

Examining moderating effects of school resources and teachers' initial training on primary school teachers' effectiveness in science education in Cameroon

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Abstract: This study examines how school resources influence the relationship between teachers' initial training and their effectiveness in delivering science education in primary schools within the Mfoundi Division of Cameroon. Data were collected from 306 primary school teachers, and hierarchical multiple regression analysis was used to assess the interplay among teacher training, school resources, and teacher effectiveness. The findings reveal a positive association between initial teacher training and teacher effectiveness, indicating that teachers with solid foundational training are better equipped to deliver quality education. However, the study highlights that this relationship is significantly moderated by the availability of school resources. Teachers working in resource-rich environments demonstrated substantially higher effectiveness compared to those in resource-constrained settings. This underscores the critical role of school resources in enhancing the impact of teacher training. The study draws attention to the inequities in resource distribution across schools and stresses the need for educational policies that address these disparities. By ensuring equitable resource allocation and strengthening teacher training programs, educational stakeholders can improve science education outcomes and support teacher performance. The findings contribute to the broader discourse on educational equity and effectiveness, offering practical insights for policymakers and educators striving for improved educational quality in science.

Keywords: teacher training; school resources; teachers' effectiveness; science education; moderation analysis; Cameroon

1. Introduction

Science education is fundamental to fostering innovation, critical thinking, and problem-solving skills, particularly in developing countries like Cameroon [1]. In a knowledge-driven global economy, scientific literacy is more crucial than ever, equipping students with the ability to understand, engage with, and contribute to technological and societal advancements. Teachers play a pivotal role in delivering quality science education, and their effectiveness is largely determined by their initial training, which provides them with the necessary pedagogical and content knowledge to educate and inspire students [2]. Initial teacher training equips educators with subject-matter expertise and teaching strategies that facilitate an inquiry-based learning environment [3]. However, while teacher training is widely recognized as a critical factor in educational success, its impact is not uniform. Various factors influence how effectively teachers apply their training, with school resources emerging as a key

determinant of instructional effectiveness [4].

Cameroon's education system exhibits significant disparities in school resources across urban and rural settings, as well as between public and private institutions [5]. These disparities affect the extent to which teachers can implement their training in the classroom. Essential resources such as laboratories, textbooks, digital tools, and classroom infrastructure play a crucial role in facilitating hands-on learning and enhancing teacher-student interactions [6]. In resource-limited environments, even well-trained teachers may struggle to translate their pedagogical knowledge into effective classroom practice, thereby diminishing the potential impact of their training [7]. Despite the acknowledged importance of school resources in educational success, research in Cameroon has largely focused on the direct effects of teacher training on student outcomes, with limited exploration of how contextual factors such as resource availability moderate this relationship [8]. Understanding these dynamics is essential for designing training programs that consider real classroom conditions and provide teachers with strategies to adapt to resource constraints.

The Cameroonian government, through the National Development Strategy Plan (NDS30), has acknowledged the need for investments in both teacher training and school infrastructure to drive sustainable development and economic growth [4]. Science and technology education are central to these national priorities, with policies emphasizing improved teacher preparation and equitable resource distribution. These priorities are also reflected in Cameroon's 2023–2030 Education and Training Sector Strategy, which emphasises teacher development and equitable resourcing [9]. However, ensuring that these policies translate into practical, effective interventions requires an understanding of the interaction between teacher training and school resources. This study aims to bridge that research gap by examining the moderating effect of school resources on the relationship between initial teacher training and teacher effectiveness in science education. Schools with adequate resources enable teachers to apply their training effectively, leading to better outcomes. Conversely, the lack of materials and infrastructure in under-resourced schools limits the practical application of training, thereby reducing its effectiveness [10, 11]. Addressing these challenges is crucial for improving the quality and equity of science education across Cameroon. To guide this study, the general research question is: How do school resources influence the relationship between teachers' initial training and their effectiveness in science education?

