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CAMINO—Career Advancement, Mentorship, Inspiration, and Opportunities: A STEM K-12 Outreach Initiative.

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1. Introduction

Hispanic Americans (HA) are the largest ethnic group in the United States. In 2022, nearly 64 million HA lived in the U.S., representing approximately 19% of the population. Notably, this population is not evenly distributed across states; about 60% reside in California, Texas, and New Mexico. Tennessee ranks as the 26th state in terms of HA population. As of 2022, 413,000 HA lived in Tennessee, accounting for about 6% of the state's population. Regarding post-secondary education nationwide, 19.1% of HA aged 25 or older have earned a bachelor's degree or higher, compared to the national rate of 34.1%. In Fall 2021, 55.8% of all HA undergraduates were enrolled in Hispanic-Serving Institutions (HSIs)—institutions with at least 25% HA student enrollment. In Tennessee, these statistics are close to the national rates; as of 2022, 21.9% of HA aged 25 or older had earned a bachelor's degree, compared to the statewide rate of 31%. While not being an HSI, the University of Tennessee, Knoxville (UTK), was the institution in the state with the second-largest HA undergraduate enrollment during the 2021–2022 academic year, with a total of 1,375 students, representing about 6% of the student body [1]-[4].

When the deep desire to make an impact on the HA community in East Tennessee emerged in the summer of 2019, UTK hosted approximately 29,000 students—23,000 undergraduate and 6,000 graduate students—, 4.4% of whom were HA. In the Tickle College of Engineering (TCE), these students comprised 3.8% of the undergraduate population and 3.3% of the graduate population. In the Electrical Engineering programs, they represented 5.5% of the undergraduate population and 2.2% of the graduate population, respectively [5]. In Knoxville, 5.9% of the population (184,281) was HA, which aligned with state demographics. However, certain towns near Knoxville had higher proportions of HA residents, such as 18.1% of the 8,965 residents in Lenoir City and 19.6% of the 29,395 residents in Morristown [6]. If the student body were to reflect regional demographics, additional efforts would be needed to broaden participation opportunities for HA students.

TCE has a proven educational infrastructure, spanning from precollege to engineering education. Through its Dwight Hutchins Engineering Diversity Programs [7], TCE offers precollege programs such as eVOL10 and HITES12, which are one-week residential programs for rising 10th and 12th graders, respectively. In these programs, precollege students from underrepresented minorities learn about careers in engineering, tour engineering labs and facilities, explore the UTK campus, and work on engineering design projects. Within TCE, some research centers also offer outreach programs for precollege students and teachers, such as CURENT in the Electrical Engineering and Computer Science (EECS) Department. Although TCE has successfully increased the number of underrepresented engineering students graduating with a B.Sc., M.Sc., or Ph.D. degree, increasing participation of HA students remains a complex issue, dependent on multiple factors and conditions. Our hypothesis is that HA students are not fully utilizing the existing TCE educational infrastructure because there is insufficient support for HA students in terms of awareness, opportunities to express frustrations and enthusiasm, building peer networks, and receiving guidance and mentorship.

To address this issue, CAMINO—Career Advancement, Mentorship, Inspiration, and Opportunities—was launched in 2021 with support from the National Science Foundation (NSF) through the NSF CAREER Award No. 2044629 [8]. CAMINO provides tailored mentorship opportunities for HA students, fostering an environment where they can receive guidance, build peer networks, and discuss their experiences and challenges in engineering. Rather than duplicating efforts, CAMINO connects various centers to integrate HA precollege students into UTK's educational system, particularly through TCE precollege programs. By 2019, eVOL10 and HITES12 had an average HA participation rate of 10%, a low figure given their focus on minorities. According to Program Directors, some HA students dropped out due to financial barriers (insurance costs and registration fees) or academic barriers (not meeting the minimum ACT math score of 25). CAMINO addresses these challenges by boosting academic performance and providing logistical and financial support to help students access UTK's educational infrastructure. Its goal is to increase HA participation in TCE's precollege programs, as outlined in Figure 1, which uses 2019 enrollment data. While CAMINO also targets HA undergraduate students, this article focuses on its efforts to inspire and impact HA precollege students.

