STEM School of Excellence Recognition Program

ITEEA's STEM Center for Teaching and Learning™ annually recognizes outstanding schools for their commitment to providing a robust Integrative STEM education program. Recognized schools exemplify outstanding leadership in the field of STEM education. Recognized schools undergo a rigorous application process requiring detailed documentation to demonstrate a strong Integrative STEM program. A panel of reviewers work to reach consensus that the documented evidence represents excellence in Integrative STEM education.

ITEEA created the designation to officially recognize those schools whose teachers, administrators, and other stakeholders are providing a meaningful STEM education experience for students. By highlighting these schools, ITEEA hopes to help others learn effective best practices and continue sharing them more broadly into the larger STEM Education community.

Awards are made at two levels using a vetted application review process:

- ITEEA STEM School of Excellence (200+ points)
- ITEEA STEM School of Merit (170-199 points)

Award recipients will be recognized at the ITEEA International Conference in Minneapolis MN, April 12-15, 2023:

- ITEEA STEM School of Excellence schools will receive a banner and certificate for display in the school
- ITEEA STEM School of Merit schools will receive a certificate for display in the school

Recognized schools will be posted on the ITEEA STEM School of Excellence website page with school program description, pictures, video links, etc. To learn more about this program, please visit our ITEEA STEM School of Excellence website at www.iteea.org/STEMschoolofexcellence.aspx. Please send any questions about the application process to stemsoe@iteea.org or call ITEEA at 703-860-2100.

The application window for the 2022-23 school year is June 22, 2022–December 18, 2022.

Application Fees:

- ITEEA members: $195.00; non-ITEEA members: $295.00
- Previous SoE Recipients (ITEEA Members) $125.00; (non-ITEEA Members) $225.00 (previous recipients should contact iteea@iteea.org for a discount code).

To Apply:

1. DOWNLOAD this file to Microsoft Word and change the file name to your school's name.
2. Complete the application that begins on the following pages.
3. Return to the Google Form Submission page at https://tinyurl.com/SoESubmit
4. Upload completed file.
5. Complete application fee.

Sample Completed Applications

- Elementary School Sample Application
- Middle School Sample Application
- High School Sample Application

2022-2023 STEM School of Excellence Application

- Supporting images can earn points and provide additional clarification of your provided descriptions.
- Point values that state “points per…” can earn you additional points either per person, event, etc.
- Multiple submissions for the same item will not earn additional points unless specifically stated.
- If you have any questions, please reach out prior to the application due date. Applications are reviewed by a committee and cannot be retracted after the due date.

School and Staff Information

Questions with * are required.

*STEM Teacher/Coordinator's Name:
Joseph H Henken

*STEM Teacher/Coordinator's Title:
Director, CBC STEM Academy

* STEM Teacher/Coordinator's Email:
henkenj@cbchs.org

*STEM Teacher/Coordinator's Phone Number:
314-985-6100 (school)
618-580-1504 (cell)

*Principal's Name:
Timothy J Seymour

*Principal's Email:
seymourt@cbchs.org

PTA or equivalent President's Name:
Theresa McKell

PTA or equivalent (Parent Organization) President's Email:
tmckell@gmail.com
cbcparentsclub@cbchs.org

*School District:
Independent
Administered by the Midwest District of the De La Salle Christian Brothers
International Institute of the Brothers of the Christian Schools

*School Name:
Christian Brothers College High School

*School Address:
1850 De La Salle Drive
Saint Louis, MO 63141

ITEEA Integrative STEM School Membership Number (if member):
106620
(Not sure of membership number? Email iteea@iteea.org)
(Not a member? Click here to Join: www.iteea.org/membership.aspx)

Qualifying Activities

Provide details and documentation for the activities and initiatives in which your school participates. Some activities require details such as specific titles to presentations and direct links to utilized resources.

In order to receive points for an activity, the required documentation should be fully documented within ***this form.*** *Add as much space as needed.*

1. School produces completers in a STEM career pathway. Describe pathway requirements and numbers of completers in 2021-22. ***(30 pts)***

As the well-documented demand for skills in STEM-related fields explodes, the available talent pool of college graduates is not keeping pace. The CBC STEM Academy has addressed this urgent need for capable talent by helping interested students prepare for STEM careers immediately after high school graduation. The stated mission of CBC identifies us a college preparatory school, with most CBC graduates (97%) continuing to higher education to pursue college degrees. Therefore, this is clearly a paradigm shift for our community. Nevertheless we have found several ways to implement these changes. First, we have worked with our administrators and guidance department to allow qualified students (those who have enough graduation credits) to alter class schedules to allow them to attend local community colleges and training centers. We have had three students take advantage of this opportunity. One student graduated with welding certification and is currently employed by the welding union. A current student has also taken advantage of the program to get certified in Arc 1, Mig, Flux, and electrical trades. Another student participated in a diversity initiative called Access Point, which helped train him in the in the IT field during his senior year and following summer, and he is now employed as a [] just a few months after high school graduation. Secondly, we have structured our curricular offerings in the Department of Engineering and Technology to allow pursuit of career-enabling certifications to be part of our school day. These students are deemed eligible by Engineering and Technology faculty based on their ability to successfully complete independent, mentored learning. The coursework is supplied by the certifying agency. Currently, we have five students taking either an engineering or computer science practicum as one of their scheduled classes. Students are completing software certifications in Unity, Python, Comp TIA A+, and Fusion 360. Another student is using his practicum to prepare for his IFR pilot certification. These industry-standard certifications will provide students with the necessary credentials upon high school graduation. The third way we present career pathways to our students is through our co-curricular activities. While these activities are not specifically preparing them for employment, they are demonstrating and communicating the need for straight-to-workforce talent. For example, three students participated in Competition in a Box, an event held by our local carpenter's union in which students competed on plan reading and wall-framing. About 20 students have participated in programs at our local racetrack, including NHRA Yes STEM and the JR 500, both focused on the need for skills in the automotive and racing industries. We recently sent 12 students to Build My Future STL, in which they spent the day in the construction industry through an interactive showcase, including operating equipment and operations labs. At least one of our students was offered a job on the spot! Fourth, the school has empowered one of our college counselors to focus on CTE options, with programs in development for geospatial applications and drone pilotage.