Research objectives

This study seeks to address the following research objectives:

- To assess the direct impact of teachers' initial training on their effectiveness in science education.
- To investigate the moderating effect of school resources on the relationship between teachers' initial training and their effectiveness.
- To explore the combined moderating effects of school resources on the impact of teachers' initial training on their effectiveness in science education.

2. Literature review

2.1. Teacher training and its importance

Teacher training is a critical component in the development of an effective educational system, particularly in contexts like Cameroon, where educational quality often varies significantly across regions and school types. Initial teacher training serves as the foundation upon which teachers build their instructional skills, pedagogical approaches, and classroom management strategies, which are all essential for effective teaching. Comprehensive training programs equip teachers with the necessary content knowledge and pedagogical techniques to deliver high-quality education, thereby improving overall instructional quality [2].

In Cameroon, the challenges surrounding teacher preparation are exacerbated by the disparities in resources available to different schools. High-quality initial training is essential for addressing these disparities and enhancing teaching performance, especially in under-resourced environments [10, 11]. The significance of teacher training in the Cameroonian context is highlighted by the government's commitment to improving educational outcomes through its National Development Strategy Plan (NDS 2030). This plan underscores the need for robust teacher training programs as a means of fostering educational equity and improving the quality of education across the country [4].

Recent literature further emphasizes the importance of well-designed teacher training programs. Guskey and Yoon [12] argue that effective training leads to improved teacher performance, which directly correlates with better educational outcomes. They suggest that training programs must be ongoing, context-specific, and aligned with the teachers' actual classroom experiences to be truly effective. This aligns with the findings of Darling-Hammond et al. [2], who noted that teacher preparation programs that combine theoretical knowledge with practical experience tend to produce teachers who are better equipped to handle the complexities of the classroom.

Moreover, recent studies indicate that the integration of technology into teacher training can significantly enhance its effectiveness [2, 13]. In many developing countries, including Cameroon, there is a growing emphasis on using digital tools to supplement traditional teacher training methods. These tools provide teachers with access to a wealth of online resources, virtual simulations, and professional learning communities, which can help them stay updated on the latest educational practices and innovations. This approach not only enhances content delivery during the training but also supports teachers in continuously improving their skills throughout their careers.

The quality of teacher training is also linked to teacher retention and job satisfaction. Teachers who feel well-prepared and confident in their abilities are more likely to remain in the profession and experience higher levels of job satisfaction [6]. In Cameroon, where teacher turnover is a significant issue, improving the quality of initial teacher training could contribute to greater teacher retention and stability within the educational system. This is particularly important in rural areas, where schools often struggle to attract and retain qualified teachers.

However, the effectiveness of teacher training in improving educational outcomes

is not uniform and can be influenced by various contextual factors. As noted in prior research [14], the success of teacher training programmes is contingent upon their relevance to the specific challenges and needs of teachers and the schools in which they work. This highlights the importance of tailoring teacher training programmes to the local context, considering the unique socio-economic, cultural, and educational challenges that teachers face in Cameroon.

Additionally, the role of mentorship and ongoing professional development in supporting teachers after their initial training cannot be overlooked. Continuous professional development opportunities, coupled with strong mentorship programs, have been shown to reinforce the skills and knowledge acquired during initial training and help teachers adapt to the evolving demands of the classroom [2, 12]. In the Cameroonian context, where resources for ongoing professional development may be limited, finding innovative ways to provide continuous support to teachers is crucial.

2.2. The role of school resources in education

School resources play an indispensable role in the educational process, directly influencing both teaching effectiveness and student learning outcomes. The availability of resources such as textbooks, laboratory equipment, and teaching aids creates a conducive learning environment that facilitates the effective implementation of instructional strategies [12,15,16]. Research consistently shows that schools with better resources generally achieve higher levels of educational success, a finding that has been confirmed across various educational settings globally [16].

