

Curriculum Evaluation of the Academy of Global Logistics Program: Connections to STEM Education

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Executive Summary

In this project, the research team examined the curriculum materials of the Academy of Global Logistics (AGL), a high school Career Technical Education (CTE) program that includes courses on global logistics and supply chain management in order to identify connections between the curriculum, Common Core mathematics practices, and Next Generation Science Standards practices. The AGL program is significant in that it exposes students to hands-on learning opportunities through extensive industry engagement and project-based learning. As seen by the supply-chain bottleneck that the nation witnessed at the Ports of Los Angeles and Long Beach in 2021–22, the future of our society demands creative solutions generated by those who understand supply chain, global logistics, and international finance.

Additionally, the AGL’s mission aligns with the core priorities identified by the California State University Transportation Consortium research program “to conduct research and workforce development activities to advance the body of usable transportation knowledge, identify implementable solutions for California, and ensure that the transportation workforce is ready to meet the forthcoming challenges.” Lastly, the AGL approach builds on the Long Beach College Promise, which provides eligible students with two-years of free community college at Long Beach City College and/or guaranteed admission to California State University, Long Beach (CSULB).

The research team found that there are many areas where the AGL curriculum provided opportunities for students to engage in the mathematics and science practices valued in the State’s curriculum standards. The research team also found that the AGL program provided authentic science and mathematics learning opportunities through project-based learning. Those project-based learning elements provide a context for students to learn science and mathematics concepts, which may have seemed inaccessible before, in more accessible and applied real-world formats. Such students could be inspired and motivated to pursue learning how to develop and build energy-efficient robotic arms that help load and unload shipping containers at the port. One thing to note: in order to create a high-quality project-based learning environment, one must meet all the project-based learning criteria put forth by project-based learning scholars, and the AGL curriculum did not do so. There were missing elements, the most frequent one was opportunity to engage in metacognition, thinking about one’s own thinking. One way would be to create opportunities for students to revisit their past academic efforts and reflect on what they would do differently. The addition of a reflective writing exercise during the course of their capstone project, and then having students review their own writing, could provide students a chance to see how far they have come.

In addition to expanding their knowledge of global logistics and supply chain, there are opportunities for students to consider their own growth and comfort in mathematics and science because this project ultimately demonstrates that the learning in AGL goes hand in hand with STEM learning. Educators need to think about utilizing programs such as AGL to expose

students not only to logistics and supply chain management but also to provide quality STEM education. In doing so, educators will have an additional way to strengthen and diversify STEM talent and those who pursue STEM careers.

1. Introduction

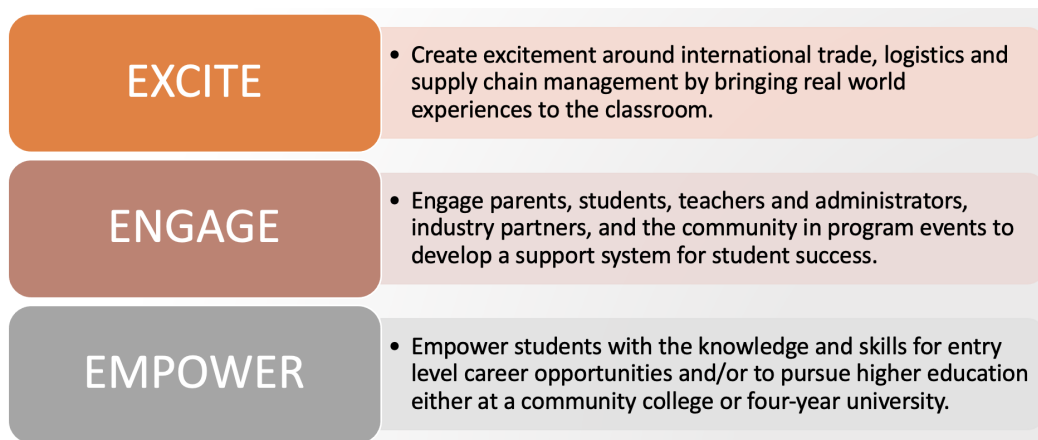
On their daily commutes to and from the Academy of Global Logistics (AGL) at Cabrillo High School, students see many huge trucks with shipping containers. Yet many do not realize that the Port of Long Beach is 4.5 miles away on the coastal horizon. In a workforce development sense, as a four-year career pathway program, AGL ensures that students have promising supply chain and logistics career opportunities on their professional horizons. AGL was launched in 2016 at Cabrillo High School through a partnership between the Long Beach Unified School District and the Port of Long Beach. Industry-education partnerships such as this one have the potential for significant impact in the capacity-building of a skilled labor force.