Admittedly, this is a burgeoning area for us as it changes the focus from our college preparatory tradition. But we have found ways to facilitate these changes, and only look for these opportunities to grow!

2. School participates in a STEM outreach or community service project during the 2021-22 academic year. Provide description of project and include (insert) photos. ***(30 pts)***

As a Catholic, Lasallian, all-boys high school, Christian Brothers College High School (CBC) is committed to the academic, spiritual, and moral development of every young man. Our faith-filled and inclusive community prepares students from all backgrounds for success and lives of leadership and service. Our vision is to create positive change in our community and world through the lives of our graduates: young men who are guided by faith, strengthened by intellect, committed to justice, and prepared to lead and serve. Serving those in need, and connecting with the community at large, is a major component to a CBC education.
The STEM program participates in several outreach and community service projects through the year. For instance, every year, we help a local scout pack with their units on robotics. We demonstrate the robots from our advanced teams and help them with a hands-on coding activity with Lego EV3 robots. Our Computer Science Honor Society members must do 10 hours of service using Computer Science each year. Frequently, members help the residents of Heritage of Hawk Ridge Retirement Community in their use of simple technology such as iPhone and email.
One of the primary ways we reach out to our community is through our admissions program. We have several events through the year to get 5th through 8th graders on our campus to spread the word about all of the great things we're doing in STEM! First, we hold summer camps for three weeks in June. Each of the three weeks is a STEM camp, in which we build rockets, learn to solder, make homopolar motors, and other activities. Last summer, we had about 85 campers in our three one-week STEM camps. During the same time period, we also have two Aviation Camps. Last year, we had 30 students in the camps, in which we learned about the basics of flight, visited local hangars to see airplanes ranging from Cessnas to F-4s to Airbus 300s. The week culminates in a discovery flight for each camper over the St. Louis area. Second, every spring we invite local 7th grade classes to come to CBC for Challenge Days. Last year, almost 150 students visited for a lesson on Newton's laws and a parachute building contest. Third, every student who makes an official visit participates in a STEM experience class to introduce the engineering design process and hands-on projects to evaluate risk in design. One group of visitors was able to join our engineering classes for a demonstration by the University of Missouri-Columbia Engineering department. They presented Spot, a robotic dog made by Boston Dynamics that made national news when he "performed" with the marching band at Mizzou's homecoming football game. Finally, we are proud to partner with the Josh Seidel Memorial Foundation, whose motto is "Work Hard. Play Hard. Help Others." This non-profit organization raises money for STEM education in the St. Louis area as a way to honor their friend, a CBC and Mizzou Engineering graduate who lost his life in a workplace accident. We

frequently volunteer with the organization at their events and support various endeavors with time and talent.

3. Photo upload (insert) of STEM outreach or community service project (maximum 1 photo or 1 PDF containing up to 4 photos). ***(10 pts)***

Clockwise: Summer Academy Aviation Camp, 8th grade official visit, 7th grade challenge days, Scout robotics

4. Two or more teachers collaborated on an integrative STEM project during the 2021-22 academic year. Provide teachers' names, subject areas, brief description of the project focusing on the integrative nature of the teaching and learning and include photos. (30 pts)

The Lasallian philosophy of the Christian Brothers embraces the innovative practices of their founder, St. John Baptist de La Salle, who is the patron saint of teachers. Over 300 years ago, De La Salle established the tradition of innovative practices in pedagogy, teacher training programs, school curriculum, and religious practices. Just as De La Salle was an innovator, we are committed to carrying forward that spirit of innovation. We value project-based work that explores real-world application of skills and subject matter taught in the classroom. We focus on offering an active-learning experience that requires all students to develop the skills of communication, collaboration, creativity, and critical thinking. Many of these innovations are a result of we call the "STEM shift" – breaking down traditional, siloed, paradigms of educational practice in lieu of authentic, empathetic problem solving commonly found in STEM courses. But, of course, these practices should not be contained by the STEM Lab doors. Every student in every class in every department can benefit from this shift. Our teachers and students are challenged to focus on learning through inquiry, imagination, problem-solving, creativity, innovation, and collaboration to develop skills necessary in a dynamic world. One of ways our faculty achieves this goal is by collaboration with peers, integrating disciplines in student projects.

As an example, students in the Pre-AP World History class (taught by Craig Nicoletti) are paired with students from the Makerspace class (taught by Clinton King). Groups are tasked with building an interactive museum exhibit for specific historical movements that are displayed and defended in public exhibition. Students collaborate with curators from local museums as they design and build the exhibits, using lights, buttons, speakers, microprocessors, motors, CNC, laser cutters, 3D printers, custom computer games and applications or other tools to engage their audience in the history. The project also introduces students to workflow using Kanban methodology, taught by a local bank's mobile app product owner, to help manage their projects.

Another pairing involves math teacher Harold Ott's students in the Advanced Topics in Math class with students from Phillip Stapleton's Intro to Computer Science. The groups are given a great deal of voice and choice in this activity. They are simply tasked with researching and brainstorming to identify an advanced math concept that could benefit from a technology-based solution. Together, the groups design, build, test, and present their application. The applications are authentic representations of the way these math topics are used in real-world situations: not just about solving for the answer but putting the solutions into meaningful contexts.

Not all collaboration needs to by synchronous. Physics teacher Kristen O'Connell works with Principles of Engineering teacher Joe Henken for her study of multiple representations of

linear motion. She lays out various motion requirements and constraints, which POE students code into Lego EV3 robots. The POE students exercise their physics and coding skills getting the robots to accelerate, decelerate, pause, move with constant motion, or change directions per her instructions. Then, the physics students run the robots, analyzing the motion mathematically and graphically. Next, as a performance assessment, they put their robots together in pairs and must predict the point at which they intersect when run together. Conclusions are supported with mathematical and graphical analysis.

