THE STEM PIPELINE IS BROKEN

Addressing the Teacher Supply Crisis for

Technology, Engineering, & Computer Science

GEORGIA EDITION

STEM EDUCATION FOR THE 21st CENTURY

NOVEMBER 2016 EDITION

STEM LEADERSHIP FOUNDATION

KELL ROBOTICS

The STEM Leadership Foundation works to develop a deeper understanding of the evolving economy and its impact on 21st century STEM education.

As a non-profit 501(c)3 foundation, we do business as the STEM Leadership Foundation and as Kell Robotics. Kell Robotics started at Kell High School in 2004 with six students and two sponsors. The team has grown to become a community team based in Kennesaw, Georgia, with members from five different high schools, across two counties, and home schooled students. Kell Robotics is a participant in the *FIRST* Robotics Competition and is a past Lemelson-MIT Inventeam.

Kell Robotics' mission is to inspire the next generation of Scientists, Technologists, Engineers, Mathematicians, and Leaders. To accomplish this mission, the Kell team has been working since 2008 to change the STEM education process through strategic partnerships with political, educational, university, and business leaders; advocating and formulating public policy; building infrastructure; and creating public value through outreach and communications.

Current research focuses on the following themes: teacher development, public understanding of STEM fields, expansion of informal STEM learning, and STEM education as an ecosystem.

Ed Barker leads the STEM Leadership Foundation and the Kell Robotics team. Student members working with team mentors, analyze and provide facts and insights to base management and policy decisions.

Kell Robotics’ activities and research are funded by partners and not commissioned by governmental agencies or corporate entities. For further information about Kell Robotics and to download reports, please visit www.kellrobotics.org

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Special thanks to Dr. Jim Cope, Kennesaw State University, Editorial Review

$ 25 million invested

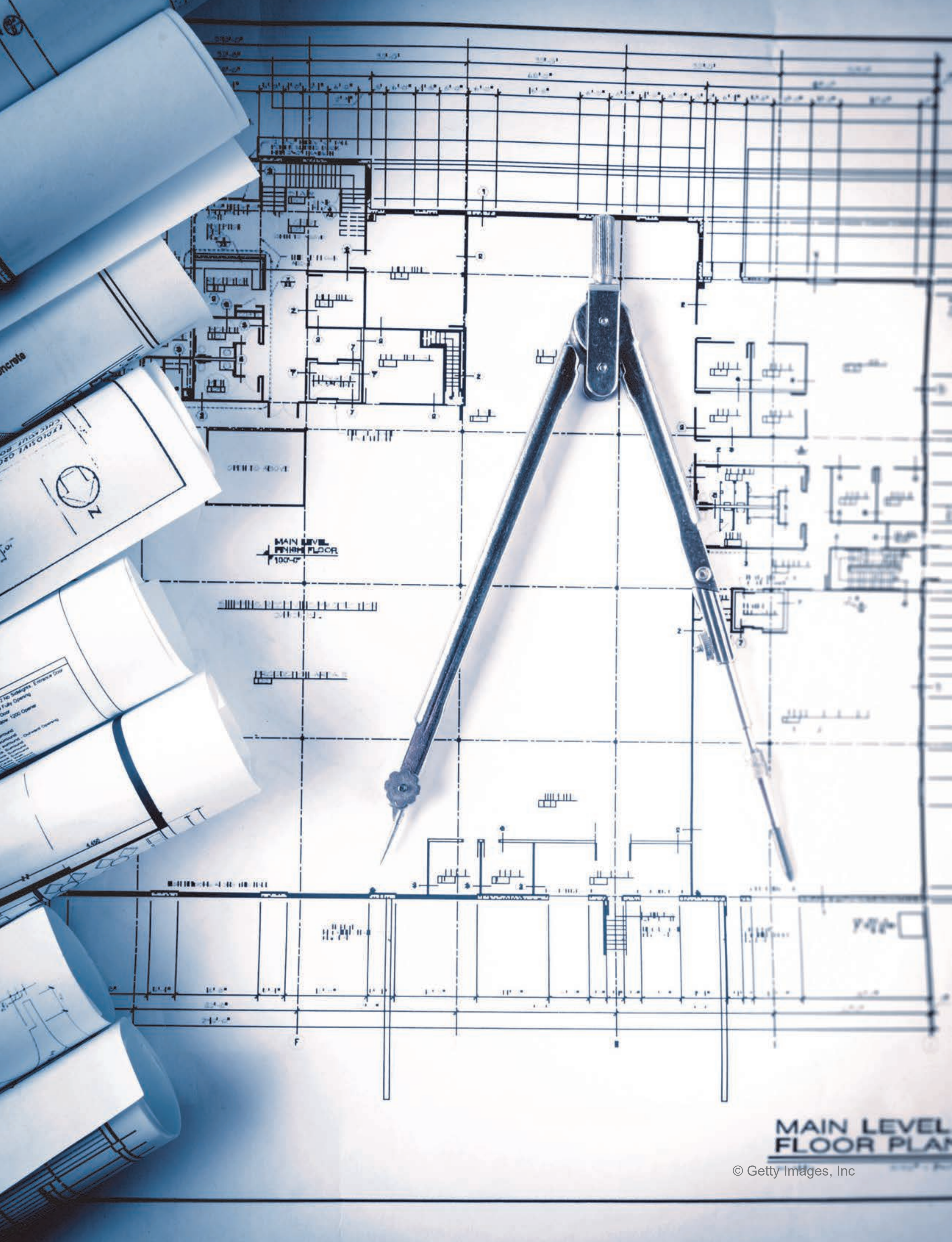
In STEM CTSOs and Informal Learning Support Systems & Teacher Development & Support; annual state investment

Chuck Koehler, Creative Commons

Yields

$ 1,000+ million

Annual growth in Georgia State Economic Product


MAIN LEVEL
FLOOR PLAN

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OVERVIEW

THE HIGH DEMAND CAREER INITIATIVE

Georgia is one of the fastest growing technology centers in the world, with biotech, manufacturing, aerospace, information technology, and cyber security sectors, to name a few.

Georgia's business climate was named number one in the nation by Site Selection magazine, one of the nation's top economic development trade publications and Georgia has the 10th largest economy in the United States, with a Gross State Product approaching half a trillion dollars (476 billion dollars).

This economic performance is good news, but how do we maintain and enhance Georgia's economic growth and development?

The economic development community, led by Governor Nathan Deal, has heard from the private sector that one of the greatest challenges facing businesses, nationally and in Georgia, is the need for a consistent, trained, and reliable workforce; particularly in the areas of Science, Technology, Engineering, and Math (STEM).

In response, Governor Deal created the High Demand Career Initiative (HDCI) to allow state partners involved in training Georgia's future workforce to hear directly from the private sector about what type of workforce they need.

The High Demand Career Initiative identified 162 unique careers and 96 skill sets in high demand in Georgia. Georgia does not currently have an adequate workforce in these areas.

To guide our educational systems and maximize future income, we must understand and resolve the misalignment between educational processes and workforce development needs.

In this report, we will outline the key tasks identified to ensure Georgia has the workforce to support the careers and skill sets identified by the HDCI.

Implementing this solution requires participation from our political and educational leaders, corporate partners, teachers, and students. This vested interest should start in kindergarten and continue with consistent support straight through to post-secondary education.

These measures, if implemented, will more than double the annual production of engineers, scientists, technologists, and other STEM career professionals, which, in turn, will add billions of dollars to the Georgia economy each year.


300,000
Industrial Robot
Global Installations / Yearly
By 2019
NATIONAL SECURITY
THE INTERNET OF THINGS
CYBER SECURITY
Data science drives Manufacturing 4.0
Booz Allen Hamilton
COMPUTER AIDED MANUFACTURING SYSTEMS

IN BRIEF

THE HIGH DEMAND CAREER INITIATIVE ADDRESSING THE CHALLENGE

This report is a result of an analysis of the current education system, how students learn, and emerging trends and movements in STEM learning. Here is a list of key observations:

- Students are express interest in taking science, technology, engineering, and math nationwide, but schools are facing a drought of educators to teach the subjects.
- School districts demonstrate high interest in offering classes in engineering, technology, and computer science, but school districts are facing a drought of educators to teach the subjects.
- There is anecdotal evidence that students have interest in teaching science, technology, engineering, and math nationwide, but are unable to pursue a world class opportunity to build a career in this area.
- The needs of 21st century educational systems are not being met because there are no teacher education programs at the undergraduate, or graduate level, which are designed to produce 21st century oriented engineering, technology, and computer science teachers. The design and implementation of current teacher production practices for engineering, technology, and computer science teachers are outdated and ineffective. Additional issues are compensation and market competition for talent.
- The units of the University System of Georgia and the Technical College System of Georgia have the capacity to solve this pressing problem through a creative partnership detailed in this report.
- Increasing support for informal STEM learning systems like Career and Technical Student Organizations is a second critical path item that has a very high return on investment.
- The third critical path item is to support the development and growth of a thriving Community of Practice and Learning ecosystem.

Implementation of the modest recommendations in this report will enhance future growth, employment, and prosperity for Georgia's citizens by injecting new dynamism into the economy.

THE MOST CRITICAL ISSUE TO BE RESOLVED !

Teacher Development, Teacher Supply, and Teacher Support


the HDCI is at risk !
The
STEM
Workforce
Development
Pipeline
Is
Clogged

EXECUTIVE SUMMARY

DEFINING THE CHALLENGE

The need for a Technology Literate workforce to replace our aging workers is well understood. There is a need to create and implement internships, on-the-job training and co-ops programs. When these opportunities are not available, we need to provide alternatives such as robotics teams in an after school setting. We need to engage students in a range of activities at a younger age including engagement in STEM activities.

Additionally we need to find ways to increase student motivation, help them improve fundamental, and advanced educational skills and develop a passion for lifelong learning, so that they may keep up with future marketplace changes. Meeting the demand for high skilled 'grey collar' employees will be especially challenging given the diversity of knowledge, skills, and ability needed to support the future economy.

Across many sectors technology and automation is changing the work environment. No longer is there a solid wall between academic and non-academic jobs. The lines are becoming blurred into a near continuum of skill sets needed from the most advanced academic researcher to the ordinary unskilled trade. The educational process no longer fits so neatly into academic and vocational tracks.

New jobs exist today that didn't exist only ten years ago. For example, business and government are using big data analytics in the transportation, energy, healthcare, and manufacturing sectors, to name a few.

Today's gray-collar jobs can often require educational levels rivaling traditional college graduates of the past. The world has changed.

We have to prepare for a harsh world of 360-degree competition that is fast, agile, and increasingly winner-take-all.

A model for preparing students for this new workplace is the *FIRST* Robotics Competition, a high school engineering competition that requires students to develop and deliver a technologically sophisticated product in only in 45 days. The students take their robots to competition events that are intense, much like a good football game. Participants have to think on their feet, and fast, responding to a constant stream of adverse events. What these students are doing rival what is happening in the 21st-century business world. Today the successful companies are those that revolve around ideas, innovation, research, and expertise. Success in business requires a workforce that is skilled, creative, and agile. Employers want to know what you can do and do well, and not only what degree hangs on the wall.

The habits of mind, competitive skills, technological prowess, and business agility skills that *FIRST* participants learn are exactly the type of behaviors needed to advance our nation.

Can we afford not to tap into this talent development pipeline?

To meet this challenge, we will introduce a new model for 21st-century teacher production. This new teacher development model redefines teacher development for engineering, technology, and computer science education. Developing a new paradigm for teacher training and support is the highest priority task in this report. We cannot bypass this issue and rely solely on other paradigms that nibble around the edges of the workforce development crisis.

THE NATURE OF 21st CENTURY JOB MARKET

"In 2018, Harvard University predicts only 33% of all jobs will require a 4-year degree or more, while the overwhelming majority will be middle-skilled jobs requiring technical skills and training at the credential or Associates Degree level.

For every occupation that requires a master's degree or more, two professional jobs require a university degree, seven or more jobs will require a 1-year certificate or 2-year degree, and each of these technicians is in very high-skilled areas that are in high demand. This ratio is fundamental to all industries. It was the same in 1950, the same in 1990, and will be the same in 2030." *[Success in the New Economy, Kevin Fleming.]*

12 %

Size of Global Manufacturing Workforce that will be impacted by advanced robotics by 2026.

McKinsey Global Institute

THE STEM PIPELINE IS CLOGGED

Advocates in the STEM community have made much progress toward increasing student interest and motivation. Student interest in STEM learning is burgeoning everywhere.

Colleges are increasingly difficulty to enter. Summer camps are full. Festivals and camps are held throught the school year. Studies report rising student interest in STEM careers. In addition, informal robotics programs are growing at rates of 15 to 20% annually. Interest among diverse audience is the highest ever.

Students that are motivated to pursue STEM initiatives at an early age but cannot progress due to systemic faults. Even worse is that candidates that would like to become a STEM teacher are unable to identify and pursue an undergraduate teacher degree program that will lead to such a position.

THE STEM PIPELINE IS BROKEN

Often students that are motivated to pursue STEM interests do not have an environment that will nurture and support their growth and development. Schools are not providing courses and facilities. Teachers are unprepared. Teacher development systems have not kept pace with new courses. New STEM training initiatives frequently are shallow in content breadth and depth and are ill-suited to prepare teachers for the challenge ahead.

Student talent exists everywhere. No school or town has a monopoly. Small towns and big city districts have very different capabilities and challenges to meet.

How do we collect and develop geographically diverse student talent, across a wide range of disciplines, without breaking our budget?