In science education, the importance of resources cannot be overstated. Effective science teaching relies heavily on the ability to conduct experiments, demonstrate concepts using tangible materials, and engage students in hands-on learning activities. Without access to adequate resources, teachers may struggle to deliver high-quality science education, regardless of their training or experience [17]. In Cameroon, the disparity in resources between schools is a significant challenge, with rural and public schools often lacking the basic materials needed to support effective teaching and learning [4].

The impact of school resources on educational outcomes has been extensively documented in the literature. Prior research suggests that adequate resourcing can strengthen the link between teacher quality and student achievement, particularly in science education [10, 11]. Even the most skilled and well-trained teachers may be limited in their effectiveness if they do not have access to the necessary instructional materials and infrastructure. This is particularly relevant in the Cameroonian context, where many schools operate with minimal resources, making it difficult for teachers to apply their training effectively.

Moreover, the availability of resources also affects the overall learning environment, influencing factors such as class size, student engagement, and the ability to provide individualized instruction. In well-resourced schools, teachers are more likely to have smaller class sizes, which allows for more personalized attention to students and greater opportunities for interactive learning [18]. This is especially important in science education, where understanding complex concepts often requires

hands-on experimentation and individualized guidance [17].

In contrast, schools with limited resources often face challenges such as overcrowded classrooms, inadequate facilities, and a lack of basic teaching materials. These conditions can significantly hinder the teaching and learning process, leading to lower educational outcomes and wider achievement gaps between students from different socio-economic backgrounds [11]. The lack of resources not only affects student learning but also impacts teacher morale and job satisfaction. Teachers working in under-resourced schools may feel demotivated and overwhelmed, which can lead to higher levels of stress and burnout [6].

The role of school resources in shaping educational outcomes is particularly critical in the context of developing countries like Cameroon, where disparities in resource allocation are prevalent. The Cameroon National Development Strategy Plan (NDS 2030) recognizes the need to address these disparities by prioritizing investments in educational infrastructure and resources as a means of achieving equitable educational opportunities for all students [4]. The plan emphasizes the importance of providing all schools, regardless of location or socioeconomic status, with the resources needed to support effective teaching and learning.

Recent research has also highlighted the importance of digital resources in education, particularly in the context of science teaching. The integration of technology into the classroom, through tools such as interactive whiteboards, online simulations, and digital textbooks, can enhance the teaching and learning experience by making scientific concepts more accessible and engaging for students [17]. In Cameroon, where access to digital resources may be limited, efforts to bridge the digital divide are essential for ensuring that all students can benefit from these advancements.

Furthermore, the availability of resources also plays a role in attracting and retaining qualified teachers. Schools with better resources are more likely to attract highly skilled teachers who are motivated to stay in the profession, while under-resourced schools may struggle to retain teachers, leading to higher turnover rates and instability within the educational system [6]. This dynamic is particularly relevant in Cameroon, where rural and under-resourced schools often face significant challenges in attracting and retaining qualified teachers.

To strengthen conceptual clarity, this study defines “school resources” in science education as a multidimensional construct encompassing laboratories and science kits, textbooks and other instructional materials, digital tools (e.g., internet access, educational software, and simulations), human resources (e.g., laboratory assistants and pedagogical support staff), and financial resources for procurement and maintenance. Conceptualising resources in these categories sharpens the operationalisation of variables and aligns the analysis with international education quality and resourcing frameworks [8,19].

In Cameroon, science teacher education typically emphasises strengthening teachers’ content knowledge, developing inquiry-based pedagogical strategies, and (increasingly) incorporating digital tools to enhance instruction [2, 3]. National policy also recognises the need to improve both teacher preparation and the resource environment in which teachers operate, particularly in rural and public schools where

resourcing constraints are most pronounced [4]. These realities underscore the importance of initial training that is adaptable and context-specific, and that prepares teachers to teach effectively in under-resourced classrooms, while also linking training reforms to resourcing and equity priorities [4,6].

2.3. Moderation models in education research

Moderation models are a valuable tool in educational research for understanding the complex relationships between variables and identifying factors that influence the strength or direction of these relationships. In the context of this study, moderation analysis is used to examine how school resources impact the relationship between initial teacher training and teacher effectiveness in science education.