The final example stretches students in a seemingly disparate collaboration. Dave Brumfield, who teaches senior AP English, joins Joe Henken, who teaches low-level freshmen Physics. Early in the school year, the physics classes are introduced to energy through a quick project on environmentalism. Students are asked to research, develop, and present a way in which our school community can reduce global warming trends. The seniors, as they practice for their own advocacy projects later in the year, help the freshmen with research techniques, making conclusions based on evidence, and developing presentations for communicating those conclusions.

5. Photo upload: collaborative, integrative STEM project (maximum 4 photos). ***(10 pts)***

Clockwise: World History/Makerspace, AP English/Freshmen Physics, Physics/Principles of Engineering, Advanced Topics in Math/Intro to Computer Science

6. School sponsored an initiative/project focused on diversity in STEM education during the 2021-22 academic year. Provide description of project and include photos. ***(30 pts)***

Our current enrollment is 845 young men, and at CBC, our diversity is our strength. Academically, CBC is proud to accept, meet, challenge, and support a wide variety of students from across the St. Louis area. Geographically, CBC serves 845 students from over 200 different grade schools throughout St. Louis' urban core and expanding out to surrounding suburban and rural areas.

Racial and ethnic diversity strengthens our school community as well. Approximately 23% of our student body is non-white, and more than 20% of our student body is non-Catholic. Economically, CBC is proud to accept students from all socio-economic backgrounds. Over $3 million dollars in tuition assistance is offered to families each year.
We provide an environment where students of varying abilities can pursue their passions and develop their unique abilities as they prepare for life after high school, ultimately to become men who will shape their communities through accomplishment, leadership, and service. While most of our graduates continue to college, and growing number are finding career and technical training as the path to success.

Specifically, there are several examples that highlight the importance of direct involvement in DEI initiatives. We worked with administration and counselors to enable a student to pilot the Access Point program, a local diversity initiative sponsored by several local corporations that facilitates a CTE path in the IT field. Based on his experience, we are currently developing our "Path to Access Point" program that will help minority students make choices early in their high school career that will position them for success in computer science as they progress through high school and beyond. We frequently work with our Diversity Club to promote engineering and technology as a career choice for our minority students. We hosted two recent graduates, one studying computer science and one already in the industry, to discuss some of the hurdles and opportunities they encountered on their path in computer science. Further, when the CSHS hosted our own hackathon, C-Hack, we engaged the diversity club and encouraged them to form a team. This event was a big success, and when local industry (Enterprise Holdings) learned about these efforts, they contacted us and offered to support our students in a DEI hackathon of their own!

7. Photo upload: initiative/project focused on diversity in STEM education (maximum 4 photos). ***(10 pts)***

Top: recent graduates describing their path in computer science. Bottom, l to r: Access Point graduate, Diversity club's hackathon team

8. School sponsored a family-oriented STEM event during the 2021-22 academic year. Provide description of project and upload photos. ***(30 pts)***

Two events demonstrate our integration of STEM in our students' families. First, our school holds an open house every November. At this open house, student programs and projects are demonstrated and presented to families from across the St. Louis region. Various classes hold student demonstrations, including several science labs such as physics, chemistry, and biology. From our Engineering and Technology Department, students represent and discuss Cybersecurity, Game Programming, Robotics, Makerspace Prototyping as well as engineering and computer science practicums for the visitors. Various technology used in these classes is on display as well, including our wind tunnel, flight simulator, and VR lab. In addition to those classes, students also represent various STEM clubs, including Pre-Med club, Drone Club, Computer Animation Club, Computer Science Honor Society, Aviation Club, Arch Engineering team, Billiken BEAMS bridge-building club, and App design (Hackathon) club. Besides these demonstrations, STEM leaders use the opportunity to explain the four tenets of the CBC STEM Academy: 1) supporting the STEM shift across all academic departments and disciplines, 2) Engineering and Technology Curricular options, consisting of 17 course offerings, 3) supporting the many co-curricular opportunities, many of which are discussed elsewhere, and 4) helping students achieve individual goals ranging from learning to use equipment in the makerspace to establishing relationships with professionals and professors. Last year, approximately 1000 visitors attended our open house.

The second event to bring STEM to our families is called HAM-fest. It is our biannual public exhibition of our students' work in a culmination of the many project-based activities for the semester. Students display their artifacts, describe their process, and defend their design decisions to members of the public. In addition to STEM courses, the exhibition includes products from the humanities and arts classes, many of which are supported by the STEM Academy in their design and construction. The event has grown, with over 400 visitors scrutinizing student work, often with a critical eye. One parent, a computer scientist herself, engaged in tic-tac-toe against an AI-powered robotic arm, and challenged the student on the game strategy he coded.

These interactions with families from our school community and community at large are invaluable. They provide a two-way interaction that strengthen and celebrate not only our students' accomplishments, but also give insight to the needs and interests of the community we serve.

9. Photo upload: family-oriented STEM event (maximum 4 photos). ***(10 pts)***

Open house/HAMfest

10. School sponsored a STEM Career Fair or similar event during the 2021-22 academic year. Provide description of project and upload photos. ***(30 pts)***

Our approach to career awareness is different than a typical “career fair”. Instead, faculty in the CBC STEM Academy are encouraged to utilize professionals in their classes and co-curricular activities, and work to develop relationships with these professionals. Whenever possible, we engage the professionals to not only present to our students, but to work in meaningful collaboration on student projects. We have worked with civil engineers on our BEAMS bridge building and Arch Engineering projects and IT professionals on several hackathons. We are routinely treated to airplane visits from pilots, both military and commercial. Students participate in hand-on learning ranging from building go-karts to framing walls with organizations such as the NHRA, WorldWide Technology Raceway, and the Home Builder’s Association of St. Louis. Field trips and guest speakers are also part of this career awareness. Last year included visits to/from industries such as IT, video game design, logistics, various engineering disciplines, robotics, cybersecurity, carpenter’s union, military,

avionics, nursing, medical, and more. Two of the student favorites were an accident investigator from Boeing who described his own experience having to eject from his carrier-based EA-6B Prowler, and a US Secret Service agent who ended every story with “and that’s all I can say about that.”