RETHINKING EDUCATION

We need to challenge a fundamental assumption about program delivery. We have built an education system on a factory model derived from the industrial revolution. Assembly lines and ringing bells rule the day.

The expansion of education beyond the basics of reading, writing, and arithmetic bring new challenges about how we deliver content. Technological content is no longer a ten feet wide, one-foot-deep pond, but a mile wide ten-foot-deep ocean. We have to rethink education delivery.

ADOPT FROM THE BEST, INVENT THE REST

The original model for teaching and learning was the apprenticeship. This model fell into decline as the industrial revolution and modern management techniques pushed aside this model.

Since the mid-19th century, the modern educational system has been modeled as a regimented factory, with requirements for minimum supporting structures that drive the cost up and availability down.

A new 21st century model of education is emerging based on a web of artisans, a community of practice, supported by collaborative partnerships.

We propose adopting the models of apprenticeships, formal education, informal learning, and the concept of networks of collaborative institutions and individuals and blend them together to create a geographically diverse community of learning and practice.

The advent of modern communication and ability to create geographically diverse networks has changed everything. Today we can offer online learning and collaboration, virtual classrooms, and build communities of practice that span the state.

Advanced robotics global impact across health care, manufacturing, and services could generate a potential economic impact of

$1.7 to $4.5 trillion per year by 2025

including more than $800 billion to $2.6 trillion in value from health-care uses

McKinsey Global Institute

ROBOTICS IN MANUFACTURING

SPORTS ANALOGY

A simple way to begin to understand this new blended framework is to view high school football as a case study. Football players develop their athletic identity through after school or informal learning. Developing the player over many years requires a larger community of practice of supporters, facilities, coaches, and supporters. This is a rigorous process of conditioning and training that eventually filters out candidates that are not suitable to be in this sport. Football is informal because it is self-elected and not cirricular.

When a football player signs on to a college team, they are certain why they are they are on the football team. They did not sign up for the team from a career brochure.

The advantage of this informal learning experience is twofold. First, it improved the candidate, and secondly it filtered out unsuitable candidates. We understand the value of high school football in the role of developing college and professional athletes. We will return to this concept later in this report.

BREAKING DOWN WALLS

We understand apprenticeships and internships. The medical profession is an example. Medical doctors blend academic rigor with intensive internships.

Breaking down the walls between informal learning and formal education is crucial to understanding and advancing to the next step. Apprenticeships are not available to everyone everywhere. Informal learning systems are available that increase availability of apprenticeship experiences. These experiences are rigorous, technically relevant, and exist inside of an apprenticeship model.

The next wall to break down is the acceptance and understanding of blending online and physical micro-class sized learning experience that bridge informal and formal learning models.

Career and Technical Student Organizations (CTSO are well known and accepted in the education community.

> "In this prescient 2005 talk, Clay Shirky shows how closed groups and companies will give way to looser networks where small contributors have big roles and fluid cooperation replaces rigid planning. " *[TED Talks: Clay Shirky: Institutions vs. collaboration]*

An example of the how institutions can collaborate to drive educational and economic development is an initiative led by the University of Georgia's Carl Vinson Institute. The Institute is working to build a network of collaborators across the business and educational community.

COMMUNITIES OF PRACTICE

A Community of Practice is a group of practitioners that shares a craft or interest. The easiest way to describe a community of practice in a context relevant to this report is to describe the *FIRST* Robotics initiatives.

This competition with over 400,000 students and 120,000 mentors and volunteers is a community of practice. Many of these volunteer mentors are engineers, technologists, computer scientists, and other professions.

APPRENTICESHIPS

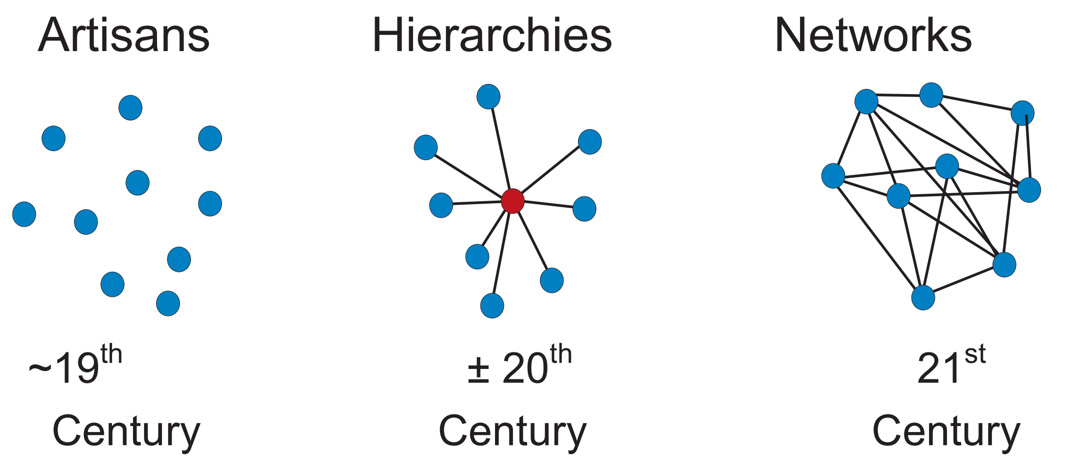
The *FIRST* Community of Practice is a mentor student apprentice system of learning. The advantage of the *FIRST* system is scalability and alignment with workforce development needs.

For some students, placement into a local industry as an apprenticeship is ideal. When this opportunity is not available to the student, informal learning is available as an option.

PARTNERSHIPS

Informal learning communities provides a basis for schools to develop partnerships that support workforce aligned learning objectives.

21st Century Systems of Learning & Work



Learning & Work has evolved from being individual artisans, to a system of hierarchies to networks of individuals & institutional collaborators

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A NEW BREED OF TEACHER

This new breed of the 21-century teacher has to have the right stuff. This is not the old school shop teacher, but a new breed that has a well-honed, balanced set of skills and knowledge that spans technical and teaching proficiency, STEM career counseling, apprenticeship development, business partnerships, and the ability to work in a networked community of practice.

This new breed of teacher will be recruited from the expanding source of STEM inspired students that are being created informal learning STEM competitions, FIRST Robotics Competition system being a prime example.

The teacher will be developed in a new type of teacher development initiative, that will combine rigorous academics, industry internships, teaching practicums, and hybrid learning models.

A NEW BREED OF STUDENTS

A second outcome of this model is the development of a student learning model that integrates into the teacher development platform.

This model is based on the world largest informal engineering design competition. Blending this informal learning system with teacher development, industry partnership, direct and proxy apprenticeships, and hybrid online learning models will allow workforce development and educational leaders to quickly gain access to a broader and more diverse audience.

BLENDED LEARNING SYSTEMS

We can steal from the best, and make up the rest by creating a blended architecture which takes advantage of Apprenticeships, Hierarchies, and Networks.

In this report we will lay out a model for teacher development aligning to 21st-century industry needs, and a new student growth model that introduces micro-classes as a new hybrid model that extends offerings beyond online and traditional offerings.

STUDENT ENGAGEMENT

How do we increase student motivation? How do we move beyond the classroom and provide students an opportunity to develop career identity?

We know from research that students develop most of their career identity (Musical, STEM, athletic, etc.) after school in what the academic community refers to as Informal Learning activities or Out of School Settings.

Some of these activities are recognized at the Federal and State level and are known as a Career and Technical Student Organization (CTSO). A few of the CTSOs of technical relevance are SkillsUSA, Technology Student Association (TSA), and Future Business Leaders of America (FBLA). In 2016 the state of Georgia created a new CTSO for *FIRST*® (For Inspiration and Recognition of Science and Technology). The new *FIRST* CTSO strengthens student recruitment by providing access to a more diverse group of students.

This group of CTSOs' complements each other, reaching different types of students and maximizing the potential for success. The CTSO model is an essential component of the STEM ecosystem model.

EXEMPLARS OF STUDENT ENGAGEMENT

FIRST, is a non-profit 501(c)3 organization built to inspire students, and is a model of how to create student interest and passion through an after school experience.

FIRST is not about the robot, but much more. The programs inspire students and help give meaning to academic studies. The programs help students develop their career identity, which is a necessary part of the solution to addressing the challenge of workforce development.

FIRST is a newly minted Georgia CTSO and is the first known instance of a state adopting ***FIRST*** as a CTSO. ***FIRST*** is the world's largest K-12 non-profit engineering inspiration organization.

FIRST and the supporting ecosystems have a long coattail, delivering students that have a diversity of skill sets, technical, and non-technical, across the spectrum of ability and talent levels.

Project Lead the Way (PLTW) is a model of a school engineering education. PLTW uses a rigorous curriculum taken over a four-year sequence of courses.

The series starts with engineering design and principles. It then progresses to specialties such as biotechnical engineering, civil engineering, and architecture. The program concludes with a capstone project. PLTW also includes programs for computer science, biomedical science, and middle school engineering.

CAUTION: STEM PIPELINE UNDER CONSTRUCTION

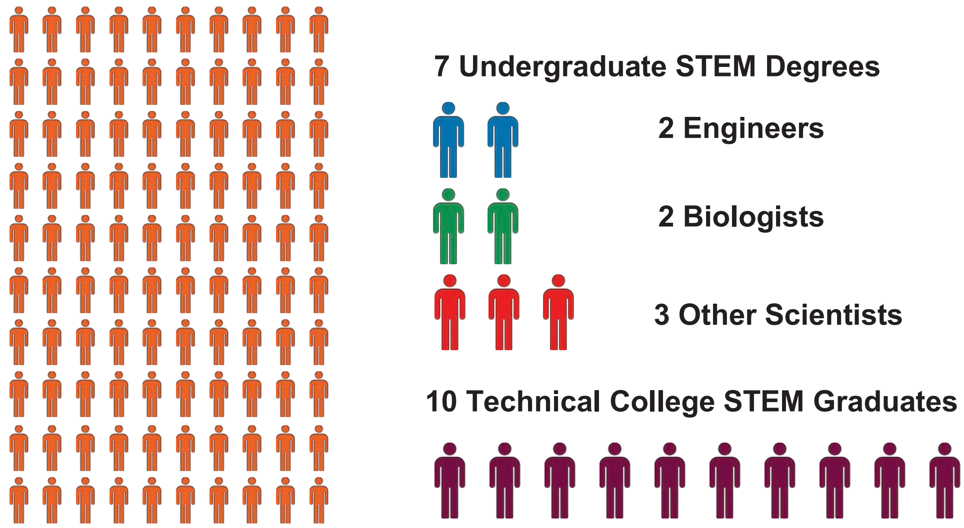
Students that are motivated from K-8 to pursue HDCI careers cannot pass through the STEM pipeline clusters to MOWR (Move On When Ready) and post-secondary opportunities.

42 HDCI CRITICAL GaDOE COURSES NOT SUPPORTED BY TEACHER DEVELOPMENT SYSTEMS

- 3-D Modeling and Analysis
- AC Theory, Electric Motors, and Hydraulic Systems
- Advanced AC and DC Circuits
- Advanced Cybersecurity
- AP Computer Science (Contact College Board for standards)
- Appropriate and Alternative Energy Technologies
- Computer Science Principles
- Digital Design
- Digital Electronics
- Electrical Motor Control
- Embedded Computing
- Energy and Power Technology
- Energy and Power: Generation, Transmission, Distribution
- Energy Systems Applications
- Engineering Applications
- Engineering Concepts
- Fluid Power and Piping Systems
- Foundations of Electronics
- Foundations of Energy Technologies
- Foundations of Engineering and Technology
- Foundations of Manufacturing and Materials Science
- Game Design: Animation and Simulation
- Industrial Mechanics
- Introduction to Cybersecurity
- Introduction to Digital Technology
- Introduction to Drafting and Design
- Introduction to Mechatronics - DC Theory, Pneumatic Systems, and Programmable Logic Controllers
- IT Essentials
- IT Support
- Networking Fundamentals
- Networking Systems and Support
- AP Computer Science Principles
- Production Enterprises
- Programming, Games, Apps, and Society
- Robotics and Automated Systems
- Semiconductors, Mechanical Systems, and Pump and Piping Systems
- Survey of Engineering Graphics
- Web Design
- Web Development
- Exploring Engineering and Technology Grade 6
- Invention and Innovation Grade 7
- Technological Systems Grade 8

Postsecondary STEM Degree Production Rate

For every 100 high school graduates in Georgia, USG & TCSG produces



SETTING A TARGET

The National Academies of Engineering, education leaders such as Dr. Wayne Clough, former President of Georgia Tech, and others, have made a simple recommendation to set a goal of doubling the production of engineering and technology oriented post-secondary graduates.

This is a tangible goal that is understandable and easier to act on.

Evidence shows that supporting Informal Learning initiatives, will double the number of students pursuing stem post-secondary opportunities.

This fact coupled with solving issues in teacher education, and classroom infrastructure will lead to a new dynamism in economic development and job growth.

Accomplishing this single goal of doubling USG and TCSG STEM production rates in the engineering and technology fields alone will accrue an additional $ 1-2 Billion annually to the Georgia State Annual Economic Activity.

CONCLUSIONS AND RECOMMENDATIONS

There are least 42 middle and secondary level courses that are at risk due to teacher supply issues. These courses are HDCI critical pathways. There is no suitable teacher development program in existence in Georgia that addresses this issue.

It is our recommendation that a set of degree programs and certifications is developed and deployed forthwith to provide undergraduate, postgraduate, and certification options to solve teacher supply issues. These programs should provide for recruitment and marketing initiatives to encourage high school students to enter the teaching field.

