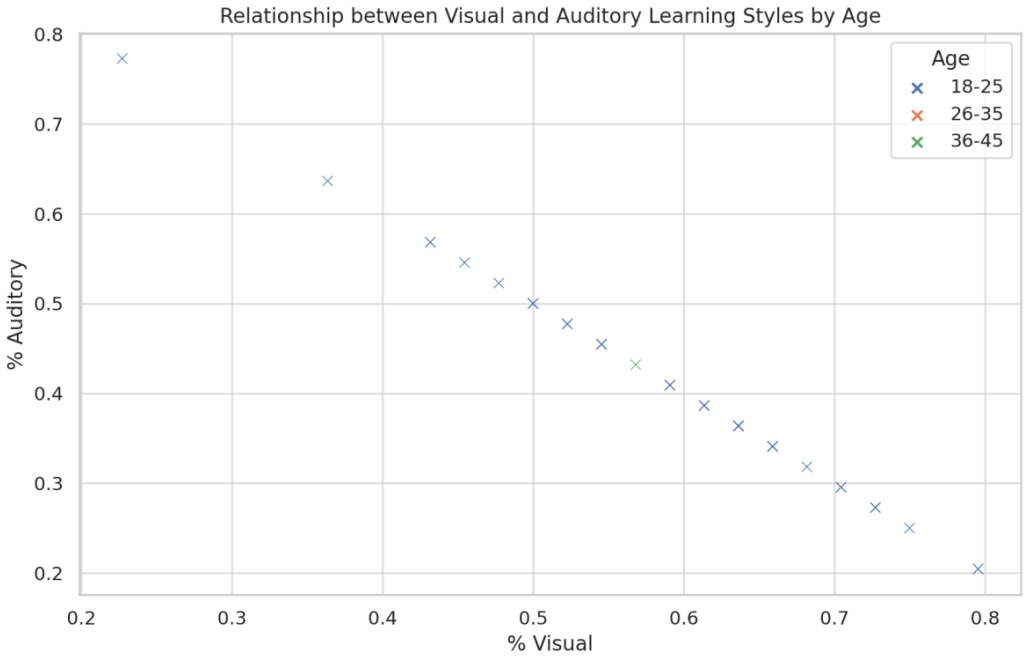

Figure 7: Scatter plot showing the dispersion of data for Visual and Auditory Learning Styles by age.

• Educational and Pedagogical Conclusions

The lack of a clear pattern supports the importance of individualization in the educational approach. In this regard, educators should consider individual learning preferences when designing and presenting instructional material.

This graph reinforces the idea that students have a range of learning preferences and that using multimodal approaches (including both visual and auditory) is likely the best strategy to reach most students. Educators could benefit from assessing the learning styles of their students to adapt their teaching more effectively, rather than assuming that certain styles are preferred by certain age groups. Finally, the diversity of learning styles illustrated in the graph underscores the need for teachers to receive training and resources to support a wide range of learning needs and to implement pedagogical techniques that are inclusive and effective for all students.

Violin Plots for Distribution of Learning Styles by Gender:

Violin plots combine the characteristics of box plots and density plots, showing the distribution of data (such as the percentage of each learning style) and providing a richer visual comparison between groups. Similar to the box plot, but providing a richer view of the distribution of preferences for the visual style, broken down by gender. The "violin" shape can show density peaks of preferences that are not evident in the box plot, offering a deeper understanding of how genders differ (or not) in their inclination towards visual learning.

• Observations from the Violin Plot

The violin for both genders shows a similar distribution with a widened area around 60-70%, indicating a strong preference for visual learning in both groups. However, there are some visible differences in the shape of the violins that could suggest variations in how these preferences are distributed (Figure 8). The violin for males (Blue) has a narrower waist, suggesting more consistent variability around the median. The interquartile range (the black box inside the violin) seems more compact, indicating less variability in visual style preferences among males (Figure 8). The violin for females (Orange) shows a broader distribution around the median, with a larger interquartile range, suggesting greater variability in their visual learning preferences compared to males (Figure 8).

