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Article

AN EXPLORATORY ANALYSIS OF METHODOLOGICAL PREFERENCES IN SCIENCE EDUCATION AMONG FUTURE TEACHERS

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Abstract: *Preparing future teachers to teach science plays an essential role in developing scientific literacy and promoting educational approaches based on investigation and active learning. This study aims to analyze students' methodological preferences in the Primary and Preschool Education Pedagogy specialization and their perceptions of the usefulness of different categories of teaching resources used in science education activities. The research was conducted with a sample of 44 students, using a questionnaire structured on a 5-point Likert scale. The frequency of intention to use didactic experiments, systematic observation, didactic games, the project method, heuristic conversation, and discovery learning was investigated, as well as the perceived usefulness of digital resources, multimedia, worksheets, recyclable materials used in experiments, and manipulative materials. Statistical analysis was performed using XLSTAT, including descriptive statistics, Cronbach's alpha, the Spearman correlation coefficient, and the nonparametric Friedman test. The results revealed excellent internal consistency for the teaching methods scale (Cronbach's α = 0.912) and good consistency for the usefulness of teaching resources scale (Cronbach's α = 0.773). At the same time, moderate and strong positive correlations were identified between active-participatory methods and educational resources, suggesting a pedagogical profile oriented toward interactive and investigative approaches. The conclusions support the need to strengthen initial teacher training by integrating strategies and resources specific to STEM education and inquiry-based learning.*

Keywords: STEM; inquiry-based learning; didactic experiment; active-participatory strategies; pedagogical competencies

INTRODUCTION

In recent decades, science education has become a priority in educational policy, given the need to develop scientific literacy, problem-solving, and critical thinking skills from the early years of schooling. Roy et al.'s study identified some gaps in the area. Considerations related to the legislation in the field or the implications for parents could contribute to improving domain performance (Roy et al., 2025). In this context, the specialized literature points out the importance of promoting teaching strategies that emphasize investigation, experimentation, and active participation, allowing students to construct knowledge through direct interaction with the phenomena and processes under study (Kim et al., 2019). The tendency is to promote active learning (AL) and inquiry-based learning (IBL) (Rezai et al., 2025, Morris, 2025, Thomas et al., 2025). The methodology used could be influenced by the teacher's practical experience (Photo, 2025, Kotsis, 2024), gained during the study period or as an employee. Another aspect that may impact educational outcomes is the educator's ability to connect with students and to set realistic goals (Zhang et al., 2024).

For preschool and primary education, these principles are embodied in methods such as the didactic experiment, systematic observation, the project method, heuristic conversation, and discovery learning, all of which have the potential to facilitate the understanding of scientific concepts and the development of investigative skills. Besides the professor's expertise, the children's prior knowledge in a field can also influence the level of acquisition (Grenell et al., 2024).

However, the effectiveness of these methods depends closely on the use of appropriate teaching resources. Manipulative and concrete materials, digital and multimedia resources, worksheets, and recyclable materials used in experimental activities can transform the learning process into an authentic experience and support the development of students' practical and cognitive skills. Consequently, the initial training of future teachers must include not only the development of methodological skills but also the ability to select and effectively integrate teaching resources into teaching and learning activities (Ochogboju and Díez-Palomar, 2025, Furner and Worrell, 2017).

The motivation for this study stems from the need to understand how students in the Primary and Preschool Education specialization perceive the relationship between teaching strategies and the educational resources used to teach science. Although much research examines the effectiveness of different teaching methods, fewer studies simultaneously analyze future teachers' methodological preferences and how these preferences correlate with perceptions of the usefulness of teaching resources. Such an approach can provide relevant information to optimize the university curriculum and develop initial training programs focused on STEM education and inquiry-based learning.

In this context, three research hypotheses were formulated. The first hypothesis (H1) to confirm that methodological preferences and appreciation of teaching resources configure a coherent pedagogical profile of future teachers, a result compatible with constructivist perspectives on science teaching. The substantiation of this hypothesis is based on the fact that methods such as the didactic experiment, the project method, or discovery learning typically integrate material and digital resources that facilitate the observation, exploration, and validation of results obtained in the learning process.

The second hypothesis (H2) presumes there are significant differences in prospective teachers' stated preferences for different teaching methods in science education.

The third hypothesis (H3) postulates that there are notable variations in the perceived usefulness of different categories of teaching resources used in science education.

The study addresses a theme at the intersection of scientific education and initial teacher training. Although the research has a pronounced psychopedagogical character, it is directly relevant to the science fields, as it analyzes the factors that can influence the implementation of teaching practices that facilitate understanding of phenomena specific to the natural sciences and support the development of the skills necessary for future citizens in a knowledge-based society. The results provide empirical data on the readiness of future teachers to use methods and resources compatible with STEM education and modern inquiry-based learning approaches, thereby strengthening the link between science research and its transfer into educational practice.

Based on these considerations, the research aims to investigate students' methodological preferences and perceptions of the usefulness of the teaching resources used in science instruction, as well as to determine whether pre-service teachers exhibit different levels of preference for inquiry-oriented instructional methods in the field. To this end, responses were analyzed using descriptive and inferential statistics in XLSTAT, including Cronbach's alpha to assess the instrument's internal consistency (Tavakol and Dennick, 2011, Taber, 2018), the Spearman correlation coefficient to examine relationships among variables (Rebekić et al., 2015), and nonparametric Friedman tests to assess possible differences between the dependent measurements. This approach provides a rigorous methodological basis for characterizing the methodological profiles of future teachers and for formulating recommendations to optimize initial training in science education.