Informal learning systems, in particular *FIRST* Robotics programs, offer the possibility of use as a K-12 engineering design system that can be used to support standards-based teacher development and training, in cooperation with existing K-12 initiatives.

We further recommend the development and expansion of infrastructure, partnerships, and informal learning support systems and activities to facilitate the growth and development of a STEM education ecosystem.

The highest priority recommendation is teacher development, with all other measures as supporting ecosystem components.

The final recommendation is the teacher development system should exist as a statewide interagency collaborative activity. USG units that meet RETP minimum (Regents Engineering Transfer Program) requirement that also host Colleges of Education are host candidates. TCSG units can provide select courses under and expanded articulation agreement.

A statewide consortium should be created to implement these measures.

TEACHER DEVELOPMENT MODEL

Solving the Teacher Supply Crisis for

Technology, Engineering , Computer Science

PREPARING TEACHERS

BUILD A WORLD CLASS EDUCATOR PREPARATION SYSTEM

Building a first class, internationally recognized K-12 Technology, Engineering, & Computer Science Education development system within universities is a requirement for resolving the demands of 21st century education.

Achieving this will give Georgia a regional advantage as no other state in the region has a comparable program.

Such a world class teacher preparation system should have five initiatives.

TECS

Technology, Engineering & Computer Science

K-12 **STEM Endorsement**

BS **TECS Education**

MS **TECS Education**

MAT **TECS Education**

Ph.D. **TECS Education**

THE DESIGNED WORLD

Medical

Biotechnology

Healthcare & Life Sciences

Energy

Information

Computing

Communication

Logistics & Transportation

Transportation Technologies

Manufacturing

National Defense

Agriculture

Construction

Water

THE DESIGNED WORLD

Chuck Koehler, Creative Commons

Our world has been permanently shaped by human action using engineering and technology. Our future depends on how well we understand and use technology from a social, cultural, economic, and ecological perspective. The need to teach engineering and technological literacy is fundamental to the success of our society. Technological Literacy isn't just knowing what technology is but knowing how to use, apply, maintain, create, and solve problems with technology.

There is an urgent need to create an educational system that is designed to educate students to become Technologically Literate. This literacy stands on top of and integrates all the fields of study that students learn in other areas, such as reading, writing, mathematics, science, history, sociology, etc.

The Designed World is everywhere and includes Agriculture, Manufacturing, Healthcare Technology, Information Processing and Computers, Communication Systems, Energy Sources and Use. It impacts our food, water, and shelter. Our energy and national security are dependent on technology. Technological Literacy is crucial to our economy. The largest challenges we have, as identified by the HDCI, are related to this issue of Technological Literacy.

Our most important economic development challenges identified by the HDCI is related to the fact that most Georgia schools are severely handicapped in teaching technology classes due to teacher supply issues.

PREPARING TEACHERS

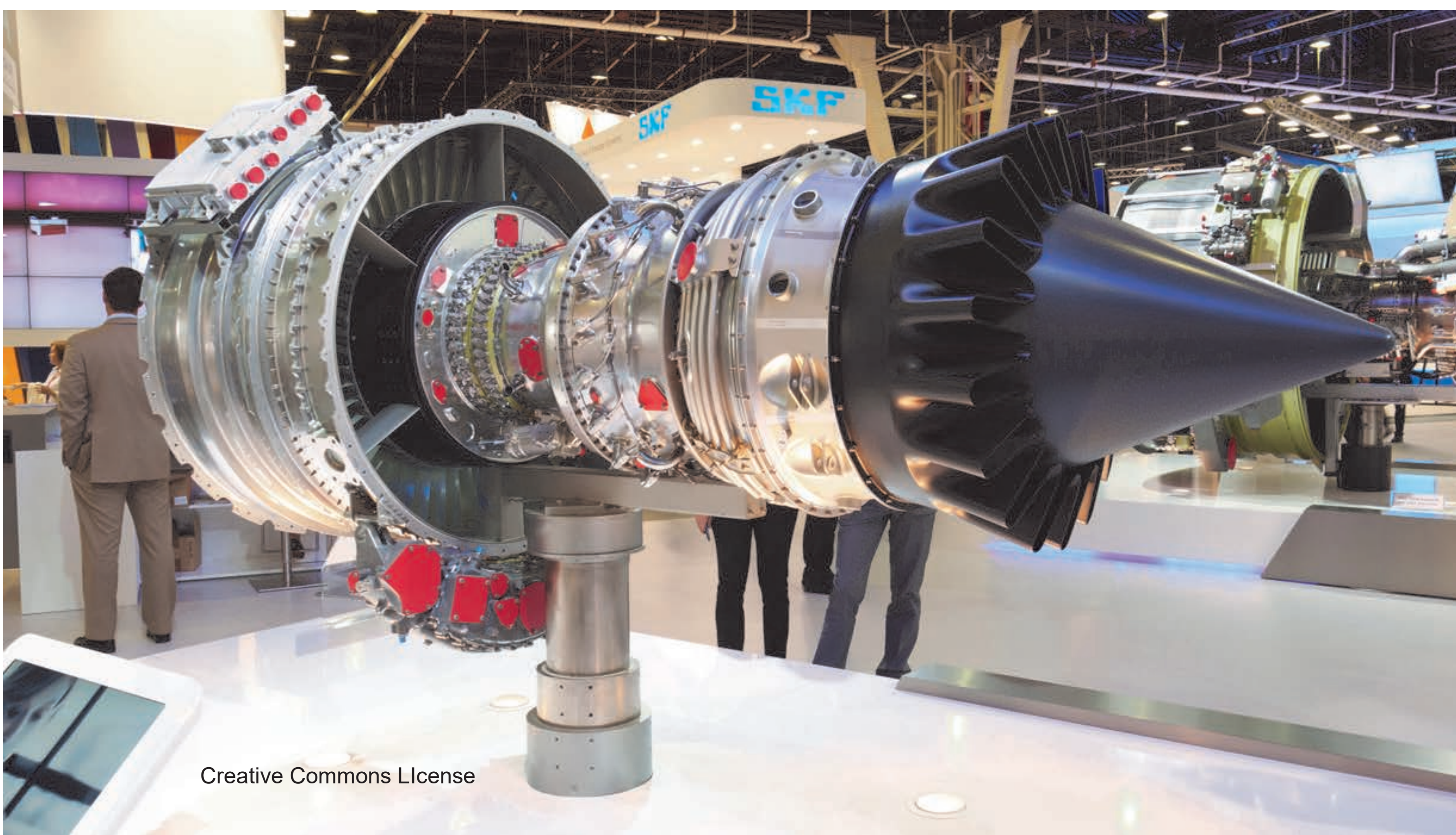
The world we live in has been shaped in many important ways by human action. We have created technological options to prevent, eliminate, or lessen threats to life and the environment and to fulfill social needs. We have dammed rivers and cleared forests, made new materials and machines, covered vast areas with cities and highways, and decided—sometimes willy-nilly—the fate of many other living things.

In a sense, then, many parts of our world are designed—shaped and controlled, largely through the use of technology—in light of what we take our interests to be. We have brought the earth to a point where our future well-being will depend heavily on how we develop and use and restrict technology. In turn, that will depend heavily on how well we understand the workings of technology and the social, cultural, economic, and ecological systems within which we live.

[Project 2016 ; The Designed World]

THE DESIGNED WORLD

The natural world consists of plants and animala, earth, air, water, and fire - things that would exist without human intervention or invention. The social world includes customs, cultures, political system, legal system, economies, religions, and the varioius other mores that humans have devised to govern their interactions and relationships with one another. The design world consists of all the modification that humans have made to the natural world to satisfy their own needs and wants. As its name implies, the designed world is the product of a design process that provides ways to turn resources - matereials, tools and machines, people, information, energy, capital, and time - into products and systems.
[Project 2016 ; The Designed World]



PREPARING TEACHERS

THE GOLDILOCKS PRINCIPAL

The Goldilocks Principal states that some solutions to a problem are inadequate, other solutions are excessive, and some solutions are ***just right***. Misalignment of teacher preparation systems are costly, inefficient, and increase barriers to success in many ways.

A review of the existing methods of production reveals an unsettling set of conclusions.

The misalignment of how we produce teachers and the types of teachers we need for the future is causing the cost of teacher production to be very high, and the quality and yields to be low.

21st CENTURY ENGINEERING, TECHNOLOGY, COMPUTER SCIENCE EDUCATOR PREPARATION

The 21st Century Educator that can teach the spectrum of STEM and IT pathway courses has to have The Right Stuff.

This new teacher is not the old school shop class teacher. The candidate has to have a rigorous academic background in math and science, combined with specialized engineering design and lab-based courses.

The preparation has to be highly experiential with a minimum level of lab and classroom experience across a range of industry aligned disciplines.

The candidate teacher has to be able to move adeptly from theory to practice, from the whiteboard to the CNC manufacturing machine. The candidate will be well versed in project management and experiential learning with the ability to work with industry, educators, parents, and students.

This preparation program can be on campus or hybrid due to the nature and intensity of the lab based courses.

KEY ISSUES

The philosophy of taking new, career changing or retired engineers and turning them into teachers will provide a few candidates.

Engineering, in general, is a vast field with an extensive range of specialties. The number of engineers that have professional field experience in all the required areas is very low, even with the current coursework that provides teacher certification.

We are losing a large pool of candidates that would like to teach. They would like to work in the STEM education space, but are not candidates for receiving a full engineering degree.

Asking students to get a full engineering degree and taking up to 60 hours of rigorous coursework that is irrelevant to K-12 education is a large waste of resources, time, and seats for other students, especially given the competition for admission to engineering universities.

Science and math teachers have a different habit of mind than engineers even though they are in the STEM field.

Workforce development degrees are weak and do not provide the correct content or rigor for this requirement.

TEACHER PREPARATION ISSUES
ENGINEERING, TECHNOLOGY, COMPUTER SCIENCE

FOUR SCENARIOS

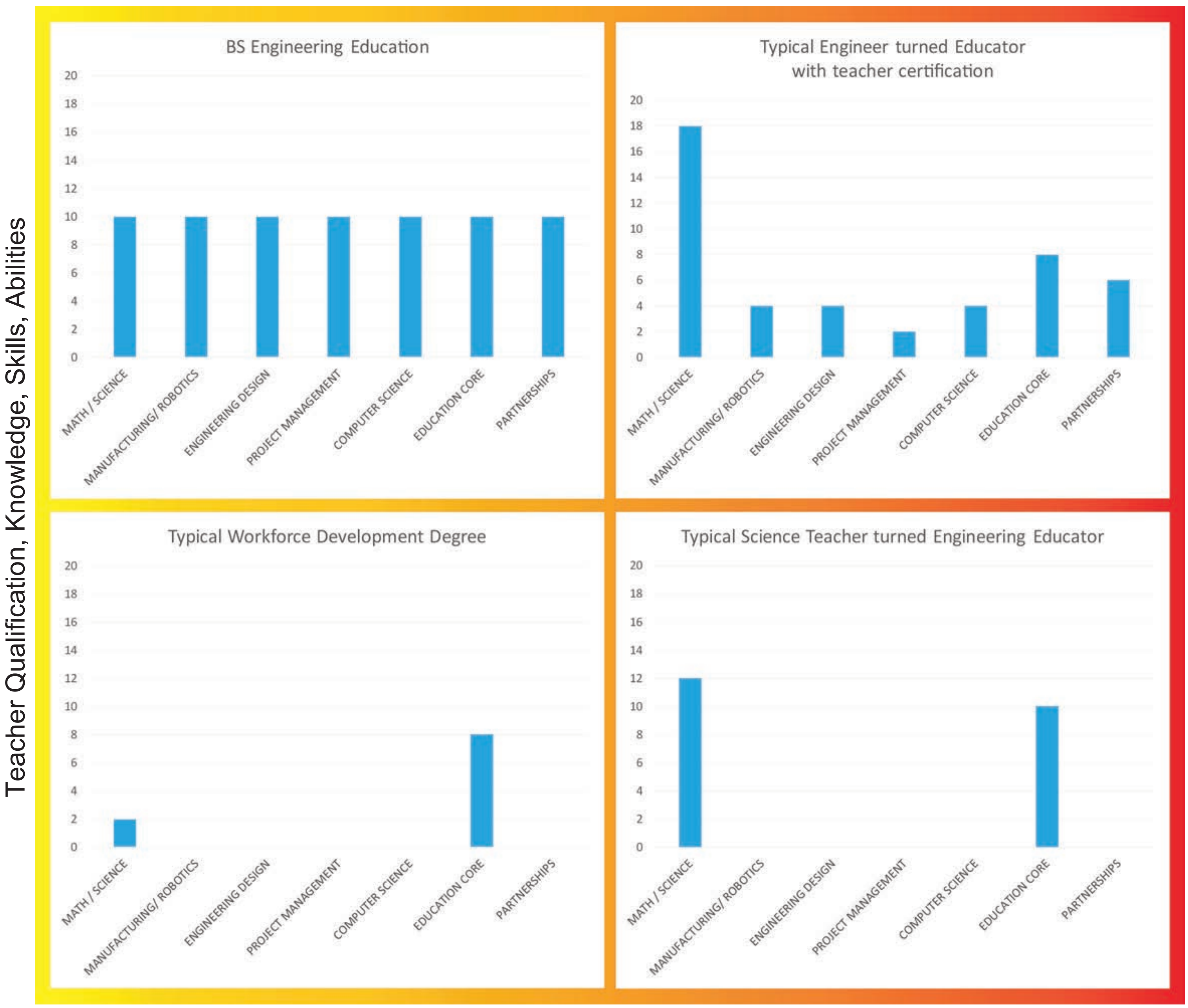
The following four charts illustrate the issues. The vertical axis is from 0 to 20.

