ATTITUDES OF HEAD TEACHERS TOWARD DIGITAL MATERIALS IN PRIMARY SCHOOL SCIENCE LABORATORIES IN GREECE

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Abstract

This study explores the attitudes of 164 elementary school head teachers toward science laboratories, focusing on the role and management of digital and conventional teaching materials. Drawing on quantitative and qualitative data from a national survey, the findings highlight a strong appreciation for both resource types while revealing significant infrastructural and pedagogical challenges. The analysis underscores the need for integrated strategies that combine effective management practices with targeted professional development. This study contributes to the growing discourse on how digital tools and inquiry-based learning can reshape primary-level science education.

Introduction

Science laboratories have become increasingly important in elementary education, offering hands-on experiences that enhance students' understanding and enthusiasm for science. This review examines the literature on the role of science labs, the importance of their effective management, and their integration of various tools. These tools, which support modern teaching practices, may be conventional (e.g., textbooks, extracurricular books, images, photographs, projectors, and scientific instruments) as well as digital (e.g., computers, digital screens, simulations, interactive whiteboards, and microscopes. As the global shift toward digital education intensifies, the strategic use of laboratories in primary schools is seen not only as a means of knowledge delivery but also as a tool for cultivating inquiry, creativity, and 21st-century skills (Polk & Santos, 2025).

Theoretical Insights in Science Laboratory Management

Science labs, which were once primarily emphasized in secondary education, are increasingly becoming recognized as an integral part of elementary schools. The importance of hands-on learning in fostering critical thinking, collaboration, and scientific literacy is widely acknowledged.

In early education, science labs provide an effective way to engage students with complex scientific concepts that may be difficult to convey through abstract teaching alone. These hands-on activities not only deepen cognitive understanding but also enhance student motivation and lead to positive learning outcomes (Kuncorowati et al., 2021). Science labs offer students the opportunity to engage in real-world scientific inquiry. They encourage exploration, observation, and experimentation, allowing students to form connections between theoretical knowledge and practical application. By providing a physical space for experimentation, students develop confidence in their ability to conduct experiments, solve problems, and generate new questions. These experiences also promote a sense of ownership over the learning process, as students actively construct knowledge rather than passively receive information. Such activities play an essential role in fostering problem-solving, critical thinking, and collaboration among students. These skills are increasingly valued in science education as they prepare students for future challenges in scientific fields (Haberbosch et al., 2025; Hofstein & Lunetta, 2004; Polk & Santos, 2025). In elementary education, these laboratory experiences lay the foundation for sustained interest in scientific inquiry and learning, making science more accessible and engaging for young learners.

The Role of the Science Laboratory in Elementary Education

Science laboratories contribute to both conceptual and procedural knowledge, which is especially important when theory is combined with practical experience. Inquiry-based learning models have proven effective in laboratory settings, allowing students to explore phenomena and develop scientific explanations. In this approach, the teacher's role shifts from that of a content provider to that of a facilitator who guides students through observation, reflection, and problem-solving (Bennett & Hogarth, 2009).

Furthermore, inquiry-based learning encourages students to engage in critical thinking and develop higher-order cognitive skills. It allows them to ask questions, conduct experiments, analyze data, and draw conclusions. This active participation in the scientific process strengthens their understanding of how science works and builds their confidence in using scientific methods. The hands-on nature of science laboratories fosters curiosity and encourages students to investigate and explore new concepts; hence, it creates a dynamic learning environment.

Beyond the cognitive benefits, science laboratories significantly impact students' attitudes toward science. Research shows that well-structured lab environments positively influence students' motivation, attitudes, and perceptions of science. For instance, early exposure to hands-on activities helps nurture long-term interest in STEM disciplines, making science engaging and rewarding for young learners. However, these benefits are contingent upon proper preparation, well-structured classroom environments, and teacher competence in facilitating effective inquiry-based learning (Evana et al., 2021).

The Importance of Science Laboratory Management

Effective management of science laboratories is crucial for realizing their full educational potential. This includes proper planning, organizing resources, and ensuring that lab activities align with curriculum goals. Strategic planning is especially critical in elementary settings where resources are often constrained (Abas & Marasigan, 2020; Evana et al., 2021). Proper management ensures that laboratories are organized to maximize accessibility, safety, and functionality, allowing students to effectively engage in learning activities.