Unlike many studies that examine methodological preferences or the use of teaching resources separately, the present study analyzes the relationship between these two dimensions. It highlights how they shape the pedagogical profile of future science teachers. The integration of internal consistency analyses, Spearman correlations, and comparisons using the Friedman test offers an exploratory perspective on the coherence between methodological orientations and the selection of teaching resources.

MATERIALS AND METHODS

Participants and Data Collection Procedure

The research consisted of collecting pedagogical preferences in science teaching among students in the field of psychopedagogy of primary and preschool education. The survey was conducted in May 2026 and was administered to second-year students, towards the end of the science and science didactics course. Respondents' anonymity was ensured, with no personal data collected. Participation was voluntary and involved completing an online Google Forms questionnaire.

The questionnaire was specifically developed for this study based on the learning objectives of the Sciences and Science Teaching course, prior literature on inquiry-based science education (Strat et al., 2024, Ganajová et al., 2025), and the methodological competencies expected of pre-service primary teachers. It was conceived as a feedback instrument to explore students' perceptions of science teaching methodologies and instructional resources. The conceptual framework comprised two complementary dimensions. The first one, methodological preferences, assessed respondents' stated intention to use selected science teaching methods in their future professional practice. The second, perceived usefulness of instructional resources, evaluated respondents' perceptions of the educational value of various instructional materials commonly used in science teaching. The methods was choses to reflect respondents' self-reported inclination toward learner-centered instructional approaches, which are considered essential in contemporary science education (Erhabor and Reis, 2026, Vidal-Esteve and Martín-Gómez, 2023, Prajoko et al., 2017, Janštová et al., 2023). The second component was intended to reflect respondents' evaluation of the pedagogical usefulness of different instructional resources that support inquiry-based science teaching.

In this analysis, six items evaluated methodological preferences and five evaluated the perceived usefulness of instructional resources. Particular attention was paid to ensuring that each item captured a distinct aspect of the construct under investigation while maintaining conceptual coherence within each dimension.

The participation rate among those enrolled in the mentioned course this academic year was around 37%. The respondents were informed that their responses would be used exclusively for academic and scientific research.

The questions used to determine students' priorities for the methods applied were designed using a Likert scale (1-never, 2-rarely, 3-sometimes, 4-often, 5-very often). The range for determining the perceived usefulness of the different teaching resources was as follows: 1-very low, 2-low, 3-moderate, 4-high, 5-very high.

Statistical Analysis

The data were evaluated using XLSTAT 2025.2.0 software. To establish the degree of correlation between the frequency of using active methods and the concrete resources, Spearman's correlation coefficient was used. The Friedman test was utilised to assess differences among six methods and within the five instruments treated as dependent variables. The approach was considered given the study's preliminary characteristics. To assess the internal reliability of the results, Cronbach's Alpha was applied. The statistical coefficients were selected considering the sample size at the time of data processing.

RESULTS AND DISCUSSIONS

The study aimed to analyze respondents' methodological preferences and their perceptions of the usefulness of different resource categories. The analysis was based on participants' responses to a Likert-type (Vagias et al., 2006) questionnaire that assessed both the frequency with which they would use certain teaching methods and the usefulness of resources commonly encountered in science education activities.

Because developing specific science skills requires teaching strategies focused on investigation, exploration, and active student involvement, preferences for methods such as the didactic experiment, systematic observation, didactic game, project, heuristic conversation, and discovery learning were analyzed. In addition, students' perceptions of the usefulness of various teaching resources were investigated, ranging from concrete, reusable materials used in didactic experiments to digital and multimedia resources.

The degree of correlation and its meaning between the frequency of use of active methods (experiment, discovery, project) and concrete resources (recyclable materials and worksheets) were determined using Spearman's coefficient (Schober et al., 2018). From the correlation matrix (Table 1), moderate and strong positive relationships are observed between active-investigative methods and teaching resources perceived as useful. The strength of the relationship between the elements considered determines the most relevant values supporting the acceptance of the first hypothesis. Additionally, the consideration is sustained by the fact that most associations between methods and resources are statistically significant ($p<0.001$) (Table 2).

Almost all correlations among the six methods are statistically significant (most $p<0.001$) (Table 2). Such a result suggests that students who report they would frequently use an active method also report frequently using other similar ones. The result could suggest that methodological preferences are not independent but form a relatively coherent pedagogical profile.

This conclusion aligns with Cronbach's alpha values (≈0.91).

Results, such as observation↔worksheets ($p=0.206$), observation↔multimedia ($p=0.094$), concrete materials↔digital resources ($p=0.081$), and concrete materials↔worksheets ($p=0.242$), indicate that not all resources are perceived as equally relevant across all teaching strategies.

The correlation analysis revealed a strong positive association between the preference for systematic observation and the perceived usefulness of manipulative/concrete materials (0.62). The result is consistent with the specificity of this method, which involves the direct investigation of objects and phenomena through material supports that facilitate exploration and the formulation of conclusions based on observation. A strong positive association was also identified between heuristic conversation and the use of recyclable materials in experiments (0.60), suggesting that students perceive heuristic dialogue and experimental activities using accessible materials as complementary elements of interactive teaching. Both results support the existence of an orientation toward didactic practices that center on students' active involvement and the valorization of concrete resources in early science education. Sowmya and Rani underlined the positive effects of studying science from an early age (Sowmya and Rani, 2025). The design and implementation of exploratory activities are also suggested by the results of Dejonckheere et al.'s study (Dejonckheere et al., 2016).