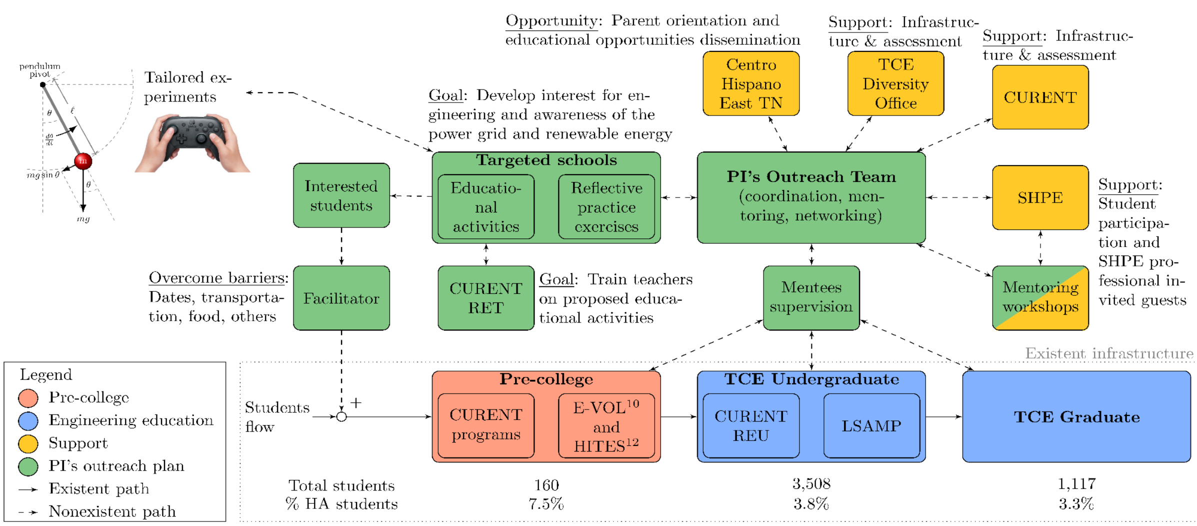

Figure 1. CAMINO–Educational plan of the NSF CAREER Award #2044629.

2. CAMINO: The program

In Spanish, CAMINO translates to "pathway." Through career advancement, mentorship, inspiration, and opportunities, CAMINO strives to be a pathway of hope—one that inspires and encourages HA students to believe in themselves and embrace the idea that they are capable of achieving their dreams. The program has primarily been a collaboration between SPEED, a research group from UTK led by Dr. Hector Pulgar, and Lenoir City High School (LCHS), one of the high schools with the largest HA populations in the Knoxville Metropolitan area.

These precollege students from minority backgrounds may limit their aspirations and avoid pursuing higher education or professional development for various reasons, including limited motivation, insufficient exposure to higher education, and unawareness of available resources and assistance. Notably, these students and their families might lack an academic role model or mentor who can provide insight and a different perspective on careers and higher education.

CAMINO seeks to decrease these barriers by integrating four key components: a mentoring scheme, cultural closeness, inspiration through engineering projects, and opportunities for pursuing further education and professional development. These components are designed to nurture and inspire students, fostering their exploration of potential areas of development, and enhancing their understanding of engineers' significant impact on their daily lives.

2.1. Peer mentoring

In the context of the CAMINO program, peer mentoring was initially conceived as a mentorship between undergraduate/graduate students who have experienced various challenges in the educational system and have advanced to higher education (mentors) and precollege students who are new to this experience (mentees). Through the execution of the program, the authors have realized that peer mentoring can go beyond this initial concept, as it can also encompass skills acquired to perform specific tasks or the ability to navigate common circumstances encountered at home or school.

It has been especially rewarding to observe, over the course of the program, how precollege students began mentoring one another, providing advice and support. Notably, mentors are not necessarily advanced HA students but can be anyone aligned with the program's goals. In Fall 2024, two non-HA undergraduate students began participating in the program activities and have been highly effective in engaging with HA precollege students, inspiring them to explore career development and higher education opportunities.

Through this work, CAMINO not only provides mentorship to precollege students but also serves as a platform for learning how to be a mentor. Two doctoral students have participated in the program since its inception. Together with the recently involved undergraduate students, they are being trained with valuable mentoring skills that can enrich their future workplaces and potentially initiate new outreach programs that can positively impact our communities.

Figure 2. Peer mentoring and Arduino's experiment.

2.2. Cultural closeness

CAMINO strives to maintain an environment where HA precollege students feel comfortable and free to express themselves. By sharing a similar cultural background, mentees and mentors have established strong relationships through shared interests beyond academics, such as sports, food, and language. During the first two years, most activities were conducted in Spanish, fostering a sense of belonging within the classroom. Teachers reported that students eagerly anticipated the monthly CAMINO visits to participate in discussions and projects. In the last year, activities were conducted in both English and Spanish, resulting in divided satisfaction among the mentees.

As an important component of fostering cultural closeness, HA professionals are invited to share their personal experiences and journeys to becoming engineers. Dr. Ivan Maldonado, who holds a Ph.D. in Nuclear Engineering and is a professor at UTK, and Jaime Torres, who holds B.Sc. in Industrial Engineering and is an entrepreneur from Chile, have participated in the program. Additional HA experts have been invited to participate and are scheduled to visit the school to give talks, bringing hands-on activities for the students. These activities are intentionally planned to inspire students and encourage them to pursuit their dreams.

2.3. Inspiration

CAMINO's approach to inspiring students in STEM is rooted in hands-on engineering activities. Mentors introduce complex STEM concepts using fundamental principles and accessible materials. For instance, students learn about electromagnets by assembling them with basic items like iron cores, copper wire, and batteries, then apply these concepts to construct a simple electrical generator. These activities highlight that complex engineering systems are founded on simple structural principles. Similarly, inspiration grows when students overcome misconceptions or fears about seemingly complex tools. This was evident when students were introduced to 3D prototyping software; even learning its basic functions helped them realize that these tools are accessible and within their reach. Once students grasped these concepts and overcome their initial apprehension, their curiosity was ignited, motivating them to participate more actively in the program.