0 represents no qualification.   Over 10 is over qualification for the stated requirement.

A PERFECT 10 is the targeted level of training, preparation, and demonstrated skills.

Preparation beyond a ‘10’ is a waste of resources. The seven areas of expertise across the horizontal axis is a generalization of the qualification skillsets.

The proposed BS program initiative is below and designed to be ***just right as possibly practical.***



TEACHER DEVELOPMENT

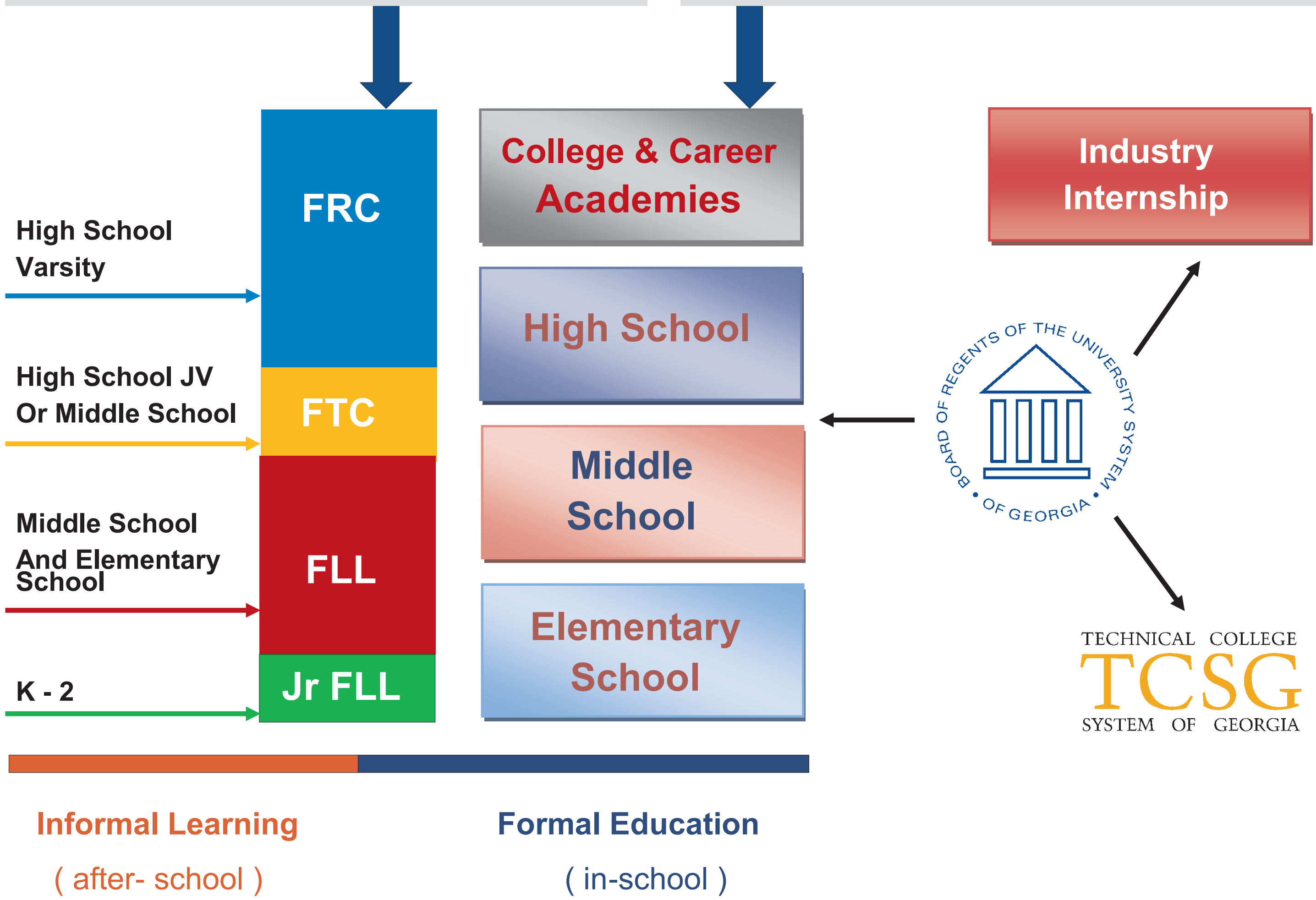
A SYSTEMS APPROACH

COMMUNITY WORKFORCE PARTNERSHIPS (CWP)

Partnerships can provide resources to schools to support robotics programs. Physical assets can be leveraged to serve multi-use curricular, co-curricular, and extra-curricular initiatives. Businesses can provide internships to students and teachers.

PRACTICUM - CLASS EXPERIENCE

Teacher candidates will conduct their Final Practicum under the tutelage of a Highly Qualified Teacher. The College and Career Academy network and technological oriented high schools that align with the undergraduate technology curriculum are ideal to support teacher practicum.



INFORMAL LEARNING ALIGNMENT

FIRST programs is an example of a system that can be adopted to provide a teacher development platform, extended opportunity for community and business partnerships and engagement, student motivation and recruitment tools, soft skills development, project-based learning, and a platform to build STEM habits of mind.

TECHNICAL COLLEGE SUPPORT

Pairing universities and technical colleges provides an opportunity to leverage assets and provide classes in advanced manufacturing and other topics.

Technical college engagement will provide candidates to acquire knowledge of the range and dispersion career training opportunities.

UNDERGRADUATE DEGREE PROGRAM

There are several routes for admission.

1) traditional undergraduate admissions
2) transfer from another university
3) transfer from a technical college with applicable credits supported by articulation agreements.

Institutional core classes can be taken on-campus, through hybrid courses, or via institutions online courses or eCore.

Candidates attending Kennesaw State can complete all coursework in-house without attend TCSG

All other USG institutions will partner with select TCSG to support selected manufacturing courses

Two new courses in engineering design should be offered online to all universities offering the under-graduate degree or the K-12 STEM endorsement.

FIELD EXPERIENCE

Field experience happens in three areas.

There is a traditional teaching practicum from K-12 with an emphasis on secondary education. The final practicum has to be performed at a applicable college and career academy or technical high school under the supervision of a highly qualified teacher.

The second part of the practicum is related to the en-gineering design process. This should happen in for-mal classrooms and informal after school settings.

The final part of the field experience is extensive long term on-site industry engagement and apprenticeship.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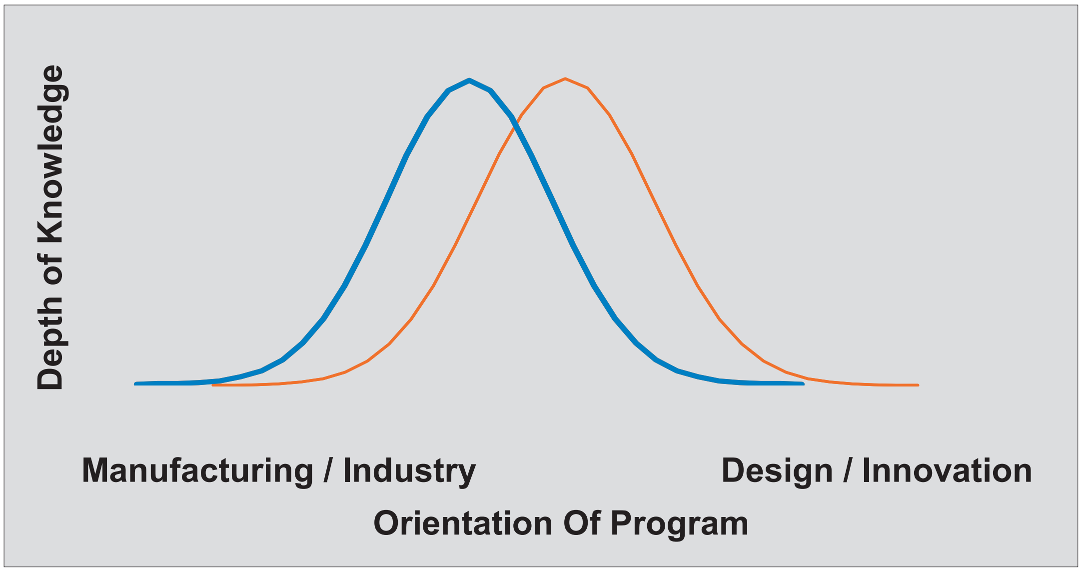
REGENTS ENGINEERING TRANSFER PROGRAM (RETP)

Institutions that participate in RETP contain as-sets that generally meet the requirement of courses that are required. This degree program shares much in common with the lower part of a traditional engineering degree.

ONLINE LEARNING

Some course work can be completed online.

New courses will be developed to support new courses, such as industry internships, and selected core discipline courses.



CONCENTRATION OF DEGREE PROGRAM ACTIVITY

Implementation of Technology, Engineering, Computer Science degree programs can vary depending on the goals and interests of the host institution.

For example, a Comprehensive University degree program may be more product design, development, innovation and entrepreneurship oriented.

A State University initiative might be more weighted toward advanced manufacturing, industrial systems, and advanced operational technologies.

Both programs cover all topics, and only the intensity of the areas are adjusted to suit host institutions.

Students may even be able to select a track or weight an emphasis in an area.

21st Century Engineering & Technology Education

BS TECS Education Degree—Proposed

Technology, Engineering & Computer Science

Standards Compliance

Georgia Professional Standards

505-3-.39 Engineering & Technology Educator

505-3-.86 Computer Science Endorsement

505-3.xx STEM Education Endorsement

ITEEA

International Technology and Engineering Educators Association

2014 Standards for Technological Literacy

GaDOE Areas Supported

STEM
Engineering
Manufacturing
Mechatronics
Electronics
Energy Systems
Engineering Drafting & Design
Pneumatic System & PLCs
Programming
Networking
Computer Science
Embedded Computing

BS TECS Degree Requirements

STEM Disciplines

Pre-Calculus, Calculus I & II
Physics I & II
General Chemistry I + Lab
Engineering Graphics & Design, I & II
Statics

Computer Science
C++ Programming for Engineers
Embedded Systems

Electronics
Electronics Laboratory
Robotics & Mechatronics
CNC Manufacturing
Numerical Control of Machines
Instruments and Controls
Product Design & Manufacturing

The Standards for Technological Literacy

Supporting Disciplines

Inquiry Approaches to Teaching
Inquiry-based Lesson Planning
Knowing and Learning in Engineering
Improving Learning with Technology
Education of Exceptional Students Part 1
Education of Exceptional Students Part 2
Perspectives in Teaching Engineering
Classroom Interactions
Project-based Instruction
Yearlong Clinical Experience I
Yearlong Clinical Experience II

Institutional Requirements

Wellness 1 hour
Written Communication 6 hours
Contemporary Social Issues 2 hours
Cultural Perspective 3 hours
Literature of the World 3 hours
Arts and Culture of the World 3 hours
Social Sciences 12 hours

Teacher Recruitment - What If We Could Recruit ?

Undergraduate Candidates

What if 10 % of Georgia's 400 high schools sent a candidate	**40**
What if 1 % of *FIRST* Robotics Competition, 20,000 seniors	**20**
Engineering Students — Change of Major	
What if 1 % of 3,000 incoming to Georgia Tech transferred	**30**
What if 1.5 % of 600 incoming to Kennesaw State changed major	**10**
Teacher Candidates	**100 / year**

Informal out of school STEM Engineering competitions is a game changer. Thousands of students want to be in the Engineering & Technology space without becoming a full-fledged engineer. These students are the 'true believers' of STEM education and engineering and technology, and some of these students would seriously consider a career in teaching if given the opportunity to matriculate into a 21st-century Technology, Engineering, & Computer Science Education program.

The second source of candidates is students that are changing majors out of engineering but desire to remain in the STEM area.

A third candidate source is transfer students from TCSG (Technical College System of Georgia) that transfer to Kennesaw State University, through existing articulation agreements.

Currently, thirteen USG (University System of Georgia) institutions implement the RETP, Regents Engineering Transfer Program. The existing assets in this program could be used to support a system-wide teacher development program.

In addition to undergraduate programs, there is a need for graduate level programs as well that lead to initial certification and programs that offer knowledge in depth.

***FIRST* Robotics Competition Championship with 20,000 student STEM champions and advocates.**

PREPARING TEACHERS

K-12 STEM Educator Endorsement

The Georgia Public Standards Commission developed the certification standard for teacher K-12 STEM endorsement during 2016. *This standard is under review and may be approved as early as Fall 2016.*

KEY ATTRIBUTES OF THE PROPOSED STANDARD IS AS FOLLOWS

STEM AS AN INTERDISCIPLINARY ENDEAVOR

Candidates will demonstrate a comprehensive understanding of and the ability to integrate STEM content standards; be able to articulate a clear definition and understanding of what STEM education is and what it looks like in practice as both an interdisciplinary and process driven activity; demonstrate the ability to apply integrated STEM and STEM-related content to answer complex questions, to investigate local, regional and global issues to make connections and to develop solutions for challenges and real-world problems; and will demonstrate knowledge of the benefits of STEM education for all citizens, enabling them to make informed decisions about challenges facing the next generation, for future STEM workforce development and related career opportunities and the skills necessary to be successful in them.