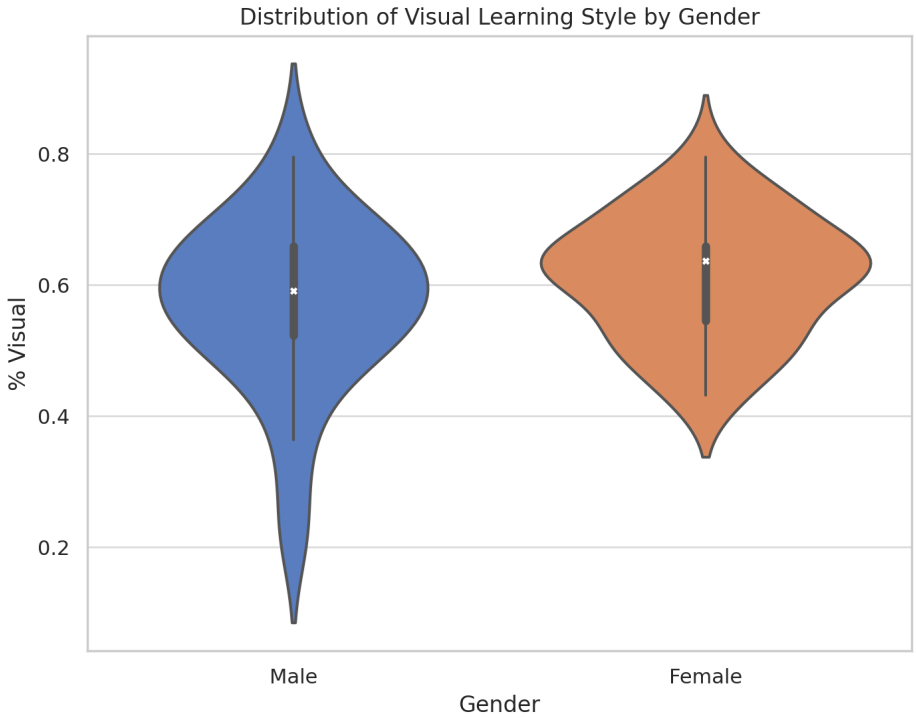

Figure 8: Violin plots showing the dispersion of data for Visual and Auditory Learning Styles by gender.

• Educational and Pedagogical Conclusions

Although both genders show a preference for the visual style, differences in variability indicate that females may have a wider range of preferences. This may require a more diversified approach when integrating visual elements into teaching to ensure that the learning needs of females are effectively addressed. The presence of a wider distribution in the female group suggests that educators should be prepared to, in similar cases to this one, adapt materials and didactic strategies to accommodate a broader range of visual learning preferences. The similarity in overall preference for the visual style underscores, again, the importance of incorporating visual teaching strategies that are inclusive for all students, while differences in variability highlight the need for customization and adaptation.

Heatmaps for Learning Styles Correlation:

Heatmaps are useful for visualizing the correlation between different variables, in this case, between different learning styles. The following heatmap shows how different learning styles (visual, auditory, kinesthetic) correlate with each other (Figure 9). Values close to 1 or -1 would indicate a strong positive or negative correlation, respectively, suggesting that students who prefer one style also tend to prefer or reject another. Values close to 0 indicate little or no direct correlation.

Heatmap Observations:

The values on the main diagonal are 1.00, which is expected since each learning style correlates perfectly with itself. The -1.00 values between visual and auditory styles suggest a strong negative correlation. This would indicate that, in this data sample, a high preference for one style is associated with a low preference for another (Figure 9).

Educational and Pedagogical Conclusions:

The values indicate a clear division in learning preferences; that is, students who are visual learners are not auditory learners and vice versa. This underscores the importance of identifying students' learning preferences to personalize teaching. Teaching strategies, in such a case, should be very specific and targeted, avoiding mixing visual and auditory elements that may conflict according to students' preferences. Similarly, the curriculum should be reviewed to ensure equitable opportunities for each learning style, recognizing the possibility that students may have opposing preferences.

In any case, it is necessary to note that, in a practical educational context, it would be unusual to design interventions based on perfect negative correlations, as learning styles are not usually mutually exclusive to such a degree. Therefore, in subsequent research, with a broader spectrum of students and across different years, we can delve deeper into this issue.