Several situations with moderate to strong correlations (0.56-0.58) and moderate ones (0.40-0.53) were observed. The moderate-to-strong positive association identified between the project method and the perceived usefulness of digital, multimedia, and recyclable materials used in experiments (0.58) suggests that students who value project-based learning strategies tend to view these resources as essential supports for investigation and practical application activities. Such a result could be seen as consistent with the project method's specificity, which involves documentation, collaboration, the creation of educational products, and the integration of concrete learning experiences. Naseer et al.'s study provides additional data that underscore the benefits of project learning (Naseer et al., 2025). Such an approach appears to impact learners' future development, independent of the educational levels they were involved in. Thus, the preference for projects appears to be associated with an orientation toward active, interdisciplinary didactic approaches, characteristic of contemporary science and STEM education. A path to encourage the transition to project-based learning implementation was suggested in Martin-Garcia et al.'s study (Martín-García et al., 2024). Their research focused on implementing this approach in learning clubs. An observed limitation of such a procedure could be related to the teachers' experience in the field.

The moderate correlation between didactic experiment and concrete resources (0.53) shows that students associate experimental activities with the use of material supports. They perceive practical materials as essential for learning sciences. The result could be seen as a natural relationship in experimental didactics (Oliveira and Bonito, 2023, Kranz et al., 2023). The manipulative materials also show a moderate correlation with discovery learning (0.54). Such a result suggests that students value exploratory learning contexts, and supports the orientation towards constructivist pedagogies and inquiry-based learning. The worksheets seem to present less important correlations, with most coefficients falling in the weak association range.

It could be considered that students who prefer active, participatory methods also find concrete teaching resources useful. As the frequency of preference for methods based on investigation and active involvement increases, so does the perception of the usefulness of practical and applicative resources.

Correlation analysis revealed a coherent pedagogical profile in which a preference for active teaching methods is associated with a positive appreciation of a diverse range of teaching resources. However, the lack of significant associations between systematic observation and worksheets or multimedia resources suggests that participants distinguish between resources appropriate for observation-based activities and those used primarily to organize or present information.

The scale's internal consistency was evaluated using Cronbach's alpha (Table 3).

Table 3. Consistency global coefficient

	Methods	Materials
Cronbach's alpha	0.912	0.773
Standardized Cronbach's Alpha	0.914	0.778
Split-Half 1	didactic experiment	concrete/manipulative materials
	didactic game	digital resources
	heuristic conversation	worksheets
Split-Half 2	systematic observation	multimedia resources
	project method	recyclable materials used in experiments
	discovery learning	

Reliability analysis shows excellent internal consistency for the scale measuring the frequency of use of didactic methods (Cronbach's α=0.912) and good internal consistency for the scale measuring the perceived usefulness of didactic resources (Cronbach's α=0.773). These results support the instrument's internal consistency (Dorsah, 2026).

The methodological preferences aspect highlights higher internal homogeneity than the perceived usefulness of teaching resources (Table 4). This result is expected because the investigated teaching methods represent complementary pedagogical strategies used in science teaching. In contrast, teaching resources include more heterogeneous categories (digital, multimedia, and concrete and recyclable materials), which may lead to greater variability in responses.

Table 4. Corrected Item-Total Correlation Values

Variable	Item-total correlation	Interpretation correlation
Methodological preferences		
Didactic experiment	0.807	Very strong
Systematic observation	0.744	Strong
Didactic game	0.672	Strong
Project method	0.709	Strong
Heuristic conversation	0.786	Very strong
Discovery learning	0.828	Very strong
Perceived usefulness of materials		
Concrete materials	0.454	Moderate
Digital resources	0.609	Strong
Worksheets	0.435	Moderate
Multimedia resources	0.699	Strong
Recycled materials	0.562	Moderate–strong

Internal consistency was evaluated using Cronbach's alpha and item-level statistics. For the methodological preferences scale, corrected item-total correlations ranged from 0.672 to 0.828, indicating strong associations between each item and the overall construct. The highest correlations were observed for discovery learning (0.828) and didactic experiments (0.807), while didactic games showed the lowest, yet still high, correlation (0.672). Furthermore, Cronbach's alpha did not improve after deleting any item, supporting the retention of all six items.

The perceived usefulness of the different instruments scale also indicate satisfactory internal consistency. Corrected item-total correlations ranged from 0.435 to 0.699, exceeding the commonly accepted threshold of 0.30. Multimedia resources (0.699) and digital resources (0.609) showed the strongest relationships with the total score, whereas worksheets had the lowest correlation (0.435), which was still acceptable. No improvement in Cronbach's alpha was observed after deleting individual items.

Friedman's test suggests the existence of global differences between teaching methods, but does not identify pairs of methods that differ significantly (Table 5 and 6).

Table 5. Friedman's test results for the methods considered

Q (Observed value)	**23.220**
Q (Critical value)	11.070
DF	5
p-value (one-tailed)	**0.000**
alpha	0.05

An approximation has been used to compute the p-value.