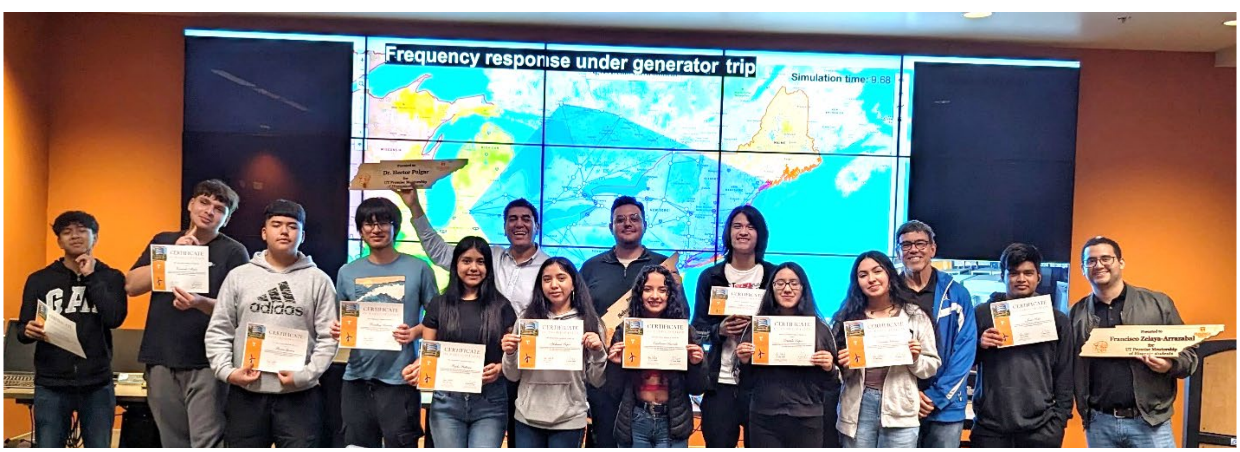

Figure 3. Field trip: CAMINO's students visiting UTK main campus (May 9, 2024).

Through this program, several engineering and physics concepts have been presented in a more tangible way, and through reflective practices, the physical descriptions, potential issues (if any), and possible solutions are discussed. We have explored concepts such as electromagnetism and induced forces, the motion of a pendulum, the concept of inertia in dynamical systems, oscillations in physical systems, wind power generation, and hydropower generation. In addition to these engineering activities, precollege students have visited the UTK main campus, where we have scheduled several lab tours and even attended actual undergraduate lectures.

2.4. Opportunities

CAMINO's goal is to serve as a facilitator, inspiring students to pursue higher education or professional development. Through this program, one student graduated from LCHS and is now pursuing a career as a certified electrician. Three other students are highly interested in engineering and are applying to the TCE precollege program, HITES12. This marks the first time students from the program have applied to a UTK precollege program. Additionally, in several meetings, we have discussed various scholarships that provide financial support to cover higher education expenses. Programs such as the Tennessee Hope Scholarship and UT Promise have been introduced to students, encouraging them to explore further opportunities. CAMINO aims to continue identifying additional sources of financial support and remains open to exploring new initiatives to ease the financial burden and support the aspirations of underrepresented students.

3. Fostering Academic and Professional Aspirations: CAMINO's Journey.

The program started with visits targeting a broader audience of students. These initial engagements were meticulously planned to ignite curiosity and establish meaningful connections with potential participants. Conducted in auditoriums, these open-floor visits were coordinated with high school governance and teachers. Recognizing the diversity in student interests and backgrounds, the program designed activities to be inclusive, engaging, and educational. Talks and presentations were carefully tailored to not only inspire interest in engineering but also provide a broader perspective on the opportunities available through higher education.
The program began with 20 students who responded to an open-floor invitation. Interactive components, such as Kahoot-style [9] questions and quizzes, were integrated to promote active participation and serve as icebreakers, fostering an enjoyable learning environment that reduced the intimidation often associated with STEM fields. Key opportunities, like the Tennessee Hope Scholarship, were highlighted to demonstrate pathways to academic and personal growth for low-income students. Peer mentoring and cultural relevance were integral to the engagement strategy, with many activities conducted in Spanish to create a sense of belonging and bridge cultural gaps. The use of Spanish not only enhanced comprehension but also established a sense of belonging, making students feel valued and understood.

Mentors played a pivotal role as academic role models, sharing personal experiences to inspire and guide students while addressing broader topics like perseverance, work-life balance, and community support. Over three years, focusing on engineering basics and personal growth, the program developed and delivered three core stages through monthly school visits. Each year concluded with a "Field Trip" to the UTK campus, where students engaged in hands-on activities that offered insights into higher education. This transformative experience ignited aspirations and reinforced the belief that higher education was both attainable and desirable.

3.1. Stage I (First year): Engineering Fundamentals and Engagement

Stage I was designed to immerse students in the foundational principles of engineering while cultivating a deeper appreciation for its practical applications. Given the authors' background, the students were immersed in electrical engineering concepts. This stage utilized a series of hands-on experiments encouraging students to actively engage with new engineering concepts. Using reflective practice model, students understood the critical role of renewable energy and the significance of the power grid for the first time, fostering curiosity and a sense of possibility.

3.1.1. **Experiment 1—Power Grid and Generating Sources:** Students were introduced to the relationship between natural resources and power production. A wind turbine kit [10] was used to demonstrate the basic principles of power generation and how the energy produced by the turbine was used to light a small bulb and charge a battery.

3.1.2. **Experiment 2—Power Grid Board Game:** An interactive board game [11] was used to explain power grid structure and the strategic decision-making involved in managing energy resources. Students explored transmission grid structure, competition, resource allocation, and long-term planning, mirroring real-world engineering complexities and highlighting the importance of system thinking and adaptability. Note that Experiments 1 and 2 provided a foundation for understanding power system infrastructure, sustainable energy, and the role of engineers and STEM professionals in electric power systems.