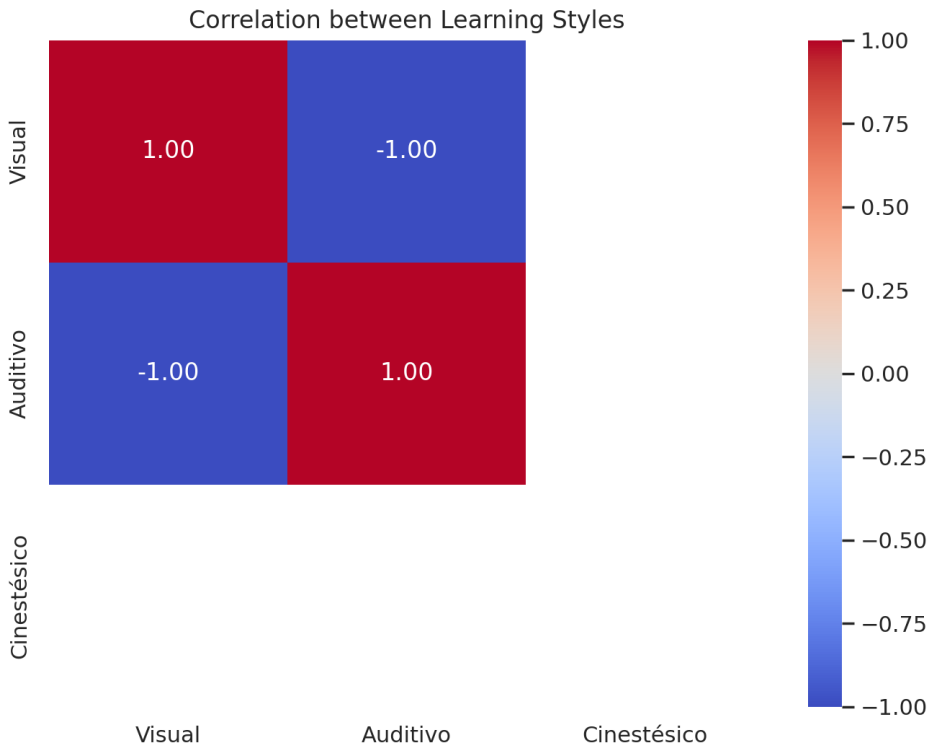

Figure 9: Heatmap on the correlation of visual and auditory learning style data.

Radar or Spider Chart for Analyzing the Distribution of Learning Styles by Gender:

Continuing with the analysis, it seems interesting to show how the specific group of students (for example, divided by age or gender) is distributed among different learning styles, offering a comparative view between groups. This chart, therefore, provides a comparative view of the averages of each learning style, allowing us to quickly see which one is the most predominant and how they relate to each other in terms of average preference. A style with a larger radius indicates a stronger average preference among all students. The radar chart shown, therefore, provides a visual representation of the average preferences for visual, auditory, and kinesthetic learning styles between two groups: males and females (Figure 10). Radar Chart Observations:

Both genders seem to have a greater visual preference than the other two, as the visual axis extends further from the center for both genders. Preferences for auditory and kinesthetic styles are lower or nonexistent (in the latter case), with a much shorter extension from the center of the chart, indicating a lower average preference for these styles compared to the visual one.

The overlap of areas for males and females suggests that there are similarities in the distribution of learning preferences between the two genders.

Educational and Pedagogical Conclusions:

The predominance of the visual style again highlights the importance of using teaching strategies that lean towards the visual. The lack of significant visible differences between genders suggests that teaching strategies may not need to be strongly adjusted by gender in terms of learning styles, although it is always important to consider individual needs. Educators must conduct ongoing assessments of their students' learning preferences to be able to adjust their teaching methods and ensure that all students are engaged and supported in their learning.

