USING VIRTUAL REALITY INNOVATION

TO ADDRESS THE IMPENDING WORKFORCE SHORTAGE IN THE OIL AND GAS INDUSTRY

September 2025

Executive Summary

The oil and gas industry is facing a significant workforce challenge: ***nearly 400,000 U.S. energy workers are nearing retirement,*** while younger generations remain hesitant to enter the field. Traditional training pipelines are fragmented, and the skills demanded of today's technicians with mechanical expertise, digital fluency, and safety awareness are evolving faster than education can adapt. Without innovative, scalable solutions, the sector risks a critical shortage of talent across exploration, production, and operations.

In spring 2025, Coterra Energy partnered with Xalter to deploy a multi-state pilot VR program to prepare the next generation of energy workers. The initiative engaged high school students in Career and Technical Education (CTE) programs, dual-enrolled college students, and educators across Pennsylvania and New Mexico. The results of the pilot confirmed that VR-based training reduces barriers to entry, standardizes learning, and creates opportunities for rural and underserved communities.

- **90% of students improved knowledge**, with average test scores doubling (36% → 75%)
- **Drive engagement** and reach even previously disengaged or at-risk learners
- **Provide safe, scalable exposure** to real-world operations without the limitations of on-site tours
- **Build career pathways** that give students early exposure to energy-specific skills and opportunities

By combining immersive training with industry collaboration, VR can modernize oil and gas workforce development to close skills gaps, rebrand the sector as a hub of innovation, and equip the next generation of energy professionals to meet rising global demand.

> *"Today's [oil & gas] workers operate at the nexus of mechanical systems, environmental stewardship, and digital innovation. Rebranding the sector to reflect this reality is more than a PR effort – It is a workforce imperative."*

About the Authors

Dr. Theresa Cullen
Instructional Design| Xalter

Theresa Cullen is the Director of Instructional Design for Xalter. She has over 20 years of experience teaching and supporting teachers in higher education. She has degrees in Biology, Computer Science, and a PhD in Instructional Design. Her research has focused on how teachers teach science and use technology in the classroom. In addition to her role at Xalter she is also the Director of Distance Learning at Eastern New Mexico University.

William desRosiers
External Affairs | Coterra Energy

William desRosiers is the Manager of Government and External Affairs for Coterra Energy. With nearly 15 years of experience, William has represented the company at both the state and federal levels, combining policy expertise with data-driven approaches to strengthen industry and community partnerships. He holds a B.S. in Management, a B.A. in History, and an MBA from Misericordia University, and earned a Master of Science in Business Analytics from the University of Scranton.

Contact Information

For more information about this project and XALTER's immersive workforce solutions, please contact:

Kevin Anderson
CEO | XALTER
kevin@xalter.com

The Xalter tool is collaborative; students can communicate with each other (even if not present in the room) and solve problems together.

Introduction

The oil and gas industry faces a well-documented workforce challenge. As exploration, production, refining, and operational environments evolve — becoming increasingly automated, remote, and technologically complex — energy companies are struggling to recruit and retain the skilled workers required to sustain and grow the sector. This challenge is most acute for on-site roles such as wellsite operators, maintenance technicians, and production personnel, where entry-level familiarity with compression, pressure systems, instrumentation, and emissions control is now a baseline requirement.

According to McKinsey & Company (2023), over a quarter of the U.S. energy workforce — approximately 400,000 individuals — is at or near retirement age, many of them frontline workers with deep operational expertise. In upstream and midstream fields especially, technicians and engineers in their 50s and 60s are expected to retire by 2030, taking decades of institutional knowledge with them.

Projections reinforce the urgency. A 2017 report by IHS Markit, commissioned by the American Petroleum Institute (API) and titled Oil and Natural Gas Industry: Supporting U.S. Economic and Employment Growth in the 21st Century, estimated that 1.9 million job opportunities — new positions and replacement openings — will emerge in the U.S. oil, natural gas, and petrochemical industries by 2040, with a significant portion driven by retirements. Yet the industry has struggled to attract a full new generation of workers.

Layoffs during past downturns (2015–2016 and 2020), combined with growing enthusiasm for advanced manufacturing, power generation, and data centers, have made young job seekers wary of committing to oil and gas careers (learnToDrill.com, n.d.; Travelers, n.d.). Meanwhile, demand for energy is not shrinking but evolving.

