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Case Report

Enhancing Rural Science Education through School District–University Partnership

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Abstract: This instrumental case study describes the steps taken to establish and implement a university–school partnership to improve rural science teachers' content knowledge and teaching practices and students' achievement in elementary science and high school biology courses. Our research questions explored the impact of professional development and place-based learning on student outcomes, with the study's methodology involving needs assessments, teacher training, and continuous support through modeling and coaching. The findings include gains in achievement and substantial gains in science education. The findings have implications for the design, implementation, and evaluation of university–school partnerships designed to build teachers' capacity to deliver high-quality science education and improve student success in rural school districts.

Keywords: rural education; placed-based learning; teacher professional development; science achievement; university–school partnerships

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1. Introduction

1.1. Federal Policy Supporting Science Education Leads to School District–University Partnerships

President Obama signed the Every Student Succeeds Act (ESSA) into law on 10 December 2015. This bipartisan act aimed to provide states with more flexibility in designing the education systems, moving away from the stringent federal oversight of its predecessor, the No Child Left Behind Act. The ESSA prioritized personalized learning, expanded access to high-quality preschool, and aimed to reduce the emphasis on high-stakes standardized testing. School districts across various states have been utilizing the state implementation of the ESSA to enhance their science curriculum. This may involve updating the existing science curriculum to meet ESSA requirements, incorporating inquiry-based learning approaches, providing professional development for teachers, and implementing assessments to measure student progress in science. School districts are leveraging the ESSA guidelines to ensure that students receive a high-quality science education that equips them with the necessary skills and knowledge for success in the 21st century.

By focusing on science education under the ESSA, the districts aimed to ensure that students receive a comprehensive education that prepares them for success in the modern world. To achieve this goal, they incorporated real-world teaching methods such as inquiry-based and place-based learning approaches. The ESSA provided states the opportunity to move beyond traditional assessment and develop new and innovative assessment models that require students to produce a product or construct an answer rather than just select from a list of options (Figure 1). These new types of assessment items and performance assessments enable state assessment systems to not only measure basic skills but also provide opportunities for students to demonstrate their proficiency in higher-order thinking skills and their college and career readiness.

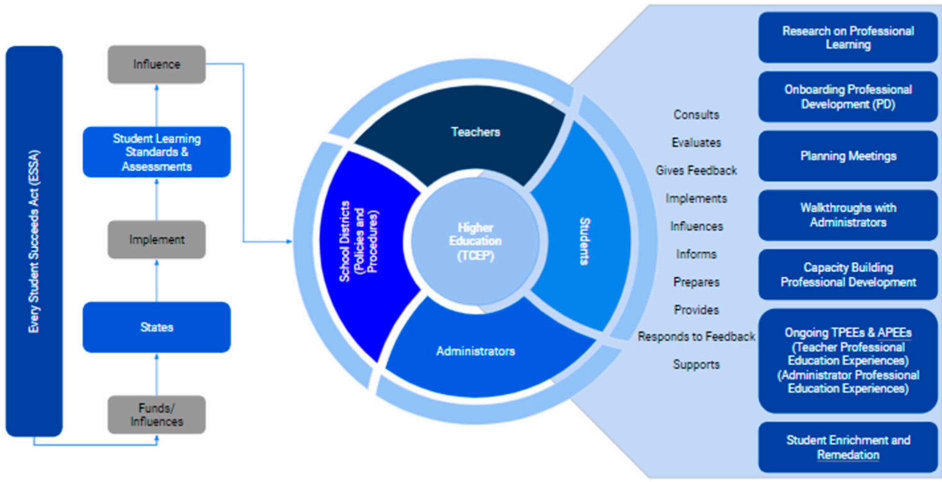

Figure 1. A Conceptual framework for supporting science education through School District–University Partnerships Consultant Approach in Supporting Science Education Conceptual Framework.

The act also sought to address achievement gaps and provide additional support to disadvantaged students while promoting the professional development of educators. Overall, the ESSA represented a significant shift in education policy, emphasizing state and local control and aiming to ensure that all students have the opportunity to succeed. State implementation involved developing and implementing science standards aligned with ESSA requirements, providing professional development for teachers, and assessing student progress in science, as shown in Figure 1.

By aligning their science curriculum with the ESSA standards, school districts aim to provide students with a more comprehensive and engaging science education. Active learning pedagogies, which prioritize student-centered, place-based, and interactive approaches, have been shown to significantly improve student learning and engagement, particularly in science education [1]. However, many science classes still rely heavily on traditional teacher-focused instruction due to limited time and resources to experiment with and implement new approaches, the need to cover a large amount of material for end-of-course tests [2], and a lack of administrative support for instructional innovation. Without access to meaningful opportunities for learning and testing active learning pedagogies, as well as support for implementing these approaches, it is unlikely that many teachers will adopt contemporary pedagogical strategies. One solution may be school district–university partnerships [3] where higher education science faculty facilitate professional development for K-12 teachers and provide support for using data to inform decisions and introduce instructional innovations [4]. Participation in science professional development led by university faculty can lead to improved content knowledge among K-12 teachers, advancements in K-12 science teaching, and increased teacher confidence in science instruction [4].

Partnerships with universities and rural education communities are critical for several reasons. Universities can provide expertise and resources that may not be readily available in rural areas, such as specialized training for teachers and opportunities for professional development. These partnerships also help bridge the gap between rural schools and academic research, leading to innovative teaching strategies and improved student outcomes. Overall, university partnerships enhance educational quality, support teacher development, and promote student success in these underserved areas.

1.2. Challenges for Teaching Science in Rural Districts

More than one-fourth (29%) of traditional public schools in the United States are in rural areas [5]. National attention is not given to these districts because of their small size, educational resource constraints, high teacher turnover, limited instructional capacity, and high student mobility rates. According to the Stanford Education Data Archive (SEDA), in the Mid-Atlantic region, the stratification of educational opportunities for rural students varies (SEDA version 4.0) [6,7]. Rural white students tend to demonstrate higher learning outcomes in elementary and middle school compared to their white counterparts in non-rural areas [8]. On the other hand, Black, Hispanic, and Native American students in rural communities and the same grades exhibit slower learning rates compared to the national averages for their respective groups [9]. Based on the findings from the National Center for Education Statistics, the Mid-Atlantic state in this study allocates only 20.9% of its state funding to rural schools within its borders, which is just slightly above the national average of 16.2% of the nation's funding dedicated to rural schools [10].

Science teachers may face challenges in teaching diverse students, meeting the needs of English Language Learners (ELLs), and supporting students who come from economically disadvantaged households with limited knowledge of technical, Tier III, or subject-specific vocabulary. Rural districts may face challenges with teachers' relative lack of professional development opportunities, leading to narrow pedagogical knowledge, high teacher turnover, and instructional and budgetary resource constraints.

1.3. Placed-Based Learning

Place-based learning (PBL) is an educational approach particularly suited to rural settings, as it emphasizes connecting students' learning experiences to their local environment and community [11]. Fundamental principles of PBL include [12]:

1. Learning occurs on-site, which can be on the school grounds or nearby natural spaces.
2. The curriculum is inclusive of multiple generations and cultures and engages with local community resources.
3. PBL centers on local issues, systems, and content.
4. Learning experiences contribute to the community's environmental quality, which serves as the foundation for comprehending and engaging effectively with regional and global issues.
5. Strong and diverse partnerships with local organizations, agencies, businesses, and government entities support the learning process to nurture a deep appreciation for one's local environment.

Place-based learning can be enhanced by incorporating various aspects of other pedagogies to create a well-rounded and engaging educational experience. A few examples that were used in support of the science reform in this rural school district study are constructivism, ecological systems theory, and culturally responsive teaching [13]. In our case, we elected to blend key elements of place-based learning with each of these pedagogies. Our objective was to employ an innovative approach to improving the instruction observed by teachers and administrators and the outcomes exhibited by the students.