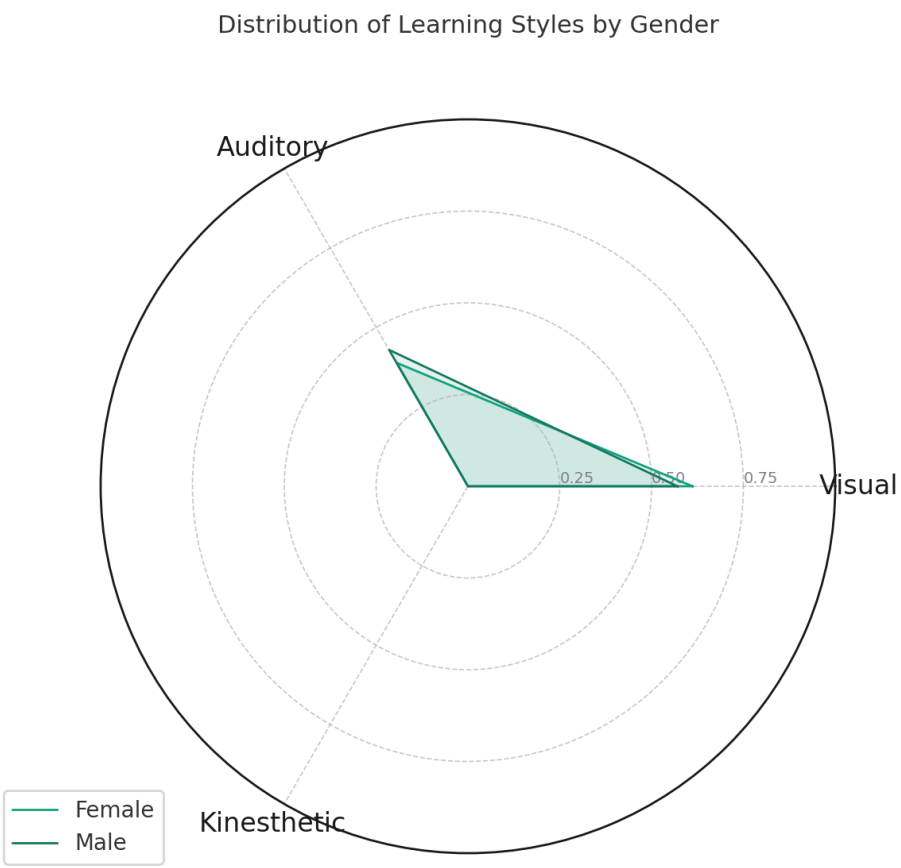

Figure 10: Radar chart of the average preferences for visual, auditory, and kinesthetic learning styles between two groups: males and females.

In any case, this chart shows that, although there is a style with a higher average preference, the differences are not extremely marked, indicating that students have a versatile disposition towards using different learning styles.

Area Charts for the Distribution of Learning Styles by Age Range:

To visualize how different learning styles are distributed across different segments, such as age ranges, showing how each segment contributes to the total of each style, we have used the area chart, which shows how preferences for different learning styles accumulate across the studied population. It allows us to visualize the relative proportion of each style within the group and how they overlap, which can help identify if one style is predominantly preferred over the others or if there is an equitable distribution of preferences (Figure 11).

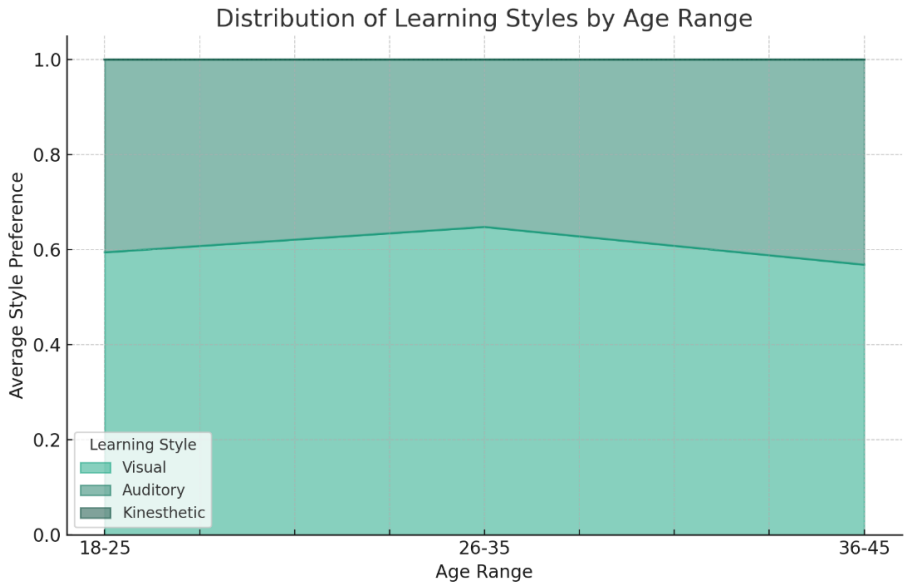

Figure 11: Area chart of the distribution of learning styles by age range.

The area chart shows the distribution of average preferences for visual, auditory, and kinesthetic learning styles among the age ranges of 18-25, 26-35, and 36-45 years.