The Center for International Trade and Transportation (CITT) at California State University, Long Beach (CSULB) provides support through curriculum development, instructor training, and industry coordination. One role of CITT has been to advise on the development of a four-year curriculum designed to prepare high school students to be academically ready to pursue two- or four-year degree programs and/or prepare students for career opportunities in global trade and logistics. The program incorporates industry-relevant learning opportunities that support the academic and career development of future trade and transportation professionals. In contrast to summer transportation institutions, in AGL, the high school students enrolled in the program take courses on global logistics, international finance, and supply chain management, as well as engage with industry as part of their regular high school curriculum. Therefore, students are immersed in training opportunities over several years that have been informed by extended involvement with industry partners. Since its inception, the program has had approximately 800 students.

Cabrillo High School is located in the Westside neighborhood of Long Beach and, according to *U.S. News and World Report*, the student body is 75.1% Latinx, 8.5% African American, 11.7% Asian, and 1.7% Native Hawaiian/Pacific Islander. The school is 47% female, and 89% of the students in the school qualify for free or reduced lunch (*U.S. News*, n.d.). The school currently offers four pathway programs. In addition to AGL, there is the Cabrillo Academy of Law and Justice, Cabrillo Engineering and Design, and the Specialized Academy of Computer Media, Arts and Animation (School Loop, n.d.).

The AGL is unique among the four pathways at Cabrillo High School due to its direct industry connection with the Port of Long Beach. AGL began in 2016 as part of the Port's Education Outreach program to create a workforce pipeline. The partners, comprised of the school district, Cabrillo High School, and the Port, developed a work-based learning plan designed to prepare students for college and/or a career. The Port of Long Beach recognizes that the goals of the AGL are to do the following (Port of Long Beach, Education, n.d.):

Figure 1. Goals of the AGL



The AGL program is significant in several regards. First, it exposes students to hands-on learning opportunities through extensive industry engagement and project-based learning. As seen by the supply-chain bottleneck the nation witnessed at the Ports of Los Angeles and Long Beach in 2021–22, the future of our society demands creative solutions generated by those who understand supply chain, global logistics, and international finance. The program was developed based on the California Career and Technical Education (CTE) standards as well as the California English Language Arts standards (Long Beach Unified School District, n.d.). Additionally, AGL courses satisfy one of the many University of California admission requirements (G of the A–G requirements). By incorporating this level of academic rigor, AGL answers the CTE expectations as laid out by Saunders and Chrisman (2011) who clearly argue that the way to ensure reformed high school CTE, referred to as “Linked Learning” (formerly Multiple Pathways), is to not replicate past CTE programs that were considered the alternative for students who were performing poorly and deemed “handed” in contrast to their “headed” peers. Instead, CTE programs are required to meet the state’s flagship public university admission requirements. Doing so, CTE programs can provide greater educational opportunities for a broad range of students (discussed further in Sections 1.2 and 1.3).

Additionally, the AGL’s mission aligns with the core priorities identified by the California State University Transportation Consortium (CSUTC, n.d.) research program “to conduct research and workforce development activities to advance the body of usable transportation knowledge, identify implementable solutions for California, and ensure that the transportation workforce is ready to meet the forthcoming challenges.” Lastly, the AGL approach builds on the Long Beach College Promise, which provides eligible students with two years of free community college at Long Beach City College and/or guaranteed admission to CSULB.