1.4. Constructivism and Place-Based Science Learning

The theoretical foundation of constructivism posits that learners actively construct knowledge through their experiences and interactions with the environment. Place-based learning aligns with this perspective by providing students with authentic, real-world contexts through which scientific concepts and meaning can be construed [14,15]. By engaging with their local environment [16], students can make connections between abstract scientific ideas and tangible experiences, enhancing their understanding and retention of scientific knowledge. By examining local environmental challenges, such as recycling, pollution, habitat loss, or climate change, students can apply scientific knowledge to analyze and propose solutions to these issues. This approach fosters critical thinking and problem-solving skills and encourages students to become active participants in addressing environmental concerns within their community [17].

1.5. Ecological Systems Theory and Place-Based Science Learning

Ecological Systems Theory [18,19] emphasizes the interconnectedness between individuals, their immediate environment, and the broader community. Place-based learning in science instruction provides a vehicle for building interconnectedness by asking students to investigate their local environment [17]. By studying the interactions between organisms, ecosystems, and human activities, students develop an understanding of the interdependence of living organisms and their environment. For example, teachers and students can participate in learning experiences including visits to state parks or investigations in their schoolyards. This provides opportunities to deepen understanding of the local environment and foster a sense of environmental stewardship.

1.6. Culturally Responsive Teaching and Place-Based Science Learning

Culturally responsive teaching recognizes and values the diverse cultural backgrounds and experiences of students. Place-based learning provides opportunities to incorporate students' local cultural knowledge, traditions, and practices into science instruction, which can lead to increased achievement [20]. By integrating culturally relevant examples and perspectives, educators can create a more inclusive and engaging learning environment, thus enhancing students' motivation, interest, and sense of belonging in science [21]. Despite the proximity of rural school districts to undeveloped natural areas, there is little connection to these places in rural schools' curricula. This may be due to schools' focus on basic academic skills in reading and mathematics [11,22], leaving opportunities to integrate local geography, resources, and connections into the overlooked curriculum.

1.7. The Present Study

This project was aligned with national policies designed to reduce inequities for disadvantaged students, including the 2015 Every Student Succeeds Act (ESSA). Specifically, this project will address the need for improved academic outcomes and bridge the gap between rural experiences and classroom learning for disadvantaged students in the state. Using the Chesapeake Bay watershed as its geographical focus, our study sought to increase teachers' and students' understanding of local environmental challenges and feasible solutions through a coordinated network that will oversee regional consensus building and planning, teacher professional development, and sustained implementation of standards-aligned Meaningful Watershed Educational Experiences (MWEEs) and student action projects.

Our university center received a request for assistance from a rural school district in the Mid-Atlantic region. The district aimed to improve its science scores across all grade levels; in the 2020–2021 school year, the district had an overall science pass rate of 30%, compared to the state's pass rate of 59%. The district's need for support was distributed across K-12 grades; the focus was placed on the tested grades in science. The pass rate for fifth-grade science was 16%, and high school Biology had a pass rate of 39%. There was a significant improvement in the subsequent year, with pass rates rising to 41% for the fifth grade (when fifth-grade teachers began teaching both the fourth- and fifth-grade science content that comprised the fifth-grade state test) and 47% for Biology. Despite this progress, the district still did not meet state accreditation requirements. The fifth grade is a critical time for students' science learning and motivation, and it is the time when they begin to select advanced science courses and consider science career aspirations [23,24]. Biology helps high school students make sense of the world around them and equips them with the knowledge to address and contribute to real-world solutions. In the state where the study takes place, biology is required for graduation.

Therefore, in this study, we examine the science education and the Standards of Learning (SOL) scores for fifth-grade and biology students. After one year of working rigorously with teachers, administrators, and students, the efforts of this study led to a 20-point increase in fifth-grade science and a 22-point increase in biology scores overall. This paper includes an overview of the impact of rural factors on student performance, a mixed methods data analysis that looks at data from the previous years to last year, and a discussion on the methods used in this study and their effectiveness, leading to such a remarkable outcome. We draw on the conceptual framework in Figure 1, and our theoretical framework combines place-based learning with constructivism and ecological systems theory to explore a strategy for improving science instruction for fifth graders, biology students, and their teachers. The aim was to improve teacher implementation strategies to enhance students' understanding of science and engineering concepts, foster environmental stewardship, and promote community engagement.

According to the fifth-grade science standards for the state, students must deepen their understanding of fundamental physical science concepts, making connections between energy and matter. They investigate energy transformations, studying electricity, sound, and light. Additionally, they learn about matter composition and how energy can alter its phases. By exploring the Earth's changing surface, students apply their knowledge of force, matter, and energy. They enhance their scientific skills by questioning, predicting, investigating, analyzing data, explaining findings, and communicating about the natural world. Since the curriculum focuses on grasping concepts, fostering critical thinking, and comprehending how information pieces intertwine, students are not only expected to acquire knowledge but also to learn how to locate, categorize, and understand various information forms in a more complex manner. They must perceive the world on a broader scale and recognize their enhanced capacity to interpret it. Mathematics and computational thinking become more integral as students progress in their scientific endeavors. Moreover, they utilize the engineering design process to address challenges using their scientific expertise. For these reasons, fifth-grade teachers must hold high expectations for their students, urging them to engage actively in their lessons, increase their ability to problem solve, pose relevant questions, and view themselves as capable learners [25]. This would require teacher training and support to cultivate the capacities required for student and teacher success.

To explore the extent to which the one-year rural school district–university partnership was associated with changes in teacher capacity and students' science achievement, we posed the following research questions:

1. Does a science teacher's professional development impact science scores in Grade 5 and biology?
2. To what extent does students' place-based learning in science contribute to the improvement of science scores in Grade 5 and biology?
3. What challenges and successes were accomplished during the partnership time period?

1.8. Positionality

In our roles as researchers, our positionality is based on the commitment to fostering equitable and inclusive educational environments in science classrooms and beyond. In providing professional development for teachers and administrators, we approached the work with a value for the knowledge and experiences that they brought and aimed to create collaborative spaces where we could collectively explore evidence-based practices, reflect on their teaching methods, and develop strategies to meet the diverse needs of their students. When providing remediation for students, we acknowledged the unique challenges the students may face and the impact these challenges can have on their learning. We were committed to creating a safe and supportive environment where the students felt empowered to take ownership of their learning. We also recognized the importance of culturally responsive teaching and strived to incorporate their students' backgrounds, experiences, and interests into our instructional practices. In supporting administrators, we recognized the crucial role they play in shaping educational policies and practices in their district. We provided them with research-based insights and recommendations that would inform their decision-making processes. We ensured that communication was constant and prioritized the collaboration between administrators and teachers. We recognize the importance of acknowledging and challenging systemic inequities within educational settings, and we are dedicated to working collaboratively with all stakeholders to create effective and engaging learning environments with hands-on, real-world experiences for all students.

2. Methods

2.1. Context

The context for this study was a small, rural school district in the southeastern portion of the United States. The district has one lower elementary school, a combined upper elementary and lower middle school, and one high school. It serves approximately 1200 students, of whom 53.1% are from economically disadvantaged backgrounds. The state classifies a student as economically disadvantaged if the student is eligible for Free/Reduced Meals, receives Temporary Assistance for Needy Families (TANF), or is eligible for Medicaid [26]. The district enrolls 52.5% African American students, 29.5% Caucasian students, 10% Multiracial students, 5.6% Hispanic students, 1.6% Asian students, and 0.8% American Indian students. Our collaboration with the school district included the provision of professional development to eleven teachers working with 5th–8th grade, high school biology, environmental science, and chemistry, 3 school-based administrators, and 2 central office administrators to enrich content knowledge, advance science teaching practices, and boost teacher efficacy.