Area Chart Observations:

The large area covered by the visual style across all age ranges indicates that it is the predominant learning style in the studied population. This style maintains a consistent and dominant presence regardless of age. The other styles show a significantly smaller presence (auditory) compared to the visual, or nonexistent (kinesthetic). The minimal overlap of these styles suggests that they are less preferred in all age groups. There are no drastic changes in style preferences across different age ranges, suggesting that learning preferences are fairly stable as people age in this dataset.

Educational and Pedagogical Conclusions:

With no significant variations in the results obtained regarding the previous analyses, nothing new can be added in this regard.

The Absence of Kinesthetic Learning Style

The kinesthetic learning style is primarily characterized by a preference for learning through physical experience and practical manipulation of objects [12]. Some of the main characteristics of this learning style are: Action-based learning: Individuals with a kinesthetic style learn best when they can engage in practical activities, participate in physical experiences, and manipulate objects with their hands. They need to be actively involved in the learning process.

Need for movement: Kinesthetic learners often feel uncomfortable or distracted when inactive for extended periods. They prefer to move, change positions, and engage in activities involving physical movement. Tactile and sensory experiences: They prefer learning through touch and physical sensation. They often like to touch and manipulate objects to understand concepts and retain information. Difficulty learning solely through reading or listening: Kinesthetic learners may find it challenging to learn solely through reading texts or listening to lectures. They need practical activities and concrete experiences to internalize concepts.

Movement-associated memory: They tend to remember information better when associated with physical experiences or bodily movements. Therefore, activities such as dramatic representations, simulations, and role-playing can be effective for their learning. Need for experimentation and trial-and-error: They often learn best through direct experimentation and trial-and-error. They enjoy trying new things and discovering how things work through active practice. Difficulty concentrating on static activities: They may have difficulty maintaining focus on static or passive activities, such as prolonged reading or listening to lectures without the opportunity to participate actively.

In conclusion, individuals with a kinesthetic learning style tend to learn best when they can actively participate, experience with their senses, and move physically during the learning process. Effective teaching for this type of students often involves practical, manipulative activities, and sensory experiences. The absence of third-year university students in the Primary Education Degree with a kinesthetic learning style can have several explanations, ranging from individual to contextual factors. It is possible that in this student population, as in this case, another learning style predominates, such as visual or auditory. But that would not explain why they are absent. However, the predominant methodology in the Primary Education degree may not favor or encourage the development or identification of students with a kinesthetic learning style. If classes tend to be more theoretical and less practical, kinesthetic students may not feel as identified or motivated. We will return to this later.

It is also possible that the choice of the Primary Education degree may attract individuals with learning styles perceived as more aligned with the "typical" activities of this profession, such as teaching, which traditionally has emphasized visual and auditory approaches. But returning to the first cause, it is possible that students' learning styles may change over time, including the transition from a predominantly kinesthetic learning style to a visual or auditory one, especially if the educational methodology used is mostly traditional and theoretical. Learning styles are not static; they are dynamic and can evolve in response to educational experiences, demands from the learning environment, and each student's personal development [13].

Indeed, students can adapt their learning strategies to better align with the demands of their educational environment. If a course or academic program favors lectures, reading, and listening over practical activities, students may develop stronger skills in visual and auditory learning styles to succeed academically. This would result in what we could call compensatory skill development. Faced with the need to understand and retain information presented predominantly visually and auditorily, students with an initial preference for kinesthetic learning may develop skills in other learning styles as a compensatory mechanism. As students' progress in their education, they experience a variety of teaching methods and learn to appreciate different ways of acquiring knowledge. This process of educational maturation can lead to greater flexibility in their learning styles.

The curriculum and teaching methodology, along with teachers' personal style, play a crucial role in developing students' learning preferences. Educators who use a variety of teaching techniques can encourage the development of multiple learning styles in their students. Furthermore, the absence of students with a kinesthetic learning style in a class can have several educational and pedagogical consequences. Firstly, without representation of kinesthetic students, the opportunity to address and adequately attend to this learning style is lost. This can lead to less inclusive teaching and less tailored to students' individual needs. Secondly, kinesthetic learners learn best through hands-on experience and movement. The absence of these students may result in a lack of emphasis on practical activities, experiments, and physical demonstrations, depriving other students of this learning opportunity. Thirdly, since kinesthetic students tend to learn best when provided with opportunities to move and engage in physical activities, an absence of these students may hinder the effective implementation of activity-focused teaching strategies, which could negatively impact another students' engagement and understanding. Fourthly, considering that kinesthetic students often benefit from active practice and physical manipulation of objects to understand concepts, their absence in the class may lead to less emphasis on providing opportunities for this type of practice, which could limit the development of practical skills and the consolidation of knowledge for other students. Fifth and finally, the absence of kinesthetic students could lead to a bias towards teaching strategies more oriented towards other learning styles, such as visual or auditory. This may result in an imbalance in the variety of pedagogical approaches used in the classroom, which may not be beneficial for all students.

