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# The university academies: an improvement science research platform for P-20 education

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The University of Texas at Tyler University Academy (UA) serves as an innovative case study in applying Improvement Science within a K-12 educational setting. This research examines how the UA, operating across rural, urban, and suburban campuses, has embedded the Plan-Do-Study-Act (PDSA) cycle to drive continuous improvement in student and teacher outcomes. Using Stake's Holistic Case Study Approach, the study explores the UA as both an intrinsic case, valuable for its unique educational model, and an instrumental case, offering insights applicable to broader educational contexts. Drawing on foundational work in Improvement Science, including that of Douglas Engelbart and Anthony Bryk, this manuscript situates the UA within a rich historical and theoretical framework. It highlights key interventions, such as blended learning for literacy, Response to Intervention (RTI), and dual credit programs, are examined as case examples to illustrate how iterative, data-driven approaches are associated with improvements in student achievement and teacher professional development. The findings suggest that continuous refinement through Improvement Science may support effective instructional strategies and context-specific adaptations across diverse educational environments, providing insights for institutions considering similar evidence-based approaches.

KEYWORDS

**improvement science, case study, plan-do-study-act (PDSA), UT Tyler University academy, student achievement, PBL, laboratory school, dual credit programs**

## Introduction

Improvement Science, a systematic approach to addressing complex problems through iterative cycles of change, has been effectively utilized across sectors such as healthcare and manufacturing. However, its potential within K-12 education remains largely underexplored. This manuscript seeks to fill this gap by demonstrating how Improvement Science can transform educational outcomes through data-informed, iterative methodologies like the Plan-Do-Study-Act (PDSA) cycle.

The University of Texas at Tyler University Academy (UA) serves as a public open enrollment laboratory school with a mission to support the School of Education's (SOE) STEM teacher preparation program through high-quality, research-driven educational practices. Established as a model K-12 STEM Academy, the UA emphasizes Project-Based Learning (PBL) with Biomedical and Engineering pathways aligned with university-level degree programs. The Academy operates across three distinct settings—rural, urban, and suburban—which provides a unique research environment to study the impact of diverse educational practices and settings on student and teacher outcomes. This paper explores the University Academy's application of Improvement Science as a strategic framework for continuous improvement in school practices and outcomes, using the PDSA (Plan-Do-Study-Act) cycle methodology to drive data-informed improvements across the academic year and longitudinally.

UA administrators and faculty work in close partnership with UT Tyler researchers and faculty to conduct collaborative research within an Improvement Science framework. This partnership extends to UA teachers, who benefit from tuition-free opportunities to pursue advanced degrees, fostering a collaborative research community. Through sustained research efforts, the UA addresses key educational needs such as achievement gap closure and student success post-graduation. The Improvement Science framework and mixed-methods approach enables the UA to engage in longitudinal research, track outcomes, and implement annual cycles of improvement to strengthen academic achievement and support STEM-focused teacher preparation. This manuscript highlights various research projects within the UA model, examining outcomes of the Improvement Science approach on school improvement and student success, particularly in STEM education and post-secondary readiness. The following mind map shows an overview of the university academy in context as a laboratory school (Figure 1).

## Literature review

The study of Improvement Science has evolved over several decades, drawing from fields such as manufacturing, healthcare, and education. While the work of Anthony Bryk et al. (2015) has been pivotal in shaping its application in K-12 settings, the broader theoretical foundation of Improvement Science extends beyond this singular framework. Early contributions from Deming (1986) established the Plan-Do-Study-Act (PDSA) cycle, a structured approach to continuous, iterative problem-solving that remains central to Improvement Science practices today.

The Improvement Guide by Langley et al. (2009) further operationalized Deming's framework, offering structured methodologies for applying PDSA cycles in complex systems. These principles were initially adopted in healthcare, where iterative refinements in clinical practices demonstrated significant improvements in patient care outcomes (Batalden and Davidoff, 2007). Over time, Improvement Science found its way into education, where schools sought structured, data-driven methods to enhance teaching quality, curriculum effectiveness, and student learning.

Engelbart (1992) introduced the concept of Networked Improvement Communities (NICs), emphasizing the power of collective intelligence and system-wide collaboration in driving sustained improvement. This model has been widely adopted in education, particularly in efforts to address systemic challenges like teacher retention, equity gaps, and curriculum design (LeMahieu et al., 2017).

In K-12 education, Improvement Science has been used to inform teacher professional development (Hannan et al., 2015), instructional design (Lewis and Perry, 2009), and assessment practices (Bryk et al., 2015). The application of PDSA cycles in school settings has demonstrated efficacy in aligning instructional goals, evaluating progress, and sustaining improvements over time. Research in higher education also underscores the value of Improvement Science in curriculum reform, student engagement, and institutional effectiveness (Kezar, 2014).

By integrating historical foundations, cross-sector applications, and contemporary research, this review provides a comprehensive understanding of Improvement Science beyond its recent applications in education. The literature suggests that system-wide, embedded Improvement Science efforts, such as those implemented at the UA, represent an evolution in the field, demonstrating that PDSA cycles can be scaled beyond isolated pilot initiatives.

## The improvement science framework and PDSA cycles

Improvement Science provides a structured approach to problem-solving that differs from traditional experimental research. Unlike

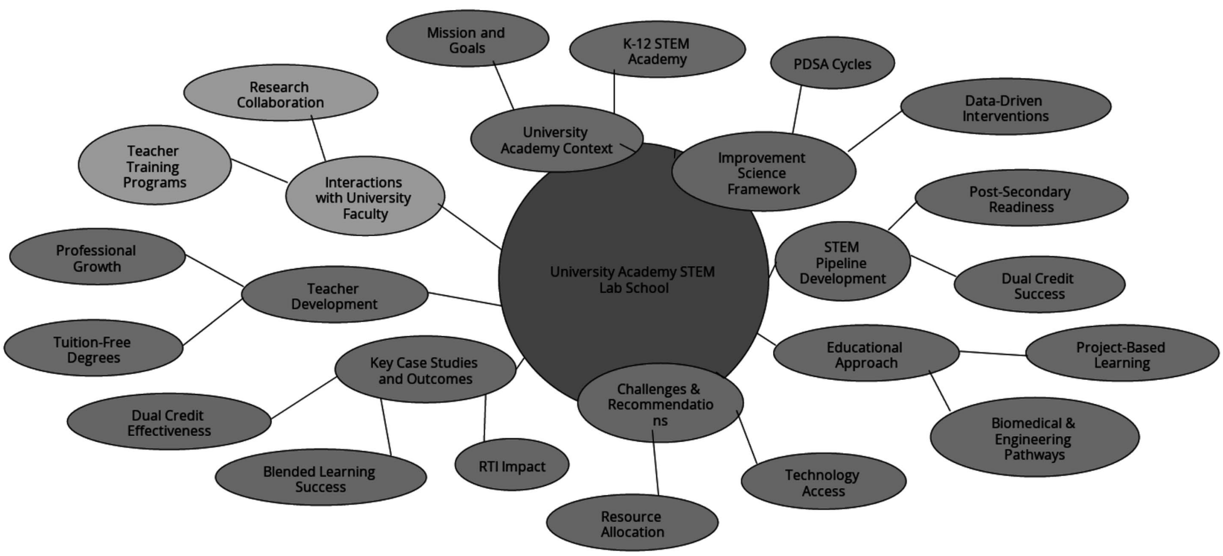


FIGURE 1
University academy in context.

randomized controlled trials, which seek to establish causality through isolated interventions, Improvement Science focuses on continuous, iterative refinement within real-world settings (Bryk et al., 2015). This approach acknowledges the complexity of educational systems and emphasizes adaptation rather than rigid implementation of predetermined interventions.