2.2. Participants

The participants included three fifth-grade teachers, one biology teacher, and 193 students (Table 1). The high-stakes testing in the Southeastern state where this case study takes place is administered in science at the fifth and eighth-grade levels and in high school biology. The eighth grade was not included in the study due to the changes in instructional personnel over the school year. The sixth grade, seventh grade, environmental science, and chemistry are not included because they are not state-tested grade levels. The 3 school-based administrators were not included in the study survey data due to other district commitments that prevented them from participating during the initial training. We focused on the results of the work with fifth-grade and biology teachers and their students.

Table 1. Participants' Demographics at the time of the study. Note. W = White; AA = African American; M = Male; F = Female.

Participant	Race	Gender	Subject	Years in Education	Highest Degree
1	AA	F	Central Administration	10+	Ed.D.
2	W	M	Chemistry	1–3	B.A.
3	W	F	Language Arts	10+	B.A.
4	W	F	5th grade Science	10+	B.A.
5	W	F	Physical Science	>1	B.S.
6	W	F	Environmental Science	1–3	B.S.
7	W	F	Biology	>1	B.S.
8	AA	F	Central Administration	4–6	M.A.
9	W	M	Physical Science	10+	B.S.
10	W	F	Life Science	10+	B.S.
11	W	F	Physical Science	>1	B.S.
12	AA	F	Mathematics	10+	M.A.
13	W	F	6th grade Science	1–3	B.S.

The students are representative of the school district's demographics. All fifth-grade students in this rural district participated in this study, which totaled approximately N = 81 of the students. The other students being represented in this study are biology students that range from ninth to twelfth grade in one high school. The teachers and central office administrators who participated in this study had experience that ranged from less than one year to over ten years. Specifically, 30.8% (4 educators) had more than 10 years in teaching, 15.4% (2 educators) had between 7 and 10 years in teaching, 7.7% (1 educator) had

4–6 years in teaching, 15.4% (2 educators) had 1–3 years in teaching, and 30.8% (4 educators) had less than a year in teaching presented in Table 1.

2.3. Design

Throughout the school year, the project design involved a collaborative effort with the science consultants/researchers working with 11 science teachers, 3 building administrators, 2 central office administrators, and their students. In addition, the consultants worked with two community partners, an environmental non-profit organization and a local state park, to implement constructivism and place-based learning approaches in the science curriculum.

The consultants/researchers played a key role by providing professional development sessions, conducting science classroom walkthroughs, reviewing common assessments and benchmark tests quarterly data, and offering feedback to teachers and administrators. This process of data analysis and feedback aimed to assist educators in designing effective remediation plans to address any skills gaps within their classes. Descriptive analysis was used to determine the impact of the study on the 5th-grade end-of-year test and the biology end-of-year test.

Thematic coding was used to look at the teacher and administrator surveys; the process involved systematically analyzing the responses, identifying common themes, and synthesizing the results to gain a deeper understanding of the perceptions, experiences, and feedback shared by the participants. Each response was reviewed, coded, and grouped based on common themes that emerged from the data.

The environmental non-profit organizations' involvement helped raise awareness and promote environmental stewardship among the stakeholders. The local state park provided students with valuable opportunities to explore and observe diverse habitats, serving as a unique field site for studying both abiotic (non-living) and biotic (living) factors. This partnership enriched the students' learning experiences and connected classroom concepts to real-world environmental issues.

2.4. Procedure

2.4.1. Needs Assessment for Science-Specific Instructional Design

The first step was to complete a needs assessment to identify gaps between current student performance trends and desired student outcomes. Needs assessments play a crucial role in understanding the requirements and challenges of students, as well as in evaluating the effectiveness of educational programs. By collecting comprehensive data, ongoing needs assessments informed the curriculum review processes, which allowed us to tailor our program to meet the evolving needs of the 5th-grade and biology teachers and their students. Our needs assessment tool was a survey adapted from Guskey's *Model of Teacher Change* work [27]. Participants completed the survey after each professional development session and before the classroom observations to support the implementation of the PD (Figure 2). The upcoming curriculum content used the survey and observational data to provide the next steps. At the end of each PD or placed-based learning experience, teachers were asked to complete the survey to provide the researchers with feedback on their efficacy in implementing effective science instruction in their classrooms, as shown in Figure 2. This survey feedback will be used to address research question one.

The feedback loop shows the process of providing professional development, observing the implementation, offering feedback, and next steps. Based on the initial needs assessment, participants reported the following topics and strategies as areas of concern: Active Learning Instructional Design, table of specifications, Science Safety, anchor charts, Alignment to Science and Engineering Practices, Tier II and III vocabulary integration, and content/cognitive-level questions for assessment.

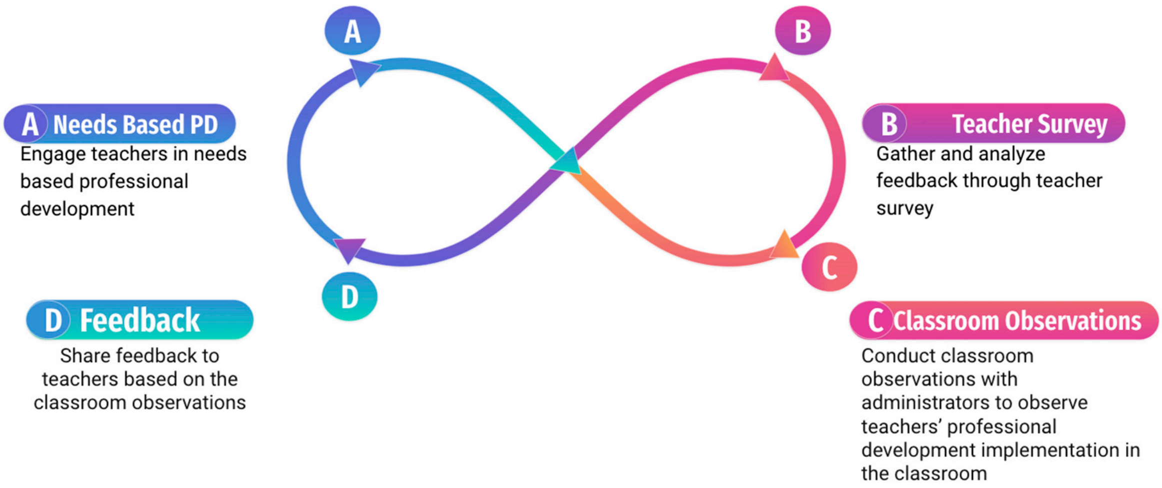

Figure 2. Participants' Feedback Loop with Higher Education Consultants.

Active Learning Instructional Design is the process where teachers are trained to take their students through stages that will transform students' conceptual knowledge, their use of science and engineering practices, and how they apply crosscutting concepts to explain phenomena happening in the natural world (Figure 3). This study used this learning model to increase student engagement by allowing students to become active learners rather than passively listening or reading about a topic. Students interacted with each other and the course material in a way that engaged them. This helped students gain a deeper understanding of the material taught while strengthening their problem-solving skills.

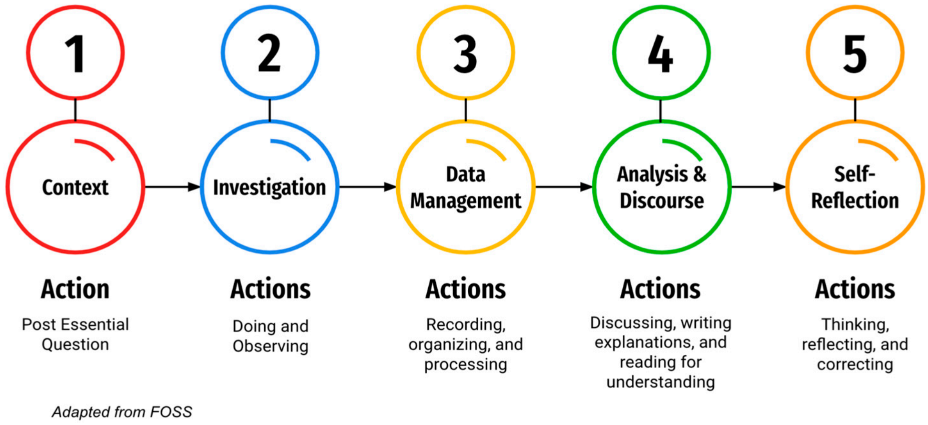

Figure 3. Active Learning Instructional Design.

