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Keywords

Professional preparedness, professional development, science, science assessment, student achievement, TIMSS Data, future Science pedagogy, critical thinking

Cover Page Footnote

This article is a version of expansive research that included more variables; however, this article is only related to teacher professional preparedness and professional development.

The Impact of Teacher Preparedness and Professional Development on Fourth-Grade Students' Science Achievement

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Abstract

Science scores among US fourth-grade students have declined compared totheir international counterparts in recent years. Recent results show that teachers are the most impactful influence on student success and accountability. Teacher preparedness and professional development are two key areas that serve as indicators of providing relevant and essential information for students' success. A correlational quantitative study was conducted to assess the relationship between teacher preparedness and professional development on fourth-grade students' science achievement. The TIMSS 2019 data were secured from the Boston College, TIMSS, and PIRLS International websites. The data was evaluated using the SPSS 27 Hierarchical Linear Regression. The study's population included 70 teachers and 1208 students representing schools located in the United States.

Results indicated that teachers who graduate with science majors have the greatest impact on students' science outcomes. Specific professional development topics that teachers studied also served askey indicators of student science success. Topics that specify the objectives found in the *Next Generation Science* curriculum had the greatest impact. The topics included future science pedagogy, critical thinking, and past and future student needs. Thus, recruitment of teachers with science majors should be the focus of human resources recruitment officers, and quality, well-developed professional development must focus on the *Next Generation Science Curriculum.*

Key Terms: Professional preparedness, professional development, science, science assessment, student achievement, TIMSS Data, future Science pedagogy, critical thinking

Introduction

Science achievement on national and international assessments has declined recently

(Nations Report Card, 2019). In 2018, the National Science and Technology Council (NSTC) released reports to heighten awareness of the decline in scores, especially the US scores (NSTC). It was determined that the average score in 2019 was two points lower for grade four than in 2015, thus verifying the decline in achievement (NAEP, 2019).

National and local administrators and educators were challenged to identify targets for improvement and increase the competitiveness of US students compared to their counterparts. The US Government responded by enacting the No Child Left Behind Act, which was later replaced with Every Student Succeed Act and the STEM Act of 2014. Funds were provided to strengthen the science curriculum and provide additional resources to increase students' activities and engagement time in the science subjects. The funds were also earmarked for teacher professional development and additional resources to help students improve theirscores on science assessments.

As educators reviewed the declining scores to make changes, it was determined that the teacher was the most impactful influence on student achievement. This study assessed the impact of teachers' professional preparedness and professional development to provide clues to the emerging needs of students that increase science achievement (Bray et al., 2003; Rockoff, 2004). The examination also served as a basis for identifying impactful professional training topics for teachers related to student achievement (Johnson, 2017).

Current Study

The decline in science assessments on international tests has raised alarms for reform. Student achievement issues are complex, and it is known that many factors may impact student success in science; however, the teacher is noted as the most impactful. Professional preparedness and professional development are teacher-focused and are two of the major keys to student achievement. This research aimed to assess the impact of teacher professional preparedness and professional development on fourth-grade science achievementusing the 2019 Trends in International Mathematics and Science Study (TIMSS) data for the United States. TIMSS is an international study that is conducted every four years. The professional preparedness and professional development data were obtained from the teacher survey and evaluated using SPSS, the Hierarchical Linear Model (HLM).

The question and hypothesis for the study were:

1. Do teacher preparedness in the form of education and professional development significantly predict students' science achievement scores?

H01: Teacher professional preparedness and professional development do not significantly predict students' science achievement scores.

H1: Teacher professional preparedness and professional development predict students' science achievement scores significantly.

Theoretical Basis

The theories of Bandura and Piaget were the underpinnings for the study. Each developed theories that relate to the education process based on the observed behavior of teachers. Bandura'sSocial Learning Theory postulates that various components in the environment influence children's individual development and behavior (Kurt, 2019). Bandura (1994) believed that specific behaviors promote and stimulate student success. He predicted that children could learn by observing and imitating behavior. Three social constructs illustrate how adults, parents, and peers can influence behavior and decision-making through interactions, modeling, and learning processes. Teachers' influence is impactful as students spend many hours observing behavior, embracing critical learning approaches, and behaving as expected (Bandura, 1977, 2007).Bandura's theory focuses on teacher behavior and student imitation of that behavior.