The Plan-Do-Study-Act (PDSA) cycle is central to Improvement Science, offering a systematic process for testing, evaluating, and refining strategies in education (Langley et al., 2009). The PDSA cycle consists of four iterative steps:

1 Plan – identify a problem, develop a hypothesis, and design an intervention.
2 Do – implement the intervention on a small scale.
3 Study – collect and analyze data to assess its impact.
4 Act – adjust the intervention based on findings and scale up successful strategies.

This cyclical, real-time learning approach has been widely adopted in educational settings to improve instructional practices, student outcomes, and institutional decision-making (Lewis and Perry, 2009). The flexibility of PDSA cycles makes them particularly effective for addressing systemic challenges, allowing schools to adapt interventions to their specific contexts while maintaining a commitment to data-driven decision-making.

## The case for systemic implementation of improvement science

The use of Improvement Science in K-12 education has traditionally been limited to small-scale pilot programs or targeted interventions, rather than systemic, large-scale applications. While effective in isolated instances, these approaches often fail to address broader structural and cultural challenges within educational systems. The UA presents a compelling case for embedding Improvement Science at an institutional level, demonstrating the feasibility of large-scale, district-led implementation.

Scaling Improvement Science across entire educational systems is inherently complex. Schools operate within multi-layered socio-political environments, making it difficult to ensure alignment of Improvement Science practices across multiple campuses. Effective implementation requires substantial investment in training, data infrastructure, and ongoing professional development, all of which present significant resource constraints. Furthermore, embedding iterative, data-driven practices necessitates a cultural shift from compliance-based approaches to improvement-oriented mindsets among educators and administrators.

The UA addresses these challenges through a multi-layered, embedded framework that integrates PDSA cycles at every operational level—from classroom instruction to district-wide policy decisions. Through its Networked Improvement Community (NIC) model, the UA fosters collaborative problem-solving across its rural, urban, and suburban campuses. The academy sustains these efforts by providing tuition-free advanced degree opportunities for teachers, ensuring a highly skilled and committed faculty.

By institutionalizing a data-driven culture, supported by real-time data collection and analysis systems, The UA has established an environment where continuous learning and improvement are embedded in everyday practice. This systemic approach illustrates the potential of Improvement Science as a scalable model for educational transformation.

## The university academy as an improvement science laboratory

The UA was founded to serve as a laboratory school that integrates Improvement Science into every aspect of its operation. This model aligns with national recommendations for strengthening STEM education, particularly those outlined in the National Academies' *Rising Above the Gathering Storm* report (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007). The report emphasized the urgent need for educational reforms to maintain U.S. competitiveness in STEM fields, advocating for the development of specialized STEM schools as hubs for innovation in teacher training and student learning.

To address this national directive, the University of Texas at Tyler established the University Academy as a research-based, STEM-focused laboratory school. The UA's model (Texas Education Agency, 2015) incorporates Project-Based Learning (PBL) and STEM career pathways, providing both pre-service and in-service teacher training that aligns with workforce needs. This dual-purpose approach supports both teacher professionalization and student readiness for STEM careers, in line with the recommendations from *Rising Above the Gathering Storm*.

The UA employs a continuous improvement model, deeply rooted in Improvement Science principles, as first articulated by Deming (1986) and Bryk et al. (2015). The Plan-Do-Study-Act (PDSA) cycle serves as the foundation for ongoing, data-driven decision-making, enabling educators to refine instructional practices in real-time. The academy has successfully scaled Improvement Science principles across all operational levels, making it one of the most comprehensive district-led applications of IS in K-12 education.

Key contributions to the field also include Langley et al. (2009) the improvement guide, which provides practical methodologies for applying PDSA cycles in schools. Building on these principles, Lewis and Perry (2009) highlight the need for adaptive research models in education, advocating for cycles of testing and refinement like those used at the UA.

Additionally, Networked Improvement Communities (NICs) play a critical role in the UA's Improvement Science framework, as demonstrated by LeMahieu et al. (2017). Their work shows how schools can benefit from collaborative, network-based problem-solving, reinforcing the UA's approach to scaling continuous improvement efforts across multiple campuses.

By embedding Improvement Science principles at an institutional level, the UA demonstrates that large-scale, systemic improvement is both feasible and effective in K-12 education. This study contributes to the literature by offering a replicable model that integrates PDSA cycles, NIC collaboration, and STEM-focused learning into a cohesive, district-wide improvement effort. As more schools and districts explore the potential of Improvement Science, the UA's framework offers valuable insights for sustaining long-term, data-driven educational transformation.

## Research questions

Using Stake (1995) case study methodology, this research aims to explore the UA as a comprehensive case study. The University

Academy serves as a unique educational ecosystem and a "living laboratory" for applying and refining Improvement Science. This study seeks to understand the longitudinal impact and efficacy of Improvement Science practices within the UA. The primary research questions guiding this investigation are:

1. How has the systematic use of Improvement Science contributed to longitudinal improvements in student achievement at the UA?
2. What practices have been most effective in achieving these gains across diverse educational settings (rural, urban, suburban)?

These questions frame the investigation into the UA's holistic approach and the variation in outcomes across different contexts, allowing for an in-depth understanding of how Improvement Science drives educational success.

# Methodology

This research employs Stake's Holistic Case Study Approach (1995) to investigate the UA as both an intrinsic and instrumental case study. The UA serves as an intrinsic case because of its unique role as an open-enrollment, university-affiliated STEM laboratory school, providing a research-based model for school improvement and educator preparation. At the same time, it functions as an instrumental case, offering broader insights into how Improvement Science principles can be embedded within K-12 educational settings.

Stake's case study methodology is particularly well-suited for studies that seek to explore complex, real-world educational environments where multiple, interdependent factors influence outcomes. Unlike traditional case study approaches that aim for generalizability, Stake's interpretivist framework prioritizes deep, qualitative understanding of a specific educational setting with distinct operational characteristics. In this study, the UA serves as the central site of inquiry, encompassing rural, urban, and suburban campuses, making it an ideal setting to examine the iterative application of Improvement Science across different demographic and instructional contexts.

The UA is an open-enrollment public school, meaning it does not have selective admissions criteria, entrance exams, or eligibility requirements beyond space availability. Any student who applies is admitted if there is an available seat, regardless of prior academic performance, socio-economic status, or background. This structure ensures equitable access and distinguishes the UA from magnet or selective schools that admit students based on competitive criteria. Like all open-enrollment public schools in Texas, the UA operates under the same policies, regulations, and accountability standards as traditional public schools and is subject to the same state-mandated assessments and performance evaluations. This ensures that the findings from this study are situated within an authentic public-school context, reinforcing that Improvement Science is being examined within a framework of real-world educational expectations, constraints, and evaluation metrics.