11. Photo upload: STEM Career Fair (maximum 4 photos). ***(10 pts)***

Clockwise: video game designer, carpenter’s union, UPS pilot, race mechanic

12. School has active ITEEA Integrative STEM School Membership (20 pts) at time of application. (Provide membership number.) ***(20 pts)***

Christian Brothers College High School, St. Louis, MO

School Member ID 106620

13. School staff are ITEEA members. Active member status at time of application is required. Provide individuals' member name(s) and number(s). ***(5 pts per member on staff)***

Joseph Henken 80727
Phillip Stapleton 106611
Tim Seymour 106631
Patrick Jennewein 106632
Clinton King 106633

14. Teacher or administrator gave a STEM or STEAM Education conference presentation during the 2022-23 academic year at a national or international conference (e.g. ITEEA Annual Conference, NSTA STEM Forum, NSTA, ASCD, ASEE, NCTM, NAEA or other National/International Conference). Provide conference title, date of presentation, presentation title, and name(s) of presenter(s). ***(20 pts)***

Not Applicable

15. Teacher(s) or administrator(s) attended the 2022 ITEEA International Conference. Provide name(s) of attendee(s). ***(15 pts per attendee)***

Not Applicable

16. Teacher(s) or administrator(s) participated in the STEM Showcase at 2022 ITEEA International Conference. Provide name(s) of presenter(s) and title of presentation. ***(20 pts)***

Not Applicable

17. STEM or STEM-Related Education publication by staff member(s) in a peer-reviewed journal in the past three years. Provide complete article citation and provide article URL if available. ***(20 pts)***

Not Applicable

18. At least one Engineering byDesign™ course was taught during the 2021-22 academic year. List teacher's name(s) and course(s) taught. ***(20 pts)***

Not Applicable

19. Post school event in ITEEA's *STEM Connections* newsletter. Provide member name, date, and title/description of post. ***(10 pts)***

Not Applicable

20. Active Technology Student Association (TSA) chapter (or STEM-related) 2021-22 school year. Provide chapter advisor name and chapter number. ***(15 pts)***

We do not currently have a TSA chapter at CBC. But we do participate in the TSA-sponsored TEAMS event (Advisor Joe Henken). Also, in terms of membership in a STEM-related organization, CBC does have a chapter of the Computer Science Honor Society, sponsored by the Computer Science Teachers Association (CSTA) (Advisor Phillip Stapleton). There are two cohorts of inductees, totally 18 current members. The other national program we participate in is FIRST Robotics (FTC) (Advisor Joe Henken).

21. Participation in a Technology Student Association (or STEM-related) event during 2021-22 school year. Provide chapter advisor name and event. ***(15 pts)***

We participate in the Tests of Engineering Aptitude Math and Science (TEAMS) event sponsored by the TSA. The event is a contest that includes an essay, a multiple-choice test, and a hands-on building component on a STEM topic. For the 2021-2022 school year, the topic was "Engineering in Entertainment". (Advisor: Joe Henken) The CSHS participates in several (local, national, international) hackathons each year, including events run by WorldWide Technology, Enterprise Holdings, Major League Hacks, and Congressional App Challenge. (Advisor: Phillip Stapleton) Last year, we had four Robotics teams that competed in FIRST Robotics Challenge (FTC). In the game Freight Frenzy, teams used autonomous and driver-controlled modes to deliver "freight" to various locations on the field, avoiding obstacles and using game theory to maximize scoring. Our season included two regional matches and a conference tournament for all four teams. One of our teams also competed at the state level.(Advisor: Joe Henken)

22. Staff member participated in a ITEEA STEM CTL™ professional development event during the 2022-23 school year: I-STEM Education PLC, EbD Summer Institute, or EbD PD Webinar. Provide staff member's name, date(s), and title of PD event. (15 pts)

Not Applicable

23. Staff STEM Spotlight participant during 2021-22 school year (15 pts). Provide link to your STEM Spotlight feature. ***(15 pts)***

Not Applicable

24. Establish a safety protocol for your STEM lab and post it on your classroom or school website (15 pts.). Provide the link to your safety protocol document(s). A safety protocol is simply a standard operating procedure for the STEM lab that may include a safety manual, safety rules, HAZMAT sheets, procedures should an accident occur, equipment, tool and chemical inventory, etc. ***(15 pts)***

    Not Applicable

25. ITEEA Task Force participant on staff. Provide participant name and name of task force. ***(10 pts)***

    Not Applicable

26. Staff members served as EbD™ course author, reviewer, or focus group participant during the 2021-22 academic year (15 pts). Provide name of participant and course. ***(15 pts)***

    Not Applicable

29. Participating staff to produce and submit a one-page written reflection that has embedded artifacts that directly relate, and show exemplary relevance to the STEL Standards listed below (e.g., link to a lesson plan relating to the standards with an explanation, an activity, etc.) ***(30 points)***
    1. The Nature and Characteristics of Technology and Engineering
    2. Core Concepts of Technology and Engineering
    3. Integration of Knowledge, Technologies, and Practices
    4. Impacts of Technology
    5. Influence of Society on Technological Development
    6. History of Technology
    7. Design in Technology and Engineering
    8. Applying, Maintaining, and Assessing Technological Products and Systems

Staff submissions

Reflection 1
Joe Henken; Director, CBC STEM Academy, Teacher/Chair, Department of Engineering and Technology