Table 6. Methods summary statistics

Variable	Mean	Median Q_1-Q3
didactic experiment	4.21±0.73	4(4-5)
systematic observation	4.36±0.72	4.5(4-5)
didactic game	4.57±0.70	5(4-5)
project method	4.23±0.80	4(4-5)
heuristic conversation	4.43±0.70	5(4-5)
discovery learning	4.52±0.66	5(4-5)

Descriptive analysis indicates that all investigated teaching methods were evaluated favorably, with means ranging from 4.205 to 4.568 on a five-point Likert scale. The highest scores were recorded for the didactic game (4.568 ± 0.695). The didactic experiment (4.205 ± 0.734) and the project method (4.227 ± 0.803) recorded slightly lower values, but remained above the level of frequent use. All data considered have an IQR of 1, indicating that the responses are concentrated between ”Frequent” and ”Very frequent”. Medians consistently indicated high preferences for all instructional methods. The didactic game, heuristic conversation, and discovery learning reached a median score of 5 (Q1–Q3: 4–5), indicating that at least half of respondents reported using these methods frequently or very frequently. The didactic experiment and project method had slightly lower median values of 4 (Q1–Q3: 4–5), although their mean scores were also generally favorable.

To assess whether these differences are statistically significant, the Friedman test for repeated measures was applied. The results revealed significant differences among the six methods investigated ($Q=23.220$, $df=5$, $p<0.001$), indicating that participants do not intend to use all teaching methods with the same frequency. This result suggests a hierarchy of methodological preferences, with a stronger orientation toward active, student-centered strategies. However, the Friedman test does not identify which pairs of methods differ significantly. Post hoc analyses would be necessary to identify the specific differences.

Therefore, the null interpretation of the second hypothesis, according to which all methods are evaluated similarly, is rejected, and the alternative form, which specifies that at least one teaching method is evaluated differently from the others, is accepted.

Regarding the instruments used, the Friedman test results indicate that the differences between the means are not statistically significant at the $\alpha = 0.05$ threshold (Tables 7 and 8).

Table 7. Friedman's test results for the instruments considered

Q (Observed value)	**9.328**
Q (Critical value)	9.488
DF	4
p-value (one-tailed)	0.053
alpha	0.05

An approximation has been used to compute the p-value.

Table 8. Instruments summary statistics

Variable	Mean	Median Q_1-Q3
concrete/manipulative materials	4.43±0.87	5(4-5)
digital resources	4.16±0.71	4(4-5)
worksheets	4.14±0.80	4(4-5)
multimedia resources	4.11±0.78	4(3.75-5)
recyclable materials used in experiments	4.34±0.74	4.5(4-5)

Participants rated all categories of educational resources investigated favorably, with averages ranging from 4.114 to 4.432. Concrete/manipulative materials (4.432 ± 0.873) and recyclable materials used in experiments (4.341 ± 0.745) had the highest values, while multimedia resources (4.114 ± 0.784) and worksheets (4.136 ± 0.795) had slightly lower values.

The only variable that is somewhat more dispersed is multimedia resources (IQR=1.25). Perceived usefulness of instructional resources was similarly high. Concrete/manipulative materials had the highest median score (Median=5; Q1-Q3:4-5), whereas digital resources, worksheets, and multimedia resources all had a median of 4 and relatively narrow interquartile ranges, suggesting a generally consistent appreciation across participants. For the variable ”multimedia resources”, Q1=3.75 indicates the use of an interpolation method for calculating quartiles.

The Friedman test did not reveal statistically significant differences among the evaluations of the five resource categories (Q=9.328; df=4; p=0.053). Although the result is close to the conventional significance threshold, it does not provide sufficient evidence to conclude that participants systematically prioritize certain resources over others. These results suggest a relatively balanced appreciation of the various teaching resources used in science education. In this case, the null formulation of the third assumption is accepted.

The median results (Q_1-Q_3) support the Friedman data, with differences detected for the methods used and being less significant for the instruments.

Spearman correlations indicated moderate to strong associations between active-participatory methods and didactic resources. Overall, the results suggest a coherent pedagogical profile oriented toward interactive, investigative, and specific approaches to STEM education. Independent of the didactic methods and materials used, the teaching activity's success could be considered highly dependent on the educator's professional and personal capacities to adapt and implement appropriate strategies to the educable's capacities and interests (Kucharčíková and Tokarčíková, 2016).

CONCLUSIONS

The results suggest that future teachers are oriented toward interactive teaching strategies. Inquiry-based methods are conceptualized alongside practical resources. There are favorable conditions for integrating STEM and inquiry-based approaches into initial teacher education. Combined interpretation of Spearman correlation coefficients and Friedman results revealed a statistically coherent pattern of methodological preferences among pre-service teachers. Strong positive associations were found between inquiry-based teaching methods and the perceived usefulness of practical and digital instructional resources, and the Friedman test confirmed significant variations in stated preferences for different teaching methods in science education (p<0.0003). These findings suggest an educational orientation toward interactive, student-centered, and resource-supported science teaching practices. Successful results regarding future teachers' capacities to implement different didactic approaches are linked to both their theoretical studies and practical experience (Sizer et al., 2021).

The results support the finding that prospective teachers have a favorable orientation toward teaching methods that promote active student engagement and knowledge construction through direct learning experiences. The high scores for didactic games, discovery learning, and heuristic conversation are consistent with current science-teaching guidelines, which recommend active strategies to develop critical thinking, investigation, and problem-solving skills.

In contrast, the lack of significant differences across the teaching resource categories suggests that respondents view these resources as complementary instead of competing. This perspective aligns with contemporary approaches to science education, which promote integrating concrete materials, digital resources, and recyclable materials based on teaching objectives and the context of learning activities (Park et al., 2023).

