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Attracting a New Generation to Engineering through Novel Online-Plus-Laboratory Experience

Prof. Scott A. Sabol, Vermont State University

Scott A. Sabol, PE, is Professor and Coordinator of Architectural Engineering Technology at Vermont State University - Randolph. He is a licensed structural engineer whose career includes building and bridge engineering in addition to instruction in those areas. He previously held positions as Director of the Delaware Transportation Institute and Senior Program Officer with the National Research Council's Transportation Research Board.

Dr. John N. Kidder Jr., Vermont State University

Dr. John N. Kidder, Jr. is Professor and chair of the Department of Engineering at Vermont State University - Randolph. He teaches courses in materials engineering and other topics.

Jeremy D Wheeler

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Abstract

Developing a sustained engineering workforce is increasingly challenging, particularly in rural regions where students may have limited exposure to engineering careers and pathways. As part of a grant-funded engineering bridge initiative at Vermont State University, we developed and piloted a dual-enrollment course, "Explore Engineering," that pairs asynchronous online modules introducing multiple engineering domains with structured, on-campus laboratory sessions held every other weekend. The course aims to increase career awareness and help students visualize themselves in engineering-related work while building early confidence through hands-on experiences. This paper documents the model, recruitment and selection approach, and early observations to inform replication and iterative improvement at other rural-serving institutions.

Introduction

Cultivating a diverse and sustained engineering talent pipeline remains a persistent challenge, particularly among rural high school students and recent graduates who often lack direct exposure to engineering as a viable field of study and career path. In rural regions, geographic dispersion, fewer local industry touchpoints, and limited access to engineering role models can further narrow students' awareness of postsecondary pathways and workforce options. To address these barriers, our university developed an online-plus-laboratory course as part of an engineering bridge program that supports transitions into associate and bachelor's engineering technology programs and employer-sponsored apprenticeship pathways, funded by a U.S. Department of Education workforce development grant [1]. This paper reports findings from the initial implementation of "Explore Engineering," a semester-long course that integrates asynchronous online instruction with hands-on campus laboratories, aiming to expand participation for rural and underrepresented learners while supporting transitions into engineering technology programs and employer-sponsored apprenticeship pathways.

The contribution of this paper is practical: it (i) situates the course within a rural-access pathway initiative, (ii) documents the hybrid model and statewide recruitment/selection process, and (iii) reports early observations and an evaluation approach that can guide iterative improvement and transfer to other rural-serving institutions.

The paper also contributes a practical framework for rural-ready hybrid course design, defined here as an instructional model intentionally structured to reduce geographic, logistical, and experiential barriers commonly faced by rural learners. Key design elements include the development of asynchronous online modules to accommodate variable student schedules and access to reliable broadband connections, on-campus laboratory sessions scheduled every-other-weekend to reduce travel frequency while promoting peer interaction, transportation support where needed, and structured hands-on laboratory experiences to build early confidence and identity in engineering. These elements were selected to directly address known participation barriers in rural contexts, including travel distance, limited access to engineering role models, and reduced prior exposure to engineering pathways.

Need to Increase High School Student Familiarity with Engineering as a College Major and Career

Multiple K-12 studies suggest many students have limited understanding of what engineers do and of the variety of engineering careers available. Youth often conflate engineers with scientists and hold narrow or stereotypical images of engineering work and careers [2]. In rural communities these awareness gaps are compounded by fewer opportunities to encounter engineering role models, coursework, and co-curricular programming, leaving many rural students with little prior exposure to engineering as an academic or professional discipline [3,4]. Nationally, interventions to mitigate this disparity have targeted high school and Career and Technical Education (CTE) participants through pathway models that combine applied experiences with postsecondary credit, including dual-enrollment and articulation structures that improve pathway visibility and readiness [5].

Online and hybrid bridge models can expand rural students’ participation in pre-engineering education by reducing scheduling and travel barriers. Previous evaluations have suggested that well-designed virtual or blended bridge experiences can achieve outcomes for preparation and retention comparable to in-person formats in some contexts, all while lowering cost and improving accessibility [6,7,8,9,10,11,12]. However, effectiveness varies by design and context, and evidence remains uneven across populations and settings.

For rural students, the central challenge is often not only access to university courses, but sustained connection to peers, faculty, and engineering identity-building experiences. Without deliberate structures for belonging and academic support, online participation alone can amplify isolation rather than reduce it. Rural-ready hybrid design therefore needs to be built around community, mentoring, and early success signals from shared hands-on learning experiences with peers, engineering faculty, and support staff [13]. Longitudinal evidence indicates rural engineering students can be disadvantaged in graduation likelihood and GPA, underscoring the need to treat rural students as a distinct population and to evaluate student supports in local context [14]. “Explore Engineering” was designed as a rural-ready hybrid that pairs online access with structured community-building and hands-on laboratory engagement, specifically tailored to rural learners’ lived participation constraints. These constraints suggest that effective hybrid models for rural learners must do more than provide access to remote learning; they must intentionally structure opportunities for connection, identity development, and hands-on engagement. Because rural students often are unable to commute multiple times or even once a week to engage in an on-campus course, this course's combination of online asynchronous coursework with every-other-week on-campus laboratories successfully enabled students to participate from across the state.

Vermont is consistently ranked as the most rural state in the U.S.; one commonly cited estimate suggests that more than 80 percent of residents live in rural areas [15]. As such, rural access is a defining condition for our potential student population, and any effort to broaden participation through online course delivery is bounded by students' access to reliable internet connectivity. Until recently, connectivity limitations severely restricted potential students' access to online instruction; however, recent infrastructure investments have substantially expanded broadband availability and fiber connectivity statewide [16,17,18,19]. This expanding infrastructure has created a practical foundation for increasing participation in college-level engineering education through the development of online-plus-laboratory courses taught by university professors.

Grant-Funded Effort to Kickstart an Engineering Bridge Experience

Vermont State University's Engineering Bridge Program was established as part of a comprehensive allocation supporting systemwide transformation of the state college system into a singular institution and expansion of pathways into high-demand advanced manufacturing and technology sectors [20]. The program portfolio includes three three-credit offerings designed for high school participants: "Explore Engineering" (the focus of this paper), Foundations of Technical Mathematics, and a technical-writing-focused composition course. Together, these courses aim to increase awareness of engineering career pathways, build foundational readiness, and connect students to degree and apprenticeship options aligned with regional workforce needs.