While Improvement Science has historically been applied in K-12 education through small-scale pilot programs or targeted interventions, its systemic application remains underexplored. Schools operate within multi-layered socio-political environments, and scaling Improvement Science across multiple campuses presents significant challenges in alignment, resource allocation, and cultural transformation. The University Academy presents a compelling case for embedding Improvement Science at an institutional level, demonstrating that large-scale, district-led implementation is feasible when iterative, data-driven processes become an embedded part of school operations rather than isolated interventions.

Stake's holistic case study approach is particularly relevant for this study because it allows for an in-depth examination of the complexities involved in scaling Improvement Science across diverse educational settings. Unlike methodologies that focus solely on measuring intervention effects, Stake's framework provides a rich, contextualized exploration of how Improvement Science unfolds within different school environments and adapts to localized needs. Boblin et al. (2013) demonstrated the utility of Stake's methodology in multi-site studies by examining how evidence-based practices were implemented across different healthcare contexts. Their findings highlight that Stake's case study approach is well-suited for research involving multiple, interconnected sites, an essential factor in this study, as the UA operates across rural, urban, and suburban campuses, each adapting Improvement Science principles to its specific context.

This study employs multiple sources of data to provide a comprehensive analysis of how Improvement Science is enacted within the UA. Longitudinal performance data, including standardized test scores, are examined to assess student achievement over time. Additionally, qualitative data collected from teachers and students—through interviews, surveys, and observations of PDSA cycles in action—provide insights into the lived experiences of educators and learners engaged in continuous improvement efforts. By triangulating these data sources, the study ensures a rigorous, in-depth exploration of how Improvement Science operates in practice.

Beyond the methodological fit, Stake's case study method provides a lens for understanding the broader structural and cultural challenges associated with large-scale Improvement Science implementation. Embedding iterative, data-driven practices requires a fundamental shift from compliance-based approaches to improvement-oriented mindsets among educators and administrators. Effective implementation necessitates significant investment in professional development, data infrastructure, and training, all of which are critical considerations for system-wide adoption. This study contributes to the growing body of research on Improvement Science by illustrating how Stake's methodology can be applied to study not just localized interventions, but full-scale, institution-wide applications of continuous improvement frameworks.

Through this holistic and embedded case study approach, the research highlights both the system-wide benefits of Improvement Science and the challenges of implementing continuous improvement strategies across diverse educational contexts.

## University academy demographic context

To understand the communities that the UA serves, it is important to note that as an open-enrollment school, any student can attend regardless of academic background or other criteria. The UA does not select students; instead, enrollment is based on a first-come, first-served basis, or a lottery system if seats are unavailable.

In our communities, the population is 56.9% White (Non-Hispanic), 17.5% Black or African American, 20.8% Hispanic or Latino, 1.7% Asian, 0.2% Native American, 0.03% Native Hawaiian or Pacific Islander, and 2.5% Two or More Races (U.S. Census Bureau, 2023). In comparison, the UA student body is 66% White, 17% Hispanic, 8% Black or African American, 6% Two or More Races, and 3% Asian, reflecting a higher proportion of White students and slightly lower representation of Black and Hispanic students than the surrounding population. This demographic distribution aligns with the UA's non-selective, equitable enrollment model, which ensures open access to students across urban, suburban, and rural communities.

# Case study structure: highlighting key elements of improvement science

## The university academy as a research platform

The UA functions as a research-driven environment where the Improvement Science (IS) framework is systematically integrated into every aspect of school operations. The PDSA cycle is a central component, guiding curriculum design, teaching strategies, and administrative decisions. In this context, data drives continuous reflection and adjustment, allowing for the iterative refinement of educational practices.

The IS framework is not confined to a single campus but is adapted and implemented across the UA's three distinct settings: rural, urban, and suburban. While the core principles remain consistent, the application of these practices is customized to meet the unique needs of each educational context. For instance, resource allocation and student support structures are tailored to the specific challenges and opportunities presented by each setting, ensuring a responsive and effective approach to education.

## Case examples to illustrate improvement science in action

To provide a detailed understanding of how IS functions at the UA, several key interventions are highlighted. The UA Improvement Science model has yielded significant insights into student and teacher outcomes across its rural, urban, and suburban campuses. This section presents case studies from key dissertations and studies to illustrate the impact of PDSA cycles and Improvement Science on academic achievement, STEM preparedness, literacy, blended learning, teacher development, and UA's role as a STEM pipeline.

## Case study 1: impact of response to intervention (RTI) on academic achievement

The study, *Impact of Response to Intervention on Achievement* (Dennis, 2023) examined how tiered interventions, differentiated based on student needs, influenced academic outcomes in key subject areas. Through data-driven instruction and continuous progress monitoring, teachers identified struggling students early and provided targeted support, leading to significant academic gains.

Quantitative analysis showed that students receiving RTI interventions demonstrated measurable improvements, particularly in reading and mathematics proficiency. The study highlighted the importance of a well-structured RTI system, which includes regular assessment, evidence-based instructional practices, and collaboration among educators. Challenges included ensuring fidelity in implementation and providing adequate resources for sustained intervention efforts. Recommendations from the research emphasized ongoing professional development for teachers, enhanced data tracking systems, and strategies for engaging parents in the intervention process.

## Case study 2: blended learning and academic growth

The study, *The Effect of a Personalized Learning Model on the Mathematical Achievement of Elementary Students* (Pedersen, 2023) investigates the impact of a blended and personalized learning model on mathematics achievement within the UA. This model integrated adaptive learning software, small group instruction, and focused teacher professional development to offer differentiated and student-centered instruction. Using the Plan-Do-Study-Act (PDSA) cycle, the research aimed to continuously refine teaching practices based on data and feedback.

Quantitative results from district and state mathematics assessments revealed that students participating in the personalized learning model showed significant gains in mathematical proficiency compared to their peers in traditional learning settings. The adaptive software provided real-time feedback and tailored practice problems to meet students' individual needs, while small group sessions allowed teachers to address learning gaps with targeted interventions. The study also found that economically disadvantaged students benefited greatly from this approach, demonstrating notable improvements in mathematics scores.

Qualitative feedback from both teachers and students emphasized the increased engagement and motivation driven by the personalized learning model. Teachers reported that students were more invested in their learning and displayed higher levels of confidence in tackling complex math problems. However, the research also identified challenges, such as ensuring equitable access to technology and the need for consistent implementation across classrooms. Teachers expressed the importance of ongoing professional development and administrative support to maintain high-quality instruction and to overcome logistical barriers.

The study recommended expanding teacher training on effective blended learning strategies, investing in reliable technological infrastructure, and fostering a collaborative culture among educators to share best practices. By leveraging the strengths of a blended and personalized learning model, the UA demonstrated the potential for scalable academic growth in mathematics, while also highlighting areas for further improvement and investment.