HOW TO THINK, USING A STEM MINDSET

The program will prepare candidates who demonstrate that they understand and can engage learners in the ways of thinking and habits of mind used in STEM and STEM-related disciplines; by demonstrating the ability to think critically, evaluate complex data, draw evidence-based conclusions, engage in effective argumentation and communicate effectively in written format.

Candidates will demonstrate the ability to engage students in STEM reasoning that reveals how STEM professionals think and solve problems; demonstrate effectiveness as an interdisciplinary STEM educators (i.e., life-long learning, value collaborations, flexible, high tolerance for ambiguity, risk taker, innovative, committed to the profession, self-reflective perseverance)

PARTNERSHIPS & COLLABORATION

Teacher candidates will demonstrate the ability to work effectively within a STEM-focused multidisciplinary professional learning community to achieve a common goal and to co-plan authentic STEM-based experiences and interdisciplinary lessons; demonstrate the ability to involve business partners in identifying and solving relevant problems; and will demonstrate the ability to engage local STEM experts in their programs.

ENGINEERING DESIGN PROCESS, SCIENTIFIC THINKING, SOFT SKILLS

Candidates will demonstrate the ability to effectively engage students in engineering design processes to solve open-ended problems or complete design challenges using authentic or investigative research to answer relevant questions; STEM reasoning abilities (i.e., computational reasoning, model-based reasoning, quantitative reasoning, engineering design-based reasoning and complex systems thinking); experiential learning; project management techniques;

Candidates will demonstrate the ability to facilitate student-led learning and to apply knowledge and skills to novel, relevant and authentic situations; the implementation of authentic teaching and learning strategies, including project-based learning, problem-based learning, and place-based education; risk taking, innovation and creativity; and student-led team-based learning with appropriate etiquette.

MENTORSHIPS / INTERNSHIPS / APPRENTICESHIPS

Candidates will be required to interact with a STEM-related business or externships with STEM professionals to gain perspective of what it is to work in a STEM or STEM related field;. Candidates will show evidence of field-based experiences that include observation of classrooms, collaborative planning and interview of teachers in an integrated STEM education environment that is evidenced by reflective documentation; and must complete an interdisciplinary STEM culminating project.

ENDORSEMENT PROGRAM DEVELOPMENT

OPPORTUNITY TO OPTIMIZE EFFORTS

The Georgia Professional Standards Commission (GaPSC) issues standards that describe the knowledge, skills, and proficiencies that professionals must meet to earn a certification or endorsement. Universities that develop and deliver teacher training are responsible for certifying that the candidate meets GaPSC standards.

While universities are free to design the system that they see fit to create endorsement programs, we recommend that they consider aligning their program of study to take advantage of and leverage the existing and growing Community of Practice of the *FIRST* programs and initiatives in Georgia.

University coursework should be created for both STEM endorsement and Engineering Educator degree programs. The potential exists to create a single set of courses that will that will support the International Technology and Engineering Educators Association (ITEEEA) Standards for Technical Literacy (STL). These standards are the basis for the GaPSC certification for engineering and technology education.

The teacher that earns an endorsement or certification through universities that utilize K-12 *FIRST* teacher development initiatives will be in optimal position to participate in the statewide *FIRST* ecosystem and other engineering design competitions across a wide realm, including other robotics systems, state and national engineering design competition such as Lemelson-MIT Inventeam, and the Georgia Tech Inventureprize competitions.

The K-12 *FIRST* programs statewide are ideal vehicles for supporting STEM teacher endorsement, and degree program delivery. Community partnership programs such as the Cobb Workforce Partnership and other similar efforts are valuable in coordinating and facilitating the corporate partnerships and funding advocacy initiatives for schools that participate in these endorsements and degree program delivery systems.

Kell Robotics has initiated an effort to create a funding stream and partnership effort to support schools and teacher development. This implementation will serve as an example of how to further enable community partnerships, workforce development, and teacher development as part of an integrated ecosystem.

Universities that incorporate ***FIRST*** into teacher preparation programs will receive the benefits of having access to the largest and most comprehensive K-12 engineering and technology design competition in the world. Adopting this model will reduce the level of work needed to implement the tasks required to meet the standards for teacher certification. This alignment provides a platform for teaching to the ITEEA and GaPSC standards and increases the opportunity for teacher candidates to be more relevant when they enter the classroom. Skills learned via this program delivery can then be extended by the teacher to other non-***FIRST*** design projects, inside and outside of the classroom.

SUPPLEMENTAL INFORMATION

ECOSYSTEM THREADS

Providing Courses

STEM GYMS

STEM Coaches

Support Ecosystems

Informal Learning

Mentors

Cobb Workforce Partnerships

Future Vision

Strategic Objectives

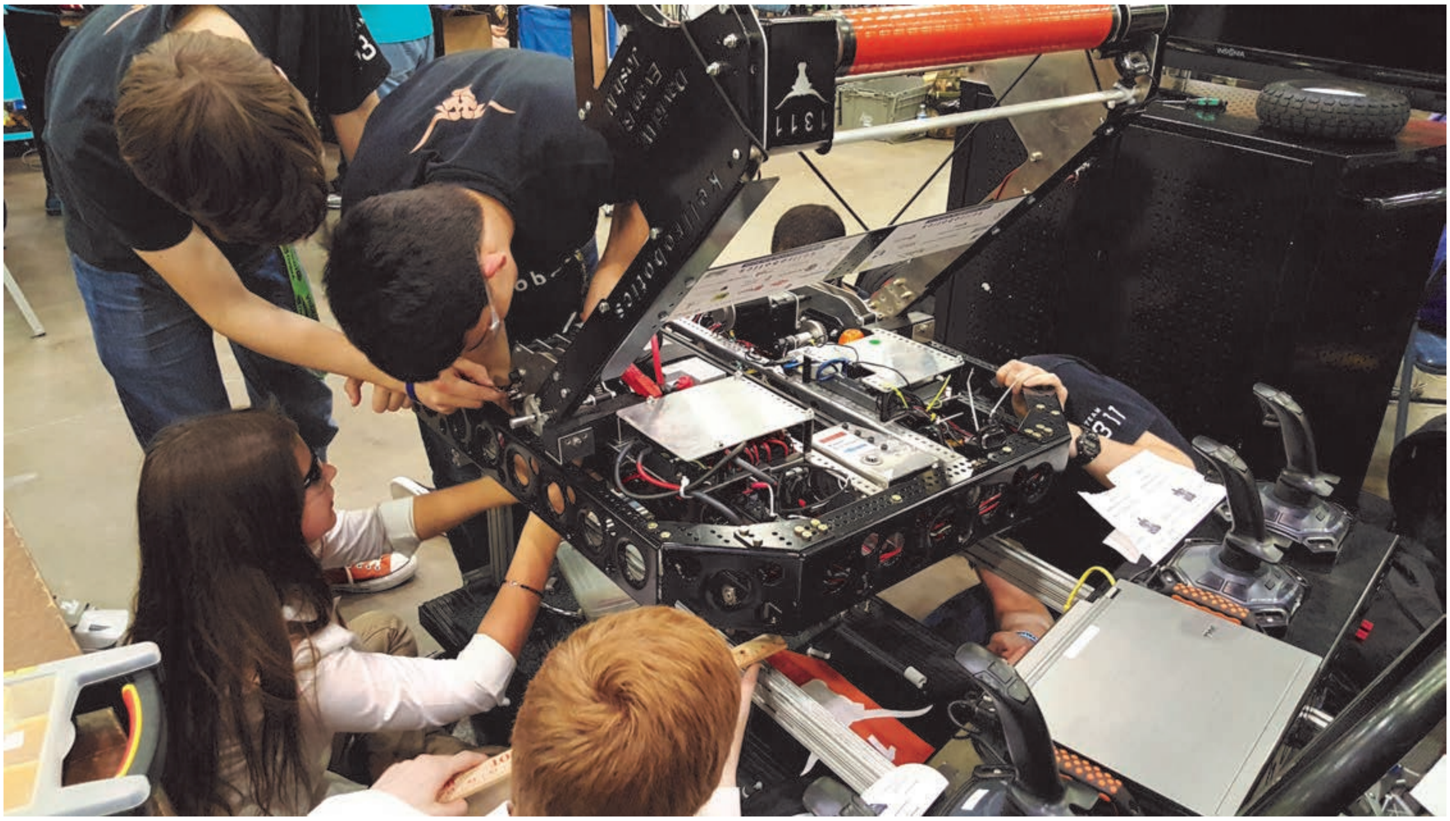
PROVIDING CLASSES

THE NEED FOR CLASSES

The world educational system has drastically changed during the past 150 years. In the 19th and 20th centuries, our schools were designed around the factory model of ringing bells and assembly lines. Subjects were taught individually, the same way factory makes parts. This model was adequate for teaching the basics of reading, writing, and arithmetic.

The world has changed, with high demands on education. What we have not yet achieved in P-12 education is sufficiency in the teaching of STEM fields as an integrative discipline. Probably the most integrative discipline is the art of engineering. A layperson views the engineering profession as a purely technical discipline. The reality is it requires a much broader set of skills that incorporates STEM fields plus the arts, economics, and soft skills.

The charts on the next page show the occurrence of engineering and technology courses in Georgia. Over two-thirds of Georgia high schools offer either no courses or a few courses. Given that over half of the high demand careers identified by the HDCI are STEM-related, and the fact that engineering and technology are crucial to the success of the 21st-century economy, this chart clearly identifies a problem that needs to be addressed.



CLASS OCCURANCE

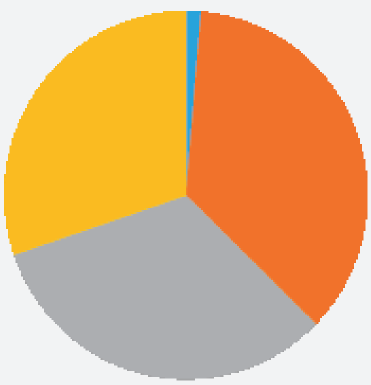
GADOE ENGINEERING CLUSTER

Who is going to teach the Engineering & Technology classes of the future ?

School Districts cannot hire teachers to teach the following classes due to

1. **Lack of undergraduate teacher preparation programs**
2. **Lack of competitive salaries.**

High School Engineering Cluster Course Occurrence



On Average: Georgia Secondary Schools teach only 1/10 of the Courses in the Pathways.

36 %	**0 courses**
30 %	**1 to 3 courses**
32 %	**4 to 11 courses**
2 %	**12 courses**

GaDOE Cluster Courses
Electronics
Energy Systems
Energy and Power
Engineering
Engineering Drafting & Design
Manufacturing
Manufacturing - Mechatronics

AY 2015-2016 Data

Middle School Engineering Cluster Course Occurrence

On Average: 1/2 of all Georgia Middle Schools teach the full set of CTAE engineering Pathways classes.

50 %	**0 courses**
50 %	**3 courses**

AY 2015-2016 Data

STEM GYMS

The physical infrastructure for supporting 21st Century Career, Technology, Agriculture, Engineering (CTAE) / STEM education has not kept pace with workforce development needs.

There are cutting edge career academies and high schools in Georgia and across the country, but in general, we have lots of work to do. Two-thirds of Georgia high schools either do not teach or teach only 10% of the technology and engineering pathway courses. Facilities often lack proper classes, labs, shops, and manufacturing facilities.

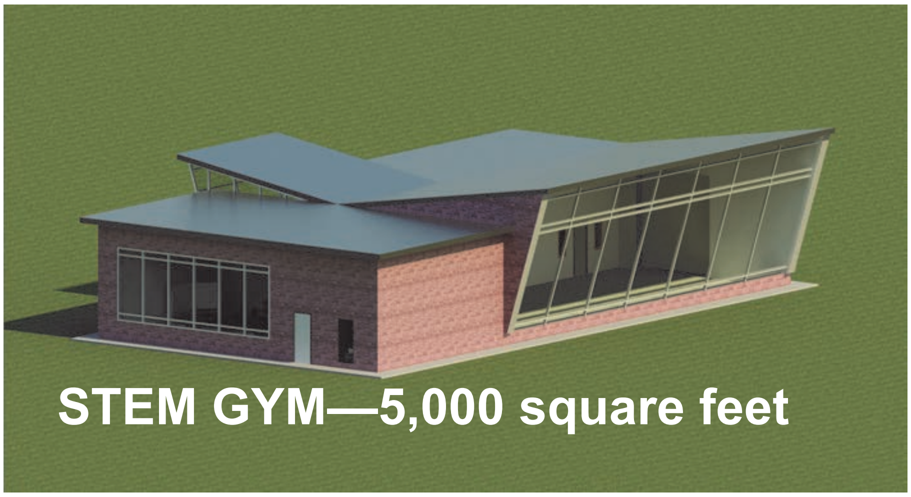
Every 21st Century high school in Georgia needs to have a STEM GYM. What is a STEM GYM?

The average high school has a dedicated set of facilities that support formal education such as physical education (PE) class and informal learning such as football, basketball, and other sports.

There should be a comparable set of facilities that is used for technology, engineering, and science instruction during the formal education day, and continues working after the bell as the support center for engineering, manufacturing, and other activities related to informal STEM learning such as robotics teams. This space could even serve as a community maker space, using a model similar to the public library, if designed and implemented correctly. Expanding on this concept, we can introduce the idea of community business incubators.

Other states have started building such STEM GYMS centers, such as the Katy Independent School District in Katy Texas. A model in Georgia has been the 3,700 sq. ft. Kell Robotics Innovation Center (IC) in Kennesaw Georgia.