Description of Explore Engineering Course and How Developed

The goal of "Explore Engineering" is to familiarize students to engineering as a field and to several specific disciplines, emphasizing what engineers do and how engineering connects to everyday life and societal needs. The overarching learning objective of the course developers was for students to become able to envision themselves in an engineering career, perhaps increasing the likelihood of them pursuing an engineering degree.

The course was intentionally structured as a combination of asynchronous online instruction and on-campus laboratory sessions held every other week, a cadence designed to reduce the frequency of travel burden while preserving regular hands-on engagement throughout the semester-long course. On-campus laboratory experiences were explicitly designed for students to build confidence through brief, guided calculations and hands-on applications. The online sequence covers seven discipline-focused modules (Electrical, Mechanical, Manufacturing, Construction Management, Renewable Energy, Civil/Environmental, and Architectural Engineering), with module order chosen so integrative fields appear after foundational topics. Each module and accompanying laboratory experience matches degree programs found in the Department of Engineering at our university. Many general fields of study were introduced, but the laboratories and lecture problems focused on engineering technology, which are the degree types we offer.

Course presentation order comprises two distinct but related parts. An online portion introduces students to engineering in general and to several specific disciplines related to them over a two-week period. At the conclusion of each two-week period, students travel to the VTSU Randolph campus to complete an in-person laboratory component with multiple hands-on applications of the topics covered. Each two-week module culminates in a four-hour Saturday laboratory session aligned to the module topic. Students commuted from up to 90 miles away to attend the on-campus laboratory sessions; transportation assistance was provided to those who needed it. Enrollment was capped at 15 students not only due to laboratory capacity, but also to support a cohort-based experience in which students could interact consistently with peers, faculty, and near-peer mentors. This small-cohort structure was intended to support early development of engineering identity and belonging among the cohort, which are often limited for rural students with minimal prior exposure to engineering professionals.

Course development was led by a single engineering faculty member, with support from technical staff, instructional designers, and grants-management personnel, using regular design meetings to align module content and laboratory experiences. Other faculty and technical staff developed laboratory experiences, with most also being the lab instructors for the course. All content was delivered through the university learning management system; the course is a three-credit dual-enrollment offering and is positioned to meet standard transfer expectations as a college-level technical elective. The only expected pre-requisite knowledge was that students would have a reasonable grasp of high school algebra and geometry.

Course Format: Online Modules and On-Campus Laboratory Components

To support students with varying prior online-learning experience with college-level courses, each two-week module followed a consistent pattern to make workload and course navigation predictable. Week 1 emphasized an overview of the discipline (history, subfields, typical projects, and career roles), and concluded with a brief discussion prompt (typically 300–500 words) assessed for clarity and organization. Week 2 introduced one or two accessible calculations using the NCEES FE Reference Handbook as the sole technical reference, followed by a short homework set that included an open-ended question connecting engineering to sustainability, inclusion, or societal impact, as an important objective was to go beyond the technical and scientific aspects of engineering to show how engineers must also be sensitive to culture and the environment.

The first of the two-week segments focused on the history, people, achievements, and organizations/companies found in that discipline. Each week had specific learning objectives. For example, for the first week, the following learning objectives were stated (note that the first one was broad and not focused specifically on electrical engineering). At the end of the week, students should be able to:

- Describe what engineering is, and the difference between engineering and engineering technology
- Describe what comprises the field of Electrical Engineering (EE)
- Discuss tasks and projects undertaken in EE
- Describe careers, people, concepts, and entities in EE

The week's online coursework was broken into the following parts, all supplemented with lecture notes, recorded lecture videos, and assigned readings:

- A review of very basic concepts (explaining things such as current, voltage, resistance, and power in simple terms) and where they affect everyday life.
- History of the field, including significant advances
- Strongly related subfields (e.g., explaining the relation of computer engineering, electrical engineering, and electromechanical engineering)
- Tasks or projects that would be part of an engineer's life
- Lists of major accomplishments in the field
- Typical careers and job titles in the field
- Notable people, companies, and professional organizations (including national, international, and regional examples)
- Typical university curricula that would be seen for that area, often distinguishing between what might be seen in an engineering program versus an engineering technology program. Students were presented with the specific curricula from our university as examples.

A significant part of the first week in each subject was the inclusion of subjects not always emphasized in the early years of engineering study. Specifically, for each subject, concepts related to sustainability, artificial intelligence, diversity, equity, and inclusion, and social justice issues were included. These were each accompanied by brief lectures and readings.

As noted, at the conclusion of the first week, each student had to post a discussion on a prompted topic. Discussion posts were generally 300-500 words and had to be the student's original work (although often with some cited reference material). Topics were open-ended. An example discussion board topic from Civil and Environmental Engineering was:

> *"Discuss a civil or environmental engineering project that could be designed and built in your home community that you think would make daily life better for your community.*

What problem is your project solving (or what opportunity is your project taking advantage of)?"

Responses were graded on clarity of expression and grammar, and how compelling the writing was. Rarely were there so-called right or wrong responses to any prompt.

The second week for each subject would focus on an engineering calculation of some sort and a laboratory experience. The learning objectives of the week were the same for each second week, but the focus would evolve. For example, from the second week on Architectural Engineering, the student was expected to be able to

- Solve calculation-based problem(s)
- Describe where the topic is seen in the real world (and perhaps in the entertainment industry, as this ties in with how some information is presented in the course)
- Practice tasks related to laboratory experiences

Lecture content for the week would focus on one or two basic engineering calculations, presented both in writing and by video, demonstrating basic concepts, the applicable equations that came into play, and a full solution. For Architectural Engineering, the sample calculations related to computing heat conduction through walls.

Topics were intentionally brief and focused, given that not all students would have the same science background or abilities. The intent was more to show what things an engineer can do, and not so much to make a student proficient, but rather show them that, with instruction, they do have the ability to solve basic real-world problems. This reinforced a course goal of making each student feel that they could become an engineer.

The only resource used for the engineering calculations each week was the NCEES FE Reference Handbook (Edition 10.4 at the time). The use of the FE Reference Handbook as a common technical resource provided an accessible and free resource for a cohort with varying academic preparation, allowing students to quickly engage with authentic engineering reference materials without assuming prior exposure. Within the online lecture, specific pages with equations or source information (e.g., thermal conductivity of a material) were shown.

The second week would include assigned homework calculations very similar to the demonstrated lecture problem, but with the student having to address permutations such as differing inputs, different units of measurement, or perhaps having to algebraically rearrange an equation from the Handbook to find a variable value that, in the lecture, had been a provided number.