A similar study was also conducted in English Language Arts. The study, *Improving Reading Outcomes Through Blended Learning* (Rasberry, 2023) evaluates the impact of integrating a blended learning model into literacy instruction at the UA. The research utilized adaptive learning software, specifically Lexia Core5, to provide differentiated, data-driven instruction aimed at improving reading outcomes for elementary students. The blended learning approach combined traditional teacher-led instruction with individualized, technology-based interventions, allowing for more personalized and effective learning experiences.

## Case study 3: dual credit and postsecondary readiness

The study, *Evaluation and Improvement of Processes and Metrics in a Dual Credit Program* (Fischer, 2023), examines the impact of dual credit programs on student readiness for postsecondary education at the UA. The research focused on the implementation and continuous improvement of dual credit pathways, emphasizing the alignment of high school and college curricula to better prepare students for the academic challenges of higher education.

Data from the study showed that over 90% of UA high school students enrolled in dual credit courses, with an impressive 85% completion rate, reflecting strong academic performance and a high level of student commitment. Quantitative analysis revealed that students who completed dual credit courses were more likely to enroll in college immediately after graduation and demonstrated higher persistence rates compared to peers who did not participate in dual credit programs. The structured approach to dual credit at the UA, which included rigorous academic standards and close monitoring of student progress, was highlighted as a key factor in these positive outcomes.

Fischer's research also detailed the role of continuous improvement efforts in enhancing the effectiveness of the dual credit program. By using the Plan-Do-Study-Act (PDSA) cycle, UA educators and administrators were able to identify gaps in curriculum alignment and refine assessment metrics to ensure that students were acquiring the necessary skills for college-level work. These iterative cycles allowed for the regular adjustment of instructional practices, ensuring that the program remained responsive to both student needs and evolving educational standards.

Qualitative feedback from teachers and students underscored the benefits of dual credit participation. Teachers noted that students gained confidence and developed time management and study skills essential for college success. Students, on the other hand, expressed appreciation for the opportunity to experience college-level coursework while still in high school, which helped them transition more smoothly into higher education environments. However, the study also identified challenges, such as the need for more faculty development to ensure high-quality instruction in dual credit settings and the logistical complexities of coordinating between the UA and the UT Tyler.

The findings emphasized the importance of sustained collaboration between the UA and the UT Tyler. Recommendations included expanding professional development opportunities for faculty to enhance their effectiveness in delivering dual credit courses and implementing robust tracking systems to monitor student performance and long-term success in higher education. Additionally, the study advocated for increased administrative support to streamline communication and improve curriculum alignment, ensuring that the dual credit program continues to foster academic excellence and college readiness.

## Case study 4: STEM preservice teacher preparation and clinical practice

The study, *The UTeach Program: Minimizing the Disconnect Between Teacher Preparation Programs and Teaching Actualized* (Veazy, 2023), explores the impact of the UT Tyler UTeach program on preservice STEM teachers, specifically focusing on the value added by clinical practice experiences in a STEM Project-Based Learning (PBL) environment at the UA. This research examined how structured and immersive clinical placements in a STEM-focused lab school influence the teaching competencies and overall preparedness of preservice teachers. UTeach is a model STEM Teacher preparation program created at the University of Texas at Austin that allows STEM majors to seek teacher certification without adding additional time to their degree (UTeach Institute, 2025). The UT Tyler School of Education is a replication site implemented in 2010.

The findings highlighted those preservice teachers who participated in the UTeach program and completed their clinical practice at the UA showed significant improvements in instructional delivery, classroom management, and the integration of STEM content with hands-on, inquiry-based learning strategies. The immersive experience in a PBL setting allowed preservice teachers to practice and refine their skills in real-world classrooms, preparing them to implement STEM-focused, student-centered teaching practices effectively. Quantitative data collected from teacher evaluations and student performance metrics revealed that students taught by UTeach preservice teachers demonstrated increased engagement and achievement in STEM subjects compared to traditional classroom settings.

Qualitative feedback from the preservice teachers emphasized the value of working in a STEM PBL environment, where they could observe and apply best practices in science and mathematics education. Participants reported gaining a deeper understanding of how to facilitate inquiry-based learning, develop interdisciplinary lessons, and use formative assessments to guide instruction. Additionally, the study identified the importance of mentorship and support from experienced UA teachers, who provided guidance and feedback that enhanced the preservice teachers' professional growth.

The research also addressed challenges faced by preservice teachers, such as managing the complexity of PBL and adjusting to the demands of teaching in a STEM-focused environment. Recommendations for improving the UTeach program included expanding professional development opportunities in PBL pedagogy, strengthening mentorship structures, and providing more extensive training on classroom management strategies specific to active learning environments.

Overall, the study underscored the significant role of clinical practice in preparing high-quality STEM educators. By engaging preservice teachers in authentic, hands-on teaching experiences at a STEM lab school, the UTeach program at UT Tyler helps bridge the gap between theoretical knowledge and practical application. This approach not only benefits the preservice teachers but also contributes to the broader goal of enhancing STEM education by equipping future educators with the skills needed to inspire and engage the next generation of scientists, engineers, and innovators.

## Case study 5: STEM pipeline development and postsecondary STEM success

The University Academy's strategic focus on developing a seamless STEM pipeline has effectively prepared students for postsecondary success in STEM fields. This case study, based on the ongoing research (Odell et al., 2024), examines the integration of Project-Based Learning (PBL) in STEM subjects to provide students with hands-on experiences and critical thinking opportunities that align with college and career readiness standards. As previously described, the UA, as a university charter public school, operates across three locations—urban, suburban, and rural—and emphasizes high-fidelity STEM learning experiences.

Metrics tracked in this study include dual credit success rates, high school STEM course completion, and postsecondary STEM major enrollment. Notably, 92% of high school students at the UA participate in dual credit courses, with an 85% completion rate. Furthermore, approximately 70% of UA graduates who completed STEM pathways during high school chose to pursue STEM-related degrees. The study highlighted that structured and aligned STEM curricula, combined with authentic inquiry-based learning experiences, significantly contributed to student interest and success in STEM fields.

Additionally, the research evaluated the effectiveness of PBL in the UA's engineering and biomedical pathways. It found that PBL not only increased STEM content retention but also enhanced problem-solving and critical thinking skills among students. By integrating real-world applications into the curriculum, the UA's PBL framework closely aligned with college-level STEM programs. This approach was instrumental in preparing students for the rigor of postsecondary STEM studies, as evidenced by high rates of enrollment in STEM majors following graduation. Student engagement was notably higher in these PBL settings, as the learning experiences were relevant and connected to practical applications, further reinforcing students' readiness for future academic and career pursuits.

The case study also emphasized the importance of continuous improvement efforts, guided by the Plan-Do-Study-Act (PDSA) cycle, to refine STEM education practices and ensure alignment with college and workforce expectations. These cycles allowed the UA to remain responsive to the needs of students and to adapt instructional practices based on data and feedback.

Recommendations from the study included expanding partnerships with industry and higher education institutions to sustain and enhance STEM programming and ensuring that STEM pathways remain aligned with emerging workforce needs. The University Academy model demonstrates the effectiveness of a well-developed STEM pipeline in promoting long-term student success and serves as a replicable model for other educational institutions aiming to strengthen STEM education.