Moderation occurs when the relationship between two variables depends on the level of a third variable, known as the moderator. In this case, school resources serve as the moderator that influences the relationship between teacher training and teaching effectiveness. By using moderation analysis, researchers can gain a deeper understanding of how contextual factors, such as resource availability, affect the outcomes of educational interventions [16,20].

The utility of moderation analysis in educational research is well-established. For instance, MacKinnon [14] highlights the importance of using moderation models to explore how different factors interact to influence educational outcomes. This approach allows researchers to move beyond simple cause-and-effect relationships and consider the broader context in which educational processes occur. In the context of this study, moderation analysis provides a framework for examining how the availability of school resources moderates the impact of teacher training on teacher effectiveness in science education.

Understanding the moderating role of school resources is particularly important in the context of Cameroon, where significant disparities in resource allocation exist. By identifying how these disparities influence the effectiveness of teacher training programs, this study can provide valuable insights for policymakers and educational stakeholders. For example, if the analysis reveals that the positive effects of teacher training are significantly enhanced in schools with better resources, this will underscore the need for targeted investments in educational infrastructure as a means of maximizing the impact of teacher training programs.

Moreover, moderation models can also help identify the specific types of resources that are most critical for enhancing teacher effectiveness. For example, some studies have found that access to laboratory facilities and science kits is particularly important for effective science teaching, as these resources enable teachers to implement hands-on learning activities that are essential for developing students' scientific understanding [17]. In contrast, other resources, such as textbooks and digital tools, may be more critical for other subjects or educational contexts. By using moderation analysis, this study can help identify which resources have the most significant impact on the effectiveness of teacher training in science education, thereby informing more targeted and effective resource allocation strategies.

Moderation analysis also allows for the exploration of non-linear relationships

and interactions between variables, which can provide a more nuanced understanding of the factors that influence educational outcomes. For instance, it is possible that the relationship between teacher training and effectiveness is stronger in schools with a moderate level of resources, but weaker in schools with either very low or very high levels of resources. This kind of non-linear moderation effect can reveal complex dynamics that might be overlooked in simpler analytical models, thereby providing more detailed insights for educational policy and practice [16].

The findings from the moderation analysis can also have significant implications for the design and implementation of teacher training programs. If the analysis shows that certain types of school resources significantly enhance the impact of teacher training, then training programs could be designed to include components that specifically address how to effectively use these resources in the classroom. For example, teacher training programs could include modules on how to integrate laboratory experiments into science lessons or how to use digital tools to support inquiry-based learning. This approach would not only improve the quality of teacher training but also ensure that teachers are better equipped to make the most of the resources available to them.

Additionally, the insights gained from moderation analysis can help in designing more equitable educational policies. In contexts like Cameroon, where there are significant disparities in resource allocation, understanding how these disparities affect the outcomes of teacher training can inform more equitable resource distribution strategies. For instance, if the analysis shows that teachers in under-resourced schools are less effective despite having undergone the same training as their counterparts in better-resourced schools, this will highlight the need for targeted interventions to support these teachers, such as providing additional resources or professional development opportunities.

Furthermore, moderation models can also be used to explore the interaction effects between multiple moderators. For example, this study could examine how the combination of school resources and other contextual factors, such as socioeconomic status or community support, influences the relationship between teacher training and effectiveness. This kind of multi-moderator analysis can provide a more comprehensive understanding of the complex interplay of factors that affect educational outcomes, thereby informing more holistic and integrated approaches to educational policy and practice [16].

The use of moderation models in this study provides a robust analytical framework for exploring the complex relationships between teacher training, school resources, and teacher effectiveness in science education. By identifying the conditions under which teacher training is most effective, this study can provide valuable insights for policymakers, educators, and other stakeholders who are working to improve the quality of science education in Cameroon. The findings from this study could also have broader implications for educational research and practice, particularly in other developing countries with similar educational challenges and resource constraints.