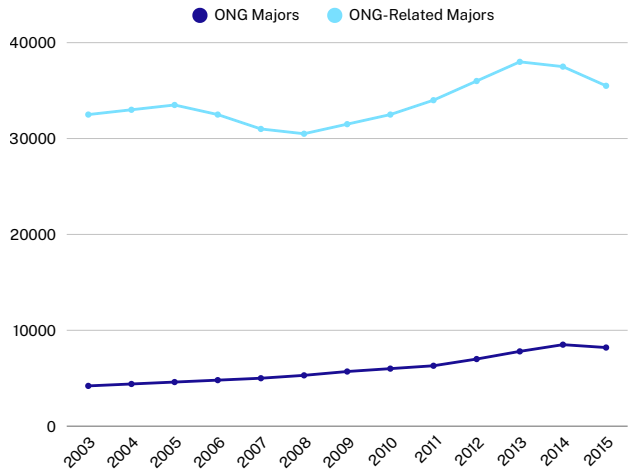
The proliferation of data centers, electrified transportation, and continued demand for petrochemicals ensures that oil and natural gas remain central to the energy mix (U.S. Department of Energy, 2024). What is needed is not only a larger workforce but one with a new blend of skills: traditional mechanical aptitude combined with digital fluency and a commitment to environmental standards.

Pipeline Gaps
TRAINING GAPS AT EVERY LEVEL

The oil and gas industry is confronting a widening talent gap on two fronts: scale and demographics. A 2023 RAND Corporation analysis for API projected the need for more than 1.4 million upstream and 350,000 midstream workers by 2024, many requiring applied technical training. At the same time, nearly half of the current workforce is already over age 45, with retirements accelerating across critical roles. Yet few U.S. colleges or technical schools offer programs dedicated to upstream or midstream operations—most instruction remains siloed in petroleum engineering or geoscience. As a result, companies are left to rely on on-the-job training or recruiting from competitors, a short-term fix that does little to build the long-term pipeline.

A 2023 RAND Corporation analysis conducted for the American Petroleum Institute (API) confirms this challenge. The report identified only a limited number of U.S. postsecondary programs dedicated to upstream and midstream energy operations, with the majority concentrated in a handful of states. As RAND noted, most energy-related instruction at the collegiate level is confined to petroleum engineering or geoscience, while applied, operations-focused programs remain scarce.

Total Number of Associate's Degrees Awarded in Oil and Natural Gas Majors, 2003–2015



SOURCE: RAND Corporation Analysis

Nationwide, associate-degree and applied science offerings in fields like petroleum technology or natural gas operations number only in the dozens—far fewer than what is needed to meet industry demand. Between 2003 and 2015, only about 6,380 associate's degrees were awarded annually in oil and natural gas fields, compared to 32,430 in related applied science fields (RAND Corporation, 2017). An updated analysis is warranted to determine whether these trends have shifted, though it is unlikely the gap has significantly narrowed.

At the high school level, the picture is similarly fragmented. Many career and technical education (CTE) centers offer strong programs in welding, diesel mechanics, and HVAC—fields that align closely with oil and gas operations. Yet few provide energy-specific pathways. This represents a missed opportunity. The foundational elements already exist, but they remain siloed. What is needed is an integrative model—one that combines existing trade instruction with immersive tools, such as virtual reality (VR), alongside direct industry engagement. This approach would enable schools to produce graduates who are both motivated to pursue energy careers and prepared to enter the field safely and confidently.

Stigma & Misunderstanding
REBRANDING THE INDUSTRY

Further complicating workforce development is the persistent stigma surrounding the oil and gas industry. The perception that these jobs are “dirty,” dangerous, or outdated continues to dissuade students and educators alike.

In reality, modern oil and gas operations are among the most technologically advanced sectors in American manufacturing. From automated drilling systems to real-time emissions monitoring and remote operations platforms, today’s workers operate at the nexus of mechanical systems, environmental stewardship, and digital innovation. Rebranding the sector to reflect this reality is more than a PR effort — it is a workforce imperative.

Industry subject matter experts assisted the design team on an actual site, documenting every detail with photos, video, and 3D scans of the entire environment.

This point was underscored by Mike Rowe, host of the Discovery Channel series Dirty Jobs. Rowe cautioned that “AI is not coming for the plumbers, the welders, and the people who keep the lights on. It’s coming for the coders.”