For the reasons stated above, AGL warrants further evaluation to assess the program’s potential mechanisms for introducing high school students to not only supply chain and logistics career opportunities, but also to develop the necessary science, technology, engineering, and mathematics (STEM) knowledge, skills, and abilities to prepare for a variety of related occupations. In 2020, Cabrillo High School graduated its first cohort of students completing four years of instruction

within the AGL framework. While there are no prerequisites, today there is a waitlist for students to join the AGL. According to preliminary data, students in the AGL program have:

- Represented a 10% increase in the number of 8th graders choosing AGL as a pathway.
- Decreased the number of Ds and Fs received by students.
- Increased AP course enrollment from 6% in 2016 to 16% in 2020.
- Decreased the number of students identified as chronically absent from 24% to 10% over the same period.

These positive changes in student outcomes (e.g., attendance, persistence in education, graduation) suggest that the program is playing a positive role.

1.1 Goals of the Project

The goals for this research project were three-fold. First, the researchers sought to contextualize the AGL in national CTE history and changes. To address this goal, the research team reviewed CTE literature as well as literature related to the changing labor market and workforce demands. By doing so, the research team is able to highlight the strengths of the AGL program that can respond to the demands of the labor market and contribute to informing future directions for workforce development.

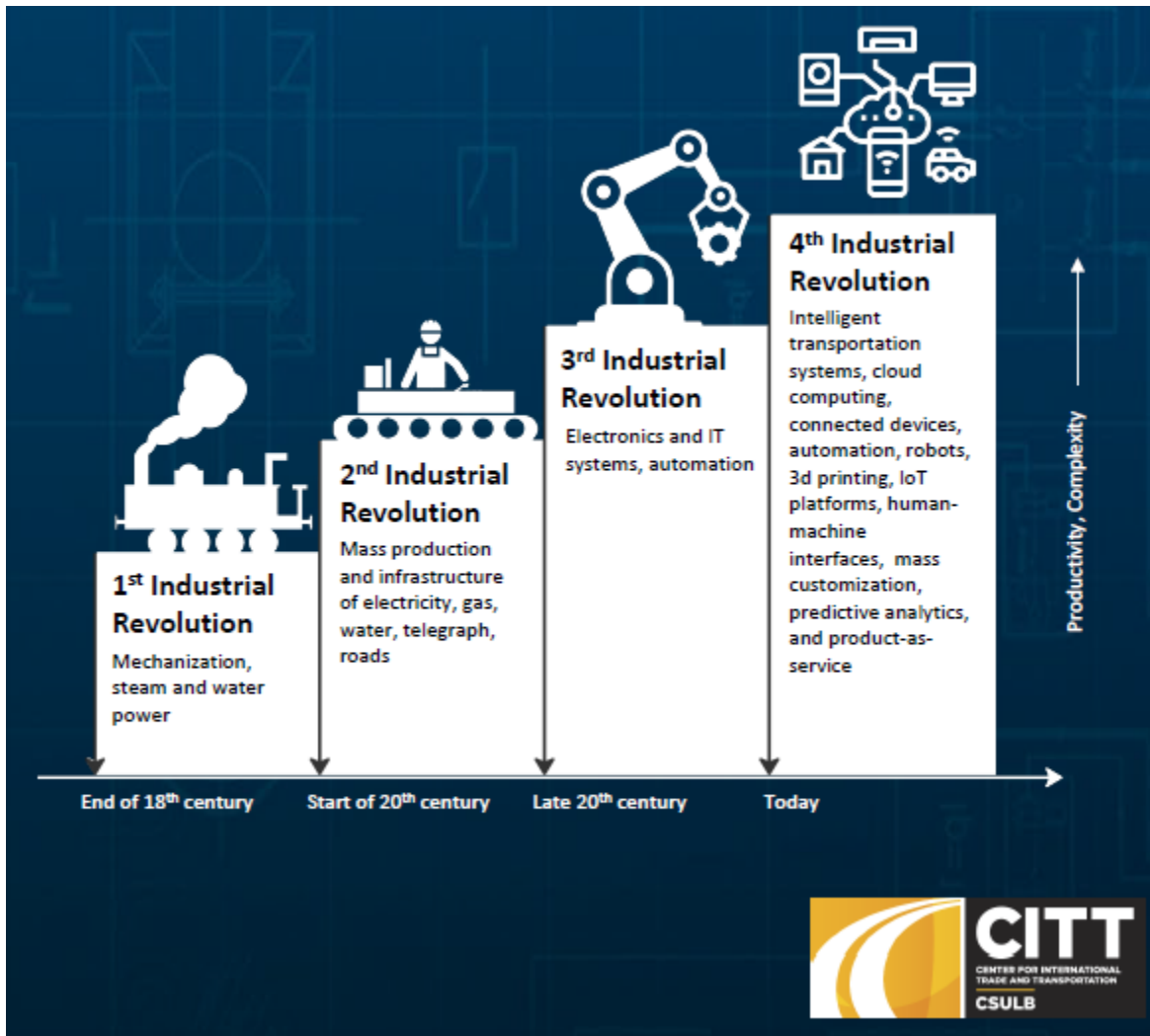
The second goal of the research project was to examine the AGL curriculum to identify elements of high school mathematics and science practices that exist in the curriculum. This investigation intended to establish connections between the AGL program and STEM learning. The third goal of the project was to examine how much of the AGL curriculum adheres to project-based learning criteria. Project-based learning is recognized as an active learning method, and empirically establishing these connections among AGL, STEM learning, and project-based learning provides the foundation for future efforts to build upon the AGL model. The research team hypothesized that a significant mechanism of the AGL program supporting student success was the creation of authentic learning opportunities. To address these two goals of identifying mathematics and science learning and project-based learning opportunities, the research team applied qualitative coding methodology to the three-year AGL course outline materials. The research team read through the course materials line by line and compared the course's expectations to mathematics standards, science standards, and project-based learning criteria (see the Methods section for further details).