## Case study 6: teacher development and continuous improvement (preliminary study)

The UA has implemented a preliminary teacher development initiative grounded in the principles of Improvement Science, designed to promote continuous professional growth and instructional effectiveness. Central to this program is the opportunity for teachers to pursue advanced degrees tuition-free at the University of Texas at Tyler (UT Tyler). Teachers without a master's degree are required to earn one, while those who already have a master's degree can enroll in a Doctorate in Education (Ed.D.) in School Improvement. This emphasis on higher education has contributed to a notable percentage of faculty achieving distinguished status under the Texas Education Agency (2025a, 2025b) Teacher Incentive Allotment program which provides financial incentives to teachers who students perform well on a set of metrics including state accountability assessments.

This preliminary study, conducted by Simmons, Pedersen, Odell, and Dennis, examined the early impact of the UA's teacher development efforts. The research focused on the implementation of continuous Plan-Do-Study-Act (PDSA) cycles, where teachers utilized student performance data to inform and refine their instructional strategies. Initial findings suggest that engaging in these cycles enhanced teachers' confidence in delivering high-quality instruction and improved their ability to adapt teaching methods to meet diverse student needs. Early indicators also show an increase in student engagement and achievement because of these improved practices.

The analysis of faculty development revealed a strong culture of lifelong learning, supported by the pursuit of advanced degrees among teachers. The structured approach to professional growth and the emphasis on continuous improvement have been instrumental in creating an environment of collaboration and instructional excellence. Although these findings are preliminary, they indicate promising outcomes related to teacher retention and overall job satisfaction, as educators feel supported and empowered.

Recommendations from this preliminary study include expanding mentorship opportunities and allocating additional resources for professional development. Leveraging the expertise of distinguished teachers to support and guide newer educators could further embed a culture of continuous improvement and sustain the positive trajectory of teaching practices at the UA.

## Case study 7: evaluation of Texas STEM and traditional school models

The study, *Innovative Education: Comparing the Success of STEM and Traditional School Models* by Kennedy (2023), focuses on evaluating the effectiveness of various Texas-based educational models, including the Texas STEM Academy (T-STEM) initiative, the Pathways in Technology Early College High School (P-Tech) model, the Early College High School (ECHS) model, and New Tech Network (2025) (NTN) school model. The research compares academic outcomes between STEM-focused schools and traditional school models to understand which approaches best prepare students for postsecondary success and careers in STEM fields.

Utilizing primarily quantitative data, such as graduation rates and standardized test scores findings revealed that STEM-focused models generally outperformed traditional schools in key metrics, including student engagement, college readiness, and STEM content mastery. Notably, T-STEM and NTN schools showed the highest levels of student achievement in science and mathematics, attributed to their emphasis on hands-on, project-based learning and real-world applications.

However, the research also identified areas for improvement. The study recommended increased support for professional development and strategic partnerships with industry and higher education institutions to sustain and enhance STEM programming. Additionally, it highlighted the importance of continuous evaluation and adaptation of these models to ensure they meet the evolving needs of Texas students and the workforce.

This statewide examination of outcome data examining different school models reinforced that the T-STEM model utilized by the university academies appeared to be an effective school model. The Texas Education Agency awards distinctions to high performing schools as part of the accountability system. Table 1 shows a snapshot of the UA distinction data compared to the state, region, and county levels. All three UA academies received all distinctions in 2022.

## Case study 8: academic achievement and differentiated instruction

One study, *An Evaluation of Factors Impeding Growth on TELPAS and Insights for Academic Advancement* (De La Sierra, 2023), focused on the effect of differentiated instruction on student achievement, particularly targeting emergent bilingual students. TELPAS is the Texas English Language Proficiency Assessment System. Through targeted interventions, teachers developed strategies tailored to linguistic and cultural needs, resulting in a measurable improvement in bilingual student outcomes over the academic year. Quantitative data from district assessments revealed a consistent closing of achievement gaps in literacy and mathematics, demonstrating the effectiveness of data-driven instructional strategies.

Further analysis revealed that while STAAR reading performance improved significantly from 2021 to 2023, TELPAS scores did not exhibit corresponding growth, highlighting a gap between content-specific skills and comprehensive language proficiency. Barriers identified included curriculum misalignment with language acquisition principles, the challenging assessment environment, and perceived difficulties of the TELPAS test. The research emphasized the need for comprehensive professional development to equip teachers with effective language acquisition strategies and administrative support to overcome these barriers. Additionally, the integration of Project-Based Learning (PBL) was shown to be particularly effective for engaging emergent bilingual students, providing contextual learning experiences that enhanced language development and personalized attention.

TABLE 1 University academy distinctions.

| Category | % Texas schools earning distinction | % Schools in our region earning distinction | University academy campuses |
|---|---|---|---|
| ELA/Reading | 19.5% | 22.5% | 100% |
| Math | 19.1% | 23.1% | 100% |
| Science | 20.2% | 22.5% | 100% |
| Social studies | 10% | 11.9% | 100% |
| Progress | 20.7% | 15.1% | 100% |
| Closing the gaps | 21.2% | 19.6% | 100% |
| Post-secondary readiness | 25.6% | 32.1% | 100% |

Source: Texas Education Agency (2021).

## Case study 9: literacy improvement through targeted interventions

A study on literacy outcomes, *Analysis of Policy Implementation: Improving Reading Proficiency Outcomes for All Students* (Magro-Malo, 2023), at the UA revealed substantial improvements following the implementation of targeted reading interventions in alignment with the PDSA cycle framework. Teachers used formative assessments to identify students at risk of falling behind and applied differentiated reading strategies across grade levels. The results showed increased reading proficiency, especially among at-risk populations, validating UA's structured approach to addressing literacy gaps through Improvement Science.

The research highlighted the importance of policy alignment with practical classroom strategies to ensure consistent gains in reading proficiency. Key components of the intervention included the integration of evidence-based reading practices, such as guided reading and vocabulary enrichment, along with professional development sessions focused on literacy instruction. Teachers participated in continuous data analysis workshops, refining their approaches based on real-time feedback and student performance metrics. Additionally, administrative support was crucial in facilitating resource allocation and ensuring that literacy goals were prioritized across the district.

Despite overall gains, the study also identified challenges, such as the need for more culturally responsive materials and the importance of family engagement in supporting literacy development at home. Recommendations for sustaining improvements included expanding teacher training on culturally responsive teaching practices, increasing collaboration among literacy coaches, and engaging families more actively in students' reading journeys.

# Results

The UA Improvement Science model has yielded significant insights into student and teacher outcomes across its rural, urban, and suburban campuses as evidenced by the cases presented. The following sections detail the outcomes derived from the integration of Improvement Science, emphasizing the tangible impacts on academic achievement, teacher development, and STEM pipeline creation.

The first research question examined how the systematic use of Improvement Science contributed to longitudinal improvements in student achievement at the UA. This section directly presented evidence of student performance gains over time, with a particular focus on the role of PDSA cycles and iterative improvements. By incorporating Table 2, which outlined longitudinal STAAR/EOC data, the trends in student achievement were visually demonstrated, reinforcing the impact of Improvement Science over multiple years. Additionally, key improvements were made to illustrate how ongoing refinements in instructional practices, informed by real-time data, led to sustained progress.