Active Learning Instructional Design is the context of student-centered learning while facilitating teacher professional development that provides evidence for how to leverage the model to promote instructional change in the science classroom [28].

The table of specifications (TOS) is a tool that is primarily used to ensure alignment between items or elements of an assessment and the content, skills, or constructs that the assessment intends to assess. This tool was used in this study to align what was taught with what was tested.

Science Safety in the K-12 classroom involves creating a safe learning environment for students during science experiments and activities. Key aspects include providing safety equipment, identifying hazards, establishing safety procedures, conducting risk assessments, providing teacher training, educating students on safety rules, and ensuring supervision. These measures helped create a safe environment for teachers and students in this study to learn and explore science.

Anchor charts are a visual learning tool used in this study to allow teachers to work collaboratively with students during instruction. They served as a reference point for students to anchor students' understanding of a concept or topic. Anchor charts were created in real-time during a lesson, which allows students to contribute to the content and help students make connections between ideas.

Alignment to Science and Engineering Practices involves integrating the practices outlined in the Next Generation Science Standards (NGSS) into science instruction. These practices include asking questions, using models, planning investigations, analyzing data, applying math and computational thinking, constructing explanations, engaging in argumentation, and communicating information. Aligning instruction to these practices in this study gave teachers the skills to help students develop a deeper understanding of science concepts and the skills necessary to think and act like scientists and engineers.

Tier II and Tier III vocabulary integration in science refers to the intentional teaching and incorporation of specific vocabulary words into science instruction. These tiers are part of a framework called the "Three-Tier Vocabulary Model" developed by Isabel Beck, Margaret McKeown, and Linda Kucan [29]. Tier II vocabulary consists of high-frequency words that are used across different subjects and are important for understanding academic content. These words are often more specific than everyday language but are not exclusive to a particular subject area. Examples of Tier II vocabulary in science include words like analyze, investigate, hypothesis, and evaluate. Tier III science vocabulary consists of subject-specific or domain-specific words that are unique to a particular science discipline. Examples of Tier III vocabulary in science include words like photosynthesis, ecosystem, mitosis, and gravity. This was a self-reported area of concern for the teachers. The consultants designed and delivered a professional development that would support the teachers in introducing Tier II and III words in the science classroom. By integrating Tier II and Tier III vocabulary in science instruction during this study, teachers were able to help students develop a deeper understanding of scientific concepts and become better equipped to communicate and engage in scientific discourse. The vocabulary integration helped students build their science-specific vocabulary knowledge and enhanced their overall science literacy.

Content/cognitive-level questions assess students' understanding and thinking at different cognitive levels. Content questions focus on factual knowledge, while cognitive-level questions require higher-order thinking. Content questions ask students to recall or explain information, while cognitive-level questions ask them to apply, analyze, evaluate, or create based on their understanding. These questions promote higher-order thinking and engagement with the content. In this study, teachers were able to assess comprehension, challenge students, and guide them toward a deeper understanding of science concepts.

The initial teacher survey indicated that educators identified specific areas for improvement in Active Learning Instructional Design, as 46% reported challenges in implementing this approach with their students (refer to Figure 3). Additionally, a significant number of respondents (70%) expressed unfamiliarity with the use of the table of specifications tool. Concerns were also raised regarding Science Safety, with 23% of teachers lacking confidence in applying safety measures with students. Similarly, a notable percentage (54%) reported difficulties in utilizing anchor charts effectively in their classes. Furthermore, a substantial portion of educators (62%) noted that they struggled to align their lessons cognitively with science and engineering practices. Integration of Tier II and III Vocabulary was also identified as a challenge, as 46% of teachers found it difficult to incorporate this strategy into their instruction. Lastly, when it came to assessment, 31% of educators expressed difficulties in creating aligned content/cognitive-level questions for their students. Based on these findings, the topics were prioritized according to their potential to advance both teachers and students toward successful science teaching and learning outcomes.

In the next section, we present an analysis of the data collected, which focuses on the alignment of the written curriculum, capacity building of the teachers, and the student performances of the fifth-grade and biology students on their respective state assessments for the 2010 and 2018 standards. Analyzing the multiple standards was necessary because the state education department administered a different test in the fall and spring of the same school year. The school district offered its biology course with a four-by-four schedule where the school year is divided into two semesters and the school day consists of four 90-min instructional blocks. The biology students in the first semester (fall) took the state assessment based on the 2010 standards, and the biology students in the second semester (spring) took the assessment based on the 2018 standards.

2.4.2. Alignment of Local Curriculum with State Science Standards

We analyzed the curriculum for its alignment with state standards. Analyzing the alignment of the district's science curriculum with state standards involves several steps [30]. We started by reviewing the science standards to ensure our understanding of the content areas, learning objectives, and skills that students are expected to know and be able to demonstrate mastery in. The next step was to examine in detail the science curriculum created by the teachers in the district. This included the sequencing of the content, curriculum documents, text resources, learning plans, and other instructional materials. We needed to ensure that key concepts and skills were covered at the correct cognitive level to ensure that students would be practicing and applying their knowledge and skills. We also examined the progression of content across grade levels to ensure that the curriculum was built upon prior knowledge and scaffolded learning in a logical manner that is aligned with state standards. Once we were done with the written curriculum, our next step was to move on to the taught and tested areas of the curriculum. The step involves evaluating the instructional strategies and assessment methods written in the curriculum. In training the teachers and the administrators on using a TOS, they were able to determine if the instructional strategies aligned with the recommended pedagogical approaches and the assessment methods outlined in the state standards. The last steps are to identify any gaps or discrepancies between the state standards and the curriculum and to make recommendations for improving the alignment between the curriculum and the state standards.

The fifth-grade students were expected to demonstrate an understanding of the following concepts: scientific and engineering practices; structure and role of plants and animals, organisms, including humans, interact with one another and with the nonliving components in the ecosystem; characteristics of the ocean environment; the importance of state natural resources; Earth's constantly changing spheres; energy resources; and the conservation of energy.

One major concern that was evident early on was that students were not participating in labs or hands-on experiences in the science classrooms. The state standards explicitly stated, "Students are to plan and conduct an experiment" or "plan and conduct an investigation" more than 12 times [25] on different topics. These were not listed in the district's curriculum. The data indicate that active learning increases students' performance across STEM disciplines as compared with direct instruction [31].

The biology students were expected to demonstrate an understanding of the following concepts: scientific and engineering practices, modern classification systems that can be used to study organisms, and the dynamic equilibria within populations, communities, and ecosystems. The same concern was evident in the biology curriculum. When reviewing the standards, it explicitly stated students are to "plan or conduct or design an investigation" 4 times, "use an argument" 6 times, "construct or use a model", "develop a model", or perform "modeling" more than 12 times; "evaluate data" or "evaluate evidence" 6 times [25].

To support the state requirement of conducting an environmental education experience at all levels, the students attended a field investigation at a local state park. This hands-on experience allowed students to deepen their understanding of ecosystems and the delicate balance between different organisms and their environment. The stations were specifically designed to align with the current course-level science standards. When students returned to school, the teachers implemented reflection activities to provide an opportunity for students to share their newfound knowledge, reconnect with the content, and draw connections between what they learned in the natural world and its relevance in both the classroom and their daily lives. These reflection activities promoted deeper understanding, critical thinking, and the application of scientific concepts in real-world contexts.