1.2 Evolving Perceptions of Career Technical Education in the United States

Definitions of CTE have evolved in tandem with industrial trends. The Smith-Hughes Act of 1917 demonstrated a federal recognition that the Second Industrial Revolution (Hobsbawn, 1990)—with its booms in mass production, infrastructure, electricity, gas, water, telegraph, and roads—required a new era of CTE programs to develop a skilled labor force (Plasman et al., 2020). In service of this new federal CTE priority, the Smith-Hughes Act supported programs to train teachers to teach vocational programs. In the decades that followed, CTE programs were implemented across the country to develop a skilled workforce prepared to address the changing demands associated with the transition to the Third Industrial Revolution in the late twentieth century with its transformational megatrends in electronics, IT systems, and automation. Because the Third Industrial Revolution is (in the big, historical picture) a relatively recent event, a precise date may prove elusive. However, technological developments begin to emerge in earnest following the Second World War (Groumpos, 2021).

In 2019, at the dawn of the Fourth Industrial Revolution (Fourth IR, Philbeck & Davis, 2018), the 115th Congress reauthorized the fifth iteration of the Carl D. Perkins Vocation Education Act (Granoskiy, 2018). The Perkins Act places emphasis not only on attaining technical skills and earning industry-recognized certificates and credentials, but also on pursuing and obtaining postsecondary degrees. In this way, considerations for both career and college readiness have become important for CTE programs and postsecondary education as a whole. The Fourth IR (depicted in Figure 2 below) is a "technological revolution characterized by a fusion of the digital, physical, and biological spheres, and characteristic of its unprecedented velocity" (Philbeck & Davis, 2018). In transportation systems that move people and goods, the Fourth IR "specifically refers to the use of robotics, artificial intelligence, automation, and digitalization in work processes" (Schwab, 2017). This sensibility of considering both career and college readiness reflects the hybrid skillsets called for in the Fourth IR with its exponential technological shifts in intelligent transportation systems, cloud computing, connected devices, automation, robots, 3D printing, Internet of Things (IoT) platforms, human-machine interfaces, mass customization, predictive analytics, and product-as-service.¹