3.1.3. **Experiment 3—Pendulum Dynamics:** Through this experiment, students delved into the principles governing pendulum motion, including oscillation periods and speed variations. By altering parameters such as rod length and mass, they observed how these changes affect motion. The experiment introduced them to frequency oscillations in synchronous generators, bridging theoretical dynamics with power system applications.

3.1.4. **Experiment 4—Car Video Game Simulation:** A computer animation mimicked a car traveling over two hills, controlled by the keyboard which was used as acceleration and brake pedals. Students had to navigate the car to the finish line in the shortest time possible without exceeding the speed limit, which would cause the car to overturn. This simulation highlighted the effects of mass and gravity, drawing parallels to the inertia challenges faced in power systems. By engaging in this exercise, students developed an intuitive understanding of dynamic constraints and optimization.

Figure 4. Engineering experiments: (Left) Pendulum's motion, (Right) Car video game.

Once the students' interest was captured, the program transitioned to a foundational project, which set the basis for the main project: the hydroelectric generator. In this stage, students constructed a rudimentary generator using simple materials such as wooden rods (serving as the rotational shaft), magnets for creating the rotor, copper wires for stationary windings, and bearings to hold the rotor in place. The project involved assembling these components into a functional generator capable of lighting low-wattage incandescent bulbs. The main goal was to establish the basic concepts of electromagnetism and to provide hands-on experience with a tangible understanding of how mechanical energy can be converted into electrical energy.

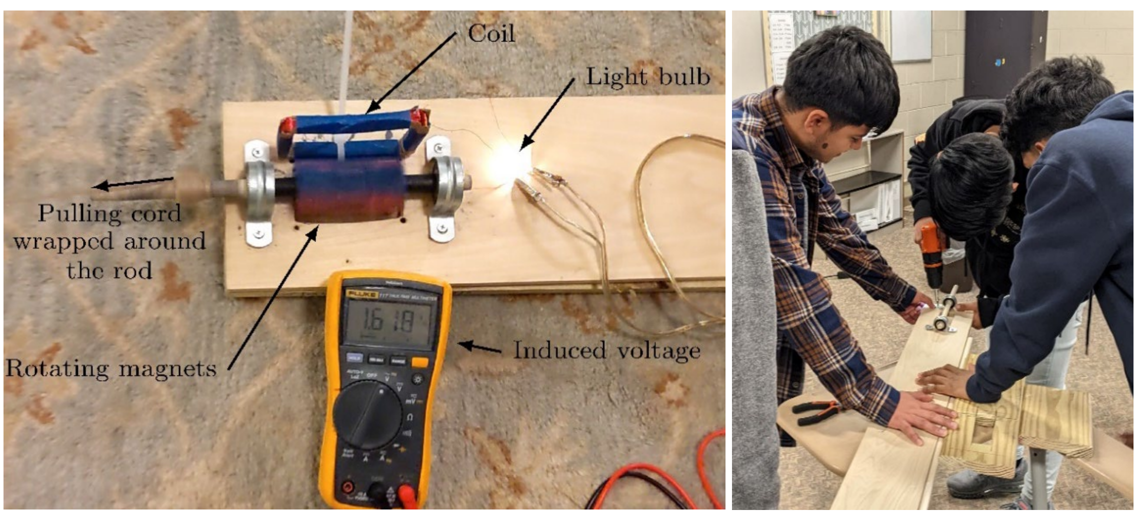

Figure 5. Rudimentary electric generator.

This initial stage concluded with a summer visit to UTK main campus, offering students a firsthand experience of higher education. The visit featured talks with faculty members and a guided tour of key locations on campus. Students worked in a university lab to complete the assembly of their rudimentary generator and conduct performance tests. This pivotal experience provided students with their first hands-on engineering project and facilitated meaningful engagement with higher education. By sparking curiosity and fostering open dialogue, the program inspired students to further explore STEM fields and embrace creativity in their educational pursuits.

3.2. Stage II (Second year): Design, Development, and Inspiration

Stage II focused on expanding students' understanding and confidence through engineering design and inspirational mentorship. This stage introduced students to a professional 3D modeling software, Fusion 360 [12]. Building on lessons from Stage I, students collaborated to design a 3D prototype of a power generator. The learning process began with comprehensive workshops on using Fusion 360. These sessions emphasized both technical skills and creative problem solving, enabling students to visualize and refine their designs. The experience was collaborative and iterative, encouraging students to evaluate and improve their ideas. Workshops, lessons and additional material can be found on CAMINO’s Github repository [13].

A pivotal moment in this stage came from one student’s innovative suggestion to incorporate a gearbox into the design. The gearbox aimed to improve the efficiency and mechanical performance of the generator, showcasing the students' ability to think critically and apply engineering principles. The team worked together to integrate this concept into the project, resulting in a more sophisticated prototype.