2.5. Data Sources

2.5.1. Teacher Observations

Data were collected using the district's walkthrough form that focused on notices, next steps, and mentions. Walkthroughs consisted of a school administrator, a central office administrator, and the science consultants. After the walkthroughs, the group met in the conference room to discuss any observations of positive actions or areas of concern seen in the classroom. Then, a list of suggested next steps was compiled. These observations, along with the suggestion of additional course-related resources, were shared with the teachers. The follow-up training sessions were based on the observed and expressed needs of the teachers and students. The consultants provided feedback to teachers on pacing, curriculum alignment, student data and engagement, lesson implementation, and remediation, as shown in Figure 2. Teachers were instructed on how to leverage their students' background knowledge to increase classroom engagement. The consultants collaborated with the school system to help the schools develop a scope and sequence to map out learning experiences as they approached their test dates, facilitated cycles of professional development to increase teacher capacity-building techniques and efficacy, and followed up with observations of the teachers with their administrators. Teacher and student experiences offered were informed by placed-based learning and the areas of need.

To improve the SOL scores, the first step was to evaluate the current science curriculum and analyze the data from the previous year's SOL scores. We discovered that the curriculum lacked clarity, logical structure, and practical applications. Therefore, to address these shortcomings, we introduced a more efficient and straightforward curriculum with a clear emphasis on experimentation and the scientific method. Collaboration with teachers was another significant factor in this process. We conducted frequent workshops on instructive methods that allowed for more engaging and hands-on experiences for students, which led to more interest and understanding of scientific topics. All workshops concluded with a survey that allowed the teachers to provide feedback on the training and their planned implementation of the learned strategies. This yielded the researchers' qualitative data regarding the effectiveness of the training in enhancing teachers' content knowledge, science teaching practices, and their overall efficacy. We also provided additional resources and feedback on lessons and teacher pedagogy to teachers. The professional development was needs-based, standards-aligned, and ranged from instructional to organizational and field-based. Based on the feedback they received, the teachers created a proposed pacing plan, aligned learning experiences, and performance-based assessments that addressed fifth- and fourth-grade content per the new 2018 science standards emphasized in Figure 2.

2.5.2. Student Observations

During the teacher walkthroughs, the group was able to focus on student engagement and student-teacher interactions and added these observations to their notices list. In this study, during the school year, placed-based learning was used with the students of the rural school district to provide them with authentic experiences to enrich their science instruction. Students received a MWEE field trip to the local state park. Student groups rotated through three hands-on environmental investigation stations with their teachers. The community partners and the science consultants/researchers conducted the stations. This allowed the teachers to observe effective science instructional techniques for implementing field experiences for their students.

2.6. Professional Development

The science consultants designed and delivered a professional development (PD) program for the school district's science teachers and administrators. The program content was based on the district's needs assessment that identified the specific areas where the science teachers required the most support. The PD program included a virtual summer check-in with the intermediate school 5th grade science team. At the start of the program, the objective was clearly defined—employ an innovative approach to improving the instruction observed by teachers and administrators and the outcomes exhibited by the students. This objective aligned with the school district's curriculum standards and the needs identified in the assessment. The four members of the Grade 5 science team were also asked to make personal and professional SMART goals (Specific, Measurable, Achievable, Relevant, and Time-Bound) to help them plan and work toward achieving the program's objective. The teachers were instructed on how to include content that was engaging, up-to-date, and aligned with best practices in the science curriculum, using effective instructional strategies and developing assessment tools that provide high-quality student feedback. To this end, the team met with the consultants to review what they had prepared. The consultants/researchers received all documents from the team, reviewed them, and provided comments, guidance, and insight into ways to ensure tight alignment with the standards and the cognitive rigor of the content [30]. The consultants assisted district administrators in providing teachers with the necessary resources and support. The consultants/researchers also took the information and documents provided by the Grade 5 science team and used it to monitor the progress of the program, adjust as needed, and prepare for the first in-person Pre-Service Summer Institute to address research question one.

The institute took place over the summer and focused on curriculum pacing. The district's pacing required their instructional staff to follow the plan and create weekly pacing guides. Based on the review from the virtual session, the consultants worked with the Grade 5 science team to develop a pacing guide of fifth-grade science standards with fourth-grade science standards folded in to ensure continuity of instruction. As a result of this institute, the team produced a weekly pacing guide for the full school year. The consultants also worked with the first-year biology teacher to construct a full-year pacing guide. As a result of this institute, the biology teacher also produced a weekly pacing guide for the entire school year.

In addition, 11 science teachers, 3 building administrators, and 2 district-level administrators were provided an additional science institute during pre-service days, professional development that occurs annually before the start of the school year, that covered topics such as alignment and best practices. The consultants planned with the district's Chief Academic Officer and Senior Director of Teaching and Learning to create the parameters and content for the institute. This professional development session addressed several of the areas of deficiency reported in the district's initial needs assessment to answer research question one. Teachers were introduced to the learning tools and strategies listed in the procedure and shown how to implement them in their classrooms. Teachers were trained on the active learning design model as depicted in Figure 3, which encouraged student engagement through interactive and collaborative classroom activities. This model required teachers to create opportunities for students to explore, experiment, and apply their knowledge in meaningful ways. Teachers were guided on how to facilitate student-led inquiries that encourage critical thinking, problem-solving, and exploration of local ecosystems and communities. They developed practices to help their students communicate their understandings with claims, support their claims with evidence, and connect their evidence to scientific principles. The teachers also practiced creating effective anchor charts that visually conveyed important facts about the science content. Since anchor charts are made during the lesson in collaboration with the students to reinforce instruction, the teachers modeled their creations with each other. In creating a table of specifications (TOS), the teachers began by unpacking the essential knowledge and practices of the standards for looking for cognitive levels and content. They then aligned them with their learning objectives by plotting the intersection between the content and level of cognitive demand for each learning objective. Finally, they indicated the intersection of Bloom's taxonomy and standard objectives on the chart to create a blueprint for what should be included or should not be included in an assessment, whether formative or summative. They were also shown how to use a TOS to improve the validity and reliability of teacher-made assessments.

Early in the school year, the consultants held a professional development session that focused specifically on Tier II and Tier III science vocabulary words. This PD session addressed the teachers' self-reported inability to incorporate Tier II and III vocabulary integration strategies into their instruction. Implementing effective strategies to teach Tier II and Tier III science vocabulary to teachers is crucial for enhancing students' understanding and retention of scientific concepts. In this PD session, the teachers focused on how they currently had their students learn Tier III science vocabulary words, the importance of explicitly teaching Tier II (process words) vocabulary, and what specific discourse structures or protocols the teachers could have in place for students. To begin, the teacher first needed to understand the distinction between Tier II vocabulary, consisting of high-frequency words used across various subjects, and Tier III vocabulary, which comprises subject-specific terms essential for understanding a particular discipline like science. The teachers reviewed various Tier II process verbs and model questions for each level of Bloom's taxonomy to help them integrate Tier II vocabulary seamlessly into their science curriculum to enhance students' overall academic language proficiency. In recognizing the importance of explicitly teaching Tier III vocabulary in science lessons, teachers need to first understand that a definition of a Tier III word is only useful to a student after they have background knowledge upon which to frame the word. Tier III words gain meaning from context, and new words must be built into a framework of existing knowledge through examples and non-examples. Teachers are left with a better understanding of teaching vocabulary by using strategies such as Everyday Words to build academic/technical language when students are likely to have an everyday functional word that describes an object, idea, concept, or phenomenon and Everyday Meanings to explicitly teach words that have multiple meanings [32]. The teachers practiced techniques that would help students learn to differentiate the meanings by allowing them to use text, diagrams, or illustrations to represent the meanings.

In the spring of the same school year, the consultants and community partners provided the district with an environmental field experience that was the epitome of place-based learning for teachers, students, and administrators. This professional development focused on helping the school system develop and implement a sustainable Meaningful Watershed Educational Experience (MWEE). Teachers and administrators spent the day at a local state park investigating what factors affect the health of their bay, its tributaries, and the watershed they live in. Activities supported place-based learning approaches and included marsh interpretations, a biotic station where they observed living organisms from the local river, an abiotic station where they tested the water quality, and a schoolyard report card. This addresses research question two. They later reconvened to connect the state science standards to the activities of the day. The goal of the workshop was for participants (teachers and administrators) to develop their understanding of environmental literacy. This professional development field experience served as a model for the place-based learning MWEE field trip for the 5th-grade and biology students. The teachers assisted the consultants and the community partners as they presented the environmental science content to students, rotating through hands-on investigation stations.