In the CBC STEM Academy, our foundational course is Principles of Engineering. It is not a survey course; we don't focus on the contrast between different types of engineering, but rather the things that all engineering types have in common. To address STEL 6, History of

Engineering, we look at the evolution of engineering through a lens of six (or more, depending on class size) civilizations that have shaped our technological world: Mesopotamia, Egypt, China, Greece, Romans, Europeans, and the modern, global, civilization. Students, in small groups, are challenged to research these civilizations and their contributions, keeping in mind geography, climate, economy, era, global population, etc. The group then develops a presentation on what problems engineers in that civilization were trying to solve. The following is an excerpt from the presentation assignment:

> For your assigned civilization, prepare a presentation that introduces the civilization, then gives the 4 major problems the "engineers " at the time were trying to solve. Make sure to focus on the problems, not the solutions. The final slide should list the websites used to research the information. It is recommended that several websites are used to ensure the salient nature of the engineering problem for the civilization.
>
> The introduction should include time frame, geographical region, climate, landscape, and any other pertinent information that may influence the set of problems addressed by the engineers at the height of the civilization's impact.

During the presentations, class discussions center on the considerations of Standard 6. Students frequently want to discuss only the “solutions” and must be redirected to focus on the “problems”, and how things like geography and climate impact those problems. Nuance like the isolation of Chinese culture, the importance of aesthetics for the Greeks, difficulties in managing a behemoth Roman empire, the Renaissance, population explosion, and industrialization for the Europeans, and the globalization of the modern world become apparent in how these civilizations impacted technological advancement.

As a result of these presentations and discussions, with a little prompting students will realize that throughout history, patterns emerge. We see that no matter the time frame, civilizations were frequently trying to solve the same problems, albeit with different requirements, constraints, and available technology. As a class, we try to characterize the problems, then develop a table to bring all ideas together and show the evolution of the problem. An example is shown below. Student groups are then redistributed to fill in the table for the problems and each civilization. One of the more interesting problems that always presents itself (with a little coaching) is mankind’s desire to understand our relationship to nature. This leads to great discussions winding through pyramids, deities, and celestial study, culminating in scientific advancement with technologies such as genome sequencing, supercolliders, and space exploration.

	Meso	Egypt	China	Greece	Romans	European	Modern
Transportation							
Agriculture							
Communication							
Construction							
Relationship to Nature							

Military			Invented gunpowder; Built a wall				
Control of water	Irrigation canals, channels				aquaducts		

At this point in the proceedings, we segue into a modern take on engineering problems. We do this several ways. First, we introduce Grand Challenges of Engineering by tying those to the historical problems and discuss where these challenges may lead, as shown in the following assignment.

From Principles of Applied Engineering by Reid, Reeping, and Stephan….
In 2008, experts convened by the National Academy of Engineering (NAE) met and proposed a set of Grand Challenges for Engineering, a list of the 14 goals for engineers to work toward during the 21st century. For any aspiring engineer, reading this list should feel like reading a description of the challenges you will face throughout your career. To read a description of each Challenge, as well as a description of some connected areas within each, visit the NAE's Grand Challenges for Engineering website at www.engineeringchallenges.org.

Please go to the website and spend a few minutes understanding the challenges. Answer the following thoroughly, with complete ideas.

1. List the challenges. For each, briefly summarize the challenge in your own words (do not copy and paste!!). Then, identify one or more types of engineering that will most likely be required to address the challenges. Explain.
2. Do any of the Grand Challenges reflect the historical problems discussed in class? Why or why not? If not historical, then were do these problems originate?
3. What are the necessary qualifications or skills, in general, that engineers must possess to solve these problems?
4. Which of the EGC is the most difficult to solve in the next 10 years, and why?
5. Which of the EGC is the easiest to solve in the next 10 years, and why?
6. Identify one additional problem for humanity that you feel should be added to the EGCs. Why do you feel it should be included?
7. Through brief research, select the challenge that you feel is the most critical.
8. Which of these problems would you find interesting? Why?

Second, we introduce several reading assignments. The introduction to the book The Amazing Story of Quantum Mechanics by James Kakalios, is a fascinating treatment on the evolution of technology and futurism as we shifted from a world in which burgeoning nuclear energy promised unlimited energy resources, into the world of the transistor, which delivered (and continues to drive technology with) unlimited information. This shift can yield wonderful discussions, research, homework that all support the ideas from Standard 6. This leads us to excerpts from the book Flying Buttresses, Entropy, and O-Rings: The World of an Engineer by James L Adams, which addresses the modern nature of engineering problems. The author posits several things that drive technology in the modern world. We tend to focus our discussion on two of his ideas, market pull and technology push, which both must be present for a successful product. For students, the point is that if the market wants a product, it will only be

successful if the technology can support it. And even if the technology is there, a product will only succeed if the market demand can be established. Our historical view of the evolution of technology and nature of engineering then takes a lighthearted turn with a look through a Sharper Image catalog, identifying things that actually address the (perceived) needs of society, such as new and better phone chargers, and those things, such as levitating light bulbs and light-up hairbrushes, that seem to fill no need other than unusual uses of technology.

This unit specifically covers the following 9-12 standards (in addition to many more K-8 standards):

STEL -1N Explain how the world around them guides technological development and engineering design.
STEL-1P Analyze the rate of technological development and predict future diffusion and adoption of new technologies.
STEL-3I Evaluate how technology enhances opportunities for new products and services through globalization.
TEL-6F Relate how technological development has been evolutionary, often the result of a series of refinements to basic inventions or technological knowledge.
STEL-6G Verify that the evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools, materials, and processes.
STEL-6H Evaluate how technology has been a powerful force in reshaping social, cultural, political, and economic landscapes throughout history.
STEL-6I Analyze how the Industrial Revolution resulted in the development of mass production, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.
STEL-6J Investigate the widespread changes that have resulted from the Information Age, which has placed emphasis on the processing and exchange of information.