He went on to argue that the greatest job security in the coming decades will be found in the skilled trades, precisely because these jobs require hands-on expertise, problem solving, and adaptability in environments that cannot be fully automated. The irony, as Rowe noted, is that while students are encouraged to pursue “future-proof” white-collar careers, the trades — long dismissed as old-fashioned — are proving to be among the most resilient and future-facing career paths.

-Senator Dave McCormick’s 2024 Energy and AI Summit | Pittsburgh, PA

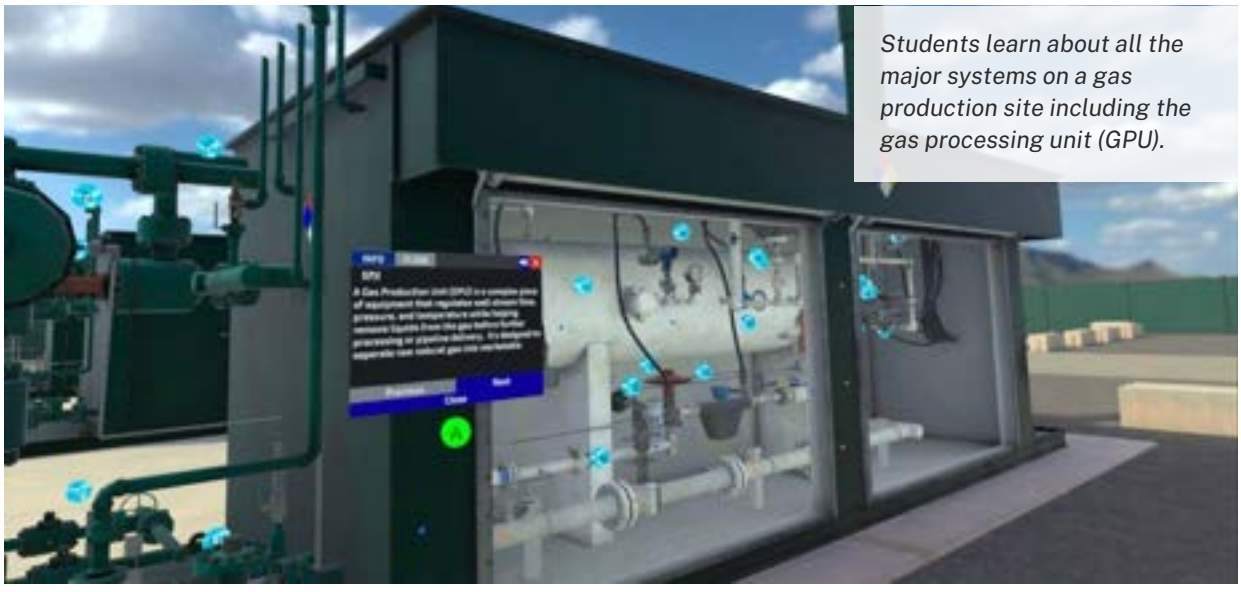
The New Technician

SKILLED, DIGITALLY INNOVATIVE, AND CAREER-READY

Gone are the days when physical strength and stamina were sufficient qualifications for fieldwork. Today's energy professionals are skilled problem-solvers and digital innovators — managing data flows, collaborating across distributed teams, and applying advanced environmental, health, and safety protocols to modern operations. Frontline employees such as wellsite operators have become the backbone of daily production, providing critical input to field managers, remote engineers, and energy marketers. Many of these workers begin their careers in CTE programs, earning certifications in welding or diesel mechanics, and increasingly pursue associate degrees in energy technology or petroleum applied science — credentials that reflect the growing technical demands of the role.

Government reports, such as the 2024 U.S. Energy & Employment Report (U.S. Department of Energy, 2024), and workforce organizations, including the Energy Workforce & Technology Council (2023) and the Society of Petroleum Engineers (n.d.), emphasize the same message: workforce development must be proactive, collaborative, and scalable. Partnerships with schools, new training models, and industry branding all play essential roles. The jobs will be there — from well pads to refineries — but only if the workforce is ready.

This need is not new. Over a decade ago, Graham (2010) warned that oil and gas workers were aging and that the industry lacked a compelling strategy for recruiting young people. More recently, Queen (2025) reported a 7% workforce reduction in 2024 despite increased demand, with over 50% of current workers over the age of 45. This confluence of under-recruitment and accelerated retirement threatens to destabilize the sector without immediate intervention.