Homework always included an open-ended question, often related to sustainability, artificial intelligence, diversity, equity, inclusion, or social justice. The following example is from the Manufacturing Engineering section of the course:

> *"Imagine yourself as a manufacturing engineer who goes onto a factory production floor to occasionally evaluate (and even use) manufacturing equipment and processes, to supervise and train some production workers, and to review the quality of finished products. Your company says that it has a commitment to diversity, equity, inclusion, and social justice.*
>
> *Now pretend (or it may actually be true for you) that you have one of the following disabilities:*
>
> - *Wheelchair-bound (unable to walk)*
> - *Blind*
> - *Deaf*
>
> *A) What challenges in that environment do you think would exist related to you performing your job well?*
>
> *B) What are one or two things that you could recommend be done to aid you in getting your work done successfully and safely?"*

The second week of each module also provided some entertaining yet instructive material by way of video clips from mass media. Examples included videos in the Civil and Environmental Engineering week on fish ladders, in the Architectural Engineering week on scenes from the 1970s television show "Kolchak: The Night Stalker," that referenced architectural engineers as a profession, and for Renewable Engineering, a video clip from the movie "The Core" that misstates how solar panels produce energy.

The culminating experience at the end of each second week of a topic was the on-campus laboratory experience. Students would come to our campus in the morning for a four-hour session that included practical, hands-on applications related to that week's topic. Examples included

- Additive manufacturing of components (Manufacturing Engineering)
- Quantity estimates and project scheduling (Construction Management)
- Irradiance meters and solar energy calculations (Renewable Energy)

Course enrollment was limited to 15 students (the first offering achieved full capacity) primarily because of capacity restrictions in the laboratory environment.

Example Laboratory Experience

A critical component of the course was the weekend in-person lab sessions, which met every other Saturday morning for four hours. The lab activities aligned chronologically with the topics being discussed in the asynchronous lectures. For faculty developing and delivering the lab activities, the FE Handbook provided a nice standard for concepts, relations, notation, etc., around which the lab activities could be framed if desired.

Laboratories emphasized hands-on work paired with simple analysis and clear deliverables (worksheets or brief reports), often allowing students to complete most work during the session. One representative lab introduced engineering materials through density measurement, alloy composition calculations, casting, and basic mechanical testing. Students measured specimen geometry and mass to estimate density, produced aluminum–copper alloys at targeted weight percentages, created sand molds using 3D-printed patterns, and then measured hardness and tensile strength using benchtop instruments. Students submitted recorded data, calculations with units, completed tables, and a short interpretation of results.

In general, the lab activities consisted of some work that applied to the engineering fields and principles discussed in the lectures. Each laboratory experience included some component of analysis, and emphasized hands-on activities such as fabricating and testing LED circuits, casting and strength testing metal alloys, etc. They all included some deliverable assignments, and it was common for students to be able to complete most of the assignment during the weekend session and any other follow-up work to meet a Sunday due date.

As an example, one lab session focused on engineering materials and the students explored metal alloys and the concepts of their weight composition and mechanical properties. A supplementary information sheet was provided that included engineering equations, geometry formulas, and other information in a readily accessible form. Students were expected to follow standard engineering practices such as recording data and observations and showing all calculations with units and annotation as needed.

This activity started with some simple measurements and calculations. Specimens of aluminum alloy and copper with different geometries (blocks and cylinders) were provided and the students measured dimensions, computed volumes, used a scale to measure mass, and compared the measured density values with published data in the FE Handbook.

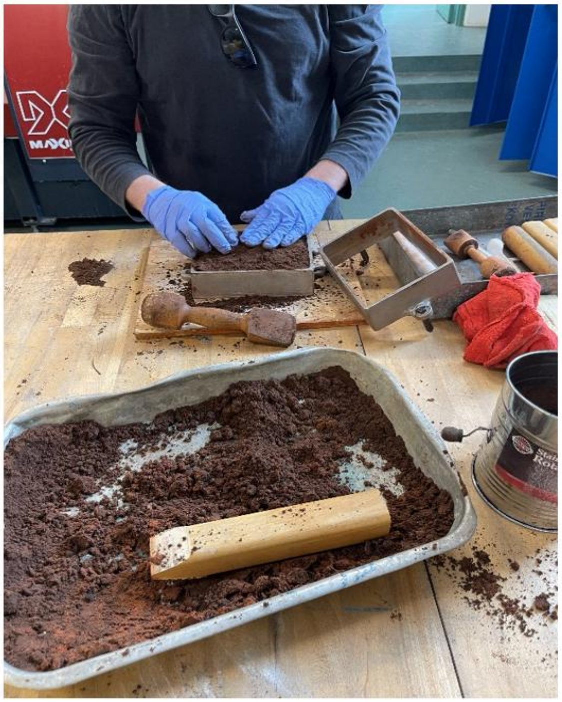
In the second part the students were tasked with producing aluminum-copper alloys of different composition by weight percent (wt%), specifically four specimens with copper composition of approximately 2-8 weight percent. This required calculations to determine relative masses needed and then measuring out scrap aluminum and copper pieces to be melted in a casting crucible.

Prior to casting, we reviewed the concept of a phase diagram, and phases of materials, and students used the phase diagram to determine the approximate melting point for the alloys to be cast. While the metal was melting, the students produced sand casting molds using 3D printed patterns to produce tensile test specimens. Once the casting was complete and cooled it was removed from the sand and a vertical bandsaw was used to cut the tensile test samples from the casting, and a sample cylinder was also cut from the cylindrical casting riser and used to measure the density of the casted alloy.

In the last stage students used a hardness tester and a simple benchtop tensile tester to measure properties. Each instrument is manually operated and simple for inexperienced students to use. Prior to tensile testing we discussed the concept of stress and strength, and students used calipers to measure sample dimensions. After testing the specimens to failure, the maximum force was used to calculate a tensile strength. Data were recorded in a provided table. The students were asked to submit recorded data and calculations, completed data tables (empty templates provided in the worksheets), and to write a concise description of what is presented in the data tables.