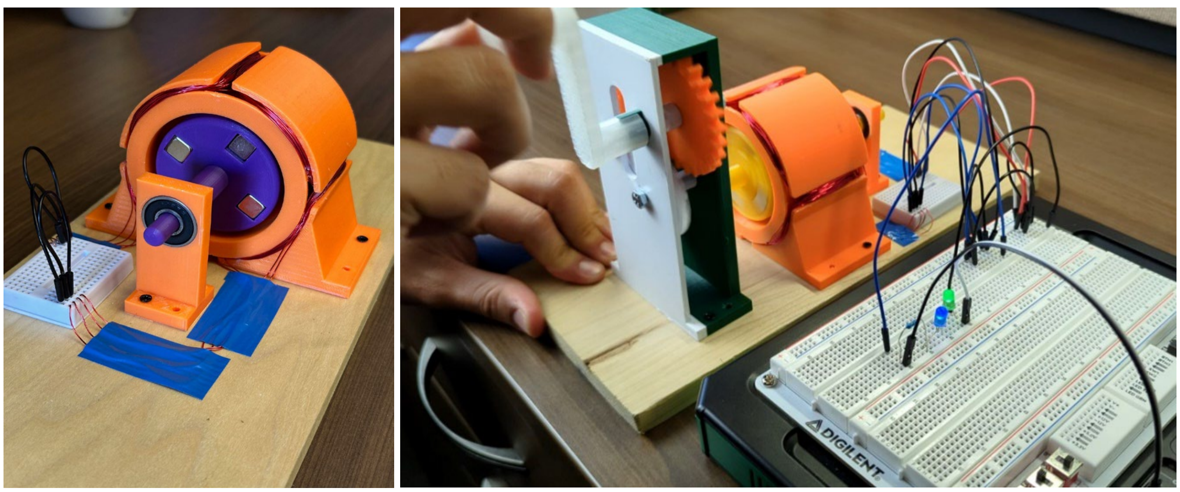

Figure 6. 3D printed prototype: (Left) Generator, (Right) Generator assembly, including gearbox, and load.

Stage II concluded with a summer visit to UTK main campus, where students had the opportunity to tour three labs within the EECS Department—the robotics, signal processing, and computer science labs—and audit a computer science undergraduate lecture. This hands-on experience offered students a deeper understanding of academic life, real-world STEM projects, and how research is conducted. The visit aimed at providing students with a clearer picture of the academic environment, encompassing lab work, appreciating a broader research culture, and academic opportunities.

3.3. Stage III (Third year): Implementation, Testing, and Growth

Stage III demonstrated CAMINO’s maturity, showcasing how far the students had come in their CAMINO journey. Building on the foundation of Stage II, which concluded with a 3D-printed generator and a hand-cranked mechanical gearbox, this stage posed the challenge of enabling the generator’s rotor to operate autonomously.

Students were immersed in the principles of turbine operation, revisiting the similarities between wind turbines and hydro turbines. After discussions, the students decided to focus on constructing a hydro turbine, selecting the Pelton turbine model due to its effectiveness in converting water flow into mechanical energy. However, recognizing the mechanical complexity of manufacturing a Pelton turbine from scratch, they opted to use an existing prototype [14] while dedicating their efforts to designing the integration of the hydro turbine with the generator.

Students and mentors designed together the structural base and the needed assembly to integrate the components into a functional hydro generator. This process involved an additional Fusion 360 workshop, where students learned advanced design techniques and tools to refine their generator model. The workshop revealed the significant progress many students had made: a subset of participants demonstrated exceptional confidence and skills, completing tasks efficiently and stepping into mentorship roles to assist their peers. The mentees became mentors.

This peer-to-peer collaboration was a breakthrough for the program, as it embodied one of CAMINO's core goals: fostering an environment where students could evolve into mentors and leaders. The students' ability to explain complex tasks and support one another highlighted their growth in both technical and interpersonal skills.

The stage concluded with the traditional summer visit, where students toured CURENT's labs at UTK main campus, particularly, the Wide-area Grid Operation, Control and Visualization room, which emulates an actual control center for a power grid. Students learned how the grid is operated and how renewable energy is impacting today's electrical infrastructure. The activity involved faculty members, research scientists, and graduate students. Students finally visited the Zeanah Engineering Complex at UTK, where they had the opportunity to use one of the state-of-the-art labs to test and conduct a workshop with the finalized hydro turbine prototype.

4. Engineering Project—Hydroelectric Generator

CAMINO's primary engineering project involves building a hydroelectric generator to provide students with hands-on experience in electromagnetism, energy conversion, and renewable energy systems. Students participated in the design, development, and operation of a scaled model, applying engineering principles in mechanical, electrical, and fluid dynamics. This process helped them gain valuable insights into real-world energy challenges and renewable technologies. This educational prototype offered a cost-effective and replicable approach, supporting the program's mission to inspire students in engineering and STEM fields.

4.1. Design and Concept

The hydroelectric generator consists of three main components: the turbine, generator, and water shaft. The system operates by converting the kinetic energy of flowing water into electrical energy. Water flow drives the turbine, which is mechanically coupled to a generator. As the turbine rotates, the generator's rotor—equipped with permanent magnets—spins within a stator containing coils of wire. This electromagnetic interaction induces voltage on the coils, providing a clear demonstration of energy conversion principles.

The prototype was specifically designed to be accessible and replicable for educational purposes. Key parts, including the generator stator, rotor, shaft, supports, turbine, and couplings, were modeled using Fusion 360 and can be found in [13]. These components were then fabricated using an Original Prusa i3 MK3SA 3D printer, ensuring that the project remained cost-effective and feasible for student implementation.

The water inlet system mimics the functionality of a penstock in traditional hydropower plants. A hose connected to a conventional water faucet serves as the water source. The hose is fitted with a barbed adapter to narrow its cross-section, increasing the water pressure as it strikes the turbine. The turbine, housed in an enclosed casing, directs water through a controlled discharge outlet.