The theory of constructivism, developed by Jean Piaget (Alanazi, 2019; McLeod, 2023), relates to teachers developing instructional approaches that embrace students' pastknowledge and problem-solving reflective of real-life situations. Yearly professional development initiatives must provide the competencies for teachers to embrace the theory of constructivism, thus improving students' science competencies.

Teacher Preparedness

Science education is a core subject of STEM and is assessed accordingly. The *Teachingfor Americas Future Report* reported teacher preparation and teacher-centered approaches as early as July 1996. The report included three core premises: (1) Teacher knowledge and practice are critical to students' learning. (2) Recruiting and retaining good teachers are primary keys to school improvement. (3) School reform must focus on teachers' working conditions. The report also emphasized that teachers' knowledge and skills must continue to develop for life (National Commission on Teaching and America's Future [NCTAF], 1996). As Meador (2020) stated, “Good teachers must be in a continuous state of preparation and planning.”

Bandura’s theory embraces the teaching of human development and behaviors that prescribe teacher processes and are modeled to promote student success. Teachers' professional preparedness is further designed to promote techniques that influence behaviors and decision-making through interactions, modeling, and instructional practices (Bandura, 1977, 2007).

The techniques used to impart knowledge to today's high-tech students are crucial to how well they receive and retain scientific information. Teachers' knowledge and techniques strongly predict student achievement (Stronge & Hindman, 2006). Planning and preparation for a cadre of professionally qualified teachers require collaboration with preservice institutions,professional science teaching associations, and planned strategies for professional development (NCES, 2004). The National Center for Education Statistics (NCES) defines teachers' preparedness for classroom requirements and encompasses several vital components. The first requirement is yearly participation in a well-defined, commonly accepted pedagogical professional development program.

Several researchers conducted studies based on teacher attitudes toward science and the attitude displayed to students about science as influencers of student outcomes (Altinok, 2004; Gokul & Malliga, 2015). If the science attitude is positive, students are more likely to do well in science. Teachers' professional preparedness and professional development are the basis for forming attitudes and interest in science (Gokul & Malliga, 2015).

As indicated by researchers, teacher preparedness for the 21st century requires the need to possess vital competencies. The general competencies include knowledge and implementation of the most relevant science curriculum, high expectations of students, inspiring students, and integrating technology in instruction (TIMSS, 2019; NSTA, 2018). If science teachers have the knowledge, skills, and aptitudes, they are prepared to continue learning each year through professional development programs centered around innovative science pedagogy (NSTA, 2018).

Professional Development

As early as July 1996, the *Teaching for Americas Future Report* included three core premises related to science: (a) Teacher knowledge and preparation serve as critical elements to students' learning. (b) Recruiting and retaining good teachers are the primary keys to school improvement; (c) School reform must focus on the conditions under which teachers work. The report also emphasized that teachers' knowledge and skills must be upgraded as curriculum, students, and economic conditions change. (National Commission on Teaching and America's Future [NCTAF], 1996).

The Framework for K-12 Science Education identifies scientific literacy as a principal goal of science education (NRC, 2012). Constant changes to science make achieving scientific literacy challenging. Science literacy requires students to become proficient in knowing, using, and interpreting scientific data of the natural world (NRC, 2012). Also, students should be able to generate and evaluate evidence to understand how scientific knowledge is developed while participating in scientific practice and discourse (NRC, 2012). Research suggests that students' conceptual understanding and use of science concepts provide opportunities to learn about and practice science inquiry (NRC, 2012).

Science literacy concepts embrace the cognitive theories of Bandura and Piaget. Bandura specifies that learning occurs through the observation and interactions of the environment, through factors of motivation, attitudes, and emotions. Piaget's cognitive theory postulates that children between seven and eleven can think abstractly and classify objects through inquiry methods (McLeod, 2023). Piaget's theory supports scientific discourse and inquiry methods, which should be professional development components. Therefore, the traditional science teaching model focusing on memorizing facts must replace inquiry and abstract principles (Alanazi, 2016; Wadsworth, 2004). The principles of inquiry and abstraction are the focus of the future science pedagogy, which is found in the *Next Generation Science Curriculum*.