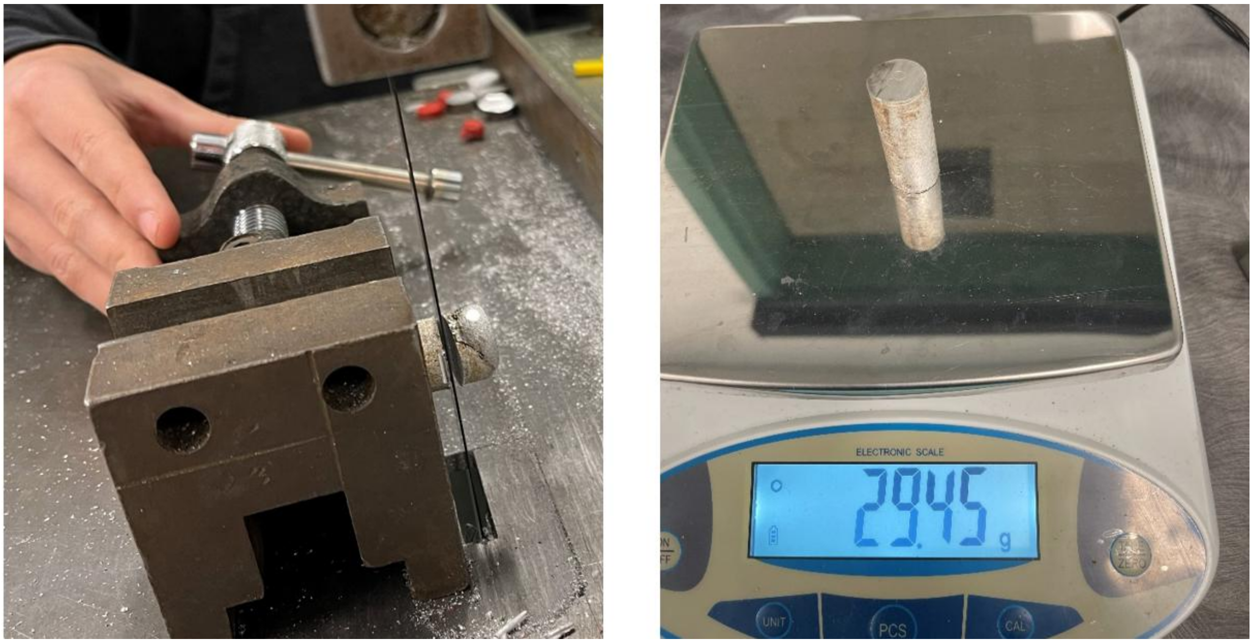
This example is representative of how the other Saturday lab sessions were structured. They sought to reinforce concepts that align with the online lectures, to use the FE handbook as a principal resource, they applied engineering tools and/or analysis, and they emphasized hands-on activities.

The figure on the left shows aluminum pieces being measured out for casting, and on the right is the benchtop casting furnace.

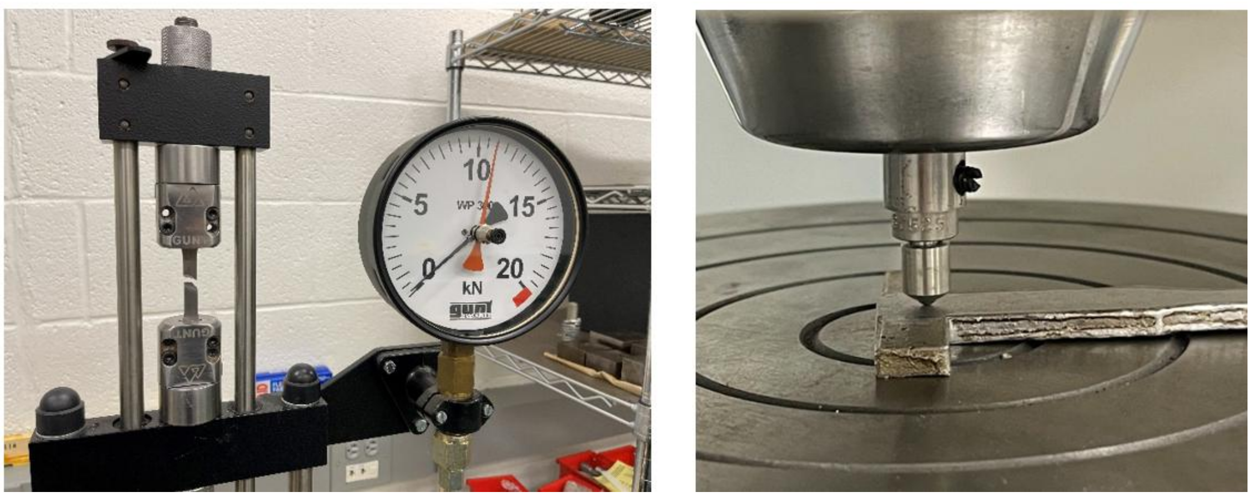


Students produced sand molds for tensile specimens using 3D printed patterns.

The figures about show the finished sand mold prior to removing the pattern, and a cast specimen after being cut from the casting.



The figure on the left shows a student cutting a sample cylinder from the casting to measure density of the cast aluminum-copper alloy, and measuring the mass of the specimen shown on the right. Calipers were used to measure dimensions to compute volume and then density.



Bench-top tensile strength and hardness tests were used to measure mechanical properties.

Solicitation of Students and Student Data on Targets and Enrollees
Recruitment, Selection, and Participant Characteristics

To recruit participants for the "Explore Engineering" course, a CRM database was assembled encompassing approximately 1,100 secondary and CTE STEM teachers, counselors, and administrators statewide to support targeted outreach through a dedicated campaign designed to familiarize STEM education stakeholders with the program's course opportunities, structure, and available scholarships. Complementary efforts included recruiting presentations by program staff during visits by high school groups to our university campus, coordinated with admissions and engineering faculty. Additional outreach extended to statewide organizations employing multi-district student support counselors. Target demographics emphasized high school juniors and seniors, CTE participants, and individuals from rural or underrepresented groups, in alignment with the program's outreach goals. Actual enrollees reflected this focus, consisting entirely of rural high school students, with many from CTE backgrounds.

Because grant funds could not be used for tuition for non-matriculated students due to Title IV restrictions, enrollment relied on the state’s dual-enrollment voucher programs, while grant funds supported course materials and delivery. Enrollment processes were managed collaboratively by grant-management personnel, university admissions staff, and the university’s dual-enrollment coordinator. For the pilot term, thirty-five (35) students applied to the Engineering Bridge program, with twenty-four (24) of those seeking enrollment in the Explore Engineering course. Enrollment in Explore Engineering was capped at fifteen (15) due to laboratory constraints, resulting in full enrollment and a waitlist of nine (9). Because enrollment demand exceeded available laboratory capacity, the pilot cohort was selected using a primarily first-come, first-served approach while maintaining alignment with the program’s outreach priorities toward rural and CTE-affiliated students. Formalized selection criteria were not implemented for the initial offering; however, the development of a more structured prioritization framework is planned for future cohorts to ensure equitable access, particularly for students with limited prior exposure to engineering opportunities. Participants were primarily rural high school juniors and seniors, with many from CTE backgrounds and several identifying as first-generation or underrepresented in STEM.