The physical organization of the lab is equally important. Ensuring that materials are properly labeled, stored, and easily accessible helps minimize confusion and fosters independent work. Younger learners particularly benefit from environments that promote order, routine, and self-regulation.

Effective management also involves creating a safe environment where students can confidently engage with equipment and materials. Furthermore, clear procedures and routines are necessary for ensuring the smooth operation of lab sessions, preventing disruptions, and ensuring adherence to safety protocols.

Effective implementation also requires that teachers provide clear guidance and align experiments with specific learning objectives. Teacher support, in addition to the availability of lab assistants, significantly enhances the quality of student engagement (Abas & Marasigan, 2020; Hofstein & Lunetta, 2004).

A regular evaluation of the effectiveness of a laboratory is vital for ensuring continuous improvement. By assessing student engagement and learning outcomes, teachers can refine lab activities to better meet students' needs. Ongoing professional development for teachers is also crucial for keeping them informed on best practices in laboratory management and new teaching strategies. The integration of teacher feedback, alongside student performance evaluations, ensures that the laboratory environment evolves to maintain a high standard of learning (Abas & Marasigan, 2020; Haberbosch et al., 2025; Polk & Santos, 2025).

The Role of Digital Materials in Modern Science Laboratories

The integration of digital materials into science laboratories has become increasingly important in modern science education. Tools such as simulations, virtual labs, and interactive whiteboards provide valuable opportunities for students to visualize scientific phenomena that may otherwise be difficult to observe. These materials extend the learning potential of traditional labs, and have been shown to improve student engagement and deepen understanding of scientific concepts (Kuncorowati et al., 2021).

Virtual laboratories offer a solution to infrastructural limitations by providing interactive environments in which students can conduct experiments without physical resources. This is particularly valuable in schools with limited access to traditional lab materials. Additionally, digital tools support differentiated instruction by adapting content to meet the needs of students at different learning paces. In this way, digital materials promote equity in science education, especially in under-resourced settings. However, the successful integration of digital tools depends on factors such as infrastructure, teacher training, and pedagogical readiness. Besides, the ability of teachers to utilize these tools is critical for ensuring that they effectively enhance the learning experience (Bennett & Hogarth, 2009; Evana et al., 2021).

Digital tools should complement rather than replace hands-on experimentation. Physical manipulation of materials in the laboratory is essential for developing practical skills such as spatial reasoning and fine motor skills, which cannot be fully replicated through digital simulations. Thus, an optimal science lab integrates both digital and conventional resources to create a rich, multifaceted learning environment (Evana et al., 2021).

Summary

This literature review has explored the role of science laboratories, their effective management, and the integration of digital tools into elementary education. Evidence suggests that well-managed laboratories promote conceptual and procedural knowledge, support inquiry-based learning, and enhance student motivation (Hofstein & Lunetta, 2004). Effective management practices such as planning, organizing, and evaluation of lab activities are crucial for maintaining these positive outcomes. The integration of digital tools into science instruction adds flexibility, interactivity, and equity, making science more engaging and accessible for students (Evana et al., 2021).

Given that science education evolves in digitally enriched environments, it is essential for elementary science labs to adapt accordingly. Continued investment in infrastructure, teacher training and resource alignment is necessary to ensure that science labs remain effective, dynamic spaces that foster inquiry, creativity, and a lifelong interest in science (Abas & Marasigan, 2020; Kuncorowati et al., 2021).

Methodology

Building on the theoretical framework outlined in the literature review, this study employed a descriptive survey approach to investigate the views of elementary school head teachers regarding the management of science laboratories, with a particular focus on digital materials. The methodology was designed to capture both general trends and deeper insights into how school leaders perceive lab resources, barriers, and benefits—practices commonly adopted in science education research to bridge policy and practice (Hofstein & Lunetta, 2004). The study addresses the following research questions:

- What are the attitudes of head teachers toward the use of digital materials in science laboratories?
- What barriers constrain the effective implementation of these materials?
- What benefits do head teachers associate with the presence of science laboratories in schools?