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These improvements were not the result of singular interventions but rather the continuous and systematic application of Improvement Science principles. The iterative nature of PDSA cycles ensured that instructional strategies evolved in response to student performance trends, allowing educators to identify challenges early and implement data-driven solutions. Unlike traditional reform efforts that rely on static, large-scale policy changes, the UA model demonstrated that ongoing, real-time analysis and localized decision-making could lead to sustained academic growth. The ability to rapidly adjust instructional methods based on both formative and summative assessments provided students with more targeted learning experiences, ultimately leading to higher proficiency rates over time.

The application of Improvement Science at the UA aligns with notable academic performance trends across core subjects, as illustrated in Table 2. From 2013 to 2019, the UA's district averages showed steady increases compared to state averages, suggesting a potential relationship between iterative, data-driven instructional approaches and student outcomes. For instance, mathematics scores rose from 48 in 2013 to 91 in 2019, and science scores improved by 42 points over the same period, reflecting ongoing refinement in instructional strategies and schoolwide interventions. For instance, mathematics scores increased by 43 points, from 48 in 2013 to 91 in 2019, and science scores improved by 42 points over the same period. Additionally, writing and reading proficiency saw marked increases, reflecting the impact of continuous assessment and refinement of teaching practices.

The table also indicates that even after the initial intervention period, academic performance remained strong through the pre-pandemic years. Although the pandemic introduced new challenges, the UA's commitment to Improvement Science helped maintain relatively high performance, with recovery efforts showing promise in subsequent years. Figure 2 shows the trend in improvement over time for years that were tested.

These examples illustrate how continuous iteration and real-time data adjustments led to measurable improvements. Unlike static interventions, Improvement Science enabled the UA educators to identify gaps, implement targeted strategies, analyze impact, and refine approaches dynamically, ensuring sustainable and scalable progress over time.

While the data in the forementioned tables and figures illustrate longitudinal improvements in student achievement, the mechanisms behind these improvements were rooted in the systematic application of Plan-Do-Study-Act (PDSA) cycles across multiple instructional and operational areas at the UA. Rather than relying on static, one-time interventions, UA educators used an iterative process of continuous refinement, ensuring that instructional strategies evolved in response to real-time student performance data.

One example of this approach occurred in literacy instruction. Early assessment data revealed that vocabulary retention was a key barrier to reading comprehension, limiting students' ability to engage with complex texts. In response, teachers initially implemented a structured vocabulary instruction program that incorporated interactive digital tools. However, while early assessments showed some improvement, student engagement remained low. Recognizing this limitation, educators adjusted the approach by incorporating structured peer discussions and gamified learning activities to enhance student interaction and retention. Over 2 years, literacy

TABLE 2 Longitudinal STAAR/EOC data.

| Subject | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022* | 2023** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-PDSA | | PDSA implemented | | | | | Pandemic impact | | | Present |
| **All subjects** | | | | | | | | | | | |
| State average | 77 | 77 | 77 | 75 | 75 | 77 | 78 | – | | | – |
| UA average | 59 | 65 | 85 | 86 | 85 | 87 | 90 | – | 86 | 91 | – |
| **Math** | | | | | | | | | | | |
| State average | 79 | 78 | 81 | 76 | 79 | 81 | 82 | – | | | – |
| UA average | 48 | 59 | 95 | 83 | 86 | 88 | 91 | – | 82 | 84 | – |
| **Science** | | | | | | | | | | | |
| State average | 82 | 78 | 78 | 79 | 79 | 80 | 81 | – | | | – |
| UA average | 51 | 67 | 80 | 89 | 85 | 88 | 93 | – | 91 | 96 | – |
| **ELA/Reading** | | | | | | | | | | | |
| State average | 80 | 76 | 77 | 73 | 72 | 74 | 75 | – | | | – |
| UA average | 75 | 74 | 90 | 87 | 86 | 87 | 92 | – | 82 | 92 | – |
| **Writing** | | | | | | | | | | | |
| State average | 63 | 72 | 72 | 69 | 67 | 66 | 68 | – | | | – |
| UA average | 48 | 53 | 80 | 79 | 78 | 79 | 75 | – | 78 | – | – |
| **Social studies** | | | | | | | | | | | |
| State average | NA | NA | 78 | 77 | 77 | 78 | 81 | – | | | – |
| UA average | NA | NA | 68 | 84 | 81 | 90 | 95 | – | 91 | 98 | – |

*2021 was the final year of the writing assessment as a separate assessment. **2023 scores are pending release from the Texas Education Agency.

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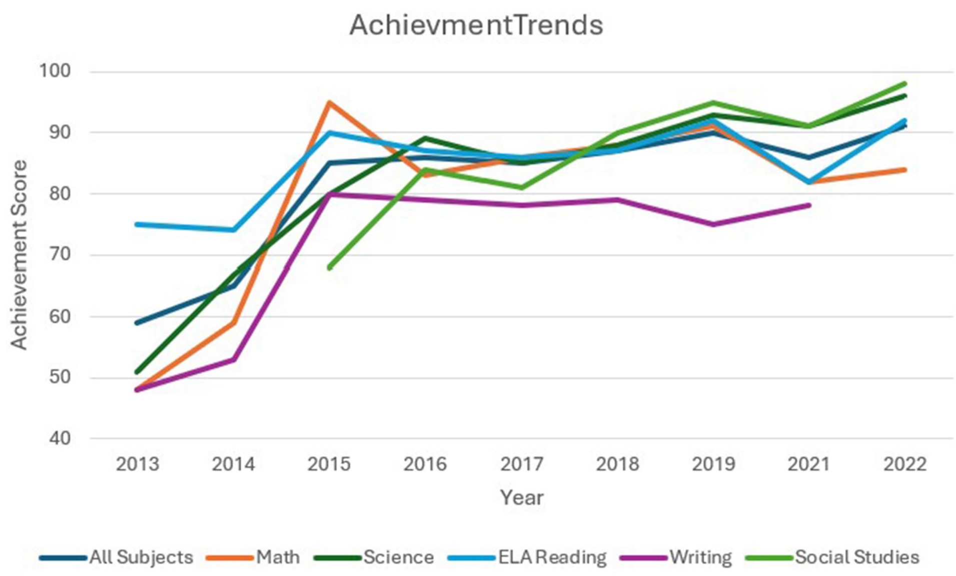


FIGURE 2
Achievement improvement trends. There was no test in 2020 due to the pandemic.

scores showed a sustained 15% increase, demonstrating how iterative refinements improved both engagement and comprehension.

A similar process unfolded in mathematics instruction. Student performance trends indicated that many struggled with multi-step problem-solving, particularly in applying mathematical concepts to real-world scenarios. Teachers piloted a blended learning approach that combined small-group instruction with adaptive learning software. Early data suggested that while students became more engaged, their conceptual understanding remained inconsistent. To address this, educators modified the intervention by integrating real-world problem applications and scaffolded practice sessions, allowing students to strengthen their problem-solving abilities in a meaningful way. This continuous refinement led to an 18% increase in math proficiency over 3 years.