Geographic Distribution, Rurality, and Broadband Access

Table 1
Participant Geographic, Rurality, and Broadband Characteristics

Student ID	Sending School	Town (VT)	RUCA Code	RUCA Category	Distance to Campus (miles)	Estimated Travel Time (min)	Broadband Tier	CTE Affiliation
S01	BFA St. Albans	St. Albans	7	Small Rural	85	100	High	No
S02	RUHS	Randolph	10	Isolated Rural	4	10	High	No
S03	RUHS	Randolph	10	Isolated Rural	4	10	High	No
S04	RUHS	Randolph	10	Isolated Rural	4	10	High	No
S05	RVTC	Springfield	7	Small Rural	64	85	High	Yes
S06	RVTC	Springfield	7	Small Rural	64	85	High	Yes
S07	RVTC	Springfield	7	Small Rural	64	85	High	Yes
S08	RVTC	Springfield	7	Small Rural	64	85	High	Yes
S09	RVTC	Springfield	7	Small Rural	64	85	High	Yes
S10	RVTC	Springfield	7	Small Rural	64	85	High	Yes
S11	RVTC	Springfield	7	Small Rural	64	85	High	Yes
S12	The Greenwood School	Putney	10	Isolated Rural	88	110	Moderate	No
S13	U-32	Montpelier	4	Large Rural	28	30	High	No
S14	U-32	Montpelier	4	Large Rural	28	30	High	No
S15	Cabot School	Cabot	10	Isolated Rural	44	56	Moderate	No

Table 2:
Summary Statistics of Participant Distance, Rurality, and Pathway Characteristics

Metric	Value
Number of students	15
Mean distance (miles)	48.9
Median distance	64
Maximum distance	88
Minimum distance	4
% students > 30 miles	66.7%
% students > 60 miles	60.0%
% Urban	0%
% Large Rural	13.3%
% Small Rural	53.3%
% Isolated Rural	33.3%
% CTE-affiliated	46.7%

To evaluate the extent to which the Explore Engineering course expanded access for its intended rural population, participant geographic data were analyzed using sending school locations, estimated travel distances to the Vermont State University Randolph campus, Rural-Urban Commuting Area (RUCA) classifications [21], and town-level broadband availability data from the Vermont Department of Public Service (2025) [22]. These geographic characteristics reflect Vermont students' rural participation constraints that informed the rural-ready hybrid design framework described earlier, particularly the need to reduce travel frequency while preserving access to hands-on learning experiences. Table 1 presents geographic, rurality, and broadband availability for the cohort. Summary statistics are provided in Table 2.

Participants in the Explore Engineering course exhibited substantial geographic dispersion across Vermont. Home locations ranged from Randolph, located approximately 4 miles from campus, to Putney at a distance of 88 miles, with a mean travel distance of 48.9 miles and a median of 64 miles. A majority of students (66.7%) resided more than 30 miles from campus, and 60.0% traveled distances exceeding 60 miles to attend the on-campus laboratory sessions. These distances represent a significant participation barrier in traditional weekly in-person course formats for rural students facing limited transportation options and extended travel times.

RUCA classifications further reinforce the rural composition of the cohort. Over half of participants (53.3%) were from Small Rural communities, with an additional 33.3% from Isolated Rural areas and 13.3% from Large Rural towns. No students in the cohort were classified as urban. This distribution confirms that the hybrid course delivery not only attracted students from nearby communities but also drew student participation from across Vermont's predominantly rural and geographically dispersed population.

Broadband access across participant locations was sufficient to support hybrid participation. Based on town-level data associated with students' sending schools, approximately 73% of participants were in areas with high broadband availability (≥90% of locations served at 100/100 Mbps or better), while the remaining 27% were in areas with moderate access, characterized by strong 100/20 Mbps coverage but more limited high-speed availability. No participants were associated with schools located in areas with broadly limited broadband access. These data reflect broadband availability at students' secondary schools; connectivity conditions in their home environments may vary substantially. As such, these measures are indicative of regional infrastructure capacity rather than those of individual student access. Despite this limitation, the data suggest that asynchronous online components were broadly accessible across the cohort. Students living in more isolated communities served by their district school faced occasional bandwidth constraints due to variability in available service levels.

Nearly half of participants (46.7%) were affiliated with Career and Technical Education (CTE) centers. This alignment with CTE pathways further supports the course's role as an accessible entry point into engineering and engineering technology education for students already engaged in applied technical learning environments.

Taken together, these data provide quantitative support for the rural-serving design of the course. The combination of asynchronous online instruction with bi-weekly on-campus laboratory sessions enabled participation from students who would otherwise face prohibitive travel demands in a conventional course structure, while also accommodating variability in broadband access across Vermont's rural communities. The observed geographic and broadband infrastructure distribution of Explore Engineering course participants suggests that the hybrid model effectively reduced access barriers associated with both distance and connectivity, aligning with the intended design to broaden participation in engineering education across underserved regions of our state.

Incentives, Pathways and Early Pathway Signals

Incentives for participation in the Engineering Bridge Program were structured to leverage existing state resources while adhering to Title IV restrictions. Course tuition was available via our state's dual-enrollment program, while materials costs for the Explore Engineering course were covered by the grant.

Completion of the course awarded three college credits, providing a tangible academic incentive and an on-ramp to further study. To encourage continuation into degree pathways, scholarship support was available to bridge participants who completed at least one bridge course and subsequently matriculated into a technology degree program. These scholarships covered tuition, fees, and program-related expenses throughout the grant period. In the first year of the broader bridge initiative, nine students from the Engineering Bridge Program matriculated into technology degree programs, three of whom were participants in the Explore Engineering Course. These incentives were designed to foster retention and progression, creating a robust talent pipeline for Vermont's engineering sector.

Results from the First Offering

Discussion postings of each first week were assessed and graded, with feedback returned to the students. Writing abilities varied among the students, and if the instructor had concern that any portions were AI-generated, students were notified. The most common feedback to students included basic grammar errors and the need to break very long posts into individual paragraphs.

