

Basic Science Achievement Profile among Early Childhood Teacher Education Students: Implications for Science Learning Management

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Received: July 22, 2024

Revised: August 29, 2024

Accepted: September 25, 2024

Published: September 30, 2024

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DOI: [10.29303/jppipa.v10i9.16107](https://doi.org/10.29303/jppipa.v10i9.16107)

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Abstract: Evidence about students' science achievement can inform course improvement, but descriptive scores should not be interpreted as direct evidence of the effectiveness of learning-management practices. This study profiles basic science achievement among 80 Early Childhood Teacher Education students at Universitas Negeri Manado and uses the profile as an input to a theory-informed evidence-to-management translation framework. A descriptive quantitative cross-sectional design was employed using archived total scores from the Basic Science Concepts course assessment (0–100). Analysis focused on the mean, median, mode, standard deviation, range, and 95% confidence interval. The cohort mean was 77.88 (SD = 3.23), the median and mode were 78, the scores ranged from 71 to 89, and the 95% confidence interval was 77.16–78.59. The narrow observed dispersion indicates a clustered cohort-level score profile, but total scores do not identify domain-specific strengths, misconceptions, or causes of achievement. Accordingly, the management implications are explicitly theory-informed rather than empirical effects. The study proposes an evidence-to-management translation framework that separates what the observed scores directly support from literature-based actions for planning, organization, implementation, learning resources, and monitoring-evaluation. Because complete psychometric documentation and item-level response data were unavailable for re-analysis, findings are restricted to the observed achievement profile and no causal claim is made about science learning management.

Keywords: Achievement profile; Basic science; Early childhood teacher education; learning management; Science education

Introduction

Science learning in early childhood education provides an initial foundation for curiosity, observation, classification, prediction, experimentation, communication, and evidence-based reasoning. At this level, science should not be reduced to memorizing facts. It should be transformed into developmentally appropriate experiences in which children explore familiar objects and phenomena, ask questions, compare evidence, and construct simple explanations. The quality of these experiences depends substantially on

teachers who understand scientific ideas accurately and can transform them into safe, concrete, playful, and meaningful activities.

Students of the Early Childhood Teacher Education Study Program are prospective teachers who will mediate young children's first structured encounters with natural phenomena. Their preparation therefore requires both sound science content knowledge and the pedagogical capacity to represent science in ways appropriate to children's developmental characteristics. Limited content knowledge may lead to oversimplified explanations, inappropriate analogies, or the

How to Cite:

Tampi, F. L., Raflesia, C., & Lengkong, J. S. J. (2024). Basic Science Achievement Profile among Early Childhood Teacher Education Students: Implications for Science Learning Management. *Jurnal Penelitian Pendidikan IPA*, 10(9), 7225–7231. <https://doi.org/10.29303/jppipa.v10i9.16107>

unintentional transmission of alternative conceptions. Studies in teacher education have consequently examined science content knowledge, pedagogical content knowledge, inquiry experience, and confidence in teaching science (Akerson et al., 2019; Menon & Sadler, 2016; Nilsson & Elm, 2017).

The development of these competencies is shaped not only by students' individual learning but also by how a course is planned and implemented. In this article, science learning management refers to the coordinated alignment of learning outcomes, content sequence, instructional activities, resources, assessment, feedback, and follow-up. Constructive alignment requires intended outcomes, learning experiences, and assessment tasks to support the same conceptual and professional competencies (Biggs & Tang, 2011). For science teacher education, this alignment should connect conceptual explanations with inquiry, experimentation, reflection, and the design of activities that can later be adapted for young children.

Science Learning Management in Early Childhood Teacher Education

For the purpose of translating achievement evidence into course-review questions, science learning management is organized into five dimensions: planning, organization, implementation, learning-resource management, and monitoring-evaluation. Planning concerns the clarity and sequencing of learning outcomes, concepts, activities, and assessment. Organization concerns time allocation, group arrangements, practical sessions, task distribution, communication, and coordination across learning modes. Implementation concerns questioning, inquiry, experimentation, discussion, reflection, and explicit connections between science content and early childhood pedagogy.