The sample consisted of 164 head teachers from a range of educational regions across urban, semi-urban and rural areas, from all 13 prefectures of Greece. Stratified purposive sampling was used to ensure representation from schools with and without science laboratories. This approach allows for robust conclusions by reflecting contextual diversity in educational settings, and involving administrative leaders in this topic is crucial (Haberbosch et al., 2025; Polk & Santos, 2025).

Data was collected through a structured questionnaire incorporating both closed- and open-ended items. Quantitative responses addressed lab infrastructure and material availability as well as challenges, while qualitative responses provided insight into perceived benefits. Quantitative data were analyzed using descriptive statistics and chi-square tests to assess differences across school types and resource categories. These techniques are appropriate for identifying statistically significant relationships in categorical datasets. All chi-square tests were conducted with an overall $\alpha = 0.05$, but to control for Type I error across our five primary comparisons we applied a Bonferroni correction, yielding an adjusted significance threshold of $\alpha = 0.01$ for each test. (Cohen et al., 2017).

Qualitative data were coded thematically to identify patterns related to innovation, engagement, visualization, and interdisciplinary teaching. This thematic approach allowed for a contextual interpretation of the quantitative trends, enriching the overall analysis (Hofstein & Lunetta, 2004). The mixed-methods strategy enabled the triangulation of data sources, which strengthens reliability and contributes to a more holistic interpretation (Kuncorowati et al., 2021).

In short, combining the mixed-methods design with statistical and thematic analysis enabled a comprehensive understanding of how head teachers conceptualize the role and management of science labs as well as the potential of digital materials within these learning environments. This approach aligns with contemporary research priorities in science education that emphasize context-sensitive inquiry, school leadership, and the evolving role of digital technologies (Kuncorowati et al., 2021). Ethical standards were applied as participation was voluntary, responses were anonymous, and informed consent was obtained (Cohen et al., 2017).

Findings

The findings from this study reveal that head teachers agree on the need for both digital and conventional materials in science laboratories. However, challenges exist regarding availability and management (Fraser et al., 2010).

Research Question 1: What are the Attitudes of Elementary School Head Teachers toward the Integration of Digital Materials in Science Laboratories?

The findings from the first research question reveal nuanced perceptions among head teachers. The data presented in Table 1 illustrate that out of the 164 responding schools, 76 possess either a dedicated science laboratory or a specially arranged room, whereas 88 schools lack such facilities.

Table 1

Availability of Science Labs among the Schools of Respondents

Availability of science labs in the schools of respondents	**Number**
It doesn’t exist and it’s not planned to happen.	59
There is no laboratory, but a classroom has been set up for this purpose.	43
It exists and is being used.	30
It doesn’t exist, but it is planned to happen.	29
It exists but is not utilized.	2
Instruments that we have in abundance for experiments in the classroom are used.	1
TOTAL	164

Table 2 shows no significant difference in availability between conventional and digital resources, as shown by a chi-square analysis ($\chi^2 = 0.00$, $p = 1.0$). The absence of universally accessible essential laboratory materials highlights persistent infrastructure limitations. This observation aligns with literature emphasizing resource scarcity as a critical barrier impacting the quality of science education (Haberbosch et al., 2025; Hofstein & Lunetta, 2004; Polk & Santos, 2025).

As shown in Table 3, a chi-square test comparing head teachers' valuations of conventional versus digital materials produced $\chi^2(2) = 7.84$, $p = 0.049$. Although $p < 0.05$ under a conventional threshold, it does not meet our Bonferroni-adjusted criterion of $\alpha = 0.01$ and is therefore reported here as not statistically significant. This conservative approach helps guard against false positives given multiple parallel tests. Head teachers implicitly associate digital tools with practices, such as interactive demonstrations and simulations, that conventional materials cannot fully provide. These findings reinforce the increasing advocacy for integrating conventional and digital resources into science education as complementary tools. However, the successful integration of both digital and conventional resource types depends significantly on adequate teacher training, administrative support, and institutional readiness, enabling educators to maximize pedagogical effectiveness within diverse classroom settings (Evana et al., 2021; Fraser et al., 2010; Hofstein & Lunetta, 2004; Kuncorowati et al., 2021).