Homework problems were graded based on presentation, clarity, and technical accuracy. As might be expected, because a similar problem had been presented in lecture, most students had a general idea of the equations and process to follow to obtain a solution. Typical errors were calculation mistakes and incorrect application of units of measurement.

Laboratory experiences varied greatly in the way they were assessed. Some required a report of some sort, many required completion of a worksheet, and others were significantly experiential in nature, with successful and accurate completion of tasks (such as successfully having a computer model generate a physical 3-D printed artifact for Manufacturing Engineering) resulting in a good grade.

The course included a final exam week which required a reflective essay in which students were asked to

- Discuss something about engineering they had not known before starting the course
- Determine which laboratory experience was their favorite and explaining why
- Describe how they could see themselves in a career as an engineer, including which type(s) of engineering they might most likely pursue.
- Discuss what biggest engineering accomplishment that they would like to be involved in to improve the world

Student feedback on the course structure and content was positive. Many students stated in their final reflections that they could see themselves pursuing an engineering career, suggesting a shift in perceived accessibility of engineering pathways associated with course participation. An interesting comment shared by several was that their impression at the start of the course was that "engineering" was restricted to what most people would consider to be "mechanical engineering." The breadth of areas such as architectural engineering, environmental engineering, and others, and the relationship of construction to engineering, was informative to many. Some student comments from the final assessment included the following:

About the labs:

- *"I would consider my favorite lab to be construction management. It was a straightforward, hands-on lab with a great teacher. However, the thing I appreciated most was her students who took a construction management degree, who took the time out of their day to come in and help us. Having the ability to talk to someone only a few years older than me who had college experience, was beginning to get into the workforce through internships, and had a well-planned trajectory for their future, was incredibly inspiring."*
- *"I think my favorite laboratory experience was the one where we used CAD and CAM to make a 3D model in Fusion 360. Being able to see something you made come into the physical world was awesome."*

About learning about engineering in general:

- *"Something I did not know about engineering before this course was just how vast a subject it was. I always knew that it was diverse, but this course further opened my eyes to its diversity."*
- *"During this course I learned how contrasting different fields of engineering could be. They all have the same basic background but beyond that they are so unique when it comes to different fields of engineering."*
- *"One key takeaway was the systematic approach to solving real-life problems, which involves creating sketches, using labels, maintaining organization, and applying equations."*
- *" I learned a lot about the specializations of engineering in this class. Before this course, I thought there were like 5 different fields of engineering, and I learned that engineering is incredibly diverse. For example, civil engineering—I learned there are surveyors, structural engineers, environmental engineers, construction engineers, all in this one category and many of them mix with other fields."*

As to whether they could see themselves in an engineering career:

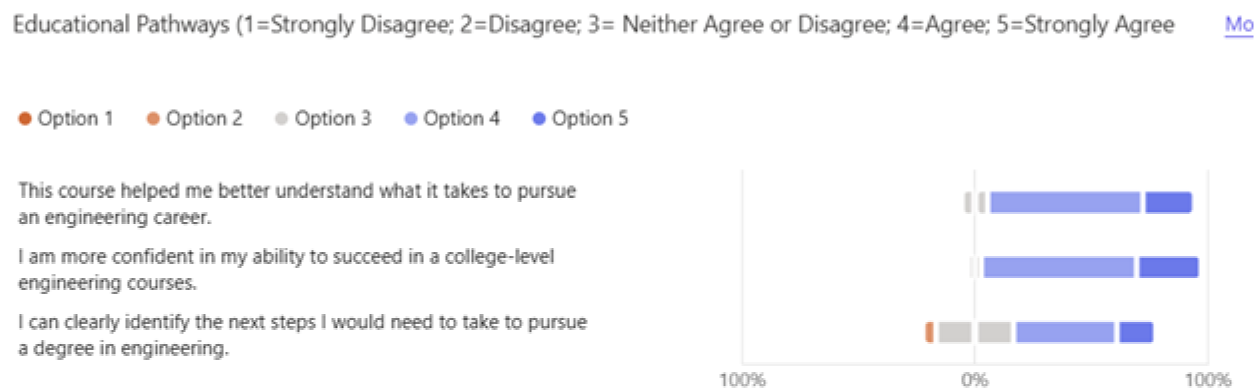
- *"While I can't say what type of job I'll have in that field I can say that [engineering] does open up many possible routes of employment that have always interested me."*
- *" The only thing that could stop me from pursuing a career in this field would be if the necessary course in college did not seem interesting or engaging. However, from participating in the lab through the Explore Engineering course, I strongly believe that I would have fun and be successful in this career."*
- *"I could see myself in either manufacturing or civil engineering. I really love building things and I think that I would enjoy it a lot."*

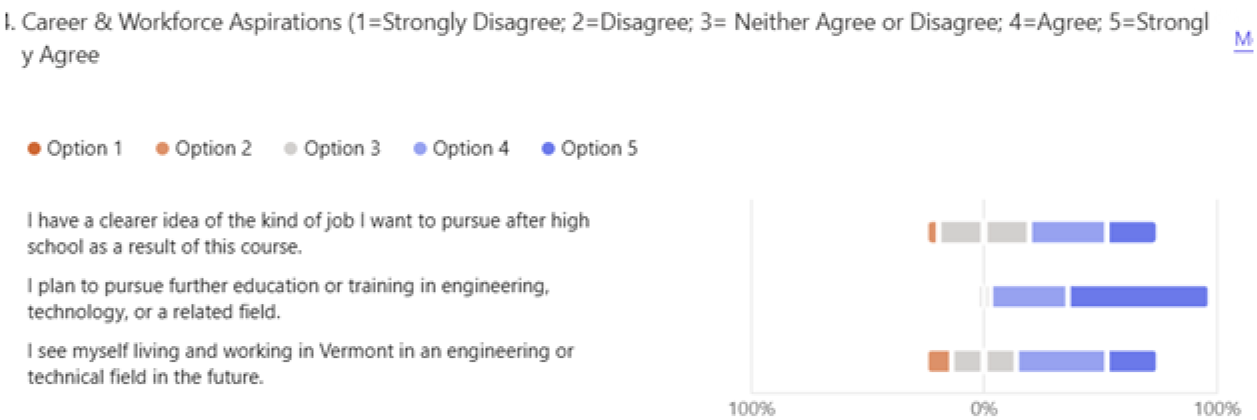
Students also answered a specific post-course survey anonymously. The data are slightly confounded by a change in the survey during the response period, resulting in 18 responses due to some duplicates.