Learning-resource management concerns the selection and use of laboratory tools, simple materials, natural objects, digital resources, and local environmental phenomena. These resources should be accessible, safe, relevant, and capable of supporting direct observation. Monitoring and evaluation include diagnostic and formative assessment, feedback, remediation, enrichment, reflection, and the use of learning evidence to improve subsequent instruction. Research on preservice-teacher learning indicates that active, collaborative, inquiry-oriented, and blended experiences can support teacher learning, although their effectiveness depends on appropriate guidance, course design, and monitoring (Kulaksız & Toran, 2022; Strat et al., 2024; Yılmaz & Malone, 2020).

Inquiry is particularly relevant because it makes students' reasoning visible and connects scientific explanations with evidence. A systematic review of

inquiry-based science education in teacher education found that inquiry experiences can support conceptual understanding and knowledge of inquiry pedagogy when adequate guidance and reflection are provided (Strat et al., 2024). In early childhood teacher education, inquiry-oriented coursework has also been associated with stronger science-teaching efficacy and instructional confidence (Özdem Yılmaz & Şahin, 2025). These findings provide a theoretical basis for course-management decisions, but they do not mean that the present study directly measures the effectiveness of any management practice.

Basic Science Achievement and Interpretive Boundaries

In this study, the available evidence consists of archived total scores from a Basic Science Concepts course assessment. Such scores can summarize overall achievement, but they cannot by themselves establish domain-specific conceptual mastery, explanatory reasoning, or misconceptions. A stronger inference about concept mastery requires evidence about the content represented by the items and the psychometric quality of the instrument, while misconception diagnosis generally requires item-level evidence about answers and reasoning, often through two-tier or multi-tier instruments (Nasir et al., 2024; Taşçı, 2024). Accordingly, the revised analysis treats the total score primarily as an observed indicator of basic science achievement.

This distinction is important for interpreting the results. The study therefore does not convert the distance from a perfect score into a misconception percentage, and it does not infer which science domains are weak from total scores alone. The purpose of the analysis is to describe the observed cohort-level score profile and then identify, with explicit theoretical support, what additional evidence would be needed for better course management.

Research Gap and Purpose

Recent teacher-education studies illustrate several dominant lines of inquiry. Menon and Sadler (2016) examined the co-development of science content knowledge and science-teaching self-efficacy in a specialized science course. Simsar et al. (2022) investigated conceptual change among preservice early childhood teachers through STEM-based science activities and reported improvement across several science topics. Nilsson and Elm (2017) focused on the development of early childhood teachers' science pedagogical content knowledge through CoRes, while Özdem Yılmaz and Şahin (2025) examined inquiry-based coursework in relation to science-teaching efficacy. Together with the systematic review by Strat et

al. (2024), these studies show substantial attention to intervention, inquiry, self-efficacy, conceptual change, and pedagogical content knowledge.

Within the literature reviewed for this study, less attention is given to an explicit process for translating a limited cohort-level achievement profile into course-management questions while clearly separating empirical evidence from theory-informed recommendations. This distinction matters because descriptive score data can justify closer diagnosis and monitoring, but they cannot by themselves demonstrate that a particular grouping strategy, resource decision, or instructional approach is necessary or effective.

The contribution of the present study therefore does not lie in the descriptive statistics themselves. Rather, it lies in an evidence-to-management translation framework that maps available achievement evidence onto five course-management dimensions—planning, organization, implementation, learning resources, and monitoring-evaluation—while marking the boundary between what the data directly support and what prior theory and research suggest. The framework is anchored in constructive alignment and science teacher-education literature (Biggs & Tang, 2011; Kulaksız & Toran, 2022; Strat et al., 2024). It is a conceptual course-review framework, not a validated management scale or a causal model.

Therefore, this study aims to: (1) describe the distribution and central tendency of archived Basic Science Concepts achievement scores among PG PAUD students; (2) specify the interpretive limits of total-score data for claims about concept mastery; and (3) use an explicit evidence-to-management translation framework to formulate theory-informed implications for course planning, organization, implementation, learning resources, and monitoring-evaluation.