The preferences for discovery learning and heuristic conversation can be interpreted in light of constructivist perspectives on learning, which hold that knowledge is actively constructed through exploration, hypothesis-making, and reflection on learning experiences. From this perspective, the teacher's role shifts from transmitting information to facilitating investigation and argumentation.

The favorable orientation toward active methods aligns with numerous studies on science teacher education, which have shown that inquiry-based university experiences increase acceptance of student-centered teaching strategies (Jerrim et al., 2022, Aidoo, 2024). At the same time, our results indicate that the didactic experiment does not rank first in the hierarchy of preferences, which may reflect perceived constraints on organizing experimental activities or students' confidence in managing them.

The results are based on self-reported preferences, instead of observations of teaching practice. Therefore, it cannot be concluded that participants will actually use the methods and resources evaluated in their professional work. Additionally, the small sample size (44 students from the same specialization) limits the generalizability of the conclusions.

The data obtained suggest the need to strengthen university activities through investigation, projects, and the integrated use of digital resources and concrete materials. The development of methodological skills should be achieved through authentic activities of designing and implementing science lessons, which allow students to directly experience the relationship between teaching strategies and the resources used.

The preference for active strategies is consistent with recent research on initial teacher education, which shows that inquiry-based university experiences foster the acceptance of student-centered methods. At the same time, our study complements these results by highlighting the relationships between methodological preferences and the appreciation of specific teaching resources.

The association between the project method and digital resources can be explained by the characteristics of educational projects, which involve documentation, collaboration, and information organization. Digital resources facilitate these processes and become natural supports for the implementation of project-based learning.

The correlation between systematic observation and concrete materials aligns with the principles of inquiry-based learning, as the observation of natural phenomena involves the use of real objects and manipulable materials.

LIMITATIONS AND FUTURE PERSPECTIVES

The results of the study highlight a tendency among future teachers toward active-participatory teaching methods and the use of various teaching resources in science education activities. The high internal consistency of the research instrument (Cronbach's α=0.912 for the methodological preferences scale), along with the positive associations identified between teaching methods and educational resources, supports the need to strengthen these dimensions in initial training programs. A person's innate abilities along with acquired competencies form their personality. Independent of the future field of activity, shaping will begin in the initial stages of the educational process. Designing and implementing participatory activities in which learners, regardless of their level of education, are integral to the process can help shape their future professional development by increasing the stimulation of acquisitions, dynamic and conscious persons (Cortes, 2025, Ma, 2023, Jakob et al., 2026, Gáspár et al., 2021).

Training programs could include more applied activities in which students design, implement, and evaluate teaching sequences based on experimentation, systematic observation, and discovery learning. Practicing these methods in authentic contexts contributes to the development of professional skills and facilitates their transfer to teaching practice.

The research results suggest that investigative-exploratory methods are perceived as complementary. Therefore, the initial training curriculum could be built on pedagogical models centered on questioning, hypothesis development, data collection, and result interpretation, in line with international recommendations for science education.

The correlations identified between the project method and digital and multimedia resources indicate the need to develop future teachers' digital skills. University activities might include lesson design using educational platforms, interactive simulations, data-collection applications, and digital presentation and collaboration tools, more than just general technical training.

Direct contact with real teaching situations can facilitate the development of skills in selecting and appropriately using teaching methods and resources. Declared preferences are not equivalent to actual teaching practices. The questionnaire measures intentions and perceptions, not observed classroom behaviors. Therefore, even if participants declare a preference for active methods and for certain resources, it cannot be concluded that these will actually be used in professional activity.

The training of future teachers could encourage the design of interdisciplinary activities that connect the natural sciences with technology, engineering, and mathematics. The project method and the didactic experiment provide favorable contexts for developing such approaches and integrating digital resources. Experimental materials can support the use of authentic, relevant problems for students.

Initial training might not be limited to presenting teaching methods. Still, it should also include systematic activities for developing learning scenarios, selecting resources for argumentative purposes, and constructing assessment tools appropriate to the competencies under investigation. Such an approach can help increase coherence among curricular objectives, teaching strategies, and the assessment of learning outcomes.

The associations observed between systematic observation and manipulative materials, and between heuristic conversation and recyclable materials used in experiments, highlight the importance of concrete learning experiences. It could be recommended that university practical activities include workshops on the design and implementation of experiments using accessible, reusable materials, in line with the principles of education for sustainable development (Levina et al., 2025, Arnab et al., 2025, Botella et al., 2022).

Statistical analyses of methodological preferences and student perceptions can provide valuable information for revising school curricula. Introducing periodic feedback collection and analysis can help adapt training content and strategies to the real needs of future teachers.

The recommendations support developing an initial training model that combines theoretical training with practical experience and promotes the integrated use of active, participatory methods and diversified teaching resources. Such an approach can help prepare teachers to design and implement science education activities that are adapted to students' current needs in preschool and primary education, and to facilitate the development of investigative skills and scientific literacy (Halimi et al., 2024). In the Gahrizsangi et al. study, the importance of adapting teaching approaches to current technological developments was highlighted. Transdisciplinarity could increase scientific knowledge and interest in science from early ages (Salehi Gahrizsangi et al., 2026). Future post hoc analyses are recommended to identify which methods differ after a significant Friedman result is obtained.

The findings should be interpreted in light of several limitations. First, the study relied on a relatively small sample (N=44) from a single teacher education program, limiting the generalizability of the results. The response rate (37%) represents an additional limitation of the study. Although similar response rates are frequently reported in voluntary surveys conducted in higher education, the possibility of non-response bias cannot be ruled out. Consequently, the findings should be interpreted as reflecting the characteristics of the participating students, not the entire population of pre-service primary teachers.