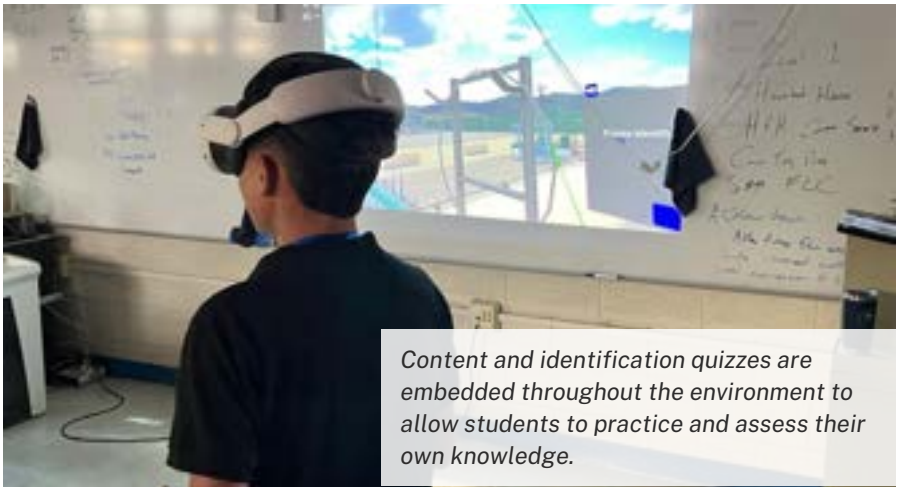


Students learn about all the major systems on a gas production site including the gas processing unit (GPU).

The Case for Immersive Learning
SAFETY, ACCESS, AND ENGAGEMENT

Cultivating student interest in oil and gas careers has many facets. First, the danger of reporting to an active job site often prevents students from engaging with real-world environments. Second, while safety training is foundational in the industry, it is challenging to simulate effectively in the classroom. Zierold et al. (2012) found that students often dismiss safety concerns unless they've experienced them directly—yet 58% of students in their study (even in lower-risk environments like food service) reported on-the-job injuries.

So, how can students gain exposure to energy environments without stepping onto a hazardous worksite? How can educators teach safety and operational understanding in a way that resonates with the digitally native students today?



Content and identification quizzes are embedded throughout the environment to allow students to practice and assess their own knowledge.

One promising answer lies in immersive learning. Maulana et al. (2021) report that virtual reality (VR, or more broadly defined as XR) is a valid and effective method for helping vocational students explore real-world problems and build career pathways in a safe, engaging environment.

A Working Solution
INDUSTRY-BACKED VIRTUAL REALITY (XR)

To meet this need, we have developed a virtual reality experience specifically designed to introduce students to upstream oil and gas operations. With support from industry partners like Coterra, Xalter built an immersive environment to mirror a real-world natural gas production site in Pennsylvania. The simulation encompasses various components, including wellhead configurations, gas production units (GPUs), compression systems, pig traps, and storage facilities. This platform provides students with a risk-free, hands-on experience that captures the complexity and sophistication of energy work, reframing the industry as one of opportunity, innovation, and relevance.

Pilot Test

3	50+	72
Classrooms	Interactive Points	Students

In the Spring of 2025, we tested the curriculum with 3 different classrooms for a total of 72 students. Students were both dual-enrollment students on a vocational energy pathway and traditional high school students. They attended school in Pennsylvania and New Mexico. Their teachers came from a variety of backgrounds; two had some experience in the oil industry, but one teacher had none.

Xalter designed a virtual ‘dry gas’ production environment that has over 50 interactive points. The site also features the ability to view system-related flows and cutaways, providing a deeper understanding of how the systems operate and interrelate. These allow students to identify key equipment and processes on an upstream natural gas production site, and take quizzes about the items and how they relate to each other and work together to perform the work in the field.