Roth et al., 2011 suggested that the effectiveness of reform-based science instruction impacts students' achievement. Elementary teachers often do not have a background in science, and many do not teach science daily, both of which relate to personal science teaching efficacy

(Banilower et al., 2013). Teachers ' participation in professional development programs allows new and innovative instructional strategies to be learned (NSTA, 2018). Concurrently, professional development programs must be a regular part of each school district's strategic plans. It will then become a long-range plan for teachers' continuous improvement and development. Also, essential to the constant evolution of professionals, teachers must have the most up-to-date relevant materials to provide the resources and basis for curriculum reform (NSTA, 2018). Research confirms that professional development ensures teachers model and infuse practices in their current curricula to improve (Supovoz & Turner, 2000).

Table 1 compares the standards for 2006 and 2018, revealing that changesoccurred concerning professional development. The 2018 position statement provides increased rigor compared to 2006. The 2018 model reflects changes that meet global challenges (NTSA, 2018). More emphasis is stressed on instructional practices for 2018 compared to 2006. Professional development for 2006 focused on learning experiences that challenged beliefs, knowledge, and habits, whereas 2018 focused on experimental, inquiry experiences that allow students to develop conclusions and make inferences. Piaget's cognitive theory supports inquiry experiences where students can form scientific conclusions. Professional development in 2006 specified that it should be integrated with other subjects, whereas in 2018, specific coursework such as life science and earth science integrated with technology were recommended.

Additionally, professional development for 2006 focused on continuous improvement while requiring them to observe, analyze, and review teaching practices, compared to the 2018 requirement that suggested that planned opportunities are provided to help teachers reflect and engage in authentic, formative, and summative assessments and discussions.

Both years emphasized that effective teachers must increase knowledge and skills yearly to meet constant changes and improve, revise, and update instructional practices to promote increased science achievement (Guskey, 2003; Richardson, 2003; Sparks, 2002).

Table 1.

NTSA Professional Development for Teachers

NTSA Proposed Professional Development Essentials

2006	2018
"Professional development should be based on the needs of science educators, on the basis that they are refined to meet teachers' 'changing needs."	"Counter pre-existing anxiety and attitudes about science through opportunities to experience hands-on, engaging learning environments and research-based."
"To best serve all students as they learn science, professional development should engage science educators in transformative learning experiences that confront deeply held beliefs, knowledge, and habits of practice."	"Involve participants in experimental activities to develop an understanding of the learning progression within both the content and processes common misconceptions, and to provide appropriate differentiation strategies."
"Professional development should be integrated and coordinated with other initiatives in schools and embedded in the curriculum, instruction, and assessment practices."	"Require specific coursework in the areas of life science and earth science designed to model the three-dimensional integration of science and engineering practices while reinforcing the nature of science in a developmentally appropriate context."
"Professional Development programs should maintain focus over time, providing the opportunity for continuous improvement."	"Include regular opportunities to develop, use and reflect upon authentic formative and summative assessment to uncover student thinking, detect possible

	misconceptions, and modify learning experiences accordingly, bothas an individual and within a professional learning community."
"Professional development should actively involve teachers in observing, analyzing andapplying feedback to teaching practices."	"Engage in meaningful discussion of methodsfor embedding reading, writing, and mathematics within the context of active science learning."
"Professional development should concentrate on specific issues of science content and pedagogy that are derived fromresearch and exemplary practice."	"Advocate for and schedule regular meetings with experienced elementary science mentors within and across grade levels to analyze data, reflect on the lesson design, and develop confidence in providing instruction for childrenof all ages."

Adapted from https://static.nsta.org/pdfs/PositionStatement_Elementary.pdf

According to Schwerdt and Wuppermann (2010), there is a strong relationship between what teachers know and how they deliver instruction that influences students' learning. A teacher'squality is critical, and aspects of quality must drive professional development for curricula and approach updates. The training must focus on the development of a continuum.

The *Full Options Science System (FOSS*) curriculum was developed as early as the 1990s but is updated yearly to reflect the needs of the 21st century. Created by the Lawrence Hall of Science at the University of California, the *FOSS* science curriculum meets the NGSS, and objective-based standards developed by states. It is three-dimensional learning; it has proven to raise science scores; it provides interactive resources and keeps students focused, regardless of economic status *(FOSS, 2021*). Several school systems have used FOSS and attest to the improvement of science scores, teacher training, and student engagement (Hampton City Public

Schools, LaCrosse School District, WI; Peabody Public Schools, MA; Indianapolis Public Schools, IN; Tupelo Public Schools, MSD, Oakland Unified School District, CA, [*FOSS, 2021]).*

The Research Model

The TIMSS, 2019, US data was used to assess the impact of teacher preparedness and professional development on science achievement. The research question and hypothesis were:

Do teachers' professional preparedness and professional development significantly predict students' science achievement scores?