Beyond subject-specific interventions, the UA also used Improvement Science principles to enhance STEM career readiness among students. Initial reviews of student performance and career interest surveys revealed that while many students excelled in STEM coursework, they lacked exposure to real-world applications and career pathways. To address this, the UA introduced an interdisciplinary, project-based learning (PBL) model, designed to integrate STEM concepts into hands-on, inquiry-based learning experiences. While early student feedback indicated increased engagement, educators recognized that many students still lacked direct exposure to industry professionals and career mentors. The program was subsequently refined to include mentorship opportunities, industry partnerships, and structured career exploration components, which contributed to a 25% increase in STEM pathway enrollment over 4 years.

These cases illustrate how Improvement Science functioned as a dynamic, data-driven process that continuously shaped instructional and operational decisions. Unlike traditional, pre-set interventions, the PDSA cycles embedded at the UA allowed for systematic testing, real-time analysis, and iterative adjustments, ensuring that educational strategies remained responsive to student needs. This approach not only strengthened academic outcomes but also created a scalable framework for sustained improvement, reinforcing the value of Improvement Science in fostering long-term educational transformation.

The second research question explored the most effective practices that contributed to these gains across the UA's diverse educational settings, including rural, urban, and suburban contexts. This section identified the most impactful interventions by drawing from both qualitative and quantitative findings. It was essential to break down the specific strategies that were successfully adapted to different school environments, demonstrating how various settings required tailored approaches. Furthermore, the role of networked improvement efforts (NICs) was highlighted, showing how collaboration and shared learning across campuses allowed for the customization of interventions to meet the unique needs of each educational setting.

The use of collaborative improvement cycles played a key role in shaping the UA's ability to adapt and sustain changes over time. Rather than relying solely on individual teacher efforts, the UA established structured mechanisms for professional reflection and shared decision-making, ensuring that faculty had access to peer insights, student performance trends, and iterative refinements from previous cycles. This approach not only strengthened instructional consistency but also fostered an institutional commitment to continuous learning and adaptation. By ensuring that faculty had a structured yet flexible approach to problem-solving, the UA reinforced the importance of context-driven decision-making within the broader Improvement Science framework.

## Teacher development and retention

The UA's approach to teacher development has not only contributed to academic success but has also cultivated a supportive and collaborative work environment. The tuition-free master's and doctoral degree opportunities for teachers have incentivized ongoing professional growth, creating a well-qualified and motivated teaching staff. The program's emphasis on Improvement Science has encouraged teachers to engage in continuous PDSA cycles, enhancing their instructional effectiveness and confidence in data-driven decision-making.

As a result, the UA has achieved high teacher retention rates of over 85%, with many educators attaining distinguished status under the Texas Teacher Incentive Allotment program. This has bolstered the overall quality of instruction and fostered a culture of lifelong learning, where teachers feel empowered to adapt and improve their practices.

## STEM focus and postsecondary success

The UA's signature pedagogy, Project-Based Learning (PBL), for all instruction has effectively established a robust STEM pipeline. Approximately 70% of UA graduates who completed STEM pathways in high school have enrolled in STEM-related majors in postsecondary education. This outcome underscores the success of the UA's STEM-focused, inquiry-based curriculum in preparing students for future academic and career opportunities.

The dual credit program has also played a crucial role in postsecondary readiness, with over 90% of high school students participating and an 85% course completion rate. The alignment between high school and college curricula, coupled with rigorous academic standards, has helped students transition seamlessly into higher education. Feedback from both students and teachers highlights the program's impact on developing essential skills such as time management, study habits, and academic confidence.

## Growth in enrollment and awards

The UA has experienced consistent growth in student enrollment, driven by its reputation for academic excellence and innovative practices. In 2024, the academies enrolled over 200 new students bringing the total enrollment to almost 1,100 students. The Academy has also received numerous awards and recognitions, further validating its success. This growth reflects the appeal of the UA's evidence-based educational model and its effectiveness in delivering high-quality learning experiences. The Academy's emphasis on Improvement Science and data-driven practices has contributed to a dynamic learning environment that attracts families seeking rigorous and supportive educational opportunities for their children.

## Supportive learning environment and culture

The UA's structured approach to continuous improvement has created a positive and supportive culture for both students and teachers. The collaborative PDSA cycles, professional development opportunities, and tuition-free degree programs have fostered a strong sense of community among educators. UA teachers report feeling valued and supported, which has contributed to high job satisfaction and a commitment to instructional excellence.

The learning environment at the UA is characterized by engagement, collaboration, and adaptability, with students benefiting from personalized and contextually relevant learning experiences. This supportive culture has facilitated long-term academic and personal growth, making the UA a model for other institutions seeking to implement similar improvement frameworks.

## COVID-19 pandemic

According to the Texas Education Agency (TEA), the 2021 State of Texas Assessments of Academic Readiness (STAAR) results revealed that only 35% of students met grade-level expectations in math, a decline from 50% in 2019. In reading, 43% met grade-level standards, down from 47% in 2019. The UA's scores were marginally impacted.

The COVID-19 pandemic disrupted educational systems worldwide, leading to significant declines in student achievement, instructional quality, and learning continuity (Kuhfeld et al., 2020). Nationally, research indicates that math and reading proficiency dropped during the pandemic, with students from underserved communities experiencing the most significant learning losses (Dorn et al., 2020).

At the UA, the pandemic introduced substantial challenges in maintaining student engagement, instructional effectiveness, and assessment reliability. Remote learning environments created disparities in access to technology and resources, particularly among students from low-income households. Despite these challenges, the systemic use of Improvement Science principles—specifically PDSA cycles—helped mitigate learning loss by allowing educators to rapidly adapt instructional strategies.

Table 2 illustrates the longitudinal trends in student achievement before, during, and after the pandemic. While state-wide scores reflected a steep decline in 2020–2021, the UA's performance remained comparatively stable, likely due to the real-time data-driven adjustments made through Improvement Science cycles. Teachers continuously refined virtual instructional methods, adjusted intervention strategies, and leveraged formative assessments to address emerging learning gaps.

The pandemic highlighted the importance of embedding continuous improvement frameworks within school systems. Schools with flexible, adaptive improvement models were better positioned to respond to crises, reinforcing the argument for system-wide implementation of Improvement Science in education.

## Overall impact

While Table 2 primarily showcases academic achievement, the broader results of the UA's Improvement Science model extend to increased student engagement, high teacher retention, a strong STEM pipeline, and a supportive educational culture. The integration of Improvement Science with a university-affiliated laboratory school model has created a sustainable framework for continuous improvement, benefiting both the School of Education and the broader educational community.

# Discussion

The implementation of Improvement Science at the University Academy provides insights into how continuous, data-informed cycles may support sustained improvements in K-12 education. By integrating Project-Based Learning (PBL) and STEM-focused curricula, the UA has developed a model that aligns with diverse learning needs, emphasizes STEM readiness, and fosters teacher professional growth. The high percentage of UA graduates pursuing STEM degrees in higher education suggests that these efforts may contribute to student preparedness for advanced study in STEM fields.