Reflection 2
Clinton King; teacher, Department of Engineering and Technology

In our Introduction to Robotics program in the CBC STEM Academy, we use the FTC Robotics challenge as critical-thinking development and a proving ground to practice those workplace soft-skills that industry will demand of the next generation labor force. Consistent with our Man For Tomorrow initiative at CBC High School, our Introduction to Robotics course targets three critical skillsets as it prepares them for future competition in Regional FTC conferences. All these objectives are directed by the assessment of an Engineering Notebook they keep throughout the course of the semester. This notebook is simultaneously a repository for critical information, a journal of their progress, an anchor to ground their daily checklists and agenda, and a means for group reflection and self-analysis. This notebook is a foundational part of our satisfying **STEL-8N**, as it is a collaborative document accessed through Microsoft Teams. Further, our students use apps online such as doodle.io, school e-mail, GitHub and Q&A

resources through FTC to draw on the coach's time, collaborate asynchronously, and share research from the substantial FTC knowledgebase.

First, and most importantly, we want students to practice acting towards a goal without instruction on how to get there. This autonomy is the critical gateway to the design skills we want to develop. How the student achieves their goals must be their own domain. Otherwise, the skills being developed may not translate to an environment where the teacher is not present. In pursuit of this learning target, we address **STEL-7W** and **STEL-7BB** by placing the burden of decision making on the student.
As captured from a student's notebook in *Figure 1*, they must devise a means to test the performance of different design approaches, in this case wheel designs in search of the optimal mobility solution. Students must consider and devise metrics by which to evaluate the different options available and then select based on controlled testing. This also demonstrates how students interact with the concepts of constraints and criteria as per **STEL-2X.** They also get exposure to design principles such as complexity, viability, and trade-offs between properties like size and agility as per **STEL-7AA.**

10/18/22	1:35-3:00	We are going to test all the different types of wheels/ wheel configurations. And make a test chart.	Today we tested out 4 different wheel styles that we could possibly add to our robot. We figured out the best one through running many different tests. Whichever robot performed the best throughout our tests was what we went with as we ended up going with double white. Here is a picture of our robot with our new wheels that we have selected:

	Most turns in 30s	Driving over obsticles	Dodging obsticles	Personal rating Chase	Personal rating Jacob
green	11	pass	6	9	9
Double white	13	pass	19	9.5	10
Single white	13	pass	18	9	9
blue	10	fail	0	3	2

Jack: Absent

Figure 1

The second objective is to promote collaboration. There are two approaches to take depending on a student's inclinations. Some are inclined to watch others work or work alone. These students are further subdivided into those who find social interactions easy but task-sharing difficult, and those students for whom all social protocol is evasive. These students need

structured interaction periods to cooperate in which to be queried and share their ideas. The remainder of the class will collaborate easily but will require an emphasis on listening and the inclusion of outside or iterated ideas. To engage with the variable needs of these different types of students, we address **STEL-7CC, STEL-7DD, STEL-2Y**, and **STEL-2Z.** As per **STEL-7CC,** Students will use the notebook to record sketches as seen in *figure 2 and* will deliberate on the efficiency of designs making a final selection through voting as was recorded in the table in *figure 3*. They also record daily reflections to promote ideation and prevent design inertia as seen in *figure 4.*

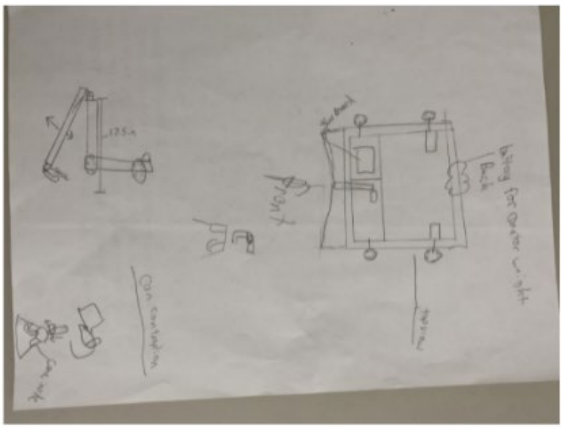


Figure 2

Idea Voting Board

Idea Proposed	Votes For	Votes Against	Comments
We use a plow to move the cones	4	0	Low complexity Medium-low efficiency
We use a elevator to move the cones	1	2	Very high complexity Medium-high efficiency
We use an arm to move the cones	4	0	High complexity High efficiency

Figure 3

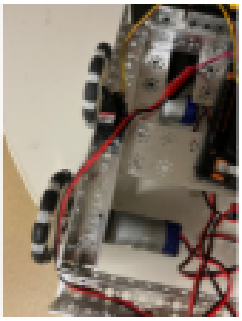
9-9-22	1:35-3:00	Continue to work on the engineering notebook and servo	Overall: We got the servo to work and wrote a page in our engineering notebook. We accomplished our goal and more, we also raced the robot and learned they have a speed of over 1.5 miles per hour. Chase: absent Jack: Helped to work on the notebook Andrew: Helped with the programing, and the notebook Jacob: worked on the notebook and worked on getting the programming perfected. 
9-13-22	1:35-3:00	Work through the engineering design process to get started on building for the challenge/game.	Overall: We met our goal today as we were able to build a moving robot arm and create a sketch for the gripping mechanism. Next time we are going to figure out what kind of gripping mechanism we will use in order to pick up the cones during the game. Jacob: Helped with starting the build of the robots arm and helped come up with ideas for the gripping mechanism. Chase: Also helped with building the robot arm and coming up with ideas for the gripping mechanism. Andrew: Came up with one of our ideas for the gripping mechanism. Jack: Watched the FTC video and took note of the important rules and constraints we will have to follow during the challenge. 