4. Discussion

• Analysis of Learning Styles

The growing interest in students' learning styles has led to the development of numerous initiatives for analysis. For example, the profile of learning styles in university students has been evaluated numerous times. In some of these analyses, significant differences have been found between groups in the Active and Pragmatic styles, with preferences for the Reflective style in younger students and in women [14]. according to Honey and Mumford's model [15. which classifies learners according to their preference in the learning cycle, and which is based on Kolb's experiential learning theory [16]. In another research, the relationship between intelligence level and learning styles in university students has been studied, without finding a significant relationship between intelligence and experiential learning style [17]. Equally interesting is the approach given to another research where the relationship between learning styles and attitudes towards learning is analyzed, as well as their association with learning strategies in students [18]. It is also interesting how the question has been addressed: how do secondary and university students learn? analyzing it from the perspective of learning styles and observing significant differences in the competitive style and most styles favorable to university students [19]. How learning styles influence the cognitive strategies of university students is also a relevant topic addressed, finding that the Reflective style is the highest among those evaluated. According to this research, each person presents cognitive strategies that are totally different, and that in turn are related to a series of internal elements and mental activity specific to the person, as well as their motivation, memory, self-esteem, skills, etc.; all of which are important elements to consider in the proper development of the learning process [20]. Learning styles have also been analyzed using exploratory and confirmatory factor analysis techniques [21].

• The Use of the Felder Silverman Learning Style Model (FSLSM)

Like us, many studies have been carried out based on the Felder-Silverman Learning Styles (FSLSM). Thus, research has investigated the application of machine learning techniques to identify students' learning styles in an online learning environment based on the FSLSM identification model [22]. In other research, the main objective has been to integrate a test based on FSLSM into an authoring tool called S.GameON, to estimate the player's learning profile, such as learning style (Figurative, Symbolic, and Semantic), and to adapt Mobile Game-Based Learning generated according to their learning style [23]. In another work, a Learning Analytics Intervention (LAI) approach was used to recommend personalized learning paths to students taking online courses, based on their learning styles according to FSLSM, and its effectiveness was evaluated [24]. Similarly, the personalization of E-learning content based on FSLSM has been studied. The ILS questionnaire

was digitized to map E-learning users according to their learning style, and content personalization algorithms were designed [25]. An adaptive online module system has been proposed that provides students with a learning environment that adapts to their learning style. The system architecture identifies the student's learning style using a questionnaire based on FSLSM [26].

• Learning Styles and Applicability by Teachers

The analysis of students' learning styles and teachers' teaching styles is also important, using different measurement instruments such as CHAEA and VARK [27]. Similarly, quantitative research has been carried out analyzing the profile of high school students based on their learning styles, identifying for each profile the teaching style of the teachers with which they identify [28].