### Implications for STEM education and postsecondary success

The UA's use of PBL in engineering and biomedical pathways underscores the importance of early exposure to hands-on, real-world STEM experiences. As evidenced in Case Study 2, students engaged in PBL demonstrated heightened preparedness for college-level STEM coursework and developed critical thinking skills that are essential for STEM careers. This approach aligns with national efforts to strengthen the STEM workforce and equip students with the skills needed to tackle complex global challenges.

The high percentage of UA graduates pursuing STEM degrees in higher education further validates the effectiveness of this model. By providing a seamless transition from high school to college, the UA has established a replicable framework that other institutions can adopt to build robust STEM pipelines. This success also highlights the need for ongoing support and partnerships between K-12 schools, higher education institutions, and industry to ensure that STEM curricula remain relevant and aligned with workforce demands.

### Teacher development and continuous improvement

The integration of Improvement Science into teacher development has proven to be transformative for the UA educators. Case Study 7 illustrates how engaging in continuous Plan-Do-Study-Act (PDSA) cycles has enhanced teachers' ability to analyze student data, adjust instructional practices, and ultimately improve student outcomes. The provision of tuition-free advanced degree programs has further incentivized teachers to pursue professional growth, resulting in a highly qualified and motivated faculty.

This approach to teacher development has also contributed to high retention rates, a critical factor in maintaining instructional quality. By fostering a culture of lifelong learning and collaboration, the UA has created an environment where teachers are empowered to innovate and refine their teaching methods. This model can serve as a blueprint for other districts seeking to improve teacher retention and instructional effectiveness through professional development and data-driven practices.

### Broader policy implications and school improvement

The success of the UA's Improvement Science framework has significant implications for educational policy and school improvement initiatives. By employing data-driven cycles of change, the UA has demonstrated how schools can achieve measurable outcomes in academic achievement, STEM preparedness, and teacher development. The structured use of PDSA cycles provides a replicable model for other districts aiming to implement evidence-based reforms aligned with state and national standards.

Additionally, the UA's focus on community and stakeholder engagement reinforces the importance of involving diverse voices in school improvement efforts. By collecting qualitative feedback from teachers, students, and parents, the UA ensures that its strategies are responsive to the needs of its community. This approach aligns with the Texas Education Agency's (TEA) emphasis on equity and continuous improvement and offers insights for policymakers on how to design effective and inclusive educational reforms.

### Addressing challenges and areas for growth

While the UA's model has yielded impressive results, the research also highlights areas for further development. Challenges such as ensuring equitable access to technology, maintaining fidelity in the implementation of PBL, and aligning curricula with language acquisition principles for emergent bilingual students require ongoing attention. The pandemic's impact on student learning also underscores the need for flexible and adaptive strategies to support academic recovery.

Recommendations for addressing these challenges include expanding professional development opportunities, investing in technological infrastructure, and enhancing culturally responsive teaching practices. By building on the strengths of the current model and addressing identified gaps, the UA can continue to drive innovation and excellence in education.

## Limitations

While this study provides valuable insights into the application of Improvement Science in an educational setting, several limitations should be acknowledged. As a case study, the findings are inherently context-specific and do not aim for broad generalizability in the way that randomized controlled trials or large-scale quantitative studies do. Instead, this research offers transferable insights that may inform similar educational contexts, particularly other open-enrollment public schools seeking to apply Improvement Science principles.

Another limitation is the absence of a control or comparison group. Because Improvement Science focuses on continuous, iterative improvement within an existing system rather than isolated interventions, this study does not employ a traditional pre-post study design. As a result, it does not establish causal relationships between specific Improvement Science strategies and student achievement outcomes. However, the use of Stake's holistic case study methodology allows for a rich, qualitative exploration of the processes and contextual factors influencing systemic change, providing depth to the understanding of how improvement efforts unfold in practice.

Additionally, the study relies on self-reported data from teachers and administrators, which introduces the potential for response bias in perceptions of Improvement Science effectiveness. While these perspectives are valuable for capturing the lived experiences of educators engaged in continuous improvement, future research could enhance methodological rigor by incorporating reflexive journals, observational field notes, and additional qualitative artifacts to further triangulate the data.

Finally, while the study examines multiple University Academy campuses serving diverse student populations, the findings remain specific to this institutional setting. Future research could extend this work by studying additional schools or districts implementing Improvement Science to better understand how different contextual variables influence implementation success. Despite these limitations, this study contributes meaningful insights into the systemic application of Improvement Science and demonstrates how Stake's case study methodology can effectively capture the complexities of continuous improvement efforts in education.

## Conclusion

In revisiting the research questions, this study provides evidence that the systematic use of Improvement Science at the UA is associated with longitudinal improvements in student achievement. The iterative application of the PDSA cycle has facilitated the continuous refinement of instructional practices and curricular strategies, contributing to observed academic gains over time. Additionally, the research identifies several effective practices that appear to support positive educational outcomes, particularly data-driven interventions, differentiated instruction, and adaptive learning models. These practices have been successfully implemented across the UA's diverse educational settings, illustrating how the Improvement Science framework allows for contextual adaptability while maintaining core principles.

The University Academy serves as an example of how Improvement Science can be applied at a systemic level in K-12 education, offering insights into how continuous, data-informed cycles may contribute to institutional improvements. Through strategic partnerships with the University of Texas at Tyler School of Education, the UA has developed a research-based laboratory school model that benefits K-12 students, teachers, preservice teachers, and university researchers. The cases presented in this manuscript illustrate how the UA's approach to STEM readiness, teacher professional growth, and student learning aligns with established continuous improvement principles. The emphasis on data-informed interventions, Project-Based Learning (PBL), and continuous improvement offers a potentially replicable model for other educational institutions seeking to enhance instructional quality and prepare students for postsecondary success.

As a scalable and adaptable framework, the UA model provides insights into how Improvement Science principles can be embedded at multiple levels of an educational system. The structured yet flexible approach used at the UA suggests a possible blueprint for other districts and schools seeking to implement continuous improvement strategies. The core elements of this framework include:

- Embedding PDSA cycles at multiple levels: ensuring that continuous improvement cycles are integrated into instructional planning, student assessment, and faculty development.
- Creating a data-driven decision-making culture: institutionalizing the use of real-time data analysis to refine teaching practices and student interventions.
- Building collaborative learning structures: strengthening professional learning communities to support shared decision-making and reflective practice.
- Ensuring adaptability to local needs: allowing flexibility in implementation to meet the specific demands of different school contexts and student populations.

By applying the principles of Improvement Science and fostering a collaborative research community, the UA continues to contribute to ongoing educational innovation. Future research could expand on these findings by exploring long-term student outcomes, examining the scalability of the UA model in varied educational contexts, and further identifying the mechanisms that support effective Improvement Science implementation. Through sustained collaboration and a commitment to continuous improvement, the UA provides a valuable case for understanding systemic educational reform and its potential impact on P-20 education.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

MO: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing – review & editing. TK: Conceptualization, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. JS: Conceptualization, Data curation, Funding acquisition, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The authors declare that Gen AI was used in the creation of this manuscript. It was used to assist in corrective writing using Grammarly which is AI enhanced.

## Publisher's note



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