Figure 2. The Industrial Revolutions



One way to address the needs created by these dramatic shifts in industry is by recognizing the unique learning opportunities CTE programs can provide and then expanding on them. There are different types of CTE programs and, in accordance with federal law (P.L. 115–224), the National Center for Education Statistics recognizes the following occupational fields for CTE:

Figure 3. Occupational fields for CTE



In the state of California, the Department of Education lists five program areas:

1. Agriculture education
2. Business & marketing
3. Family and consumer science education
4. Health careers education
5. Industrial & technology education (CA Department of Education, n.d.)

AGL may seem to obviously fall into field #14 of the national CTE categories, Transportation, but upon closer inspection, one can see that AGL also falls into: #2 Business support, finance, and management; #4 Computer and information sciences; #5 Construction; and #8 Engineering and architecture. In terms of the five program areas, the AGL is not limited to one category: it includes education on business and marketing (2), as well as industrial and technical education (5).

1.3 High School CTE for Career- and College-Ready Students

In response to calls for high school reform and the emphasis on the CTE to prepare students for the workforce and for college or university, many states have pursued the creation of academically rigorous CTE programs (Saunders & Chrisman, 2011). The California Department of Education is not an exception and clearly states CTE as, “A program... that involves a multiyear sequence of courses that integrates core academic knowledge with technical and occupational knowledge to provide students with a *pathway to postsecondary and careers* (emphasis added by authors).” For a high school CTE program to begin to be academically rigorous, it must first meet the state’s academic standards. California is one of the many states that has adopted the Common Core and

Next Generation Science Standards (NGSS) as its state standards (CA Department of Education, 2022a). Both Common Core and NGSS have dramatically changed educational expectations due to the focus on students achieving and demonstrating mastery in core academic subjects (Park et al., 2017). Requiring mastery is a high level of academic rigor because, in order to demonstrate mastery, the individual must be able to apply the knowledge. Traditional teaching and learning methods, such as lectures and memorization, are ineffective in developing mastery. This demand of mastery as well as other changes in the standards laid out in the Common Core intend to prepare students for first-year college courses (Common Core State Standards Initiative, 2015).

Preparing students for a career has a high bar as well. Research on career readiness identifies that high school graduates and even college graduates often do not meet the expectations of employers. For instance, a global study surveying CEOs found that 74% of CEOs are concerned about job applicants not having the key skills necessary for the job (PwC, 2020). Many employers are looking to hire employees who can work well in teams and have leadership, communication, and problem-solving skills (Ritter et al., 2018). To develop those problem-solving skills, students need to work in experiential learning ecosystems that provide them a real-world context for learning, which is a departure from traditional methods of instruction. Kapareliotis and colleagues (2019) found that “soft” skills, such as being able to take initiative, manage time, and collaborate, are effectively developed through internships as students learned which professional competencies were expected by employers and gained confidence in applying them. The question pursued by this project is: how does the AGL meet the expectation of preparing students to be college and career ready?

1.4 Project-based and Authentic STEM Learning

Another area anticipated as contributing to positive changes in AGL student outcomes was curricular content showing real-life applicability, both in industry and the sciences. One instructional method where inquiry is at the focus and students engage in real-world problems so that they may develop knowledge authentically is project-based learning (Brundiers & Wiek, 2013; Krajcik & Shin, 2014). Towards the end of the 20th century and in the early years of the 21st century, project-based learning gained attention and popularity as a promising way to encourage authentic and active learning (Erdogan & Bozeman, 2015). There are many models for project-based learning, which makes it difficult to define (Erdogan & Bozeman, 2015); however, there are common elements shared by all of the models. Typically, project-based learning addresses a real-world problem that students attempt to solve by utilizing problem-solving and decision-making skills (Capraro & Slough, 2008; Buck Institute, n.d.)