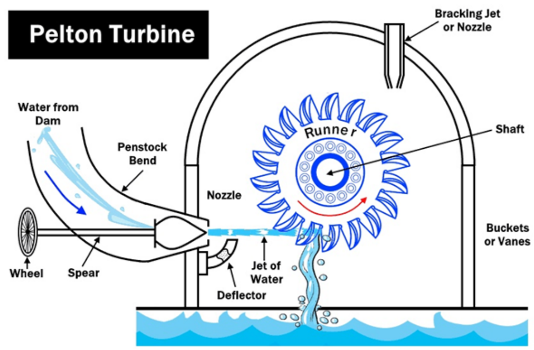

Figure 7. Pelton turbine parts and general scheme—figure taken from reference [14].

Mechanically, the turbine is coupled to the generator's rotor through a shaft. The rotor is fitted with four permanent magnets, which interact with four coils that are wound on the stator. This design enables the generation of an induced voltage at each winding terminal as the rotor spins. The stator windings are connected in series, producing a combined output voltage suitable for powering a load, such as LEDs or low-wattage equipment.

4.2. Materials and Tools

The core of the prototype was constructed using 3D-printed parts made of Polylactic Acid (PLA), while the base and case, where the turbine and generator were mounted, were made from recycled wood. The 3D prototypes were created using the Fusion 360 student version of Autodesk. All pieces were printed on an Original Prusa i3 MK3SA. A detailed list of materials can be found in [13].

4.3. Construction Process

4.3.1. Generator: The generator consists of two principal parts: the stator and the rotor. The former is a stationary structure where the coils are mounted, while the latter is the rotating part where the permanent magnets are mounted. Two other identical components were designed to support the rotor from each end of the shaft, and bearings were mounted to facilitate the rotation.

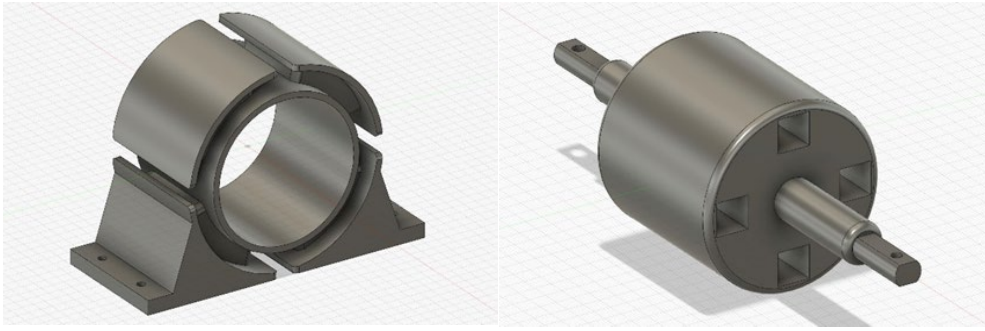

Figure 8. 3D printed components of the generator: (Left) Stator, (Right) Rotor.

These parts can be replicated using the data in [13], which includes the .stl files, materials, and workshop guides. This information provides the foundation for replicating the construction process. Mentors are encouraged to develop their own practice based on this data, incorporating measurements, detailed instructions, and guidance on which specific Fusion 360 functions should be used during construction.

4.3.2. Gearbox: Initially, the generator prototype was tested using a drill. Although this method helped validate the prototype, it was not practical for implementation. Additionally, it caused the shaft to break multiple times, as the drill's speed and the torsional force applied to the PLA model were too high. A gearbox was considered to address this issue. The gearbox is an additional component designed to safely test and validate the generator's design. Its main objective is to apply mechanical torque to the generator's shaft. Although this component was not used in the final design, it is a valuable tool for teaching mechanical engineering concepts to students, improving their engineering skills, and sparking curiosity. The gearbox model used in this project was adapted and modified from [16].

4.3.3. Turbine: The turbine model used in this project is a Pelton turbine adapted from [15], featuring 18 buckets securely fastened to its base with nuts and bolts. The water shaft is a cylindrical component that passes through the bucket base and turbine casing, ultimately connecting to the generator's shaft via a 3D-printed cylindrical adapter. This shaft is also supported by two bearings embedded in the walls of the turbine casing. The turbine is housed in a custom casing made from hand-crafted wood, sealants, and a front acrylic sheet, designed to fit the turbine's dimensions and align seamlessly with the generator. Additional structural components such as supports, corners, and bearing stands, were also fabricated and integrated into the design.

Figure 9. 3D printed hydro turbine.

4.3.4. Water inlet—Hose, hose support, and hose end: The water inlet is constructed using a combination of a hose, a hose support, and a nozzle, all embedded into the turbine casing. The hose support (nozzle) was modified from its original design [15] to perfectly adapt to the selected hose end. This was one of the most challenging aspects of the design, as it needed to fit both the correct hose end and its adapter. A ¾-inch hose was used for the water inlet, while the hose end had a 1/8-inch output dimension.

Attention to details during assembly is crucial for a robust prototype. All 3D-printed components should be sanded to remove imperfections. Couplings, bolts, and nuts must be tightened to specified torque values to ensure stability and durability. These practices result in a cohesive unit capable of efficient operation under varying conditions.

Based on the CAMINO experience, assembling the hydroelectric generator is manageable for K-12 students with clear instructions. However, turbine design requires advanced engineering knowledge, leading the team to adapt an existing, tested design. This approach balances accessibility for students with the technical rigor needed for a functional generator.