A subsequent limitation concerns the data, which were collected via self-reported Likert-scale responses and therefore reflect participants' perceived preferences, not the observed teaching practices. All variables exhibit a ceiling effect, as most responses cluster around values 4 and 5. This limits variability and may reduce the ability of statistical tests to detect more subtle differences between methods or resources.

Also, the cross-sectional design does not allow causal inferences or the examination of changes in methodological preferences over time. Although the statistical analyses revealed significant associations between teaching methods and instructional resources, these relationships might be better interpreted as correlational instead of causal. Future research should include larger, more diverse samples, longitudinal designs, and complementary observational methods to provide a more comprehensive understanding of pre-service teachers' science teaching practices.

Table 1. Correlation matrix (Spearman)

Variables	Methods						Materials				
	didactic experiment	systematic observation	didactic game	project method	heuristic conversation	discovery learning	concrete/manipulative materials	digital resources	worksheets	multimedia resources	recyclable materials used in experiments
didactic experiment	1	0.74	0.55	0.69	0.68	0.66	*0.53*	***0.56***	0.32	*0.43*	*0.53*
systematic observation	0.74	1	0.55	0.49	0.65	0.53	***0.62***	0.31	0.19	0.26	*0.50*
didactic game	0.55	0.55	1	0.48	0.47	0.72	*0.48*	0.38	0.33	*0.50*	*0.40*
project method	0.69	0.49	0.48	1	0.68	0.68	0.37	***0.58***	*0.55*	***0.58***	***0.58***
heuristic conversation	0.68	0.65	0.47	0.68	1	0.61	*0.52*	*0.48*	0.31	*0.45*	***0.60***
discovery learning	0.66	0.53	0.72	0.68	0.61	1	*0.54*	***0.56***	0.39	***0.57***	*0.40*
concrete/manipulative materials	0.53	0.62	0.48	0.37	0.52	0.54	1	0.27	0.18	0.45	0.52
digital resources	0.56	0.31	0.38	0.58	0.48	0.56	0.27	1	0.52	0.72	0.35
worksheets	0.32	0.19	0.33	0.55	0.31	0.39	0.18	0.52	1	0.48	0.41
multimedia resources	0.43	0.26	0.50	0.58	0.45	0.57	0.45	0.72	0.48	1	0.42
recyclable materials in experiments	0.53	0.50	0.40	0.58	0.60	0.40	0.52	0.35	0.41	0.42	1

Values in bold are different from 0 with a significance level alpha=0.05

Table 2. p-values (Spearman)

Variables	Methods						Materials				
	didactic experiment	systematic observation	didactic game	project method	heuristic conversation	discovery learning	concrete/manipulative materials	digital resources	worksheets	multimedia resources	recyclable materials used in experiments
didactic experiment	0	<0.0001	0.000	<0.0001	<0.0001	<0.0001	0.000	<0.0001	0.037	0.003	0.000
systematic observation	<0.0001	0	0.000	0.001	<0.0001	0.000	<0.0001	0.044	0.206	0.094	0.001
didactic game	0.000	0.000	0	0.001	0.001	<0.0001	0.001	0.010	0.030	0.001	0.008
project method	<0.0001	0.001	0.001	0	<0.0001	<0.0001	0.013	<0.0001	0.000	<0.0001	<0.0001
heuristic conversation	<0.0001	<0.0001	0.001	<0.0001	0	<0.0001	0.000	0.001	0.044	0.003	<0.0001
discovery learning	<0.0001	0.000	<0.0001	<0.0001	<0.0001	0	0.000	<0.0001	0.010	<0.0001	0.007
concrete/manipulative materials	0.000	<0.0001	0.001	0.013	0.000	0.000	0	0.081	0.242	0.002	0.000
digital resources	<0.0001	0.044	0.010	<0.0001	0.001	<0.0001	0.081	0	0.000	<0.0001	0.020
worksheets	0.037	0.206	0.030	0.000	0.044	0.010	0.242	0.000	0	0.001	0.006
multimedia resources	0.003	0.094	0.001	<0.0001	0.003	<0.0001	0.002	<0.0001	0.001	0	0.005
recyclable materials in experiments	0.000	0.001	0.008	<0.0001	<0.0001	0.007	0.000	0.020	0.006	0.005	0

REFERENCES

AIDOO, B. 2024. A reflective study on adopting inquiry-based science teaching methods. *Disciplinary and Interdisciplinary Science Education Research,* 6**,** 29. https://doi.org/10.1186/s43031-024-00119-3

ARNAB, S., MASTERS, A., PURNOMO, R. A., MAHON, D. & MINOI, J.-L. 2025. Playful and frugal learning design: A value-based approach to inclusive and sustainable STEM education. *Social Sciences & Humanities Open,* 12**,** 101923. https://doi.org/10.1016/j.ssaho.2025.101923

BOTELLA, P., BAENA-MORALES, S., GARCÍA-TAIBO, O. & FERRIZ-VALERO, A. 2022. Effects of Self-Construction of Materials on the Ecological Awareness of Physical Education Primary School Students. *Journal of Environmental Research and Public Health,* 19**,** 14176. https://doi.org/10.3390/ijerph192114176