H_{01}: Teacher professional preparedness and professional development do notsignificantly predict students' science achievement scores.

$H_{1:}$ Teacher professional preparedness and professional development predict students' science achievement scores significantly.

Demographics, professional preparedness, and professional development data were provided from 17 questions on the Teacher Questionnaire (Appendix 1) (TIMSS, 2019). The Hierarchical Linear Model (HLM), using SPSS 27, was used to calculate the descriptive and correlation matrix of the model. HLM Level 1 and Level II analyses were used to evaluate the impact of teacher preparedness and professional development on fourth-grade students' science achievement (Wen & Chiou, 2009). The scores were entered into the HLM model in two steps. Step one included the student assessment scores. Five plausible science assessment scores were entered to serve as a Null Model. Teachers' preparedness and professional development scores were added to level two of the HLM model. A regression model was created with the science scores and the teacher preparedness and professional development scores (Table 2).

Results

The purpose of this quantitative study was to investigate the impact of teachers' professional preparedness and professional development on science achievement among fourth-grade students in the United States. SPSS data (HLM) also provided predictive answers.

Population and Sample

The data were obtained from the 2019 Trends in International Mathematics and Science Study (TIMSS) retrieved from the Boston College, TIMSSre, and PIRLS International Study Center website. Specific variables were analyzed from a random sample of schools in the United

States of America. Data were analyzed from the teachers' responses on the Teacher Questionnaire and assessed with the fourth-grade science scores. The population consisted of 70 teachers and 1,208 students. Descriptive statistics and exploratory data plots were examined. The smallest number of students per teacher was four, and the largest was thirty-nine. The mean number of students per teacher was seventeen, the same as the median.

Teacher Preparedness

While not statistically significant, in this study, formal education and a major in science had positive relationships with science scores. Formal education had a positive influence with a value of 3.5, and the major of science had a value of 15.87, with $p < .49$, not significant at $p < .05$. The National Center for Education Statistics (NCES) defines teachers' preparedness for classroom requirements and encompasses several vital components. The first requirement is participation in a well-defined, commonly accepted pedagogical and professionalprogram that provides the foundation to continue learning throughout their professional lives (Altinok, 2004; NSTA, 2018). The NSTA supports all programs aligned with the Next Generation Science Standards (NGSS, 2013) goals and standards in concert with the Framework for K-12 Science Education (NRC, 2012).

Listed in Table 2 are the values for Years of Teaching (6.2468), Formal Education (3.5865), and Major in science (15.879). All the factors mentioned earlier positively impacted science achievement, with a major in science being the most impactful.

Table 2

		Value	Standard Error	DF	t-value	*P*
Variables	Science AVG. Score	743.1843	99.74014	893	7.451206	0.0000*
ATBSO8AA +	Review Past Science Content	-28.5946	15.0317	893	-1.902483	0.0574*
ATBSO8BA	Review Future Science content	-9.9076	24.22715	893	-0.408947	0.8227
ATBSO8BB	Future Science Pedagogy	5.2014	23.20175	893	0.224183	0.8227
ATBSO8BE	Future Critical Thinking	21.6277	20.09874	893	1.076073	0.2822
ATBSO8AF	Past Science Assessments	-31.6466	25.10517	893	-1.260561	0.2078
ATBSOBF	Future Science Assessments	-46.3434	27.75798	893	-1.669553	0.0990
ATBSO8AG	Past Student Needs	34.3929	20.82790	893	1.651292	0.0990
ATBSO8BG	Future Student Needs	33.2846	27.62001	893	1.205092	0.2285
ATBSO8AH	Past Integrate Science	-20.5474	17.92341	893	-1.146398	0.2519
ATBSO9	Professional Development Hours	-9.4633	9.01072	893	-1.050231	0.2519
ATBGO1	Years Teaching	6.2468	4.06443	893	1.536945	0.1247
ATBGO2	Sex	-13.3264	19.56.417	893	-0.681165	0.4959
ARBGO3	Teachers Age	-1.6783	8.52254	893	-0.196920	0.8439
ATBGO4	Formal Education Completed	3.5865	12.89554	893	0.278118	0.7810
ATBGO5AD	Major-Science	15.8795	23.01994	893	0.689815	0.4905

Teachers Professional Development Training

Professional development variables were dichotomous, except for professional development hours. The variables are listed in Table 3 below. Listed in Table 3 are the professional development variables, followed by a brief explanation.