Figure 4

Some students this semester had trouble staying on task and practicing autonomy even to the point where they were actively detrimental and distracting to the learning and productivity of others in their own group and in other groups. To counter this, we created roles for members of

the team to manage “Quality Control.” These QC roles were mostly perfunctory requiring them to check the notebook was done for the day (the “Documentarian) or that they weren’t stow tools in their storage bins (the “Storemaster”). We also assigned one person the “Head Programmer.” *Head* programmer so as to indicate that responsibility for understanding the codebase was distributed across the whole team. However, the critical role was that of “Chief Report.” This person was a kind of Project Manager or Liaison between the team and me. It leveraged the social strengths of those students most prone to distracting others. They utilized their communications skills to make sure everybody had a task, and then report that to me at the beginning of class. Further, at the end of class they reported their effectiveness that day. Essentially this parroted the information in the notebook, but it reinforced the reflection process and gave those students grounding responsibility and a sense of purpose (even importance, since they relayed my orders back to the team). As reflected in *figures 5 and 6,* the students divided up responsibilities and performed daily quality control checks based on those roles. This addressed **STEL-2Y & STEL-2Z**, giving them a process, they can adjust based on their observations of its effectiveness and building institutional resources managing workflow that are inherited and built on by the next academic class. We also make use of the differing level of technical skill our students bring to bear. In pursuit of **STEL-2V**, our more talented or ambitious programming students will build autonomous codebases that pull information from sensors feeding live positional, video, and kinematic data to direct the robot in the FTC competition’s autonomous phase. Meanwhile, as documented in *figure 7,* we pull on resources like 3D modeling and 3D printing Tetrix gear to augment and repair our parts-set supporting **STEL-7DD & STEL-8P**.

Teammate Jobs:

Teammate	Main job	Main Job’s Description
Devin	Team leader/Chief Report	-Will check in with each teammate. -Will report goals & progress to manager (Mr. King)
Grant	Documentation	-Make sure all notebook entries are recorded -Review notebook; check spelling, and grammar
Jonah	Storemaster	-Responsible for maintaining & retrieving parts inventory -communicate parts needed to management (Mr. King)
Karson	Head Programmer	-Maintain & build code base -Coordinate with build team, brief them with functionality

Figure 5

TEAM MEETING PROCEDURE

Not a super complicated procedure each day we:

- All get into class and watch KCBC
- Look at the robot and try to find a weakness, issue, or what can we do to progress ourselves and make that our goal
- Write the goal into the notebook and report to Mr. King
- Finally begin work.

End of day:

- Look at goal
- Look at progress
- Report if we completed our goal or not
- Look at how we can improve

Figure 6

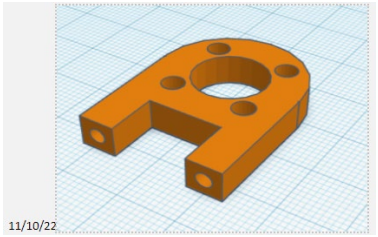
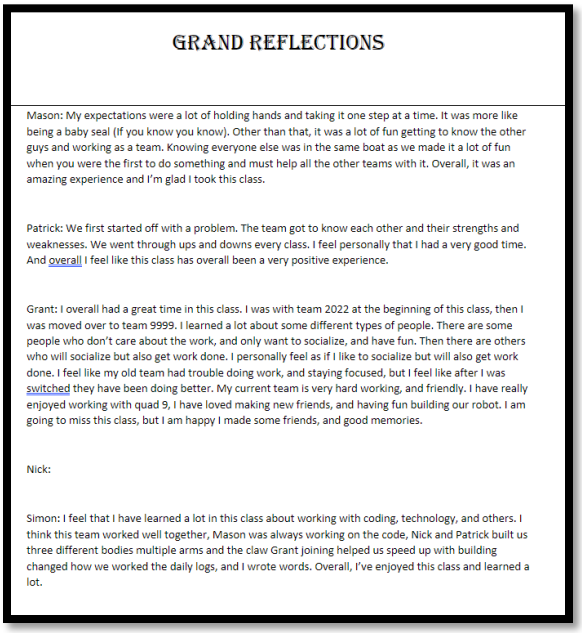


Figure 7

The final objective is built on mastery of the first two, which is goal setting. Ultimately, the students will, as a team, be able to set a daily agenda, execute on those tasks, and reflect on their effectiveness to adjust their own procedures. In addition to seeking best practices and reflecting on daily progress towards goals, students complete a grand reflection at the end of the semester. We encourage them here to look at the class and the team as the object of focus rather than the robot. We teach that the robot is indirectly influenced by their decisions, and that team behavior and rulesets are the foundational objective. These grand reflections and recommended best practices, as exampled in *figures 8 and 9*, support **STEL-2U** in helping to find flaws in the class structure and robot prototype and manufacturing process itself and the social and technological systems that inform that. The students are thereby participating in a self-correcting system that should refine itself over the years.



GRAND REFLECTIONS

Mason: My expectations were a lot of holding hands and taking it one step at a time. It was more like being a baby seal (If you know you know). Other than that, it was a lot of fun getting to know the other guys and working as a team. Knowing everyone else was in the same boat as we made it a lot of fun when you were the first to do something and must help all the other teams with it. Overall, it was an amazing experience and I'm glad I took this class.

Patrick: We first started off with a problem. The team got to know each other and their strengths and weaknesses. We went through ups and downs every class. I feel personally that I had a very good time. And overall I feel like this class has overall been a very positive experience.

Grant: I overall had a great time in this class. I was with team 2022 at the beginning of this class, then I was moved over to team 9999. I learned a lot about some different types of people. There are some people who don't care about the work, and only want to socialize, and have fun. Then there are others who will socialize but also get work done. I personally feel as if I like to socialize but will also get work done. I feel like my old team had trouble doing work, and staying focused, but I feel like after I was switched they have been doing better. My current team is very hard working, and friendly. I have really enjoyed working with quad 9, I have loved making new friends, and having fun building our robot. I am going to miss this class, but I am happy I made some friends, and good memories.