CORTES, S. T. 2025. Advancing science education through a participatory action research guide for science teachers. *Social Sciences & Humanities Open,* 12**,** 102077. https://doi.org/10.1016/j.ssaho.2025.102077

DEJONCKHEERE, P. J., DE WIT, N., VAN DE KEERE, K. & VERVAET, S. 2016. Exploring the classroom: Teaching science in early childhood. *European Journal of Educational Research,* 5**,** 149-164. https://files.eric.ed.gov/fulltext/EJ1109852.pdf

DORSAH, P. 2026. The Use of Cronbach's Alpha Reliability in Educational Research: A Systematic Review. *European Journal of Contemporary Education E-Learning,* 4**,** 39-50. https://doi.org/10.59324/ejceel.2026.4(2).04

ERHABOR, N. I. & REIS, G. 2026. Low-Cost Educational Materials and University Student Teachers' Recycling Knowledge and Attitudes: A Quasi-Experimental Study. *Education Sciences,* 16**,** 325. https://doi.org/10.3390/educsci16020325

FURNER, J. M. & WORRELL, N. L. 2017. The importance of using manipulatives in teaching math today. *Transformations,* 3**,** 2. https://nsuworks.nova.edu/transformations/vol3/iss1/2

GANAJOVÁ, M., OROSOVÁ, R., SOTÁKOVÁ, I. & LETOŠNíKOVÁ, P. 2025. The effect of inquiry-based teaching on students' attitudes toward science as an academic subject as well as science and technology in general. *Frontiers in Education,* Volume 10 - 2025. https://doi.org/10.3389/feduc.2025.1708139

GÁSPÁR, J., HIDEG, É. & KÖVES, A. 2021. Future in the present: Participatory futures research methods in economic higher education–the development of future competencies. *Journal of Futures Studies,* 26**,** 1-18. https://doi.org/10.6531/JFS.202112_26(2).0001

GRENELL, A., ERNST, J. R. & CARLSON, S. M. 2024. Preschool Children's Science Learning: Instructional Approaches and Individual Differences. *Early education development,* 35**,** 1891-1919. https://doi.org/10.1080/10409289.2024.2360884

HALIMI, F., TRYZNA, M. & BRUNSTEIN, A. 2024. Motivational orientation and perception of active learning instruction by pre-service language teachers. *Frontiers in Psychology,* 15**,** 1307733. https://doi.org/10.3389/fpsyg.2024.1307733

JAKOB, M., BÜCHEL, K., STEFFEN, D. & BRUNETTI, A. 2026. Participatory teaching improves learning outcomes: Evidence from a field experiment in Tanzania. *Journal of Development Economics***,** 103742. https://www.econstor.eu/bitstream/10419/278646/1/1859899595.pdf

JANŠTOVÁ, V., NOVOTNÝ, P., CHLEBOUNOVÁ, I., GUITART, F., FORNE, E. & TORTOSA, M. 2023. Identifying key features of digital resources used during online science practicals. *PloS one,* 18**,** e0283054. https://doi.org/10.1371/journal.pone.0283054

JERRIM, J., OLIVER, M. & SIMS, S. 2022. The relationship between inquiry-based teaching and students' achievement. New evidence from a longitudinal PISA study in England. *Learning and Instruction,* 80**,** 101310. https://doi.org/10.1016/j.learninstruc.2020.101310

KIM, S., RAZA, M. & SEIDMAN, E. 2019. Improving 21st-century teaching skills: The key to effective 21st-century learners. *Research in Comparative International Education,* 14**,** 99-117. https://doi.org/10.1177/1745499919829214

KOTSIS, K. T. 2024. Integrating inquiry-based learning in the new Greek primary science curriculum. *European Journal of Education Pedagogy,* 5**,** 63-71. https://doi.org/10.24018/ejedu.2024.5.6.899

KRANZ, J., BAUR, A. & MÖLLER, A. 2023. Learners' challenges in understanding and performing experiments: a systematic review of the literature. *Studies in Science Education,* 59**,** 321-367. https://doi.org/10.1080/03057267.2022.2138151

KUCHARČÍKOVÁ, A. & TOKARČÍKOVÁ, E. J. 2016. Use of participatory methods in teaching at the university. *TOJSAT-The Online Journal of Science and Technology,* 6**,** 82-90. https://dergipark.org.tr/tr/download/article-file/210211

LEVINA, O., LINDAUER, F. & REVINA, A. 2025. A Participatory Workshop Design for Engaging Young People in IT Sustainability. *Education Sciences,* 15**,** 1570. https://doi.org/10.3390/educsci15121570

MA, Y.-C. 2023. Using Participatory Teaching in Hands-On Courses: Exploring the Influence of Teaching Cases on Learning Motivation. *Education Sciences,* 13**,** 547. https://doi.org/10.3390/educsci13060547

MARTÍN-GARCÍA, J., DIES ÁLVAREZ, M. E. & AFONSO, A. S. 2024. Understanding Science Teachers' Integration of Active Methodologies in Club Settings: An Exploratory Study. *Education Sciences,* 14**,** 106. https://doi.org/10.3390/educsci14010106

MORRIS, D. L. 2025. Rethinking Science Education Practices: Shifting from Investigation-Centric to Comprehensive Inquiry-Based Instruction. *Education Sciences,* 15**,** 73. https://doi.org/10.3390/educsci15010073

NASEER, F., TARIQ, R., ALSHAHRANI, H. M., ALRUWAIS, N. & AL-WESABI, F. N. 2025. Project based learning framework integrating industry collaboration to enhance student future readiness in higher education. *Scientific Reports,* 15**,** 24985. https://doi.org/10.1038/s41598-025-10385-4