The study is limited to verified total achievement scores. Science learning management was not measured as an independent variable, and no intervention was manipulated. Consequently, the article reports an achievement profile and theory-informed management implications; it does not test a statistical association or causal effect of learning management on achievement.

Method

Research Design

The study used a descriptive quantitative cross-sectional design based on secondary analysis of archived course-achievement data. This design was appropriate for describing the score profile of PG PAUD students at one point in their teacher preparation. No instructional treatment was manipulated and no causal relationship was tested.

Participants and Setting

The research was conducted in the Early Childhood Teacher Education Study Program at Universitas Negeri Manado. The analyzed dataset consisted of 80 students who had completed or were taking the Basic Science Concepts course. All supplied records contained a complete total score and were included in the descriptive analysis.

Operational Definition and Management-Implication Framework

Basic science achievement was operationally defined as the archived total score obtained on the Basic Science Concepts course assessment, reported on a 0–100 scale. Because the available dataset did not include complete item-level response data or psychometric documentation for re-analysis, the score is treated as an observed achievement indicator rather than as a fully validated latent measure of concept mastery. The evidence-to-management translation framework uses five dimensions—planning, organization, implementation, learning-resource management, and monitoring-evaluation—to distinguish direct empirical inferences from theory-informed course-management implications.

Table 1. Framework for Separating Empirical Evidence from Theory-Informed Management Implications

Dimension	Evidence boundary and management use
Planning	Evidence: overall cohort performance only. Use: add domain-level diagnostics and align outcomes, activities, and assessment before setting concept-specific priorities.
Organization	Evidence: total scores do not justify grouping or remediation. Use: assign tutorials or support only after diagnostic evidence identifies specific needs.
Implementation	Evidence: no teaching strategy was tested. Use: inquiry, experimentation, discussion, and reflection may be adopted from prior literature and evaluated directly.
Learning resources	Evidence: the score dataset contains no resource information. Use: select safe, contextual PAUD resources and evaluate resource adequacy separately.
Monitoring-evaluation	Evidence: item/domain and psychometric information is missing. Use: strengthen formative assessment, item-level analysis, feedback, and documentation of validity/reliability.

Research Instruments

The archived dataset contained total scores from a Basic Science Concepts course assessment on a 0–100

scale. The reported content scope included matter and its changes, force and motion, energy and its transformations, living systems, ecosystems, and Earth-space phenomena. However, the revision dataset did not contain the item-level responses, item blueprint, item-validity coefficients, reliability coefficient, difficulty indices, discrimination indices, or domain subscores needed to re-establish instrument quality or diagnose domain-specific understanding. The analysis therefore reports only the observed total-score profile.

Because complete psychometric documentation was unavailable, the analysis deliberately avoids stronger construct claims than the data support. The term achievement profile is used for the observed total-score distribution, and no percentage of ‘unachieved’ points is interpreted as a separate diagnostic construct. The lack of complete psychometric documentation is a substantive limitation. It means that the present analysis cannot independently verify the validity and reliability of the assessment or determine whether all science domains were represented with adequate breadth and difficulty. For that reason, the results should be interpreted as a profile of archived course scores and not as definitive evidence of mastery in every basic science domain.

Data Quality and Interpretive Boundaries

All 80 supplied total scores were complete and fell within the expected 0–100 scale. The analysis examined the mean, median, mode, standard deviation, minimum, maximum, range, standard error, and a 95% confidence interval for the mean so that the observed distribution was not summarized by a single statistic.

A definitive diagnosis of misconception requires item-level evidence about answers, reasoning, and preferably confidence. Accordingly, the present study does not infer misconceptions or domain-specific conceptual weaknesses from total scores. Such questions are identified as priorities for follow-up assessment rather than as findings of the current dataset.

Data Collection and Ethics

The analysis used anonymized academic score data and did not include student names or direct personal identifiers. No instructional treatment was administered as part of this secondary analysis. Any institutional authorization or ethical-clearance requirements applicable to the use of academic records should be documented by the corresponding author in accordance with Universitas Negeri Manado and journal policies.