2.4. Hypotheses

Based on the literature reviewed, the study proposes the following hypotheses:

- **H1.** *Teachers' initial training positively influences their effectiveness in science education.*
- **H2.** *School resources moderate the relationship between teachers' initial training and their effectiveness, with higher resource availability enhancing the positive effects of training.*
- **H3.** *The interaction of high school resources and effective initial teacher training strengthens the impact on teachers' effectiveness in science education.*

3. Research design and methodology

3.1. Research design

This study employed a quantitative research design to explore the complex relationships between teachers' initial training, the availability of school resources, and teachers' effectiveness in science education within primary schools in the Mfoundi Division of Cameroon. A quantitative approach was deemed appropriate as it allows for the systematic measurement and analysis of variables, enabling the testing of hypotheses through statistical methods [21]. The primary analytical techniques used in this study were hierarchical multiple regression, which is a robust tool for examining direct and moderating effects within educational research.

Hierarchical multiple regression was chosen to test the moderating effect of school resources on the relationship between teachers' initial training and their effectiveness. This method allows for the sequential introduction of variables into the regression model, which is particularly useful in understanding how different factors contribute to variations in teacher effectiveness [16]. Specifically, this technique helps to isolate the unique contribution of school resources by controlling the effects of initial teacher training before adding school resources into the model.

3.2. Participants

The study's participants comprised 306 primary school teachers drawn from seven subdivisions within the Mfoundi Division of Cameroon. This region was selected due to its diverse mix of urban and rural schools, which provides a representative sample of varying levels of school resources and teacher training experiences. The sample size ($N = 306$) was determined using Krejcie and Morgan's sample size determination table to ensure adequate statistical power for the regression analyses [22].

Stratified random sampling was used to select participants to enhance the representativeness of the sample by ensuring that subgroups within the population are adequately represented [21]. The strata were defined based on two key factors: the level of school resources and the type of initial teacher training received. This approach ensured that the sample included teachers from both well-resourced and under-resourced schools, as well as those who had received different types of initial training (e.g., traditional, competency-based, and digitally enhanced training). This stratification was crucial for examining how variations in these factors influence teacher

effectiveness in science education.

The demographic characteristics of the sample included a mix of gender, age, teaching experience, and educational qualifications, reflecting the diversity of the teaching workforce in the region. Participants included both novice and experienced teachers, providing a comprehensive view of how initial training and school resources impact teacher effectiveness across different career stages. This diversity is essential for generalizing the study's findings to the broader population of primary school teachers in Cameroon.

3.3. Data collection instruments

The instrument used for data collection in this study has three sections: Teacher training records, a school resources inventory, and a teacher effectiveness survey. These instruments were adapted from established tools, notably the OECD teaching and learning international survey (TALIS) framework for school resources and the teacher sense of efficacy scale for teacher effectiveness [6,23]. This instrument was carefully selected and adapted to align with the study's objectives, ensuring the collection of relevant and reliable data.

Teacher training records: The first section involved collecting comprehensive records of the teachers' initial training programs. These records included detailed information on the content of the training, the delivery methods used, the duration of the training, and any follow-up support provided. The records were obtained from participating primary school teachers and relevant administrative training records. The choice of this section was informed by the need to capture the quality and depth of the initial training that teachers received, which is a critical variable in understanding their effectiveness in the classroom [19].

School resources inventory: The second section was a school resources inventory integrated into the survey instrument, a detailed checklist designed to assess the availability and quality of resources in the participating schools. This inventory covered a wide range of resources, including laboratory facilities, teaching materials, classroom infrastructure, and access to digital tools. The inventory was based on guidelines from OECD [6], ensuring that it was comprehensive and aligned with international standards for evaluating educational resources. This approach provided an accurate and objective measure of the resources available in each school, which was crucial for analyzing their moderating effect on teacher effectiveness.