In addition, various place-based learning activities were conducted on school grounds to enrich the educational experiences further. One such activity involved students using information from a schoolyard report card to identify environmental issues within their school or local community and work collaboratively on finding solutions. The schoolyard report card, created by the Chesapeake Bay Foundation, addressed possible areas of concern like runoff and erosion, transportation, vegetation, biodiversity, and awareness [33].

Based on their report card findings, teachers were encouraged to facilitate stewardship projects with their students, such as implementing a composting or recycling program, creating a garden space on the school grounds, or raising oysters for habitat restoration. Additionally, partnerships were established with community organizations, local businesses, and experts in relevant fields to provide students with hands-on experiences and real-world connections to their learning. Field trips to nearby parks, nature reserves, or sustainable businesses allowed students to explore the broader environment and understand the interconnectedness between their school and the surrounding community. These activities deepened students' understanding of their local environment and instilled a sense of responsibility and empowerment in taking action toward positive change.

2.6.1. Preparation to Take the End-of-Course Tests

At the state education level, science standards were revised in 2018. Along with revisions to the essential knowledge and practices for each standard, the state test also had changes. Traditional recall questions were no longer being asked as the test moved toward questions that drive higher-order thinking. In addition to the standard multiple-choice questions, students were being asked a series of questions, or cluster questions, that focused on a central scientific topic or theme. Students were asked more about the application of a concept rather than general recall. Students were also expected to interact with some test questions to collect their responses through technology-enhanced items (TEI) like fill-in-the-blanks, drag-and-drop, graphing, or multiple selection questions. These changes in the state science tests called for training for both teachers and students. Prior to the start of the state testing window, the consultants held a workshop that addressed the changes in the test format and student test preparations. The workshop revolved around the idea that teachers should be teaching content that is aligned with expectations provided in the state's science curriculum framework. This will result in improved performance on classroom and state assessments. Another central idea addressed in the workshop was the need to integrate science and engineering practices with science content throughout instruction and assessment. Teachers concluded the workshop by exploring what instruction should look like through the lens of the teacher and the student to understand what mastery looks like for each student to address question three.

2.6.2. Reviewing Quarterly Benchmark Assessment Data

Throughout the school year, the consultants/researchers reviewed common assessments and benchmark tests quarterly data and provided feedback to teachers and administrators to assist them in designing a plan for the remediation of skills for their classes. The consultants provided teachers with science resources that targeted the specific areas of deficit. Once students in need of remediations were identified by the administrators, the consultants worked directly with this group to provide additional testing support for the 5th grade and biology state assessments. Remediation activities were based on standards testing items most likely to be seen on the assessment and based on constructivism principles. Activities focused on using constructivist teaching strategies to help students synthesize content information while integrating science and engineering practices into their learning experiences. Working in small, collaborative groups, they became more familiar with the overall content and with test testing strategies. Through modeling and guided questions, the consultants helped the students understand desired outcomes and take ownership of their successes.

3. Data Analysis

3.1. Teacher Professional Development Surveys Data

Data from surveys conducted with teachers following professional development sessions was coded thematically. This method was used to identify and analyze surveys collected from each teacher and administrator at the end of each PD session. All teachers and administrators reviewed and signed an agreement that allowed the researchers to collect and use the data. Surveys were administered digitally to the participants to gather feedback, insights, and concerns about each PD topic. The responses were compiled and organized for systematic analysis. The data collected and reviewed from the surveys served as the primary source for the thematic coding. Inductive and deductive coding were used to address the research questions of this study. In qualitative analysis, inductive reasoning involves reviewing raw data and condensing it into themes or categories based on inferences and interpretation [34]. The top–down (deductive) approach was used to address Research Questions 1 and 3; the codebook was developed to guide the researchers through the coding process. During the coding process, themes emerged from the data. Researchers refined the codes and grouped related codes to develop coherent, meaningful themes that fully encapsulate the participants' responses. The feedback gathered from these surveys guided the refinement of professional development offerings, ensuring alignment with teacher needs and goals.

3.2. Place-Based Learning Data

Data collected specifically on the place-based learning component were observational notes and photographic records; it included student interactions with hands-on exploration of diverse habitats at each learning station in the local state park, offering insights into the impact of real-world experiences on student learning. Analysis of place-based learning data highlighted connections made between classroom concepts and environmental issues, fostering a deeper understanding of scientific principles within authentic contexts. This observational data-informed future place-based learning initiatives and underscored the value of experiential learning opportunities.

3.3. Increase in State Testing Scores and Walkthrough Data

Assessment data tracking the increase in state testing scores provided quantitative evidence of the project's impact on student achievement to address Research Question 2. Comparing the last few years of state testing results allowed for measuring student academic growth, skill development, and knowledge retention. Analyzing the increases in state testing scores demonstrated the effectiveness of the constructivist and place-based learning approaches in enhancing student learning outcomes and academic performance in science.

Through conducting a descriptive analysis to investigate the connection between the fifth-grade pass rate from the previous school year and the biology pass rate for the 2022 and 2023 school years utilizing the 2010 and 2018 test standards, the goal of understanding how the changes that occurred during the study with placed-based learning and science education have impacted student achievement was met.

During the classroom walkthroughs, data were collected through note-taking, photographs, and recordings if needed for reflective teaching for the teachers so that we can draw on the findings of the walkthroughs to respond to research question one. The administrators were encouraged to record evidence of effective science instruction and teachers' conversations with students, such as students actively involved in scientific investigations, discourse, or collaborative assignments.

Overall, the comprehensive data analysis encompassed classroom walkthroughs, teacher professional development surveys, place-based learning methods, and improved state testing scores, offering a multifaceted evaluation of the project's success in promoting engaging and effective science education support.

4. Results

4.1. Teacher Learning and Change

The school district–university partnership significantly impacted the educators' approach to teaching. Through the professional development sessions, classroom walkthroughs, science and constructivist pedagogy, and place-based learning implementation, the teachers exhibited notable improvements in several key areas, including positive changes in instructional practices, classroom strategies, and overall approach to teaching.

These interventions inspired teachers to embrace innovative pedagogical approaches, emphasizing student-centered learning, hands-on exploration, and real-world connections. Teachers included more interactive and inquiry-based lessons that engaged their students in the learning process. Teachers also included anchor charts and introduced science vocabulary during the lessons rather than front-loading them, which had been previously performed. Through field-based instruction, teachers demonstrated a heightened awareness of the importance of incorporating place-based learning into the science curriculum. They integrated local environmental issues, community resources, and outdoor learning experiences to enrich the educational content and make science concepts more relevant and relatable to students' daily lives.

The adoption of place-based learning strategies and science pedagogy resulted in heightened student engagement and interest in their science classes. This was observed during walkthroughs with administrators and discussed with the teachers during the feedback sessions. Teachers reported observing a greater sense of curiosity in their students as they connected classroom learning to their surroundings, fostering a deeper appreciation for the natural world.

The PD sessions fostered a culture of collaboration and shared learning among teachers, encouraging the exchange of ideas, best practices, and resources. The collaboration among the teachers to share best practices and resources for teaching science vocabulary also enhanced the effectiveness of vocabulary instruction in the classroom. Teachers and administrators worked together to implement innovative lesson plans, leverage community partnerships, and create meaningful learning experiences that promote student success. The teachers demonstrated professional growth and reflective practices as a result of the PD sessions and classroom walkthrough feedback. They began to expand their pedagogical toolboxes and integrate new technologies and experiential learning tools into their instruction. The focus on place-based learning and science pedagogy empowered the teachers to be lifelong learners committed to ongoing improvement and innovation in their instruction.