Project-based learning has been implemented to teach various subjects (see Laverick, 2018 for project-based learning used in second language acquisition) but has received the most attention in the domain of STEM. Project-based learning lends itself well to the learning of complex science, engineering, and mathematics content because it creates opportunities for authentic and active learning. Authentic learning refers to learning that happens through students taking on complex

real-world problems (Lombardi, 2007). This is different from learning about discipline content, such as geometry, without a real-world context. For example, authentic learning opportunities would expose students to seeing how shapes and angles are important in architecture. Active learning commonly refers to any teaching method that involves the students in the learning process and can be understood in contrast to more passive ways of learning, as in a lecture (Prince, 2004). In addition to learning content, one of the strengths of project-based learning is that it contributes to students learning soft skills, such as critical thinking, teamwork/collaboration, and communication skills, that are important for many 21st-century careers (e.g., Baran et al., 2021; Hussin et al., 2019; Wan Husin et al., 2016).

Preparing students for a career is an educational challenge as well. Research on career readiness identifies that high school graduates, and even college graduates, often do not meet the expectations of employers. Many employers are looking to hire employees who can work well in teams and have leadership, communication, and problem-solving skills (Ritter et al., 2018). These are skills that need opportunity to develop, and the traditional ways of instruction are limited in preparing students for the workforce.

2. Study Data and Methods

2.1 Common Core Mathematics Standards, Next Generation Science Standards, and Project-Based Learning Criteria

In order to draw connections between AGL and mathematics and science, the State of California's standards for high school education were applied to the AGL curriculum. Common Core Mathematics lays out the academic expectations to be met in high school. There are two component requirements: concepts and practices. The practices investigated in this research project were the following:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

The content of mathematical topics such as algebra, geometry, and calculus were not examined. Rather this research project intended to examine whether students gained opportunities to utilize and apply the mathematics practices emphasized by Common Core in their AGL courses to determine the opportunities for STEM learning in this CTE.

With regards to the science standards, NGSS has three dimensions. The first dimension is *disciplinary core ideas* that focus on the knowledge and concepts students need as they progress through education. The second dimension is *crosscutting concepts* that refer to the greater ideas, such as identifying patterns or understanding cause and effect that students need to gain an understanding of throughout their science education. Lastly, the third dimension is *science and engineering practices*, which refers to attitudes and behaviors such as asking questions, defining problems, and analyzing and interpreting data (CA Department of Education, 2022b). The NGSS practices refer to the following:

1. Asking questions and defining problems.
2. Developing and using models.
3. Planning and carrying out investigations.
4. Analyzing and interpreting data.
5. Using mathematics and computable thinking.
6. Constructing explanations and designing solutions.
7. Engaging in arguments with evidence.
8. Obtaining, evaluating, and communicating information.

Here too, as AGL is not a science curriculum, the research team did not expect it to include any more science content than was relevant for students to learn global logistics, supply chain management, and to complete their capstone projects. Rather, the research team was interested in how much students were able to utilize and apply science and engineering practices in their AGL courses.

Lastly, the research team applied the project-based learning criteria from the elements described above and those compiled by Sun and colleagues (2016):

1. Have an ill-structured/defined problem/task that can have several solutions.
2. Solutions need to be derived by student exploration (not rote memorization).
3. Require students to identify the problem and its constraints.
4. Students have an opportunity to conduct research.
5. Students have an opportunity to pursue ideation (generate many ideas).
6. Students have an opportunity to analyze ideas.
7. Students have an opportunity to test and refine own ideas.
8. Students have an opportunity to communicate.
9. Students have an opportunity to engage in metacognition.

The primary researcher minimally revised the elements informed by the literature to separate out the behaviors students were expected to adopt (criteria #3–#9) and the learning environment students needed to engage in (criteria #1 and #2) for project-based learning to authentically occur.