One question asked, “What aspect of this course most influenced your thinking about engineering as a potential career path?” Some selected responses include:

- *“This course didn't influence my thinking because I was already on the path to engineering as a career. However, if I hadn't already been on this path previously, getting the hands-on learning would've influenced me the most.”*
- *“It helped me eliminate fields of engineering that I didn't want to go to.”*
- *“Learning what it takes. Solving problems where you first look at them and they look like an alien wrote them. This course showed me that a job can be fun! Not always grueling work, at least.”*
- *“It helped to see a sample of what we would do in those fields, the labs showed us what kind of things we like and don’t like.”*
- *”Being able to learn about each of the different types of engineering and learning its much more than simply sitting at a desk.”*

These reflections provide insight into students’ perceived changes in awareness, confidence, and interest; however, they represent self-reported outcomes and should be interpreted as indicative rather than causal. To strengthen the assessment of these outcomes, future iterations of the course will incorporate a structured pre- and post-course survey designed to measure changes in key elements aligned with engineering identity research, including interest, recognition, and perceived competence. These instruments will enable more systematic evaluation of shifts in student attitudes and understanding over the duration of the course. Other results to selected questions are presented below. A future task for the course is to try to determine what specifically made a few students less inclined toward engineering having taken the course.





An incentive to attract students was originally the follow-on benefit of free tuition and fees at our university through part or all of a degree. This was to be funded through the US Department of Education grant that also sponsored development of the course. However, the grant was curtailed at the end of August 2026 when many grant requests for no-cost time extensions were denied. This resulted in the grant only being able to cover fall 2025 tuition for the students. However, our university stepped in for spring 2026 to provide financial aid to the students from the course that had enrolled at the University. While the course stands as a useful experience on its own, the promise of free tuition was a major marketing advantage, and our university is trying to address how to continue enrollments in a different environment. Collaborations with other institutions' efforts to attract high school students toward engineering careers are currently underway.

The Explore Engineering course is anticipated to be offered again, depending on enrollment. Plans for enhanced enrollment-management tactics for a spring 2027 offering are already being considered, with more aggressive outreach to K-12 instructors.

For 2027, the course itself will likely incorporate an artificial intelligence laboratory experience related to the electrical grid through a collaboration with another university. In addition, a pre-assessment and post-assessment tool will be incorporated to better gauge the change in understanding about engineering that occurred during and because of the course. The first offering provided post-course commentary from students, but not a true measure of change in them based on having taken the course.

One of the assessment challenges in the course relates to the on-campus laboratories. It was deemed not feasible to provide make-up lab experiences for students who missed a lab due to illness or other reasons. Additional challenges existed for students who would have vacation travel during their high school breaks that would make interacting with the online component difficult. Our solution was to simply drop the lowest assessment grade for each student in each major category, whether that grade was low due to non-attendance or simply inferior performance. In 2025, no winter weather events resulted in laboratory cancellations due to campus closure, but that is another issue being reviewed for future offerings.

The 2027 offering also anticipates a potential simulation-based laboratory exercise related to electrical engineering and artificial intelligence, based on our interactions with our state's R1 university, the University of Vermont. This "virtual lab," not requiring on-campus presence, could be a "make-up" lab for any student who misses an in-person session. It may also provide information useful for institutions who want to develop a similar course but that do not have significant laboratory facilities.

Assessment Approach and Limitations

Assessment of student outcomes in the initial offering relied primarily on qualitative measures, including discussion posts, laboratory assignments, reflective essays, and a post-course survey. These assessments were designed to capture students' awareness of engineering fields, perceived confidence in their ability to engage with engineering concepts, and evolving interest in engineering pathways.

While these measures generated valuable insight into student experience, they were not specifically designed as instruments for measuring changes in engineering identity or self-efficacy over time. As such, findings from the initial offering should be interpreted as preliminary indicators of perceived impact rather than evidence of measurable change.

To address this limitation, future offerings will incorporate structured pre- and post-course surveys aligned with established methods in engineering identity research, including interest, recognition, and perceived competence. These survey instruments will be piloted and iteratively refined through each course offering to improve reliability and validity for our target student population, enabling more systematic evaluation of changes associated with course participation.

Outcomes of the Explore Engineering course can be considered across two time horizons. Immediate outcomes include increased awareness of engineering disciplines, improved confidence in engaging with engineering concepts, and early signals of engineering identity development. Longer-term outcomes, which require longitudinal tracking, include matriculation into engineering and technology degree programs, persistence in those programs, and progression into workforce pathways such as apprenticeships or technical careers.

These longer-term outcomes will be tracked through institutional research data, including enrollment, credit accumulation, persistence, and degree completion. Long-term outcome tracking for those who choose non-degree pathways, such as participation in industry apprenticeship or workforce training programs, could also be gathered through follow-up engagement with participants. These longitudinal measures, when combined with improved short-term assessments in future iterations of the course, will provide data to support more rigorous evaluation of course impact and inform subsequent research.

Adaptability and Replication Considerations

While the course model described here leverages VTSU Randolph's on-campus laboratory facilities, its core structure is adaptable to a range of institutional contexts. The essential components of the hybrid model include asynchronous online modules, structured reflection and problem-solving activities, and periodic hands-on engagement in a cohort setting. For institutions without comparable laboratory infrastructure, hands-on components may be delivered through partnerships with regional CTE centers, industry facilities, or mobile labs. Such adaptations could support broader replication of the model across rural-serving institutions with varying resource constraints.

Adjustments Due to Unforeseen Circumstances

The prospect of extended tuition support tied to grant funding was a primary marketing incentive for the Engineering Bridge initiative. Late-stage changes to grant timing constrained the duration of this support, reducing certainty for students making enrollment decisions. To maintain continuity for matriculated students, our university supplemented aid beyond the original grant window and is pursuing partnerships and alternative funding structures to sustain future cohorts. While the course stands as a useful experience on its own, the promise of free tuition was a major marketing advantage, and our university is trying to address how to continue enrollments in a different environment. Collaborations with other institutions' efforts to attract high school students toward engineering careers are currently underway.