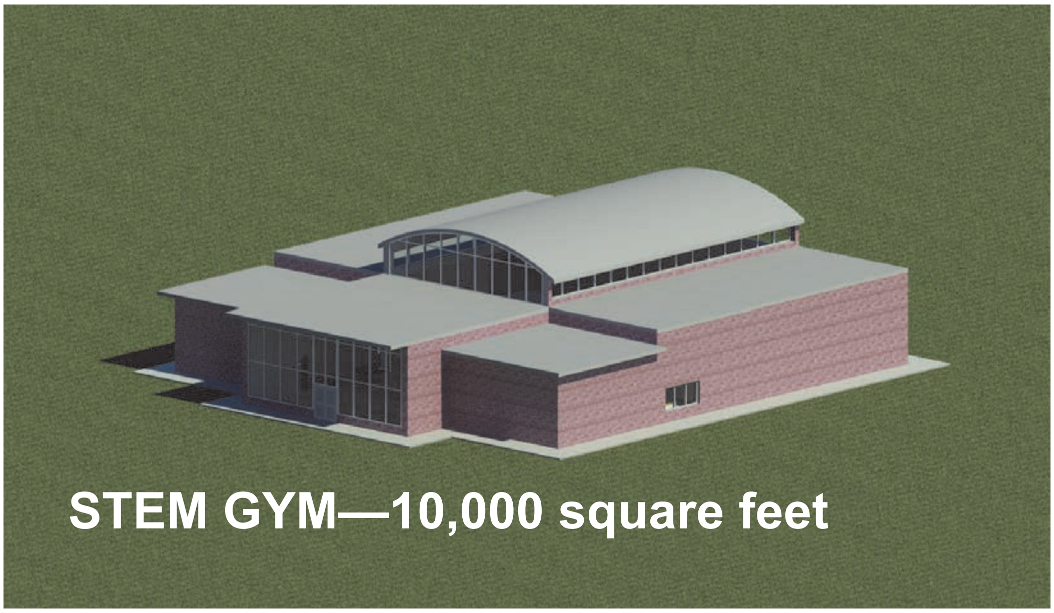
Every high school in Georgia should work toward implementing the features of a STEM GYM, using existing facilities if available or by new construction. On the opposite page are three concepts of STEM GYMS, that support Technology, Engineering, & Computer Science Education needs.

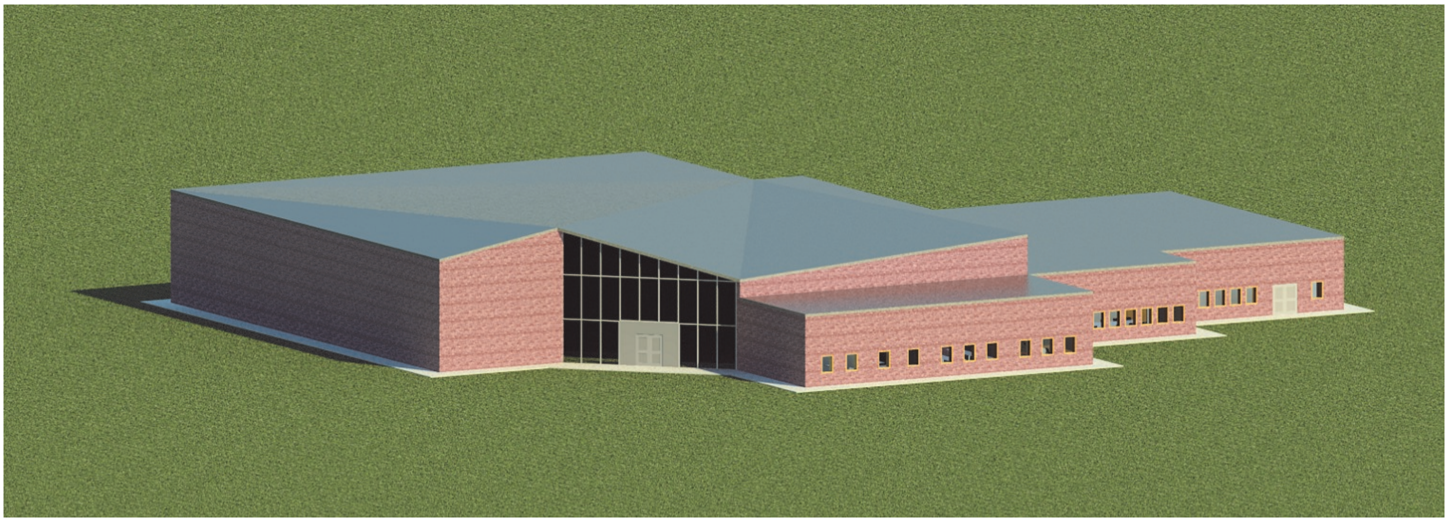


The following concepts are derived from experience at the Kell Robotics Innovation Center, and knowledge gained from other centers in the country.

This 5,000 sq. ft. concept contains a single classroom, machine shops, work and assembly areas, and storage.

This 10,000 sq. ft. facility adds another classroom, a larger CNC manufacturing area, and a full robotics competition practice field.





This 21,000 sq. ft facility builds upon the previous models, adding labs capable of physics, chemistry, and bio-sciences labs, invention & product development space, and additional space for other types of instructional areas such as automation and mechatronics.

Designs above by: David Williams, Kell Robotics

STEM COACHES

STEMMING THE LOSS

High school girls were asked, "Who do you talk to when you want advice about career choices?" Most girls indicated that their parents are influential in listening to them and guiding them about future careers. Friends and peers are a close second to parents. Teachers tie with siblings for third. School counselors and professionals are the fourth most cited group. [Extraordinary Women Engineers Final Report, April 2005]

Students and the people who influence them—teachers, school counselors, parents, peers, and the media—do not understand what a STEM career in engineering looks like and therefore don't consider it as a career option.

The cornerstone of a successful educational system is the 21st Century Technology, Engineering, Computer Science teacher development system and the surrounding ecosystems that develop and support teacher and students.

The teacher training model described in this report is designed to help the candidate understand and more accurately articulate and influence students' choice of post-secondary and co-secondary education and career choice.

These options no longer fall into academic and non-academic vocational tracks but have become highly dispersed across a spectrum of skill sets and abilities.

The teacher/coach model goes beyond traditional "sage on the stage" training. The model requires an ability to teach, coach, and counsel students about careers. It will require an ability to support and facilitate student growth in curricular, co-curricular, and extra-curricular learning activities.

The coach will understand and facilitate business and industry partnerships, provide career development support and guidance.

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University-based teacher education programs in the United States have specific selection criteria that guide which students are admitted to the program, but relatively few programs have a systematic program for actively recruiting students into their programs. Instead, program doors are left open and students self-select to become a teacher. [Analyzing Factors Influencing Teaching as a Career Choice Using Structural Equation Modeling; Padhy, Emo, Djira, Deokar; 2015]

The coach must be knowledgeable in guiding student to STEM careers including careers in teaching. This strategy is intended to provide students with an better understanding of the professional demands of teaching.

The 21st-century teacher for Technology, Engineering, and Computer Science will have the right type of training and development. This new teacher will be able to counsel students on a full spectrum of post-secondary options that goes beyond the traditional career counselor model.

Industry STEM Liaison

- Co-Op
- Internships
- Apprenticeships
- Go Build Georgia
- WBL - Work Based Learning
- Great Promise Partnership

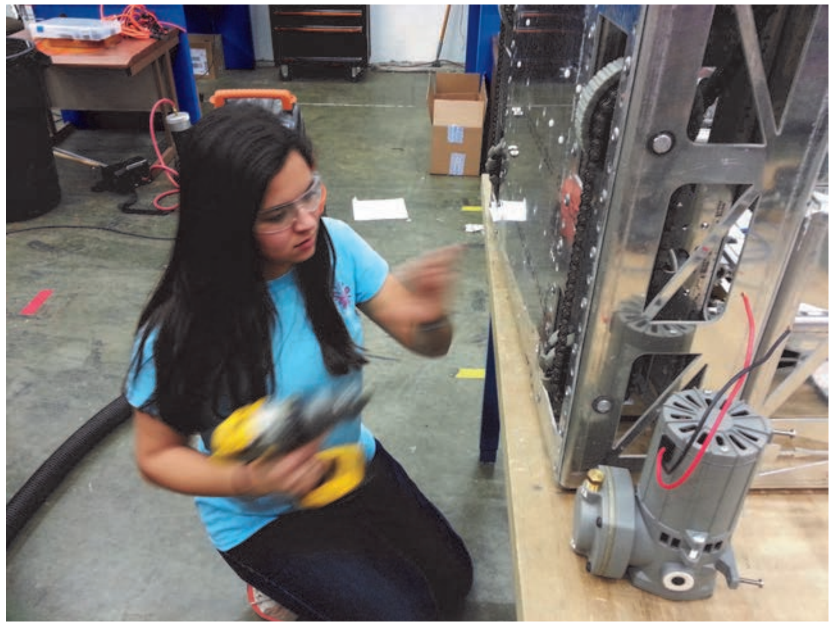
Informal Learning

- STEM Coach
- AMP It Up
- STEM Competitions
- Robotics Competition
- Engineering Competitions

STEM Career Counseling

- Recruiting Events
- Teachers in Industry
- Manufacturing Day events
- Advanced Manufacturing Marketing

Community of Practice Facilitator



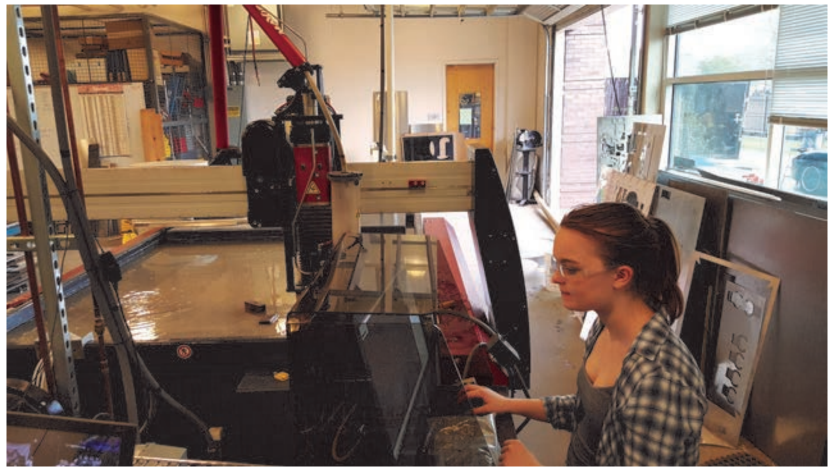
STEM Coach

Research consistently identifies the need to support and advance a broad range of activities to support workforce development.

The Georgia Tech Enterprise Innovation Institute's Northwest Georgia Regional Advanced Manufacturing Strategy report, the Governor's High Demand Career Initiative report and the Harvard Pathways to Prosperity Report are three samples of these reports.

We should implement teacher/coaches to facilitate a blended system of education. The teacher or coach can teach and support robotics teams and other STEM informal learning activities. The coaches can also support the implementation and management of implementing partnerships, apprenticeships, co-ops, etc. This high school STEM coach would also work with feeder elementary and middle schools to help with teacher support and alignments. The implementation could be a person working for a school or a person shared with industry or a technical college.

SUPPORT ECOSYSTEMS



GaDOE (Georgia Department of Education) has recommended the implementation of initiatives such as robotics competition teams as part of the process of becoming STEM certified. As schools have worked to implement these initiatives, it has become painfully evident that high school students do not have adequate access to modern manufacturing facilities. Not only do student not have access to manufacturing facilities, but also they often do not have access to something as primitive as a screwdriver.

Generally speaking, high schools do not have the facilities that can be used as design and manufacturing centers. This lack of infrastructure is a national problem. Even where these services exist, the physical infrastructure of schools must drastically change to remain competitive and relevant to satisfying workforce development needs. High schools are beginning to make progress with the implementation of College and Career Academies, or STEM GYMS, but there is much work to be done in this area.

Currently, high school robotics teams often may partner with a local business that has manufacturing capability. This solution works only in narrow circumstances. The local sponsor has to exist and have capacity that aligns with student needs.

Given the lack of capacity in high schools, a hybrid approach has emerged to support high school robotics teams. We are working with other USG and TCSG units to align and increase support for this informal STEM learning K-12 ecosystem.

The vision is to create a hub and spoke network of the USG & TCSG institutions and in some cases Georgia College and Career Academy units. The purpose of a hub is to help their regions efforts to align, promote, and develop K-12 STEM formal education and informal STEM learning.

Some of the Hub activities include:

- Manufacturing Support
- Hosting Workshops:
- Competition Kickoffs
- Student, Teacher, Mentor Training
- Conferences
- Professional Development Events
- Hosting Competitions
- Working with area schools to promote and align K-12 Informal STEM Learning
- Provide recruitment on-ramps to students that develop STEM interests
- Host CTSO and non-CTSO symposiums, conferences, workshops, and other activities

COMMUNITIES OF PRACTICE

USG & TCSG SUPPORT FOR *FIRST* ROBOTICS COMPETITION

A STEM Hub support model has evolved at **Kennesaw State University** through a partnership with Novelis and Kell Robotics.

Starting in Academic Year (AY) 2015-2016 this support center started a manufacturing support effort that supports high school ***FIRST*** Robotics teams. The project is building on earlier success in supporting mentor and teacher conferences, workshops, and other activities.

Other successes are the creation of an Innovation Center at **Albany Technical College**. This model follows the example of the Kell Robotics Center.