The positive changes in the participants' teaching practices, an increase in student engagement in the classroom, more collaborative learning environments, and professional growth reflect a commitment to student-centered, experiential learning and a dedication to nurturing a culture of inquiry, exploration, and environmental stewardship in the classroom.

4.2. Science Classroom Walkthroughs

The consultants/researchers conducted monthly and quarterly science classroom walkthroughs with a school administrator and a central office administrator present to provide ongoing monitoring and support for effective science instruction. We conducted walkthroughs in the science classrooms to gain insight into the teaching and learning practices, instructional strategies, and student engagement specific to science education. The focus was on observing science instruction in action, providing feedback for improvement, and ensuring alignment with the written and tested curriculum. During the walks, each observer recorded notes on various aspects of the lesson, such as the learning objectives, the use of instructional materials, the implementation of hands-on activities, the level of student participation and engagement, the use of technology, and the integration of scientific inquiry and problem-solving skills. After each walkthrough, the administrators joined the science consultants/researchers to compile the data collected, discuss the strengths and areas for improvement observed, and suggest the next steps. The next steps were sometimes additional PD or resources needed from the consultants. Teachers would then join the team immediately for feedback and recommendations, which may include commendations for a successful execution of the lesson or suggestions for enhancing instruction before their next class.

4.3. Teacher Feedback Sessions

A teacher walkthrough feedback session was a structured meeting conducted by the science consultants, administrators (central and school-based), and the teacher to provide feedback on the classroom observation. The purpose of the session was to offer constructive feedback, recognize strengths, address areas for improvement, and support teacher professional growth. The session typically began with a review of the objectives and goals of the walkthrough. The walkthrough team shared specific observations and notes gathered during the classroom visit that focused on instructional strategies, student engagement, science content, and overall teaching effectiveness. Positive aspects of the instruction were highlighted, acknowledging effective practices and successful student interactions. Areas for improvement were also discussed in a supportive and collaborative manner. The team provided actionable feedback, suggestions for enhancement, and resources for further professional development. The teacher would then be allowed to ask questions and seek clarification on any points raised during the walkthrough observation. The teacher was also encouraged to reflect on the feedback, which is the final step of the active learning instructional design shown in Figure 3. The sessions aimed to foster a culture of continuous improvement, professional learning, and collaboration within the school and district.

Overall, a teacher walkthrough feedback session serves as a valuable opportunity for teachers to receive constructive feedback, reflect on their practice, and work collaboratively with science consultants and administrators to enhance instructional effectiveness and student learning outcomes. The administrators would discuss the follow-up support needed based on the findings from the walkthroughs. The science consultants offered ongoing support and resources to science teachers and administrators, which included sharing best practices, implementing place-based learning strategies, providing access to science education resources, and facilitating professional development workshops tailored to the needs identified. These findings allow us to respond to research questions two and three. Our science classroom walkthroughs with the administrators serve as a valuable tool for promoting effective science instruction, supporting teacher development, and ensuring that students receive high-quality science education aligned with standards and best practices.

4.4. Student Achievement

The state introduced updated science standards in 2018, with the new standards test being administered for the first time in spring 2023. The district offered the biology course as a semester-long subject, and some students took the older 2010 standards test version while others took the more recent 2018 version, as shown in Table 2. In contrast, all fifth-grade students sat for the 2018 standards version of the test, as their course spanned the entire academic year.

Table 2. Pass rates in state-standardized tests.

Grades	Spring 2021	Spring 2022	Fall 2022	Spring 2023
Fifth grade	(2010): 16%	(2010): 42.11%	N/A	(2018): 62%
Biology	(2010): 39%	(2010): 47.62%	(2010): 59.52%	(2010): 71% (2018): 69%

The state's Department of Education reported in September 2023 that students in Grades 3–8 were still struggling to recover from learning loss due to the pandemic. The 2022–2023 SOL tests showed that students are not performing as well as their pre-pandemic peers [35]. The state's scores stayed primarily flat, with only a 2%–5% increase between the 2021–2022 and 2022–2023 school years in biology and fifth-grade science, respectively [35]. However, the end-of-course test pass rates for fifth-grade science and biology students in the study's school district experienced a remarkable 20 percentage points increase on a new, more rigorous test, soaring to an impressive 62% in fifth grade and 71% (2010) and 69% (2018) in biology.

Previously, teachers had been instructing students on the 2010 standards. In the study school year, teachers were required to learn new content and standards to prepare their students for a new test with new styles of testing items mentioned in the "Preparation to Take the End-of-course Tests" section. Table 2 depicts the district's student achievement with historical data showcasing the steady improvement over the years.

Upon conducting a thorough examination of the available data on the state school quality profile beginning in 2021, it is evident that targeted teacher professional development and place-based learning strategies played a pivotal role in this significant improvement. The current district administration also attributed this increase to the support of the consultants, which led to the high school becoming fully accredited. Descriptive statistical analysis confirmed a statistically significant growth in student performance, underscoring the effectiveness of the implemented interventions. The positive impact of these initiatives on student outcomes highlights the importance of data-driven decision-making and tailored instructional approaches in fostering academic success among fifth-grade science and biology students within the district.

4.4.1. Teacher Learning

Qualitative data obtained through teacher and administrator surveys, classroom observations, and teacher feedback sessions provided valuable insights into the factors contributing to the improvement in science scores. The themes emerging from the qualitative data analysis highlighted the effectiveness of the implemented pedagogical approaches, the impact of teacher professional development on instructional practices, and the importance of place-based learning in enhancing student engagement and learning outcomes (Table 3). Through the utilization of thematic coding, researchers were able to effectively extract meaningful insights from the participants to inform future decision-making and program improvements for the school district, as shown in Table 3.

Table 3. Codebook for Teacher and Administrator Surveys.

Themes	Code	Definitions	Examples from Teacher and Administrator Surveys
Effectiveness of the Implemented Pedagogical Approaches	Pedagogy	This code relates to feedback or perceptions on the effectiveness of the pedagogical approaches implemented in the classroom.	"Every workshop treated the teachers as learners; hence, we were able to "see" how to translate this to student engagement and learning". Participant 3
Impact of Teacher Professional Development	PD	This code pertains to the influence of teacher professional development sessions on instructional practices, policies, and teaching methodologies.	"As a result of the professional learning, teachers feel more comfortable with Science. They understand the importance of LEAFs, MWEEs, and alignment of the written-taught-tested curriculum". Participant 1
Importance of Placed-Based Learning in Enhancing Student Engagement and Learning Outcomes	PBL	This code represents insights into the significance of placed-based learning in improving student learning in improving student engagement, academic performance, and overall learning outcomes.	"They really broadened my horizons on how I can make local connect[ion]s to the material I'll be teaching this year". Participant 6

The three research questions of this study have been answered by the development of the codebook that reflected effective feedback or perceptions on the effectiveness of pedagogical approaches in the classroom, the impact of teacher professional development, the significance of place-based learning on student outcomes, and participant survey responses and quotes. A review of the research questions and how each was addressed is presented in Table 4.

Table 4. Research Questions and Data Type.

Research Questions	Data Type
1. Does science teacher professional development impact science scores in Grade 5 and biology?	Participant responses (coded)
2. To what extent does students' place-based learning in science contribute to the improvement of science scores in Grade 5 and biology?	Table 2: participant responses (coded)
3. What challenges and successes were accomplished during the partnership time period?	Participant responses (coded)

4.4.2. Teacher and Administrator Quotes

Participant 3 commented, "Every workshop treated the teachers as learners; hence, we were able to "see" how to translate this to student engagement and learning". Participant 1 disclosed, "As a result of the professional learning, teachers feel more comfortable with Science. They understand the importance of LEAFs, MWEEs, and alignment of the written-taught-tested curriculum". Participant 8 noted, "The workshops were very well organized and informative, giving me an opportunity to learn about the different topics in a hands-on and interactive way". Participant 6 felt, "They really broadened my horizons on how I can make local connect[ion]s to the material I'll be teaching this year".