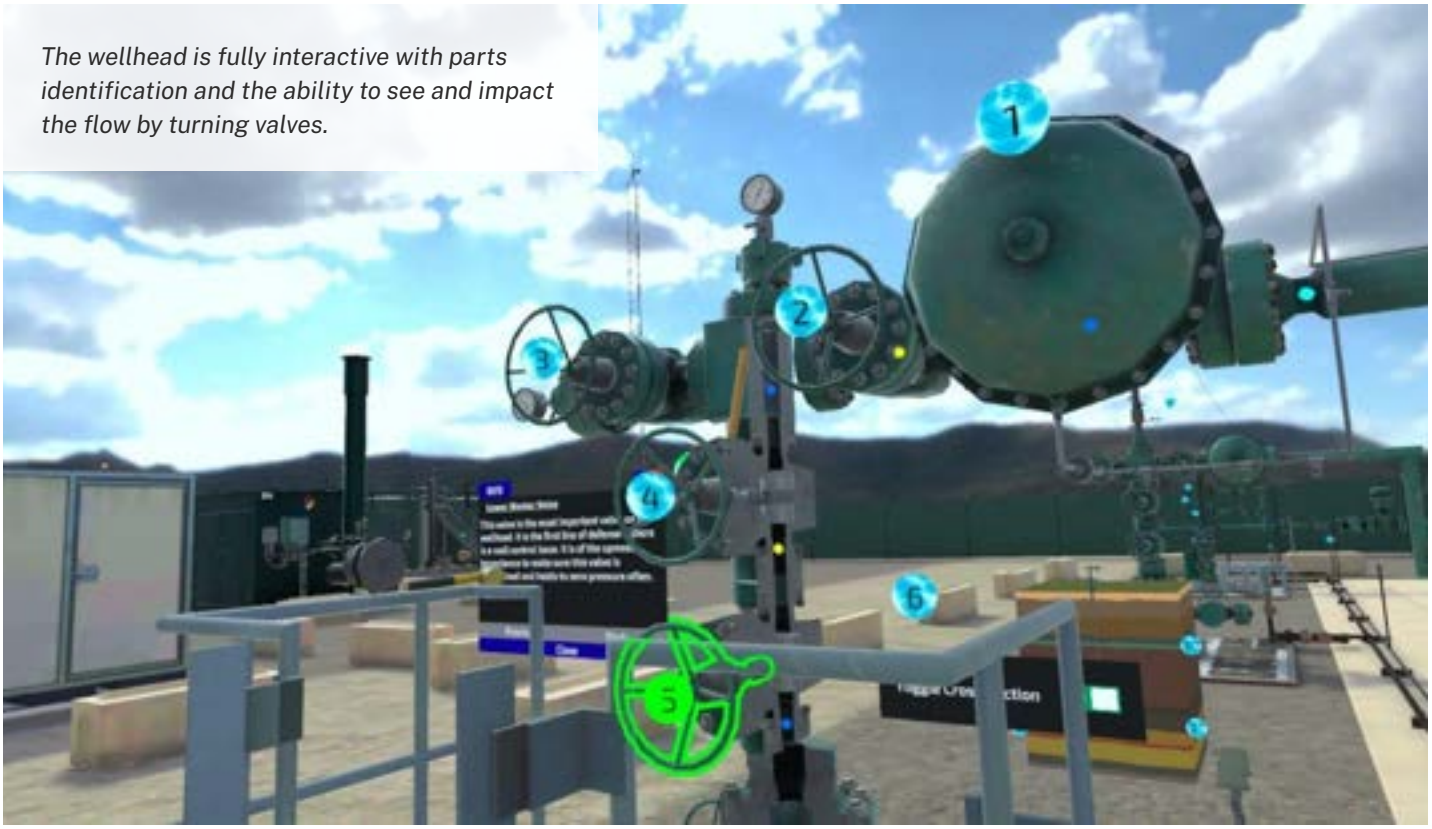
Students are guided through an overview of the entire production site, giving them insight into how all the various systems work together to get the product from the source to the pipeline, as well as proper safety guidelines and protective equipment while on the real-world site. Then, students are invited to deep-dive into the particulars of the various components and functions of the wellhead and the gas production unit, where they can go virtual ‘hands-on’, turning valves, selecting components, and even using 3D pens to make notes in the environment.

Pilot Test

The teachers chose to deliver the content in different ways. Each teacher was provided with 3-5 Meta Quest 3's preloaded with the content. Some of the teachers opted to have students explore the content in small groups during class time. Others allowed the students to check out the headsets and complete the activities as "homework". Both approaches produced positive results, as measured by a pre- and post-test design that assessed participants' knowledge before and after the module.

The pre- and post-test questions were developed in collaboration with industry professionals, focusing on the knowledge expected of entry-level workers during initial training. Teachers were interviewed to debrief the activity and gather feedback for future development.

The wellhead is fully interactive with parts identification and the ability to see and impact the flow by turning valves.