Data Analysis

Descriptive analysis included arithmetic mean, median, mode, sample standard deviation, variance, minimum, maximum, range, standard error, and a 95%

confidence interval for the mean. The sample standard deviation used $n-1$ in the denominator, and the confidence interval used the t distribution because the population standard deviation was unknown. No correlation, regression, p -value for group comparisons, or coefficient of determination was calculated because no independent learning-management dataset was available.

To avoid arbitrary classification, the revised analysis does not convert scores into qualitative categories because the available dataset did not contain a validated or institutionally documented cut-off scheme. Likewise, 100 minus the mean is not treated as a separate analytic indicator because it is algebraically redundant with the mean and does not identify misconceptions or specific conceptual difficulties.

Result and Discussion

Participant Characteristics

The verified dataset consisted of 80 PG PAUD students who had completed or were taking the Basic Science Concepts course. Student identities were anonymized, and the analysis was based exclusively on archived total achievement scores.

Observed Basic Science Achievement Profile

The archived scores had a mean of 77.88 (SD = 3.23), a median of 78.00, and a mode of 78. Scores ranged from 71 to 89. The 95% confidence interval for the mean was 77.16–78.59. The closeness of the mean, median, and mode, together with the relatively small observed standard deviation, indicates that the total scores were concentrated around the upper-70s within this cohort.

No qualitative achievement categories are assigned in the revised analysis because a validated or documented cut-off scheme was not available. More importantly, the total-score distribution cannot show whether students performed differently across matter, force and motion, energy, living systems, ecosystems, or Earth-space topics. The empirical result is therefore limited to the overall score profile shown in Table 2.

Table 2. Descriptive Statistics of Archived Basic Science Achievement Scores

Statistic	Value
Number of students	80
Mean	77.88
Median / mode	78.00 / 78
Standard deviation	3.23
Minimum–maximum	71–89
Range	18
95% confidence interval	77.16–78.59

Theory-Informed Management Implications

Table 3 intentionally separates empirical support from theory-informed action. The observed scores justify describing the cohort and identifying the limits of total-score evidence. They do not demonstrate that a particular grouping arrangement, inquiry strategy, or resource choice caused the observed performance. Those actions are retained only where they are supported by learning theory and prior science teacher-education research, and they should be evaluated directly in future course cycles.

Table 3. Theory-Informed Implications Derived from the Limits and Uses of the Current Evidence

Dimension	Evidence boundary and theory-informed implication
Planning	Current scores can prompt closer diagnosis but cannot identify weak concepts. Add domain-based baseline/formative assessment and align outcomes, activities, and assessment (Biggs & Tang, 2011).
Organization	Total scores and SD alone do not justify flexible grouping, peer support, or remediation. Use future diagnostic evidence to assign support.
Implementation	The design does not test any instructional strategy. Inquiry, prediction-observation-explanation, discussion, and reflection are literature-supported options to evaluate in future cycles (Strat et al., 2024).
Learning resources	No direct evidence about resource adequacy or safety was collected. Select safe, contextual, reusable PAUD materials and evaluate resource use separately.

Interpretation of the Achievement Profile

The observed mean of 77.88, median and mode of 78, and narrow score range indicate a relatively concentrated cohort-level performance on the archived course assessment. However, the score should not be interpreted as a complete representation of basic science mastery because the instrument’s item-level psychometric evidence was not available for re-analysis. The most defensible conclusion is therefore descriptive: within the available records, students tended to obtain total scores in a relatively narrow band around the upper-70s.

This pattern should also be interpreted cautiously in relation to previous research. Direct numerical comparison with other studies is inappropriate because instruments, content coverage, scoring systems, and research designs differ. Nevertheless, prior findings help explain why a stable total-score profile does not rule out domain-specific difficulty. Simsar et al. (2022),

for example, reported conceptual change among preservice early childhood teachers across specific topics such as living and non-living things, force and motion, and Earth-space science after STEM-based activities. Menon and Sadler (2016) similarly showed that preservice elementary teachers’ science conceptual understanding can change during specialized coursework. These studies used richer designs than the present secondary analysis and therefore could examine change that a single total score cannot reveal.