Table 2

Availability in the Schools with Science Labs or Appropriately Designed Rooms

Material Type	Available
School books	29
Organs & instruments	29
Extracurricular books	28
Images and photographs	27
Computers with internet access	26
Projectors	25
Interactive whiteboards	25
Projection screens	23
Computers without internet access	15
Microscopes	11

Table 3

Attitudes toward the Value of Both Material Categories of Head Teachers in Schools without Science Labs or Appropriately Designed Classrooms

Material	Absolutely Valuable	Not Necessarily Valuable	Never Valuable
School books	52	25	8
Extracurricular books	56	26	5
Organs & instruments	80	4	4
Images and photographs	50	26	8
Projectors	59	18	9
Computers with internet access	71	10	4
Computers without internet access	45	21	20
Interactive whiteboards	72	11	5
Projection screens	61	17	6
Microscopes	50	20	17

Research Question 2: What Challenges and Barriers do Head Teachers Perceive Regarding the Use of Digital Tools in Science Labs?

Regarding the second research question, Table 4 highlights the primary barriers reported by head teachers: financial limitations, insufficient teacher training, and inadequate technical support. Statistical analysis using chi-square ($\chi^2 = 4.39$, $p = 0.82$) showed no significant difference in barrier frequencies between schools with and without laboratory facilities, indicating that these challenges are systemic across schools.

Financial constraints hinder procurement and maintenance, while gaps in teacher training and technical support impede the effective use of laboratory resources. These findings support previous research emphasizing that providing resources alone is insufficient without adequate training, leadership, and support (Evana et al., 2021; Kuncorowati et al., 2021).

Table 4

Frequency of Barriers Mentioned by Head Teachers

Barrier	Frequency	Schools with Lab	Schools without Lab
Lack of financial resources	129	58	71
Lack of required training	59	29	30
Lack of time for management	56	25	31
Lack of educational staff	37	19	18
Lack of teaching staff	34	17	17
Absence of relevant legislation	31	15	16
Lack of trained staff	29	16	13
There are no challenges at all.	9	7	2
Lack of trained personnel	6	3	3
Lack of teaching staff.	3	2	1
Other	12	0	0

The open-ended responses further highlighted specific operational constraints. For instance, one head teacher noted, “We struggle to integrate innovative tools due to a rigid curriculum timetable,” while another cited, “Digital tools remain unused due to a lack of IT technicians.” These comments underline how curriculum constraints and a shortage of technical personnel limit innovation and operational readiness. These findings emphasize the need for holistic strategies to support laboratory-based science education, including professional development, financial investment, technical support, and flexible administrative policies. School leadership must play an active role in securing resources and fostering environments that enable effective use of lab facilities (Abas & Marasigan, 2020; Bennett & Hogarth, 2009; Fraser et al., 2010; Hofstein, 2004; Kuncorowati et al., 2021).

Research Question 3: Head Teachers’ Evaluation of the Usefulness and Impact of Digital Materials on Science Teaching and Learning

Regarding the third research question, Table 5 categorizes the responses of head teachers, with the majority associating science labs with enhancing science teaching and providing hands-on experimentation opportunities. Several respondents also noted broader educational benefits such as interdisciplinary learning and increased student engagement. These findings align with the literature on the pedagogical value of inquiry-based, hands-on instruction, which fosters deeper learning (Fraser et al., 2010; Haberbosch et al., 2025; Hofstein & Lunetta, 2004; Polk & Santos, 2025).

Whereas digital materials were not explicitly mentioned by most respondents, categories such as “innovation” and “visual support” suggested a readiness for integrating digital tools into science laboratories. Digital tools can enhance science laboratories by providing access to complex scientific phenomena, thus supporting better understanding (Kuncorowati et al., 2021).

Table 5

Benefits of the Science Lab

Responses	Frequency
Better teaching of science	155
Mainly by conducting experimental activities	148
Opportunity for innovative actions in natural sciences	58
Better teaching of other subjects	47
Opportunity for innovative actions in other subjects	31
Opportunity for innovative actions in natural sciences	6
Other	12

Responses in the "Other" category, such as "students work better in teams when engaged in inquiry" and "it allows interaction with external experts," reflect a broader view of science labs as spaces that foster collaboration, engagement, and real-world connections. These views underscore the role of science labs in enhancing pedagogy and social interaction. Overall, head teachers consider science laboratories not only as places for practical experiments but also as spaces for digitally supported innovation and learning, supporting the need for a flexible design model that integrates both digital and conventional resources (Abas & Marasigan, 2020; Hofstein, 2004).