This process exemplifies the program's mission to inspire and educate through hands-on STEM projects. By leveraging open-source designs [15,17], customization, and guided assembly, CAMINO provides students with an engaging pathway to explore STEM concepts and develop foundational engineering skills.

4.4. Operation and Testing

Before conducting any tests, it is essential to verify that all components are securely assembled, following the recommendations provided in the construction process section. The initial test should be performed in open circuit mode, meaning the generator operates without any electrical load connected. Begin by attaching a hose to a water faucet to simulate the water flow. Connect a voltmeter and frequency meter to the generator terminals. Gradually open the faucet to introduce a low water flow, allowing the turbine to begin rotating. Verify that voltage and frequency readings are displayed on the meters. Once initial readings are established, progressively increase the water flow to achieve the design operating speed. The goal is to reach a frequency of 60 Hz and a voltage of approximately 15 V.

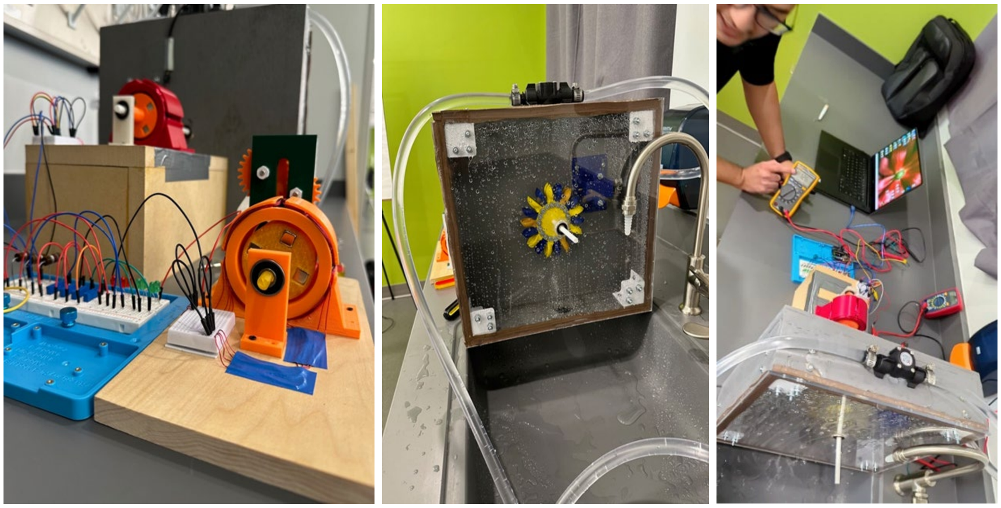

Figure 10. Hydro turbine generator and testing: (Left) Generator and load side, (Middle) Hydro turbine side, (Right) Top view of the testing setup.

To further test the generator's performance, connect an electrical load after reaching the design speed. Begin by attaching small loads, such as incandescent light bulbs, to the generator terminals. Observe the changes in voltage and frequency as the load increases. A drop in these values is expected and demonstrates the generator's voltage and speed regulation characteristics. This test provides students with a tangible understanding of load effects and system behavior in real-world scenarios.

These operational and testing procedures offer K-12 students an opportunity to engage with foundational engineering concepts. By conducting these experiments, students gain hands-on experience in system operation, testing protocols, and performance validation. These activities foster a deeper appreciation for the complexities of renewable energy systems and the practical application of engineering principles.

4.5. Applications and Extensions

The hydroelectric generator described in this chapter offers a dual benefit: it provides an enriching, hands-on learning experience for students while also serving as functional equipment capable of powering small devices, such as LED lights or low-wattage chargers. Through this project, students gain a tangible understanding of renewable energy principles and energy conversion processes, making it an effective tool for both education and application.

The CAMINO team has already extended the reach of their work by collaborating with an outreach program at the University of Bio-Bio in Chile. This partnership has sparked interest in replicating the generator design, with efforts currently underway to develop a prototype at the Chilean university. Future collaboration aims to explore alternative stator and rotor designs, allowing undergraduate students to study how different generator configurations impact performance. These international connections not only enhance the educational value of the project but also foster cross-cultural exchanges and knowledge sharing.

The hydroelectric generator project is an evolving initiative, with ongoing efforts to refine its design and functionality. For instance, the team is developing an Arduino-based controller to enable automatic speed regulation and enhance the generator's operational efficiency. Additional upgrades include a redesigned turbine casing, an optimized water inlet system, and integrated water flow measurement capabilities. These enhancements aim to improve the prototype's performance while offering students deeper insights into system optimization and design iteration.

5. Assessment: Results and Discussion

A survey is used to assess the impact of CAMINO on STEM education of HA high school students. The survey questions are presented in Table 1 and results are discussed next. A few open-ended survey questions were also provided to the students, and these are shown in Table 2. This study involved the participation of 10 HA high school students, including 7 male and 3 female, all in grades 10 and 11. Among the participants, 30% primarily spoke Spanish at home, while 70% reported speaking a combination of Spanish and English. The educational level of the parents or guardians of the students ranged from none to some college-level education. Notably, only one student reported that a parent or guardian had completed a bachelor's degree or higher. All students (100%) demonstrated awareness of STEM careers, primarily due to their interaction with teachers at school. A few students also reported learning about STEM through friends (40%) or via online resources (10%).

Table 1. Survey questions provided to the students and responded with a Likert-type scale.