Results

Seventy-two students completed both the pre- and post-test, which included questions about upstream gas site safety, terminology, and function. 90% of those students showed improvement between their pre- and post-test, with average scores increasing from 36% on the pretest to 75% on the post-test. Between the pre-test and the post-test, students spent about 2 to 2 ½ hours engaged in the module activities.

over **100%**

Average score Improvement

Overall average student test scores improved from 36% (pre-test) to 75% (post-test).

72

Student Participants

Total participating secondary education students from four school districts in two states (PA and NM)

9 *out of* **10**

Students Improved

Students whose post-test score improved over the pre-test after time learning immersively.

30 *hours*

Total Time on XR Site

Active time spend by students in the virtual training environment.

Data provided by Xalter

Funding for the development and deployment of the hardware was provided in part by:

COTERRA

Teacher Insights

Teachers provided the most insight into the effectiveness of the module. Each teacher was interviewed via Zoom and asked questions about curricular and classroom integration. The interviews also served to provide feedback on the design of the environment and offer suggestions for future design.

Teachers used the modules collaboratively with the students. One teacher explained that three students were wearing headsets and one student was on the computer, so others in the classroom could see what was happening. Students quickly became comfortable in the environment and also showed each other around, navigating collectively. Another teacher found success having students take turns using the headsets at home and extending classroom instruction.

Given that this was a beta test of the module, teachers were flexible with how students used it. They found that solving problems as a group also allowed them to assign roles to students - for example, in the classroom, one student was designated as a safety monitor to ensure that students adhered to their boundaries during group activities. Students also used the computer or projected the environment to the classroom so that others could observe interactions and problem-solving approaches, even if they were not in a headset.

The modules reached students who may not have otherwise been engaged. One teacher shared that students completed in-class work early in order to use the headsets, “It was the kids who never want to finish notes and never want to do things in class that did the most in the headset.“ One teacher shared that a student who was added to the class late and had discipline issues was really engaged in the headset. Even with missing a lot of class, the student earned the highest score in the class and opted to continue in the energy pathway for a second year.

Teachers liked that the XR module evened the playing field for their students. “One of the things that I appreciate the most about the headsets is that it's giving equal access to all students and you're getting around some of those safety constraints... not every kid can go on a field trip.“ Field trips and bringing in industry people are important to the teachers’ curriculum, one teacher explained, “That's the beauty of the VR headset is that kids can actually experience it in the classroom with the teacher...I make a huge effort to take my kids on field trips, and it's a lot of work...It's a lot of paperwork and logistics and planning, and money.”

The teachers also found that the immersive experiences supported their teaching and professional development. A teacher explained, “I worked on drilling rigs before becoming a teacher. So, I lean on that experience a lot. But the thing about the energy pathway is it's very broad. It's trying to show students all of the industry from upstream to downstream.... I don't think a lot of industry people even have all of that experience from start to finish.”

Discussion & Future Projects

This case study showed that immersive learning using virtual reality was a valid approach for students to explore industry careers in both a safe and engaging environment. All of the content created was in collaboration with industry experts to make sure what students learned is industry-aligned and relevant. While the learning objectives for this module were introductory in nature, it lays the groundwork for more in-depth career exploration and career preparation for students. The expansion of the project to include instruction on field-related operational and maintenance tasks, as well as diagnostic and troubleshooting scenarios, is already in development with the continued support of Coterra and collaboration from other industry companies.

As we tackle the issues related to the need for people to work in the field, Immersive learning offers solutions to address this issue. Learning in virtual reality removes many of the obstacles that prevent teachers and students from having the experiences and exploration needed to envision themselves in these high demand, high reward careers. This is especially important for rural students, where exposure to different environments and careers is limited. Accelerating access means students can build their skills at an earlier age and increase their trajectory. One instructor explained, “here are kids that are mechanically inclined.... if you have the drive... you can be a compression tech and .... make a stupid amount of money for five years while you're young .. (those kids) end up going into the management side of the compression technology and managing for those companies”.

The success of this pilot project highlights the transformative potential of immersive technologies, such as XR, in addressing the energy sector’s workforce challenges. By delivering safe, scalable, and engaging learning experiences, virtual reality offers a new model for career exploration and technical training—one that resonates with today’s digital-native students and supports educators in bridging industry knowledge gaps. As the oil and gas industry works to replenish its talent pipeline and rebrand itself as a hub of innovation and opportunity, XR emerges not merely as a tool, but as a strategic catalyst. With continued collaboration between educators, technology providers, and industry leaders, immersive learning stands poised to inspire, equip, and elevate the next generation of energy professionals—securing a more resilient and future-ready workforce.

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