OCHOGBOJU, A. O. & DÍEZ-PALOMAR, J. 2025. Modeling Concrete and Virtual Manipulatives for Mathematics Teacher Training: A Case Study in ICT-Enhanced Pedagogies. *Information,* 16**,** 698. https://doi.org/10.3390/info16080698

OLIVEIRA, H. & BONITO, J. 2023. Practical work in science education: a systematic literature review. *Frontiers in Education,* Volume 8 - 2023. https://doi.org/10.3389/feduc.2023.1151641

PARK, J., TEO, T. W., TEO, A., CHANG, J., HUANG, J. S. & KOO, S. 2023. Integrating artificial intelligence into science lessons: teachers' experiences and views. *International Journal of STEM Education,* 10**,** 61. https://doi.org/10.1186/s40594-023-00454-3

PHOTO, P. 2025. Teaching Experiences Connected To The Implementation Of Inquiry-Based Practical Work In Primary Science Classrooms. *Research in Science Education,* 55**,** 1493-1516. https://doi.org/10.1007/s11165-025-10235-3

PRAJOKO, S., AMIN, M., ROHMAN, F., GIPAYANA, M. J. I. J. O. E. & EDUCATION, R. I. 2017. The Usage of Recycle Materials for Science Practicum: Is There Any Effect on Science Process Skills? *International Journal of Evaluation and Research in Education,* 6**,** 1-8. https://scispace.com/pdf/the-usage-of-recycle-materials-for-science-practicum-is-34vbn6lvjf.pdf

REBEKIĆ, A., LONČARIĆ, Z., PETROVIĆ, S. & MARIĆ, S. 2015. Pearson's or Spearman's correlation coefficient-which one to use? *Agriculture*. https://doi.org/10.18047/poljo.21.2.8

REZAI, A., AHMADI, R., ASHKANI, P. & HOSSEINI, G. H. 2025. Implementing active learning approach to promote motivation, reduce anxiety, and shape positive attitudes: A case study of EFL learners. *Acta Psychologica,* 253**,** 104704. https://doi.org/10.1016/j.actpsy.2025.104704

ROY, G., SIKDER, S. & DANAIA, L. 2025. Adopting scientific literacy in early years from empirical studies on formal education: a systematic review of the literature.

International Journal of STEM Education, 12**,** 26. https://doi.org/10.1186/s40594-025-00547-1-025-00547-1
SALEHI GAHRIZSANGI, H., KEWALRAMANI, S. & RICHARDS, G. 2026. Multimodal Technology-Integrated Approaches for Teaching Early Childhood and Early Primary Science: A Scoping Review. *Education Sciences,* 16**,** 586. https://doi.org/10.3390/educsci16040586
SCHOBER, P., BOER, C. & SCHWARTE, L. A. 2018. Correlation Coefficients: Appropriate Use and Interpretation. *Anesthesia and Analgesia,* 126**,** 1763-1768. https://doi.org/10.1213/ane.0000000000002864
SIZER, A., THARP, H., WRIGLEY, J., AL-BATAINEH, A. & PARK, D.-Y. 2021. The impact of pre-service teachers' orientation on the implementation of inquiry-based science instruction. *EURASIA Journal of Mathematics, Science Technology Education,* 17**,** em2028. https://doi.org/10.29333/ejmste/11247
SOWMYA, A. & RANI, R. N. 2025. Emerging interest in science during early childhood period and evaluating its effectiveness. *Scientific Reports,* 15**,** 38683. https://doi.org/10.1038/s41598-025-22513-1
STRAT, T. T. S., HENRIKSEN, E. K. & JEGSTAD, K. M. 2024. Inquiry-based science education in science teacher education: a systematic review. *Studies in Science Education,* 60**,** 191-249. https://doi.org/10.1080/03057267.2023.2207148
TABER, K. S. 2018. The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education,* 48**,** 1273-1296. https://doi.org/10.1007/s11165-016-9602-2
TAVAKOL, M. & DENNICK, R. 2011. Making sense of Cronbach's alpha. *International journal of medical education,* 2**,** 53. https://doi.org/10.5116/ijme.4dfb.8dfd
THOMAS, M. B., MUSCAT, A., ZUCCOLO, A., LUGUETTI, C. N. & WATT, A. 2025. Navigating Pedagogical Innovation in Higher Education: Education Academics'Experiences with Active and Inquiry-Based Learning in Intensive Teaching. *Innovative Higher Education,* 50**,** 1917-1943. https://doi.org/10.1007/s10755-025-09807-y
VAGIAS, W. M. J., RESEARCH DEVELOPMENT, D. O. P., RECREATION & TOURISM MANAGEMENT, C. U. 2006. Likert-type scale response anchors. clemson international institute for tourism. 4.
VIDAL-ESTEVE, M. I. & MARTÍN-GÓMEZ, S. 2023. Digitalization of Classrooms: A Comparative Study on Teachers' Perceptions about the Use of Digital Teaching Materials in Early Childhood and Primary Education. *Education Sciences,* 13**,** 1156. https://doi.org/10.3390/educsci13111156
ZHANG, H., YANG, J. & LIU, Z. 2024. Effect of teachers' teaching strategies on students' learning engagement: moderated mediation model. *Frontiers in Psychology,* Volume 15 - 2024. https://doi.org/10.3389/fpsyg.2024.1475048

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