Nick:

Simon: I feel that I have learned a lot in this class about working with coding, technology, and others. I think this team worked well together, Mason was always working on the code, Nick and Patrick built us three different bodies multiple arms and the claw Grant joining helped us speed up with building changed how we worked the daily logs, and I wrote words. Overall, I've enjoyed this class and learned a lot.

Figure 8

GOOD DAILY PRACTICES

- Maintenance check (gears, servos, screws, chains, wheels, ect.)
- Do the daily log, with goal for the day, and attendance

Figure 9

Reflection 3

Patrick Jennewein; teacher, Department of Engineering and Technology

In teaching AP Computer Science Principles, my main goal is for students to discover the foundational concepts that underpin all of computer science. One of these core concepts is crafting clear and specific directions for basic processes that we undertake in our everyday lives. These directions will, eventually, become actual code that a computer can read to make the process more efficient.

One example of a basic process like this is a gradebook. Of course, gradebooks have constraints, such as that one cannot record a grade of less than 0 or greater than 100, and that every grade must correspond to a student, to an assignment, and to a class. Meanwhile, the gradebook must allow for user input that takes these constraints into account. The gradebook must further account for "user error" in this input, so that – if a teacher erroneously inputted that he or she has "1000" students instead of "10" students – the gradebook would catch it and ask the user to re-input. Finally, the gradebook must look organized so that a teacher can very clearly see the data set.

One lesson I designed took these problems and asked students, as a group, to brainstorm how to instruct a computer to do this. Following this, students were to craft this gradebook (using the C++ computing language) over the span of multiple days. For the students who were less challenged by this assignment, I presented an additional constraint: print the gradebook, but drop the lowest grade for each student; signify the dropped grade by placing a "DR" in the gradebook in place of the grade.

The task was challenging, and many students had productive struggles. Some questions that students encountered were the following:

"How do I organize this data using arrays?" At this point, students were only taught how to using single-dimensional arrays but, in this context, a multi-dimensional array is the most effective way to organize multiple-dimensional data. Students had to figure this out on their own and use their skills in research

"How do I allocate the appropriate amount of memory dynamically, i.e. how do I allocate memory based upon user input?" Memory allocation is a challenging subject for students, but students were ultimately able to determine that memory could be allocated dynamically by (1) asking the user to input the appropriate number of students and assignments, and (2) using that number to populate a multi-dimensional array.

"How do I print the gradebook in a way that is organized, regardless of the user input?" Students determined that the <iomanip> header file provided functions to space data appropriately, just like a "real-world" gradebook.

Other, smaller challenges arose too, but these were the most popular.

Ultimately, many of the students excelled and, for the students who needed more help, other – more proficient – students were able to assist. Though I could provide multiple finished products, this one sets a prime example of what the assignments was all about. See the next page.

This lesson demonstrates (1) The Nature and Characteristics of Technology and Engineering; (2) Core Concepts of Technology and Engineering; (3) Integration of Knowledge, Technologies, and Practices; (4) Impacts of Technology; (5) Influence of Society on Technological Development; and (7) Design in Technology and Engineering.

Artifact

```
> sh -c make -s
> ./main
Number of students: 3
Number of assignments: 4
Grades for Student 1:
Assignment 1: 98
Assignment 2: 93
Assignment 3: 68
Assignment 4: 100

Grades for Student 2:
Assignment 1: 80
Assignment 2: 86
Assignment 3: 78
Assignment 4: 90

Grades for Student 3:
Assignment 1: 60
Assignment 2: 75
Assignment 3: 68
Assignment 4: 89

NORMAL GRADEBOOK:
      Student 1:  98  93  68 100
      Student 2:  80  86  78  90
      Student 3:  60  75  68  89

MODIFIED GRADEBOOK:
      Student 1:  98  93  DR 100
      Student 2:  80  86  DR  90
      Student 3:  DR  75  68  89
>
```

```cpp
#include <iostream>
#include <iomanip>
using namespace std;

int getInput(int min, int max, string message);

int main()
{
    int students = getInput(1, 20, "Number of students");
    int assignments = getInput(1, 20, "Number of assignments");

    // populate gradebook
    int gradebook[students][assignments];
    for (int i = 0; i < students; i++)
    {
        cout << "Grades for Student " << i + 1<< ": " << endl;
        for (int j = 0; j < assignments; j++)
            gradebook[i][j] = getInput(0, 100, ("Assignment " + to_string(j + 1)));
        cout << endl;
    }

    // print gradebook
    cout << "NORMAL GRADEBOOK: " << endl;
    for (int i = 0; i < students; i++)
    {
        // print gradebook row
        cout << right << setw(14) << "Student " << i + 1 << ":";
        for (int j = 0; j < assignments; j++)
            cout << right << setw(4) << gradebook[i][j];
        cout << endl;
    }

    // find lowest, dropped grades
    int dropped[students];
    for (int i = 0; i < students; i++)
    {
        int lowestGrade = gradebook[i][0];

        // iterate through all grades
        for (int j = 1; j < assignments; j++)
        {
            if(gradebook[i][j] < lowestGrade)
                lowestGrade = gradebook[i][j];
        }
        dropped[i] = lowestGrade;
    }
    cout << endl;

    // create gradebook with lowest, dropped grade and print
    cout << "MODIFIED GRADEBOOK: " << endl;
    for (int i = 0; i < students; i++)
    {
        // print gradebook row
        cout << right << setw(14) << "Student " << i + 1 << ":";
        for (int j = 0; j < assignments; j++)
        {
            if(gradebook[i][j] == dropped[i])
                cout << right << setw(4) << "DR";
            else
                cout << right << setw(4) << gradebook[i][j];
        }
        cout << endl;
    }
}

int getInput(int min, int max, string message)
{
    int input;
    do
    {
        cout << message << ": ";
        cin >> input;
    }
    while(input < min || input > max);
    return input;
}
```