Future Plans

Building on the initial Spring 2025 offering of "Explore Engineering," the course is being offered for continued annual spring-semester delivery with the next offering expected Spring 2027. Future iterations hope to expand participation through improved outreach and enrollment management and development of a summer offering. For 2027, planned enhancements include adding a laboratory experience in collaboration with our state's flagship R1 research university and implementing improved pre/post assessment instruments to measure shifts in student attitudes, understanding of engineering, and career awareness. By tying some pre-assessments specifically to course discussion topics or homework topics, a stronger sense of the changes in student engineering identity and understanding that would have evolved solely through course participation. Future offerings may incorporate structured pre- and post-course assessment instruments aligned with engineering identity constructs, enabling more systematic and quantitative evaluation of changes in student attitudes, confidence, and understanding. A summer version under consideration would be a hybrid model anchored by a two-week residential intensive, consolidating the hands-on work into cohort-based, design-oriented laboratory experiences culminating in team presentations while retaining asynchronous online coursework across the full summer term.

The summer model could also function as a foundational element of our university's participation as a subawardee in an NSF ExLENT-funded statewide work-and-learn program led by our state's flagship R1 institution. In that program a two-week residential practicum is followed by year-long paid internships with in-state employers supported by workplace and faculty mentorships, with pathways into continued employment, advanced manufacturing apprenticeships, or technology degree programs. Within the program structure, "Explore Engineering" would serve as the academic core of the practicum, enabling participants to earn three college credits while developing college and workplace readiness skills. The program targets recent graduates without immediate postsecondary plans, particularly those facing barriers related to rurality, income, first-generation/newcomer status, or underrepresentation in STEM.

Anecdotal evidence suggests a longer-term impact on enrollment, persistence, and success in engineering studies. One student who took the course in Spring 2025 applied to enroll at our university programs for Fall 2026, a full year later. Observations of students who enrolled in our university programs indicate impressive performance in coursework and specific feedback as to the continued effect the course had on them.

Selection criteria for whom to enroll if demand exceeds supply are currently being investigated, and may include:

- Giving those latest in their K-12 progression first priority (as they would not have the opportunity to apply again in following years)
- Determining if a demographic distribution of students is desirable (imposing a cap on enrollees from any specific sending school)
- Considering applicant lack of access to any other exposure to engineering based on their location or school.

Longer-term plans for this effort at Vermont State University include annual improvement cycles informed by assessment results (e.g., career-confidence gains and subsequent enrollment outcomes) and dissemination through ASEE and other venues to support replication in other rural contexts. With sustained grant support and institutional commitment, Explore Engineering is positioned to remain a scalable, broadband-enabled entry point into engineering and related technical careers for learners across Vermont. Our findings suggest that intentionally designed hybrid models can expand access to engineering pathways for rural learners, while highlighting the importance of continued evaluation to understand long-term impact and scalability.

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References

1. System Transformation of Workforce Development, Libraries, and Institutional Research, U.S. Department of Education, Award Number: P116Z220074; hereinafter “Workforce Transformation Grant”
2. Lyons, Jed, Bethany Fralick, and Jennifer Kearn (2009). "A survey of middle school students’ attitudes toward engineers and scientists." 2009 Annual Conference & Exposition.
3. Donham, Brent L., and Matthew Elam (2022). "Promoting interest in engineering in rural school districts through summer camps." 2010 GSW.
4. Beckwith, J. K., & Hirshfield, L. (2021, July), “Motivating Factors That Encourage Rural Students to Pursue Engineering.” Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. 10.18260/1-2—37517
5. Labrie, J., et al. (2024). Improving Electrical Engineering Education Structure by Bridging CTE, Community College, and University Programs Through Hands-on Skills Integration. ASEE PEER.
6. Smith, J., and Williamson, J. "Summer Bridge Programs for Engineering Students: A Systematic Literature Review." 2024 ASEE Annual Conference & Exposition. 2024.
7. Gonzalez, A., et al. (2021). Work in Progress: Design Activities in a Summer Engineering Program Implemented in Both Virtual and Hybrid Modality. ASEE PEER.
8. Larsen, A. (2023). Exploring Blended Learning Supports for First-Generation and Underrepresented College Students. BYU ScholarsArchive.
9. Every Learner Everywhere. (2021). Improving Critical Courses Using Digital Learning and Evidence-based Teaching Practices.
10. National Academies of Sciences, Engineering, and Medicine. Transforming Undergraduate STEM Education: Supporting Equitable and Effective Teaching. 2025.

11. Mahase, K. K. (2023). Bridging the Gap Between Education and Employability in Electrical Engineering: An Action Research Study. Northeastern University Repository
12. Eugenijus, Lesley. "Integrating blended learning and stem education: Innovative approaches to promote interdisciplinary learning." Research and Advances in Education 2.9 (2023): 20-36.
13. Shahhosseini, A., et al. "Strategies for increasing enrollment, retention, and graduation in two baccalaureate degree STEM programs: Mechanical Engineering Technology (MET) and Safety Management (SM)." 2020 ASEE Virtual Annual Conference Content Access. 2020.
14. EbrahimiNejad, Hossein, et al. "Pathways and outcomes of rural students in engineering." 2019 IEEE Frontiers in Education Conference (FIE). IEEE, 2019.
15. https://www.fhfa.gov/blog/insights/who-lives-in-rural-america
16. Vermont Department of Public Service. (n.d.). Broadband High-Speed Internet Availability in Vermont. (retrieved from: https://publicservice.vermont.gov/telecommunications-and-connectivity/broadband-high-speed-internet-availability-vermont)
17. BroadbandNow. (n.d.). Internet Access in Vermont: Stats & Figures. (retrieved from: https://broadbandnow.com/Vermont)
18. Vermont Community Broadband Board. (2025). 2025 Annual Report. (https://legislature.vermont.gov/assets/Legislative-Reports/Annual_Report_End_of_Year_2025.pdf)
19. Vermont Department of Public Service. Broadband Funding (https://publicservice.vermont.gov/vt-community-broadband-board-vcbb/broadband-resources-towns/broadband-funding)
20. System Transformation of Workforce Development, Libraries, and Institutional Research; Performance Period: 09/01/2022 - 08/30/2025; Award $3,708,000; US Dept. of Education, Agreement # P116Z220074
21. U.S. Department of Agriculture Economic Research Service. (2020). Rural-Urban Commuting Area (RUCA) codes. https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes
22. Vermont Department of Public Service. (2025). Broadband availability in Vermont: 100/100 Mbps and 100/20 Mbps service coverage by town. https://publicservice.vermont.gov/telecommunications-and-connectivity/broadband