Teacher effectiveness: The third section was a Teacher Effectiveness Survey, a questionnaire designed to evaluate the effectiveness of teachers in delivering science education. The survey focused on key dimensions of teacher effectiveness, including pedagogical skills, classroom management, the ability to engage students in scientific inquiry, and the use of assessment to support learning. The survey was adapted from established instruments used in previous research on teacher effectiveness, such as the teacher sense of efficacy scale [23, 24]. The reliability and validity of the survey were tested through a pilot study conducted with a small sample of teachers from non-participating schools, ensuring that the instrument was appropriate for the Cameroonian context.

Reliability and validity of the questionnaire: Reliability analysis yielded a Cronbach's alpha of 0.88 for the teacher effectiveness survey and 0.85 for the school resources inventory, indicating high internal consistency. Convergent validity was confirmed using average variance extracted (AVE) scores above 0.50 for all constructs, while discriminant validity was supported by comparing the square root of AVE values with inter-construct correlations. These results validate the instrument's robustness for assessing science teacher effectiveness in the Cameroonian context. The survey focused on key dimensions of teacher effectiveness, including pedagogical skills, classroom management, the ability to engage students in scientific inquiry, and the use of assessment to support learning.

3.4. Data collection process

Data collection was conducted in one phase to gather comprehensive and reliable data while minimizing disruptions to the participating schools and teachers. The survey was conducted towards the end of the 2023/2024 academic year to capture an accurate picture of teacher training records, school resources inventory, and teacher effectiveness once teachers had settled into their teaching routines. The survey was distributed in both paper and digital formats, allowing teachers to complete it at their convenience. The research team provided support to ensure a high response rate, including follow-up reminders and assistance with survey completion for those who needed it.

3.5. Data analysis

The data analysis process involved multiple steps, each designed to rigorously test the study's hypotheses and provide a comprehensive understanding of the relationships between the variables.

Descriptive statistics: The first step in the analysis involved calculating descriptive statistics, including means and standard deviations. These statistics provided an overview of the data, highlighting central tendencies and the variability within the sample. Descriptive statistics were particularly useful for summarizing the key characteristics of the teacher training programs, the availability of school resources, and the levels of teacher effectiveness observed in the study. These initial analyses also helped to identify any outliers in the data that might need to be addressed before proceeding with more advanced analyses.

Moderation analysis: The core of the analysis involved testing the moderating effect of school resources on the relationship between teachers' initial training and their effectiveness using hierarchical multiple regression. This technique allows for the step-by-step introduction of variables into the regression model, enabling the assessment of how the addition of school resources influences the relationship between teacher training and effectiveness [16]. The analysis was conducted in stages, with the first model testing the direct effect of teacher training on effectiveness, and subsequent models introducing school resources as a moderator. Interaction terms were included to test for moderation effects, with significant interactions indicating that the relationship between teacher training and effectiveness varied depending on the level of school resources.

4. Findings

This section presents the findings of the study, including descriptive statistics and moderation analysis results. These findings provide insights into the relationships between teachers’ initial training, school resources, and teacher effectiveness in science education within the Mfoundi Division of Cameroon.

4.1. Descriptive statistics

The descriptive statistics provide an overview of the data, highlighting the central tendencies and variability in teacher effectiveness and school resources. **Table 1** summarizes the descriptive statistics for the key variables in the study: teacher effectiveness, initial training, and school resources.

Table 1. Descriptive statistics for initial teacher training quality, school resources, and teacher effectiveness.