2.2 Data and Analyses

The three core AGL course outlines were examined: Global Logistics, Supply Chain, and Capstone. A student takes each course during the entire academic school year. In addition to the course overview, the course outline included additional general information (e.g., course learning outcomes, course length, etc.) and laid out the description, objectives, required assignments, suggested assignments, materials, and assessed standards for each unit.

The Global Logistics course is often the first course students take as a 9th-Grade student. The currently implemented course overview explains this course as:

...an analysis of logistics activities, distribution network alternatives, and customer service aspects; examination of freight traffic functions within the firm's logistics system, analysis of rate and classification systems and carrier selection; evaluation of logistics procedures and strategies and their appropriateness to different industries. Students will research, analyze and write a proposal outlining the steps and processes used to import/export goods from one country to another. The semester project will require the students to utilize trade-related publications, resources, and web sites. The students will interview business professionals as additional resources. The culminating project will be evaluated based on industry standards. In addition to the written portion of the projects, students will prepare a verbal presentation and will be required to defend the proposal to members of the logistics program advisory committee and other logistics professionals.

Table 1. Global Logistics Course Topics

2 semesters. Prerequisites—none	1- Career Awareness. 1-week unit
	2- Where in the World. 1-week unit
	3- Time Zones. 1-week unit
	4- Weights & Measures. 1-week unit
	5- World Cultures. 3-week unit
	6- Transportation & Options. 1-week unit
	7- Effects of Trade Agreement. 4-week unit
	8- Import & Trade Barriers. 4-week unit
	9- Exports. 2-week unit
	10- Security Initiatives. 2-week unit
	11- Packaging Requirements. 3-week unit
	12- Insurance Coverage. 2-week unit
	13- Modes of Transportation. 1-week unit
	14—Logistics Providers. 1-week unit
	15- Freight Forwarder. 1-week unit
	16- Power of Attorney. 2-week unit
	17- International Documentation. 4-week unit
	18- Culminating Project. 2-week unit

While the Supply Chain Management course:

...expands on the components of logistics systems and further develops the importance of the supply chain in a firm's success. Students will be introduced to forecasting and demand management, procurement and purchasing, benchmarking supply chain performance and the role of information technology in making supply chain decisions. Students will identify the goal of a supply chain and evaluate the impact of supply chain decisions on the success of a firm as well as categorize the performance measures that are relevant to a supply chain. Students will examine the role of forecasting as a basis for supply chain planning, and create a time series forecast using moving averages, exponential smoothing, and regression. In addition, students will explain the "bullwhip effect", and illustrate through examples, the flow of material between supply chain partners. Students will compare the major applications of supply chain information technology as well as identify the benchmarking of supply chain performance and research ways to reduce the weaknesses. Students will calculate demand management and forecasting with real world applications profits. Furthermore, students will demonstrate the role of information technology in a supply chain as well as researching the elements of Six Sigma, and Lean Manufacturing, and their impact on supply chains.

As a part of the course, students will be using technology and will have the foundation and opportunity to sit for the Microsoft Office Specialist (MOS) Certification in Word 2016 and Excel 2016. Students will participate in leadership opportunities through class, community and/or Future Business Leaders of America (FBLA) projects.

Table 2. Supply Chain Course Topics

2 semesters.	1- Fundamentals of Supply Chain Management. 4-week unit
Prerequisite course— accounting and international finance	2- Processes. 4-week unit
	3- Customer Service, Satisfaction, and the Supply Chain. 4-week unit
	4- Procurement. 4-week unit
	5- Information Technology. 4-week unit
	6- Anticipatory Response-Based. 6-week unit
	7- Manufacturing. 4-week unit
	8- Planning & Forecasting. 3-week unit
	9- Supply Chain Globalization. 4-week unit

Lastly, the Capstone course:

...represents a unique collaboration between academics and industry professionals where student teams will get an opportunity to apply the advanced skills they have acquired over their course of study by addressing hypothetical situations encountered in the business world. Students will have access to consultants from the international business industry to offer input and guidance along all the stages of their capstone project. Students are empowered to collect and analyze information with accuracy and precision to creatively solve potential problems along with investigating and modeling the impact of the solutions on the business. Upon completion, students will present their findings to a panel of business leaders for comment and feedback.