Table 3

Professional Development Topic of Study (11 variables)

Variable Name	Description
ATBSO8AA	Review Past Science Content
ATBSO8BA	Review Future Science
ContentATBSO8BB	Future Science Pedagogy
ATBSO8BE	Future Critical Thinking
ATBSO8AF	Past Science Assessments
ATBSO8BF	Future Science
AssessmentsATBSO8AG	Past Student Needs
ATBSO8BG	Future Student needs
ATBSO8AH	Past-Integrate Science
ATBSO9	Professional Dev. Hours

The professional development activities were completed by teachers with a Yes = 1 or No=2 response.

1. **Reviewed Past Science Content - ATBSO8A**

   Twenty-six teachers (33.3%) answered Yes, whereas 43 (62.3%) answered No on Review Past Science Content.

2. **Reviewed Future Science Content - ATBSO8BA**

   Forty-two (63.6%) teachers answered Yes, whereas 24 (36.3%) teachers answered No for Future Science Content.

3. **Reviewed Future Science Pedagogy - ATBSO8BB**

   Forty teachers (58.8%) answered Yes for ATBSO8BB whereas 28 (41.1%) teachers answered No for ATBSO8BB.

4. **Reviewed Future Critical Thinking - ATBSO8BE**

   Forty-five (68%) teachers answered Yes for ATBSO8BE, whereas 21 (31.8%) teachers answered No.

5. **Reviewed Past Science Assessments ATBSO8AF**

   Eleven (16.1%) teachers answered Yes, whereas 57 (83.8%) answered No to ATBSO8F.

6. **Reviewed Future Science Assessments ATBSO8BF**

   Thirty-six (51.5 %) teachers answered Yes, whereas 34 (48.5 %) answered No to ATBSO8BF.

7. **Reviewed Past Student Needs - ATBSO8AG**

   Seventeen (24.6%) teachers answered Yes for ATBSO8AG, whereas 52 (75%) B teachers answered No for ATBSO8AG.

8. **Reviewed Future Student Needs - ATBSO8BG**

   Fifty-seven (77%) answered Yes for ATBSO8BG, whereas 17 (22.9%) teachers answered Yes. Answered No for ATBSO8BG.

9. **Past Integrate Science- ATBSO8AH**

   Eighteen teachers (26.4%) answered Yes for Past Integrate Science, whereas 50 (73.5%) answered No.

Based on the analysis of topics discussed for professional development, the most prevalent topics were related to future science needs, science pedagogy, and critical thinking. The future science needs, science pedagogy, and critical thinking topics are recommended for the Next Generation Science Initiatives (NGSS, 2013).

The professional development (ATBSO9) hours ranged from one to more than thirty-five hours. The number one represented none, a score of two represented six hours or less, a score of three represented 6-15 hours, a score of four represented 16-35 hours, and a score of five represented more than 35 hours of professional development. The mean number of professional development hours for this study was 2.12, which indicated that most teachers had six hours or less of professional development. Increasing the number of hours for professional development may provide results that assure a more significant impact on science achievement scores. Many noted that more hours are needed for professional development programs.

Relationship of Professional Development to Fourth-Grade Science Achievement

As indicated in Table 2, the average Science score was 743.1843 and significant at p=0.000. The professional development programs for teachers indicated that positive relationships existed for Future Science Pedagogy (5.2014), Future Critical thinking (21.6277), Past Student Needs (34.3929), Future Student Needs (33.2824), The values were not significantat p=,.05. However, the positive values served to increase science scores. For instance, for every increase in Future Science Pedagogy, science scores increased by 5.2014; For every increase in Future Student Needs Score, Science scores increased by 33.2824. The scores were insignificant but provided positive clues for Future Science Professional Development.

There were also negative scores, which indicated that professional development initiatives may have a negative impact. Some of the negative trainings were Review Past Science Content (-28.5946), Review Future Science Content (-9.90), Past Science Assessments (-31.6466), and Future Science Assessments (-46.3434). The negative impact of these variables maybe due to the time spent on the concepts while placing more emphasis on Future Science Pedagogy, Critical Thinking, and Student Needs. Also, a limited amount of time was invested inprofessional development, suggesting that more than limited to modest investments may be needed to increase the science achievement of elementary school children.