Variable	N	Mean	Standard deviation	Minimum	Maximum
Teacher effectiveness (overall)	306	4.23	0.68	2.90	5.00
Pedagogical skills	306	4.30	0.72	3.00	5.00
Classroom management	306	4.15	0.65	2.75	5.00
Initial teacher training quality	306	4.10	0.75	2.80	5.00
School resources index	306	3.80	0.85	2.50	5.00

The data indicate that teachers in schools with higher resource levels demonstrated significantly greater effectiveness in science education. Specifically, teachers who received comprehensive initial training (Mean = 4.10, SD = 0.75) exhibited notable improvements in pedagogical skills (Mean = 4.30, SD = 0.72) and classroom management (Mean = 4.15, SD = 0.65). The School Resources Index, which aggregates various resource indicators (e.g., laboratory facilities, teaching materials), had a mean score of 3.80 (SD = 0.85), suggesting moderate resource availability across the sampled schools. Teachers’ effectiveness in science education, measured through a composite score of pedagogical skills and classroom management, had a mean of 4.23 (SD = 0.68), indicating generally high effectiveness among the sampled teachers.

4.2. Moderation analysis results

The moderation analysis aimed to examine whether the relationship between teachers’ initial training and their effectiveness in science education was moderated by the availability of school resources. Hierarchical multiple regression was used to test this moderating effect. **Table 2** presents the results of the regression analysis.

Table 2. Hierarchical multiple regression results.

Model	R ²	ΔR ²	B	SE B	β	t	p
Step 1: Initial training	0.34	-	0.48	0.06	0.58	8.00	<0.001
Step 2: School resources	0.41	0.07	0.35	0.05	0.44	7.00	<0.001
Step 3: Initial training × Resources	0.47	0.06	0.22	0.04	0.32	5.50	<0.001

The results from **Table 2** show that initial training significantly predicts teacher effectiveness in science education ($\beta = 0.58, p < 0.001$). The inclusion of school resources in the model significantly increased the explained variance ($\Delta R^2 = 0.07$), indicating that schools with better resources tend to have more effective teachers. Most importantly, the interaction between initial training and school resources was significant ($\beta = 0.32, p < 0.001$), confirming the hypothesized moderation effect. This finding suggests that the positive effects of initial training on teacher effectiveness are more pronounced in schools with higher resource availability. In other words, teachers who received high-quality initial training were particularly effective in schools that provided adequate resources, such as well-equipped laboratories and sufficient teaching materials.

5. Discussion

5.1. Summary of findings

The findings of this study demonstrate a strong alignment with the research objectives and contribute meaningfully to the discourse on science teacher education in Cameroon. The first objective, assessing the direct impact of teachers' initial training on their effectiveness, was supported by the data, which revealed a statistically significant and positive relationship ($\beta = 0.58, p < 0.001$). This aligns with previous research indicating that comprehensive teacher training enhances pedagogical skills, classroom management, and the ability to implement inquiry-based science instruction [2, 3]. These results reinforce the value of initial teacher preparation programs, particularly those that integrate theory with practice and emphasize scientific inquiry and experimentation. Hypothesis 1 (H1), which proposed that teachers' initial training positively influences their effectiveness in science education, was clearly supported by the regression analysis. The results confirmed that comprehensive training significantly enhances pedagogical skills and classroom management.

The second objective investigating the moderating role of school resources, was addressed through hierarchical multiple regression, which demonstrated that school resources significantly strengthen the relationship between training and effectiveness ($\Delta R^2 = 0.07; \beta$ for interaction = $0.32, p < 0.001$). Hypothesis 2 (H2), which posited that school resources moderate the relationship between initial training and effectiveness, received empirical support. This pattern is consistent with prior research highlighting the importance of contextual and resourcing conditions for translating professional preparation into effective classroom practice [10, 11]. Notably, the Cameroonian context presents marked disparities in resource allocation, with urban and private schools often better equipped than their rural or public counterparts [4, 5]. This highlights the critical role that equitable distribution of physical, digital, and human resources plays in enabling science teachers to leverage their training.

The third objective—exploring the combined effects of training and school resources—revealed that their intersection is particularly potent. Teachers in well-resourced environments were significantly more effective, suggesting that training programs must not only be high in quality but also context-sensitive,

equipping teachers with adaptive strategies to manage limited resources where necessary. Integrating modules on low-cost experiments and locally available teaching aids may help teachers bridge the resource gap. Hypothesis 3 (H3), which suggested an interaction effect between training and school resources, was confirmed by the significant interaction term in the final regression step ($\beta = 0.32, p < 0.001$). This indicates that the positive effects of initial training are amplified in schools with higher resource availability. Together, these findings highlight the interconnected roles of training and context in shaping teacher effectiveness in science education, reinforcing the conceptual model proposed in this study.