Georgia Tech is the kickoff host of the high school varsity level ***FIRST*** Robotics Competition. **Kennesaw State University** is the kickoff location for ***FIRST*** Tech Challenge, a junior varsity level robotics competition.

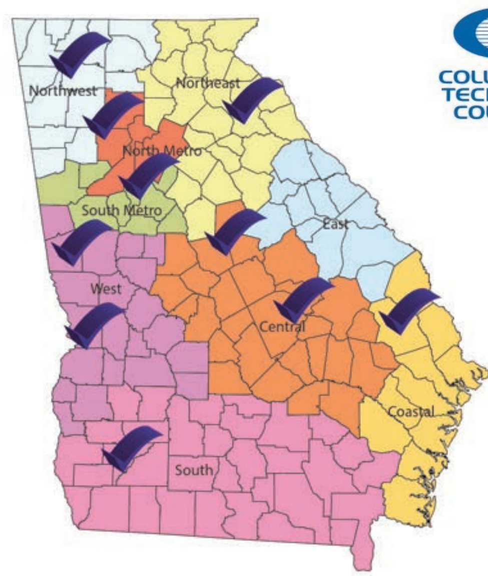
Starting in 2016 the University of Georgia is the host for the ***FIRST*** Robotics Competition state championship, held at the Stegeman Coliseum.

Northwest Georgia is part of the "Investing in Manufacturing Communities Partnership" (IMCP). While this effort is not an official IMCP partner, this development is a fascinating case. **Georgia Northwest Technical College** and the **Northwest Georgia College & Career Academy** are going through the process of implementing and supporting ***FIRST*** teams in Dalton and Rome Georgia.

Another success is the implementation of **FIRST** at the **Heart of Georgia Career Academy**. We are also moving forward with initiatives with **Thinc Academy** in LaGrange, GA.

While not a state university, **Mercer University** has worked for several years to support ***FIRST*** teams in middle Georgia.

Other participants in this system include **Georgia Southern University, Columbus State University, Columbus Technical College, and Dalton State University.**



INFORMAL LEARNING

As defined by the National Science Foundation, education is something we “do to” students and learning is something that students elect “do to” themselves.

Informal learning is how we learn in an out-of-school-time (OST) setting. It is how most employees learn after they leave the education world.

Informal learning includes on the job learning, learning from mentors, conversation, observation, and experience. Informal learners have to take charge of their education and learn self-reliance.

Learning opportunities occur throughout the day and year, in a wide variety of settings, and through a range of experiences.

Informal learning takes place in designed settings, such as museums, zoos, nature, and environmental programs; in after-school youth programs, clubs, and citizen science; and through the media, such as gaming, television, radio, and the internet. Students want to learn about engineering and technology.

The shortage of opportunities for students to learn about engineering and technology is crippling our efforts to recruit, motivate, and retain students in the engineering and technology pipeline.

Athletes develop their athletic identity in the field of sports in the same manner that students develop their STEM identity through informal learning.

Po Bronson and Ashley Merryman, the co-authors of "Nurtureshock," expand on this: "Teens need opportunities to take real risks. They require more exposure to other adults, and even kids of other ages—and less exposure to teens exactly their age. They need part of their life to feel real, not just a dress rehearsal for college. They will mature more quickly if these elements are in their life."

Mentor-based apprentices are examples of how to create a real life dress rehearsal for student learning.

As the Oregon GEAR UP Survey states: “A student who makes the connection between obtaining a college degree and his or her career goals is a full six times as likely to attain a degree as one who doesn’t.” Aside from academic preparation, another study titled "Completion by Design" calls this factor the single largest impact on student’s likelihood of completing college.

In our experience, there is a significant disconnect between policy, educational leaders, and students on the issue of how students choose and commit to careers. We have become a helicopter society by shuttling students around, pushing them through a linear education factory, and not paying enough attention to the normal, natural development processes of these students.

The physics of how humans develop, or how students learn and grow, is as immutable as the law of gravity. To succeed in maximizing the development of a future STEM workforce, we should pay attention to how students develop and make career choices.

DEVELOPING STEM IDENTITY

There is a precipitous drop in student participation in school starting in 9th grade. Some drop out of school and others drop out academically, even though they are still attending school and eventually graduate.

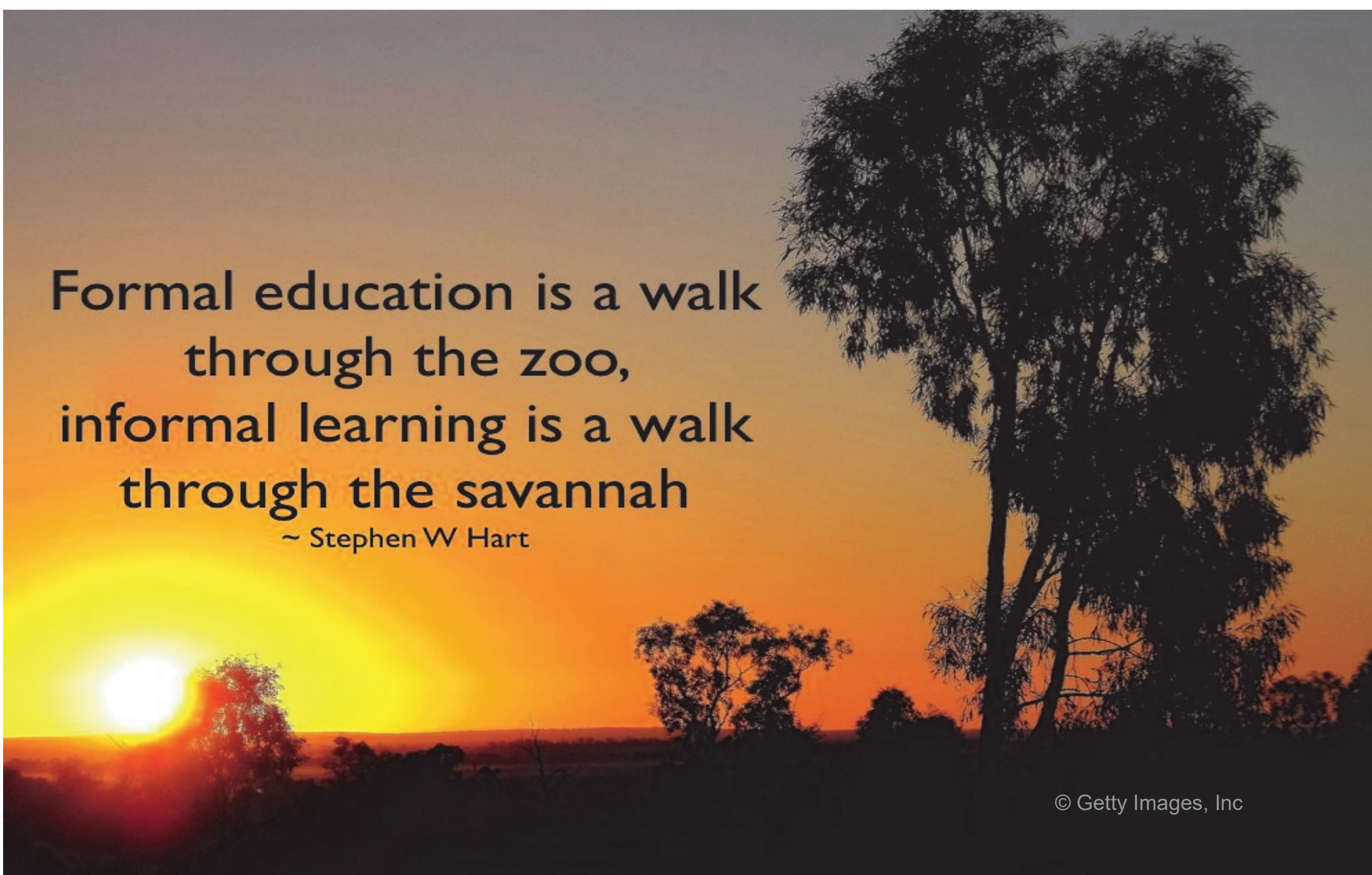
Students go through a series of critical developmental processes that extends well beyond the acquisition of knowledge. During their growth, students must be given opportunities to build confidence, to think independently, develop autonomy, and to work toward self-knowledge of their interests, knowledge, skills and abilities.

By depriving children of opportunities to experiment and try out 'new careers' through informal learning, to play on their own, to step away direct adult supervision and control, we are depriving them of opportunities to learn how to take control of their lives. We may think we are protecting them, but in fact, we are diminishing development, and reducing their ability to make correct and committed career choices and the development of soft skills.

This denial of students' opportunity to experience informal learning and gain knowledge of themselves and gain alignment and commitment to the appropriate careers and post-secondary education experience is having a substantial negative economic and societal impact.

In the current architecture of education, these students' career decisions are often deferred until their 20's and 30s'. Human development psychology strongly indicates that when a person reaches 19 years of age, their interests have moved beyond the existential question of "who am I, what will I be" to social relationships. Then life happens, and when these students finally decide on a career and post-secondary education, they often are much older, having lost several years of their career.

Informal Learning provides students opportunities to explore careers in a safe risk taking, mentor-based, apprentice like environment, which will give us the opportunity to make progress on these issues.



MENTORS

mentor

Pronunciation: /ˈmenˌtôr/ /ˈmenˌtər/

NOUN

1 An experienced and trusted adviser:

1.1 An experienced person in a company, college, or school who trains and counsels new employees or students.

VERB

[WITH OBJECT]

Advise or train (someone, especially a younger colleague).

WHY MENTOR?

Mentoring, at its core, guarantees young people that there is someone who cares about them, assures them they are not alone in dealing with day-to-day challenges, and makes them feel like they matter. Research confirms that quality mentoring relationships have powerful positive effects on young people in a variety of personal, academic, and professional situations. Ultimately, mentoring connects a young person to personal growth and development, and social and economic opportunity. Yet one in three young people will grow up without this critical asset. *[mentoring.org]*

STEM Mentoring

> “When a young person, even a gifted one, grows up without proximate living examples of what they may aspire to become – whether lawyer, scientist, artist, or leader in any realm – their goal remains abstract. Such models as appear in books or on the news, however inspiring or revered, are ultimately too remote to be real, let alone influential. But **a role model in the flesh provides more than inspiration**; their very existence is confirmation of possibilities one may have every reason to doubt, saying, **“Yes, someone like me can do this.”** *US2020]*

Young Adults Who Were At-Risk for Falling Off Track But Had a Mentor Are:

- 55% more likely to enroll in college
- 78% more likely to volunteer regularly
- 90% are interested in becoming a mentor
- 130% more likely to hold leadership positions. *[US2020]*

Much More than Mentoring

Being involved as a mentor is being part of a ***Community of Practice***(COP). It is part of a Master / Apprentice system. Communities of Practice & Master / Apprentice systems of learning have existed for thousands of years and are an important part of how people develop skills for lifelong learning and career development. Mentoring in this community develops and enriches the skills of the mentors, and mentees.

Mentoring Programs

BENEFITS TO COMPANIES AND MENTORS

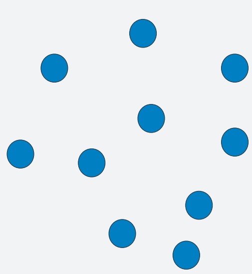
The business case for more corporate engagement in youth mentoring is clear. It builds business acumen for employees, including experience in managing and developing talent, improving communication and customer service skills, and fostering better understanding and deeper appreciation for the cultural, ethnic and racial diversity of both the youth mentors serve and their co-workers. Mentoring also provides companies with improved employee engagement and retention, enhances recruiting, strengthens the communities where businesses operate, and develops the talent pipeline by preparing young people for college and careers. *[David B. Shapiro, President and CEO, MENTOR: The National Mentoring Partnership and Nancy Altobello, Global Vice Chair, Talent, Ernst & Young]*

Mentoring

- Is an exemplar of employee engagement
- Is a way to be a role model
- Help students develop their career identity
- Develops and identifies future potential employees
- Improves the leadership and mentoring skills of the mentoring employee
- Connects students to future career success
- Builds partnerships between industry and schools
- Strengthens the understanding and collaboration between industry and educators
- Supports alignments between industry, educator, and student needs

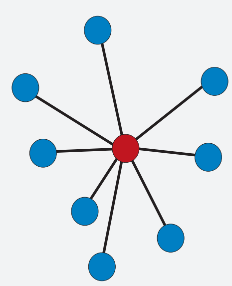
21st Century Systems of Learning & Work

Artisans



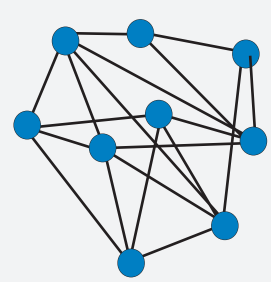
~19th Century

Hierarchies



± 20th Century

Networks



21st Century

Learning & Work has evolved from being individual artisans, to a system of hierarchies to networks of individuals & institutional collaborators

COBB WORKFORCE PARTNERSHIP

AREA SPOTLIGHT

COBB'S COMPETITIVE EDGE

COBB CHAMBER
achieve more

COBB
WORKFORCE PARTNERSHIP

CARL VINSON INSTITUTE OF GOVERNMENT
The University of Georgia

COBB WORKFORCE PARTNERSHIP ADAPTS HDCI TO LOCAL NEEDS

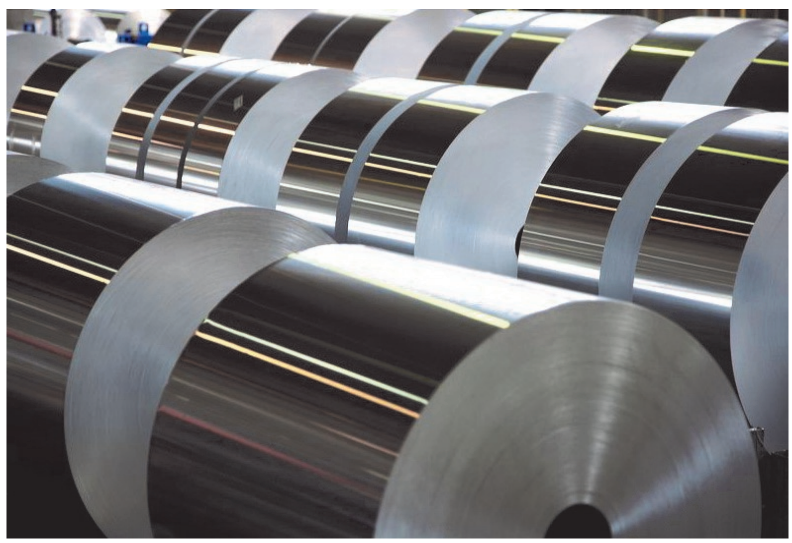
Cobb Workforce Partnership

Home to the state's most comprehensive educational infrastructure, as well as a thriving and growing business community, Cobb County has taken the lead in implementing the vision of the High Demand Career Initiative. In 2015, the Cobb Chamber engaged the Carl Vinson Institute of Government, who facilitated the HDCI, to replicate the full process on a county level—identifying current and future workforce needs and skills gaps—while going a step further than the state. Cobb intends to use the finding of our study to implement innovative approaches to education and skills training through the use of sector partnerships and community initiatives.