Focusing on student involvement, Participant 5 stated, "The workshops were very helpful in teaching me how to ensure that the students are driving the instruction. They need to be the ones doing the talking. The students also need adequate time to be able to ask questions. This workshop helped to enhance this skill for me". Regarding using resources, Participant 2 noted, "Anchor charts were something I had very, very misunderstood. They were able to show me a new model of an anchor chart that will hopefully be more effective". Participant 10 added, "Our vocabulary workshop gave me useful tools to use to help students reach mastery". Participant 7 wrote, "As a first-year teacher the workshops provided valuable resources to assist in my instruction". Participant 5 even stated, "Dr. Ferrell as an amazing energy when it comes to teaching science, and I could feel it while she was teaching us how to teach. I would love for her to come back and do more workshops on how to create engaging, exciting lessons for science".

4.4.3. Local Community Partners' Quotes

One partner stated, "{our organization} is proud to partner with {school district} and The Center for Educational Partnerships to provide professional learning opportunities for the teachers and outdoor field experiences for students. It has been exciting to see the students embrace the outdoors and learn from hands-on activities".

Another partner stated, "I loved hearing from the teachers about why they believed this work is important. It showed me how different people with varying perspectives can come together for this goal".

5. Discussion

5.1. Summary

The theoretical framework of place-based learning in science instruction for the fifth grade and for biology was well situated for this study. Scores in both fifth-grade science and biology increased by 20 or more points overall. In addition, by grounding scientific concepts in local contexts, students were able to develop a deeper understanding of scientific principles, engage in critical thinking and problem-solving, and become active participants in addressing environmental challenges.

The descriptive analysis investigated the connection between fifth grade and biology pass rates for the 2022 and 2023 school years, respectively, and helped identify trends or patterns over time. Further exploration of these test results may uncover future trends over time and provide valuable insights for educational planning and policy decisions in the district.

Based on the impact of the school district–university partnerships led by the higher education faculty on the rural school district's teachers, students, and administrators, this study employed a needs assessment, teacher training, and ongoing support through modeling and coaching that resulted in changes to teachers' classroom instruction, changes in students' learning opportunities, and year-on-year increases in pass rates on the state assessments.

5.1.1. Summary of the Learning Process

The learning process for the participants in the study proved to be effective in allowing the teachers to gain an understanding of place-based learning and active learning instructional design. Teachers grasped the idea that place-based learning involved connecting classroom curriculum to local environments, communities, and resources [36]. The strategies and practices included identifying local resources, designing relevant learning experiences, and aligning activities to the state curriculum standards. This method stressed the importance of hands-on experiences and practical, real-world applications for students, as evidenced by the field experiences embraced by both teachers and students. As a result, the district sought and secured funding to support future MWEEs that will take place over the upcoming years.

Collaborating with teachers on the active learning design model approach empowered students to take ownership of their learning and establish connections between classroom content and the surrounding world. Throughout the training process, teachers are encouraged to engage in self-reflection (refer to Figure 3) on their teaching methods and the influence of place-based learning on student involvement and success. Continuous reflection and feedback assist participants in refining their instructional approaches and improving the learning experience for students, enabling them to self-reflect on their learning (refer to Figure 3).

In summary, the learning process for teachers trained in delivering place-based learning through the active learning model involves understanding the principles of place-based learning, integrating active learning strategies, planning engaging lessons, facilitating student inquiries, and reflecting on teaching practices to improve student outcomes.

5.1.2. Summary of Modeling and Coaching

Consultants modeled and coached the science teachers throughout the school year, which involved demonstrating effective teaching practices with their students and providing support to enhance their instructional skills and strategies observed during the classroom walks with the administrators. The process included showcasing best practices in science education, guiding teachers in implementing inquiry-based learning techniques, and offering ongoing feedback and guidance to improve teacher efficacy in the classroom. Through modeling and coaching, science teachers were encouraged to reflect on their teaching practices, collaborate with teachers across the district during professional development sessions, and continuously improve their instructional methods by implementing placed-based learning and active learning design models to enhance student learning outcomes in the science classroom.

5.1.3. Summary of New Strategies Implemented

In the science classroom, various new strategies were implemented to enhance student engagement and learning through this study. Through the active learning design model, teachers facilitated their students to be fully involved in their learning through hands-on activities, discourse, and interactive experiments, fostering deeper understanding and retention of scientific concepts. Another strategy used in the study was anchor charts, which teachers were trained to use interactively with their students to provide a reference point and help them visualize and remember key information and processes in science. The table of specification was utilized with teachers during the planning of their lessons to help them outline the content coverage and cognitive levels of questions in assessments, ensuring a balanced and comprehensive evaluation of student knowledge and skills. Questions at all levels of Bloom's Taxonomy were introduced to ensure that teachers incorporated a variety of knowledge, application, analysis, synthesis, and evaluation-level questions to stimulate critical thinking and problem-solving skills among their students. During the study, the main focus was to ensure that all lessons and activities were aligned with state and national science standards to ensure that students were meeting the required learning objectives and competencies. The next strategy that was used with teachers in the study was focused on Tier II and III vocabulary. The emphasis was placed on helping teachers reinforce Tier II (academic) and introduce Tier III (science) vocabulary to enhance students' language proficiency and comprehension of scientific terminology. Teaching teachers how to effectively instruct Tier II and Tier III science vocabulary is essential for promoting students' academic success in science education. By equipping educators with the necessary tools, techniques, and strategies to teach science vocabulary, they can empower students to develop a strong foundation in scientific literacy and critical thinking skills to address research question one. Overall, these new strategies were implemented in the science classroom to promote active learning, improve the visual representation of information, enhance assessment practices, build vocabulary skills, ensure curriculum alignment, and foster higher-order thinking skills among students.

5.2. Perceptions of Effective Science PD and Support

At the end of each professional development session, the participating teachers and administrators were given a professional learning survey to collect feedback on the science professional learning workshops and support offered in the district each year. This helped determine what they felt was most useful for the support and implementation of instruction. The survey questions were designed to assess the participants' skill levels and their ability to put into action the science strategies that were presented in the PD before and after the professional development session occurred. Participants (Table 1) were also asked if the workshops and support met or exceeded their expectations. The consensus to the workshops and support was that they provided needed instruction and input on teaching science in and out of the classroom.

5.3. Limitations

The research presented here is a case study and, as such, is limited in its generalizability to other districts and points in time. A second limitation is the relatively brief period during which the school district–university partnership was active, which prevents us from examining the longer-term impacts of the partnership activities and the potential impacts of sustained, multi-year support. Despite these limitations, we find that even a one-year partnership that focuses on X, Y, and Z revealed a substantial capacity for increased learning among rural teachers, administrators, and students.

Moving forward, this study prompts consideration of how to maintain the progress and teacher capacity that resulted in positive student outcomes within the rural school district. The challenges encountered, such as limited resources, small size, high teacher turnover, and restricted instructional capacity, underline the importance of addressing these factors to sustain the growth observed. By strategizing ways to mitigate these challenges, such as enhancing educational resources, implementing retention strategies for teachers, and building instructional capacity, the district can work toward ensuring continued success in improving student achievement and fostering a conducive learning environment.

6. Conclusions

In conclusion, a one-year school district–university partnership was associated with substantial increases in pass rates for fifth-grade and biology students when compared to historical data gathered before the onset of the partnership. Our team's methodology, involving curriculum updates, teacher training, administrative support, STEM integration, and collaboration with community partners, is highly effective. The research affirms the potential impact of school district–university partnerships led by higher education faculty who enter into needs-based, collaboratively designed partnerships that provide professional development for K-12 teachers. The study highlights the positive outcomes of these collaborations in enriching content knowledge, advancing science teaching practices, and boosting teacher efficacy. By addressing the challenges teachers faced in a diverse student population within a rural district, the study emphasized the critical role of science education, particularly in grade levels where students take end-of-course state tests.

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