The findings also align with research emphasizing that science knowledge and science teaching competence are related but distinct targets in teacher preparation. Nilsson and Elm (2017) showed the value of explicitly developing science pedagogical content knowledge, while inquiry-focused research indicates that guided inquiry and reflection can support both conceptual and pedagogical learning (Strat et al., 2024). The present data do not test these mechanisms; rather, they reinforce the need for future assessment that can connect content-domain evidence with the pedagogical decisions expected from prospective PAUD teachers.

Theoretical Implications for Science Learning Management

From a management perspective, the strongest implication of the current evidence is procedural rather than causal. Planning should begin with clearer domain-level learning outcomes and diagnostic evidence; organization of tutorials or support should follow identified needs rather than the overall standard deviation; implementation strategies should be selected from established science-education literature and then evaluated; and monitoring should retain item- or domain-level evidence so that course decisions can be linked to specific learning needs. This sequence is consistent with constructive alignment, in which outcomes, learning experiences, and assessment are intentionally coordinated (Biggs & Tang, 2011).

Inquiry, experimentation, discussion, reflection, and contextual resources remain reasonable options for PG PAUD science courses, but they are not empirical findings of this study. Their inclusion is supported by prior teacher-education research, including work on inquiry-based science education and participatory course design (Kulaksız & Toran, 2022; Strat et al., 2024). Future studies should measure these management dimensions directly if the aim is to test whether they are associated with or contribute to changes in science achievement.

Implications for the PG PAUD Study Program

For the PG PAUD Study Program, the immediate practical priority is to improve the quality of evidence used for course review. Each major science domain should be represented in a documented assessment

blueprint, and future analyses should retain item-level responses or domain subscores. Practical and microteaching activities can then be aligned with the same concepts so that lecturers can determine not only whether students obtain acceptable total scores, but also whether they can explain concepts accurately and translate them into developmentally appropriate activities for young children.

At the program level, the present score profile can serve as a baseline for subsequent cohorts, provided that future assessments use documented validity and reliability procedures. Repeated cohort-level analysis, combined with domain-level diagnostics and direct measures of learning-management practice, would allow curriculum mapping, resource planning, lecturer collaboration, and remediation decisions to be evaluated with stronger evidence than is available in the current dataset.

Limitations

Several limitations must be recognized. First, the study involved one study program and one archived cohort, so generalization to other PG PAUD programs should be cautious. Second, the cross-sectional descriptive design does not test change or causality. Third, the available dataset contained total scores only; item-level responses, domain subscores, a complete assessment blueprint, and psychometric documentation were unavailable for re-analysis. This substantially limits claims about construct validity, domain-specific mastery, item difficulty, misconceptions, and explanatory reasoning. Fourth, learning-management practices were not measured directly. Consequently, all management recommendations in this article are theory-informed implications rather than observed effects. Future studies should use validated assessment instruments, preserve item-level data, collect direct measures of course-management implementation, and consider longitudinal or quasi-experimental designs.

Conclusion

The archived Basic Science Concepts scores of 80 PG PAUD students at Universitas Negeri Manado showed a mean of 77.88 (SD = 3.23), a median and mode of 78, and an observed range of 71–89. These statistics describe a relatively concentrated cohort-level achievement profile. Because complete psychometric documentation and item-level responses were unavailable, the findings should not be interpreted as definitive evidence of mastery in every science domain or as a diagnosis of misconceptions.

The principal contribution is an evidence-to-management translation framework that distinguishes

direct empirical conclusions from theory-informed course-management implications. The current data most strongly support the need for better domain-level diagnostic assessment and documentation of instrument quality. Recommendations concerning inquiry, learning resources, grouping, remediation, and formative feedback should be treated as literature-based options to be implemented and evaluated in future course cycles, not as effects demonstrated by this study.

Future studies should compare cohorts over time using validated instruments, report item- and domain-level achievement, and measure planning, organization, implementation, learning resources, and monitoring-evaluation directly. Such data would allow the proposed framework to be tested empirically and would provide a stronger basis for evaluating how science learning management relates to achievement in early childhood teacher education.

Acknowledgments

The authors thank the students and the Early Childhood Teacher Education Study Program at Universitas Negeri Manado for supporting the preparation of this research.

Author Contributions

All authors contributed to the preparation and critical review of the manuscript and approved the submitted version.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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