The positive scores indicated that professional development for science should focus on Future Science Pedagogy, Future Critical Thinking, and student needs of the past and future. The professional development hours had a negative impact. This may be due to the limited number of hours teachers participated, with an average of 2.12 hours. While the negative score of -9.46 is low, it indicates that more time is needed for professional development to impact student achievement positively. This study's findings did not show that the professional development hours had a positive impact, perhaps due to the number of hours teachers participated. Research studies have shown that more than modest professional development investments may be required to impact students' substantialachievement significantly. More professional development hours will provide a more positive outcome.

Research studies have shown that professional development provides teachers with the latest tools to infuse instructional practices to assist students in becoming proficient in science. (*FOSS,2021).* Since professional development is the predominant means for teachers to learn new, relevant knowledge, students will benefit if teachers are engaged in well-designed, high-quality programs that follow the standards *of Learning Forward* (Jones & Kahn (2017). The teachers indicated that professional development needed more time to process and practice the latest information for student success.

Discussion

This study provided insights into teacher variables that influence fourth-grade science students' assessment scores using TIMSS 2019 data. Though not statistically significant, the findings imply that formal education and a major in science do have a positive relationship to science achievement. A major in science had a value of 15.87, which means that science scores increased by 15.87 points due to a teacher majoring in science. Specifically, this research indicates that teachers' professional preparation should include a major in science, and professional development must be strategically planned and implemented yearly to provide new information and strengthen instructional practices.

The professional development should focus on the components of the Next Generation Science initiatives, such as the FOSS (Full Option Science System). Key topics related to future pedagogy, critical thinking, and past and future student needs were the topics that positively impacted science scores. Using the suggested topics from this study can serve as a template to develop a professional development plan that allows teachers to learn new information and collaborate with peers to develop inquiry-based practices and critical-thinking processes. Piaget and Bandura's theories support the recommendations concluded from the findings.

While the number of hours for professional development was not specified in research studies, the researchers recommend a minimum of 30 hours yearly. The 30 hours is suggested based on the increasing complexities of life, with science and technology serving as the driving forces. Future research studies using the abovementioned recommendations can provide insightful implications for increasing students' science achievement.

Additionally, further research will refine the variables with the most significant impact so that professional development training can be done. The dedicated time can be spent only on the variables and topics that serve to increase students' science achievement.

Limitations

This study was limited to the populations reflected in the TIMSS 2019 study. It was limited to secondary, aggregated data from participants in the United States. It wasfurther limited to science, fourth-grade students, and teachers. Therefore, the results may be generalizable only to US fourth-grade students and teachers.

The data were limited to scientific assessments conducted in 2019. TIMSS data is collected once every four years. Choosing the latest version allowed the researcher toevaluate data close to the year of research.

Conclusions and Summary

The impact of teacher preparedness and professional development on fourth-grade students' science achievement research study was conducted with the following questions and hypotheses:

Do teacher preparedness in the form of education (professional preparedness) and professional development significantly predict students' science achievement scores?

H_{01}: Teacher professional preparedness and professional development do not significantly predict students' science achievement scores.

$H_{1:}$ Teacher professional preparedness and professional development predict students' science achievement scores significantly.

Based on the findings of this study, students' science achievement was impacted by teachers' professional preparedness and professional development, though not significantly at $p<.05$. Therefore, the test indicates that there is not enough evidence to reject the null hypothesis and is accepted. The alternative hypothesis is rejected.

While the findings were not statistically significant, there were clues that specific variables strongly impacted science achievement scores reported by the TIMSS study for2019. The professional preparedness variables that had an impact on science scores were teachers who had completed a formal education (3.5865), majored in science (14.8795), and years teaching (6.2468). These variable values served to increase the science achievement scores.

Several professional development variables also substantially impacted the science achievement of fourth-grade students. They included future science pedagogy (5.2014), future critical thinking (21.6277), past student needs (34.3929), and future student needs (33.2486). These positive values increased science achievement scores for the fourth-grade students included in this study.

School administrators may consider evaluating the components of this study's findings to develop and expand professional development time, with a focus on the four positive correlations that had a substantial impact on student achievement: past and future student needs,future science pedagogy (*Next Generation Science Curriculum*) and future critical thinking.Further research will also provide comparative data and additional clues to the strength of variables that statistically impact students' science achievement.

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