Conclusions

This study explores the attitudes of elementary school head teachers toward science laboratories, focusing on digital materials and their educational benefits, challenges, and perceived value. The study findings support the theory of an integrative science lab design that combines conventional and digital tools to create dynamic, student-centered learning environments. This highlights a shift toward inquiry-based teaching (Polk & Santos, 2025).

Three key patterns emerged across the research questions. First, head teachers consider conventional and digital materials equally important. This is evident in both their preference data and open-ended responses, which connect digital tools to innovation, visualization, and student engagement. Despite infrastructure challenges, digital resources are seen as essential (Haberbosch et al., 2025; Polk & Santos, 2025). Second, systemic barriers such as insufficient funding, lack of professional development, and inadequate technical support affect both schools with and without labs. The chi-square analysis in this study revealed no significant difference in the types of constraints reported by these schools, emphasizing that challenges are systemic. These results align with previous research, which highlights the need for strategic planning and investment in human resources to implement sustainable science laboratories (Fraser et al., 2010). Third, head teachers consider science labs not only as spaces for experiments but also as pedagogical and community resources. The labs foster teamwork, public engagement, and interdisciplinary learning. This reinforces the literature that positions science labs as transformative spaces that are capable of driving holistic educational development (Abas & Marasigan, 2020; Hofstein, 2004; Kuncorowati et al., 2021).

The study suggests a theoretical model that advocates for the hybridity of digital and conventional resources in science laboratories. This model calls for both types of materials to support instruction, inquiry-based learning, and long-term scientific literacy (Haberbosch et al., 2025; Polk & Santos, 2025). Future research could explore regional differences and incorporate perspectives of science teachers and students (Cohen et al., 2017).

References

Abas, M. C., & Marasigan, A. C. (2020). Readiness of science laboratory facilities of the public junior high in Lanao del Sur, Philippines. *IOER International Multidisciplinary Research Journal*, *2*(2), 12–20.

Bennett, J., & Hogarth, S. (2009). Would you want to talk to a scientist at a party? High school students' attitudes to school science and to science. *International Journal of Science Education*, *31*(14), 1975–1998. https://doi.org/10.1080/09500690802425581

Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education* (8th Ed). New York: Routledge. https://doi.org/10.4324/9781315456539

Evana, Y., Fitria, H., & Fitriani, Y. (2021). The management of science laboratory at senior high school in the digital era. *JPGI (Jurnal Penelitian Guru Indonesia)*, *6*(3), 660-667. https://doi.org/10.29210/021105jpgi0005

Fraser, B. J., Aldridge, J. M., & Adolphe, F. S. G. (2010). A cross-national study of secondary science classroom environments in Australia and Indonesia. *Research in Science Education*, *40*(4), 551–571. https://doi.org/10.1007/s11165-009-9133-1

Haberbosch, M., Deiters, M., & Schaal, S. (2025). Combining virtual and hands-on lab work in a blended learning approach on molecular biology methods and lab safety for lower secondary education students. *Education Sciences*, *15*(2), 123. https://doi.org/10.3390/educsci15020123

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, *88*(1), 28–54. https://doi.org/10.1002/sce.10106

Kuncorowati, W., Habibi, M. W., Mosrifa, C. T., & Ilafi, M. M. (2021). The effectiveness of utilization of the Science Laboratory in Integrated Science Learning at MTs Unggulan Al Qodiri 1 Jember. *INSECTA: Integrative Science Education and Teaching Activity Journal*, *2*(2), 165–174. https://doi.org/10.21154/insecta.v2i2.3287

Polk, M. E., & Santos, D. L. (2025). Science practices in action: Group engagement with different degrees of inquiry in general chemistry laboratory. *Journal of Chemical Education*, *102*(4), 1380–1388. https://doi.org/10.1021/acs.jchemed.4c01314

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