Item	Question
Q1	Before joining CAMINO, how familiar were you with STEM (Science, technology, engineering and mathematics) careers?
Q2	What STEM subjects or fields interest you the most? (select all that apply)
Q3	Why did you join CAMINO?
Q4	CAMINO's ability to make STEM topics engaging and enjoyable is excellent
Q5	The activities or sessions hosted by CAMINO helped me feel more confident in pursuing STEM studies
Q6	How well CAMINO addresses challenges specific to Hispanic students in STEM?
Q7	How often have you interacted with Hispanic STEM professionals in CAMINO?
Q8	Would seeing more Hispanic STEM professionals in leadership roles encourage you to pursue a STEM career?

Responses to Q1 indicated that 50% of the students were somewhat familiar with STEM topics, 40% were not familiar, and 10% were very familiar. These findings highlight the need to enhance the integration of STEM concepts into their education, which aligns with the primary objectives of the CAMINO program. In response to Q2, most students (90%) expressed an interest in Engineering as a STEM career. Students were allowed to select multiple categories,

with other STEM career interests—including Mathematics, Robotics, Physics, Computer Science, Biology, and Chemistry—receiving responses at or below 40%.
The impact of the CAMINO program was evaluated through questions Q3 to Q6. Responses to Q3, which allowed for multiple selections, revealed that most students participated in the CAMINO program to explore STEM career opportunities (80%). Additionally, 40% of students joined to connect with mentors, and another 50% aimed to improve their academic skills. Notably, 90% of students “agreed” or “strongly agreed” that CAMINO is both engaging and enjoyable (Q4) and that the activities provided helped them feel more confident in pursuing STEM careers (Q5).

According to student feedback, the CAMINO program addresses challenges specific to HA students in STEM (Q6) to varying degrees, with 40% indicating it does "somewhat well," 40% stating "well," and 20% reporting "very well." Similarly, responses to Q7 regarding interactions with HA professionals in STEM through the program varied, with 20% of students reporting such interactions occurred "often," 20% indicating "rarely," and the remaining students describing their interactions as occurring "sometimes" or "a few times." Finally, responses to Q8 revealed that 70% of students agreed that seeing more HA STEM professionals would encourage their enrollment in STEM careers, while 30% responded with "maybe."

Table 2. open-ended survey questions provided to the students participating in the CAMINO program.

Item	Question
P1	Please share an event/activity that increased your confidence in STEM
P2	Are there any cultural aspects or practices in the program that make you feel more connected? Please describe
P3	How have interactions with Hispanic STEM professionals influenced your interest in STEM careers? Please describe.
P4	What do you like the most and what do you like the least about CAMINO?
P5	What changes or additions would improve your experience in CAMINO?
P6	Is there anything else you would like to share about your experience with CAMINO?

Responses to question P1 varied, with some students expressing enjoyment in building a turbine, others highlighting their interest in coding and programming, and several noting that “hands-on” learning activities were particularly beneficial to their learning experience of STEM concepts. It is noteworthy that only 50% of students responded to question P2, with 30% of them expressing appreciation for the workshops being conducted in Spanish. Additionally, interactions with HA professionals were reported as highly beneficial by the students. Responses to question P3 revealed that seeing successful HA professionals in engineering significantly motivated and inspired students to pursue STEM careers aligning with the CAMINO goals.

Students expressed enjoyment of the hands-on, engaging learning activities and the trips to UTK, with no negative responses reported for question P4. Regarding potential changes to the CAMINO program experience, three students suggested incorporating more activities and increasing the frequency of meetings, while 70% of participants indicated satisfaction with the current delivery method. Responses to question P6 further highlighted that students found the CAMINO program to be fun and enjoyable, with many expressing gratitude for the opportunity to participate.

6. Conclusion

This paper describes CAMINO, a STEM program focused on career advancement, mentorship, inspiration, and providing opportunities for K-12 Hispanic students. The program has proven to be an effective pathway for HA precollege students, connecting them with higher education through peer mentoring, cultural relatability, inspiration, and hands-on engineering experiences. By addressing the challenges faced by HA students, CAMINO fosters both academic and professional aspirations while raising awareness of STEM opportunities.

The combination of hands-on experience and mentorship from culturally relatable mentors motivates students to confront academic challenges and encourages them to break preconceived paradigms and stigmas surrounding their future aspirations. Additionally, through hands-on engineering activities, students gain a solid understanding of fundamental STEM concepts, as evidenced by the final prototype of a hydroelectric generator presented in this work. The involvement of students in the design, construction, and testing of an actual prototype—starting from rudimentary parts to 3D-printed versions—demonstrates the power of beginning with basic concepts and progressing toward more complex STEM challenges. Positive feedback from both students and mentors confirms the program's success in creating an inclusive and empowering environment in STEM activities and academics.

CAMINO will continue its efforts pursuing a higher HA participation in STEM, serving as an example of how underrepresented groups can be inspired by relatable mentors. Survey results further highlight the program's success, showing an increased interest in engineering and STEM fields among participants. Hands-on activities and interactions with HA professionals were particularly impactful. The results also suggest areas for improvement, such as more frequent sessions and interactions with STEM professionals to maintain student commitment. Although this is an area for improvement, it is valuable feedback as it demonstrates the students' desire for a more intensive program. Overall, the experiences highlight CAMINO's potential to foster a diverse STEM pipeline and to empower HA students in traditionally underrepresented fields.

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