• Variability in Learning Styles

While some have believed that students' learning style is part of their personality and cannot be changed [29]. In our analysis, based on a total absence of the kinesthetic style in the analyzed students, we believe we have detected as a working hypothesis that it is very likely that the predominant traditional teaching methodology with lectures in the Primary Education Degree may have caused a modification or gradual evolution from an initial kinesthetic learning style to others more in line with that methodology, i.e., visual or auditory. In this sense, Rasool et al [30]. showed that the visual learning style was the most common and the kinesthetic learning style was the least common learning style in a group of nursing students. A cross-sectional study was conducted on 200 nursing and obstetrics students in their 2nd year using the census method. The data collection instrument was the VARK learning style questionnaire. The prioritization of preferred learning styles by students was as follows: Visual (the most common learning style) and Kinesthetic (the least common learning style) used by the students who participated in this study. In line with what we propose in our study, comparisons of university student learning styles at the beginning, middle, and end of the educational course are being made precisely to analyze these changes. Koohestani & Baghcheghi, for example, have conducted a longitudinal descriptive study from 2015 to 2018 of health professions over a 4-year study period to determine changes in learning style over time [13]. Let's focus on this study for its relevance to our objectives. In this case, learning styles were assessed using the Perceptual Learning Style Preference Questionnaire three times in the study at the beginning (T1), halfway (T2), and at the end of the educational course (T3). The data were analyzed using repeated measures ANOVA. At T1, auditory (mean = 13.99) and visual (mean = 13.54) styles were preferred as main learning styles, meaning that participants preferred auditory-oriented materials as a learning method at the beginning of their program. Finally, kinesthetic (10.45 ± 2.11) and group learning (11.33 ± 3.1) scores were in a negative or insignificant category, so students found it difficult or uncomfortable to participate in activities that required group work. At T2, the visual style (mean = 13.6) was the only main preferred learning style. At T3, the main learning styles were kinesthetic (mean = 14.32), tactile (mean = 13.98), and visual (mean = 13.58). That is, at the end of the program, participants showed a preference for styles that included a practical and experiential approach to learning. Students preferred a more engaging approach to the learning experience at this stage. The high preference for the kinesthetic learning style among students at the end of the program can be attributed, according to these researchers, to the acquisition of clinical skills and learning in a clinical environment and to the student's commitment to practical activities. The conclusion of this study would go along the same lines as our working hypothesis: learning styles can change depending on the context, environment, teaching method, and subject matter of the learning material and, probably, are a changing and flexible characteristic rather than an inherent fixed characteristic that a student possesses [13]. In that case, most students had an auditory learning style at T1, which could be explained by the fact that the main teaching style in school and high school is auditory. Considering that the visual learning style was the most common learning style at the beginning of the program, using visual teaching tools in the early stages of the program could improve student learning. But it is true that the results of such analyzes do not always coincide [31]. Indeed, in the same line, but with another result, research describes a three-year study with the aim of detecting modifications in learning styles according to the Felder-Silverman learning style model, highlighting the variability and stability of learning styles over time. Experimental results show that individual LSs measured after one or two years/s, are subject to high variability. On the contrary, changes in the mean LS values (calculated on homogeneous groups) - useful for highlighting the effects of a specific curriculum or educational environment on subjects - are much more stable, although they deserve low sensitivity [32].

According to another study, the aim was to know and evaluate the learning style presented by Early Childhood Education and Educational Psychology university students to determine if modifications occur throughout their years of university studies, and identify the differences observed according to the specialty, using the learning styles questionnaire (CHAEA). According to the results obtained, the learning style, with a higher average, is Reflexive, where no significant differences are shown between the different specialties and courses analyzed [20]. Another study investigates the relationship between learning styles and learning outcomes of campers attending the Oklahoma FFA Alumni Leadership Camp, focusing on what is retained over time [33].

5. General Conclusion

This study provides a comprehensive insight into the learning styles of university students training to be teachers in the Primary Education Degree, specifically focusing on the distribution and prevalence of visual, auditory, and kinesthetic learning styles. Through descriptive and statistical analysis of the data collected at the beginning of the educational course, we have achieved several significant findings and important conclusions that have direct implications for educational and pedagogical practice.

The visual learning style was identified as the predominant one

among students, regardless of their gender or age group. This result suggests a clear trend towards a preference for materials and teaching strategies that emphasize visual elements, such as diagrams, videos, and infographics, highlighting the need to review and adapt teaching methods to incorporate more visual resources that can facilitate the learning process. The absence of students with a kinesthetic learning style in our sample indicates a possible influence of traditional educational methodology on the evolution of learning styles. This raises the hypothesis that the lack of practical activities and the predominant focus on theoretical classes may be limiting the identification or development of the kinesthetic style among students. This finding emphasizes the importance of incorporating and valuing a wider variety of pedagogical strategies that include practical activities and sensory experiences to support all learning styles.

The results of the study underline the importance of adopting an inclusive and diversified pedagogical approach that recognizes and adapts to the different learning styles of students. The marked preference for the visual style over other styles highlights the need to design learning experiences that integrate technologies and methodologies focused on visual learning. However, it is also crucial not to neglect minority learning styles, such as auditory and especially kinesthetic, by promoting educational practices that are effective and engaging for all students. There is a recognized need to broaden the spectrum of research to include a larger number of participants and to follow up over different periods and academic years. This will allow us to determine whether the absence of the kinesthetic style is a persistent trend and how teaching methods affect the evolution of learning styles over time. Future research could delve into how to adapt curricula and teaching strategies to foster a more balanced and effective learning environment for all learning styles [34-36].

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