5.2. Implications for educational policy

The study's results have significant implications for educational policy, particularly in contexts like Cameroon, where resource disparities are pronounced. Policymakers should prioritize investments in school resources to maximize the benefits of teacher training programs. Ensuring that schools are equipped with essential materials such as science kits, laboratory equipment, and teaching aids is vital for helping teachers apply their training effectively. The evidence suggests that improving resource availability can lead to substantial gains in teaching effectiveness [10,11]. Furthermore, addressing resource disparities is crucial. Schools with fewer resources often struggle to implement effective teaching practices despite high-quality training. Policymakers should focus on equitable resource distribution to ensure that all schools, particularly those in underserved areas, have the tools necessary to support effective teaching [4,10].

A comprehensive approach to educational reform is essential, based on the study's findings. While enhancing teacher training is important, it must be accompanied by significant investments in school resources to achieve meaningful improvements in teacher effectiveness and student outcomes. Providing targeted support to under-resourced schools, such as additional funding, resource-sharing initiatives, and partnerships with better-resourced schools, can help bridge the effectiveness gap. Such measures can maximize the impact of teacher training programs and improve overall educational quality [4]. Ultimately, a holistic strategy that integrates both improved training and enhanced resources is necessary to drive substantial progress in science education and address the disparities present in the educational system [4].

The study underscores the critical role of school resources in moderating the effects of teachers' initial training. While initial training provides the foundation for effective teaching, its impact is significantly enhanced by adequate resources. This finding is consistent with the notion that resources enable teachers to implement new strategies and techniques learned during training more effectively [10,11].

For instance, well-equipped science laboratories and access to modern teaching aids allow teachers to engage students in hands-on learning activities, which are essential for effective science instruction. Conversely, teachers in resource-constrained environments may struggle to apply their training fully, leading to less effective teaching practices. This dynamic highlights the importance of addressing both training quality and resource availability to optimize teaching outcomes.

However, this study is not without limitations. First, the research was conducted within a single division (Mfoundi), which may limit the generalizability of the findings across all regions in Cameroon. Future research should consider larger and more diverse samples to explore regional variations. Second, the study relied on self-reported measures of teacher effectiveness, which may be subject to bias. Including observational or performance-based measures in future studies could strengthen validity. Moreover, longitudinal research could explore how the effects of initial training and resource availability evolve over time, particularly as educational reforms take root. Further exploration is also warranted into which specific types of resources (e.g., digital tools versus laboratory equipment) have the greatest impact in different contexts, to inform targeted resource allocation.

6. Conclusion

In conclusion, this study provides valuable insights into the interplay between teachers' initial training, school resources, and teacher effectiveness in science education. The findings confirm that while initial training is a critical factor in enhancing teaching quality, its impact is significantly moderated by the availability of school resources. Teachers in well-resourced schools were better able to utilize their training, leading to improved science education outcomes.

The study underscores the need for a comprehensive approach to educational reform in Cameroon. Policymakers should focus not only on improving the quality of teacher training but also on ensuring that schools are adequately resourced. Addressing resource disparities and investing in both training and resources can lead to more effective teaching practices and better educational outcomes for students. The findings emphasize the importance of considering contextual factors in evaluating and designing educational policies and interventions.

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Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Data availability statement: The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy and ethical restrictions.

Conflict of interest: The author declares no conflict of interest.

AI use statement: AI tools, including ChatGPT, were used to assist in refining and enhancing the manuscript. Their contributions included language and style improvement and proofreading. All AI-generated content was reviewed and edited by the author to ensure accuracy and originality. The final manuscript reflects the author's expertise, with AI serving as a supportive tool in the writing process.

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