The Cobb Workforce Partnership is a coalition of both Cobb County and Marietta City Schools, Kennesaw State University, Chattahoochee Technical College, Georgia Highlands College, Life University, CobbWorks, and over 30 Cobb businesses—as a unified commitment to identify and address the workforce needs of our business community and to establish a pipeline of job-ready workers in Cobb. The vision is that every Cobb employer has an opportunity to educate and train their future workforce in partnership with educators as early as K-12, and every Cobb student is connected with career pathway opportunities in our community through every level of their educational track.

Partnerships are Key to Success - An Example

In 2016 Kell Robotics led the development and implementation of an informal public/private partnership that will support high school students in the ***FIRST*** Robotics Competition.



The KSU College of Engineering supports these students by providing part manufacturing services on a newly installed waterjet cutting system.

Novelis is the world's largest producer of rolled aluminum sheet, with global headquarters in Atlanta, and a Research and Technology Center in Kennesaw Georgia.

Novelis provides resources to support KSU college students, and ***FIRST*** high school students for product design and development.

This program also provides resources needed to support teacher professional development initiatives and community engagement initiatives such as Girl Scout STEM making, inventing,and engineering programs.

This effort is an example of how public/private partnerships accelerate the growth and development of our workforce development efforts and the development of the STEM support eco-system.

The aluminum acquisition project was designed and implemented by Kell Robotics, with participation and support of several members of the Cobb Workforce Partnership.

A VISION FOR THE FUTURE
ADVANCING FORMAL & INFORMAL LEARNING

The STEM Renaissance Project is a vision for a facility to house an interdisciplinary unit that would support the initiatives in this report. This facility, pictured below, would be the home base that would nurture communities of practice, teacher development, competition, symposiums, conferences, research and development, entrepreneurship, business development, leadership, and innovation.

It is not an active university project, but it is a proposal for a Disneyesque vision for learning and economic development. It is a facility that supports a regional system of K-20 STEM Community of Practitioners and Learners.

This one-of-a-kind facility will integrate technology, innovation, and art museum; 2,500 seat arena; exposition hall; innovation and creativity laboratory; general purpose science lab; classrooms; lecture halls; machine and workshop; technology and business incubators; television studio, and cafeteria. The arena's design will be optimized to accommodate competitions, exhibitions, and conferences. This facility is expected to be the first of this type in the world, a facility built to support the high-performance STEM competitions that are emerging in the 21st century.

The building described here is designed to house a multi-disciplinary set of initiative that will support teacher production and development, business development and incubation, Informal STEM Learning and Competition Support, product innovation and development, and engineering and scientific research.

The building would be an architecturally iconic facility that will be recognized around the world as a celebration of STEM learning and leadership in 21st Century STEM education. The concept pictured above was designed to live on the front door of the Kennesaw State University campus. Locating this building as a front door to the campus would activate the campus edge and energizes the surrounding community. This visionary concept is a Big Bang idea, supporting and celebrating STEM activities as a vital part of our world community.

*Model shown above is by **R Design Works**, AIA, Kennesaw, GA*

A LESSON FROM WALT DISNEY

On October 16, 1923, Walt Disney officially started the Disney Company. Twenty-five years later he began developing an idea for a new kind of amusement park. Walt told his wife that he was going to create an amusement park; she said he was nuts. Amusement parks of that day were the carnivals. By today’s terms, they were not family friendly at all. As the saying went: “Beware the Autumn People”. In the post-war period of the1940’s Walt set out to design a new type of amusement park.

> After several years of planning and construction, the new park opened July 17, 1955. Disneyland was a totally new kind of park. Observers coined the term “theme park,” but even that does not seem to do Disneyland justice. It has been used as a pattern for every amusement park built since its opening, becoming internationally famous, and attracting hundreds of millions of visitors. Walt said that Disneyland would never be completed as long as there was imagination left in the world, and that statement remains true today. New attractions are added regularly, and Disneyland still is as popular as it was in 1955. [2016 Just Disney]

Kennesaw State University ***FIRST*** Robotics Competition Event, April 2016

STRATEGIC OBJECTIVES

1) Create world class engineering, technology, and computer science educator development programs to be delivered by the University System of Georgia resulting in national recognition.
2) Significantly increase the number of post-secondary STEM degree graduates by assisting and supporting the placement of STEM in every school to enhance informal and formal STEM learning and education.
3) Expand collaboration and partnerships to create a fully connected, high-performance STEM community of learning and practice, that will enhance and sustain lifelong learning and economic prosperity.

Universities

TEACHER PRODUCTION

Objective # 1

K-12 STEM Endorsement

- Engineering Thinking
- Soft Skills
- Project Based
- Experiential Learning
- Industry Engaged

BS TECS Education

- Engineering
- Computer Science
- Manufacturing
- Energy
- Mechatronics / Robotics
- Product Development
- Economic Development
- Technology & Innovation

MAT TECS Education

MS TECS Education

PhD TECS Education

Universities & Technical Colleges

COMPETITION SUPPORT

Objective # 6

21st Century STEM Competition

Activities such as robotics competitions are large high impact productions.

This is not your parents' old school science fair. These are physically large, and geographically wide competitions.

There is a very high demand for facilities across the STEM competition universe. Responding to the need for facilities is necessary to allow the growth of student interest in STEM fields.

Current USG & TCSG participants in STEM completion support includes:

Georgia Tech

University of Georgia

Kennesaw State University

Albany Technical College

Columbus Technical College

Georgia Northwest Technical College

Northwest Georgia College and Career Academy

SUPPORT SYSTEMS

Objective # 5

Regional Community of Learning & Practice Facilitator

Manufacturing Support

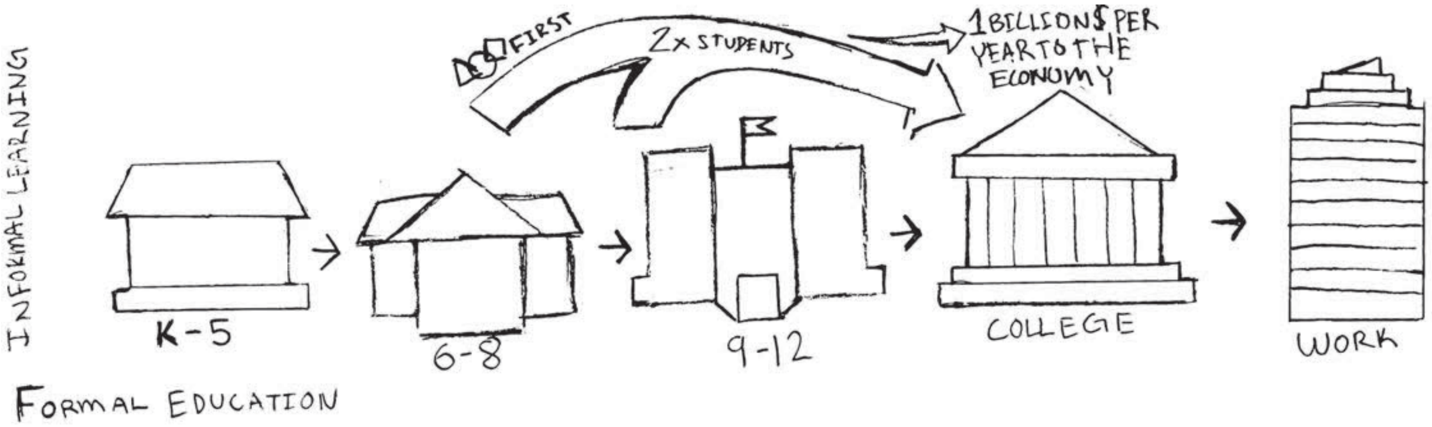
Provides advanced manufacturing and other support for CTSO and non-CTSO organizations student engineering design competitions,

Symposiums, Conferences & Workshops

Host events for CTSO, and non-CTSO STEM organizations. Students, mentors, teachers, and parents will be the primary persons that will design, conduct, present, and attend these events.

Regional Economic Development

Partners will facilitate information flow to regional stakeholders in this Community of Practice ecosystem. Advocates for postsecondary institutional support for the broader Community of Practice ecosystem.



School Districts

STEM COACHES

Objective # 4

Industry STEM Liaison

Co-Op
Internships
Apprenticeships
Go Build Georgia
WBL - Work Based Learning
Great Promise Partnership

Informal Learning

STEM Coach
AMP It Up
STEM Competitions
Robotics Competition
Engineering Competitions

STEM Career Counseling

Recruiting Events
Teachers in Industry
Manufacturing Day events
Advanced Manufacturing Marketing

Local Community of Learning & Practice Facilitator

COURSEWORK

Objective # 2

Science, Technology, Engineering, and Mathematics

Electronics
Engineering and Technology
Engineering Drafting and Design

Energy

Energy Systems
Energy and Power: Generation, Transmission, and Distribution

Manufacturing

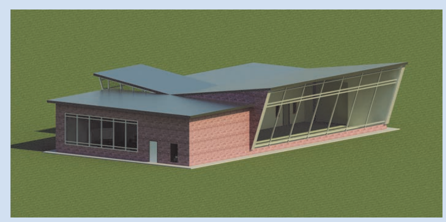
Manufacturing
Mechatronics
Industrial Maintenance
Granite Technology

Information Technology

Cybersecurity
Computer Science
Game Design
Internet of Things
Networking
Programming
Web and Digital Design
Web Development
Information Support and Services
Health Information Technology

STEM GYMS

Objective # 3



5,000 sq. ft.
Engineering, Technology, Robotics, Manufacturing Labs

10,000 sq. ft.
Adds additional Labs, Classrooms, Shops, and Practice Area

23,000 sq. ft.
Adds additional Labs, Classrooms, for BioSciences

Let Us Finish Building
The Stem Pipeline

CREATE Educator Development & Support Initiatives For

Technology, Engineering, and Computer Science

PROVIDE

STEM GYMS

STEM Coaches

OFFER

Broad deployment of STEM courses

Select courses online as Move On When Ready

INCREASE SUPPORT

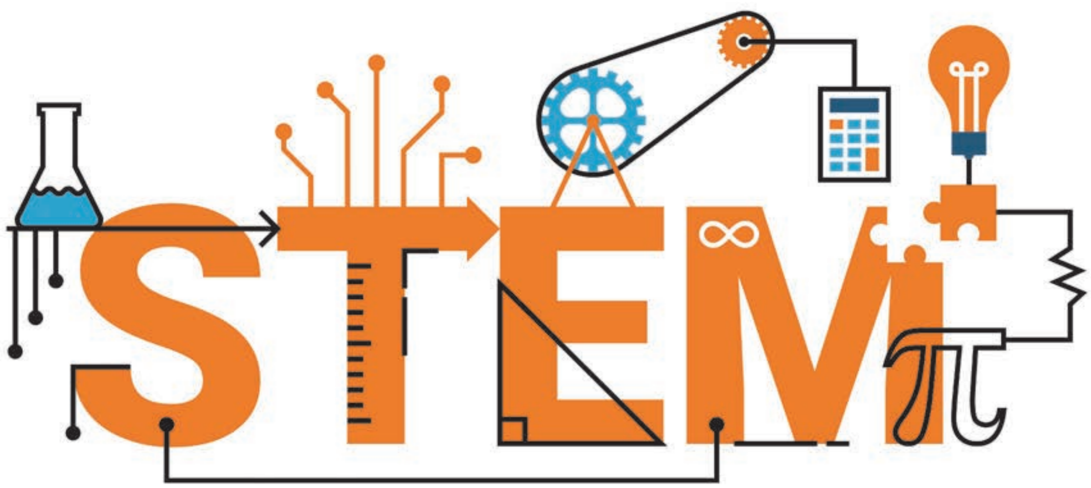
Career and Technical Student Organization, CTSO

Informal STEM Learning

Informal STEM Competition Systems

GROW

Community Partnerships


STEM