Table 3. Capstone Course Topics

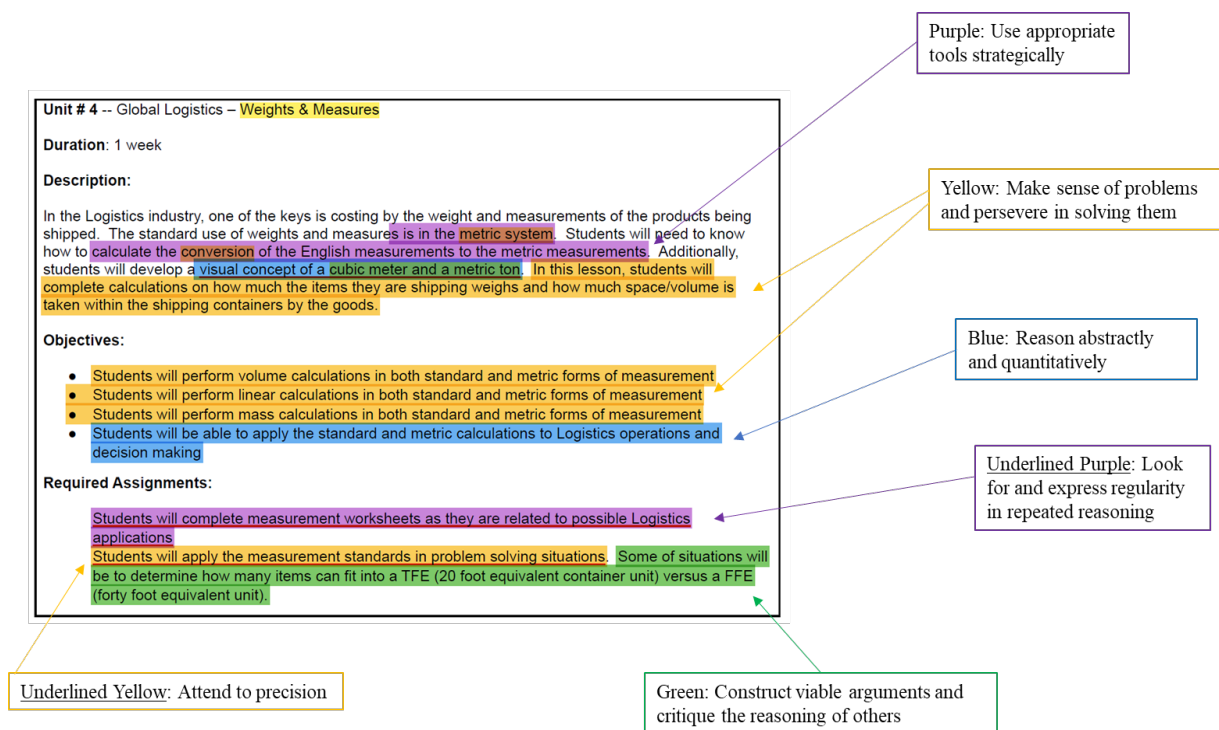
2 semesters. Prerequisite course— supply chain management	1- Characteristics of Successful Teams. 4-week unit
	2- Research Strategies. 4-week unit
	3- Problem Identification and Situational Analysis. 4-week unit
	4- Situational Analysis. 4-week unit
	5- Generating Alternatives. 4-week unit
	6- Rationale (Pros/Cons). 4-week unit
	7- Implementation Plan. 4-week unit
	8- Finalizing the Written Report. 4-week unit
	9- Preparing the Presentation. 4-week unit

Overall, both the Global Logistics course and the Supply Chain course are intended to expose students to their respective content material. In contrast, the Capstone course is qualitatively different from the other two courses because the entire course is intended for student teams to tackle one project related to industry over the course’s two semesters. Therefore, at the beginning of the course, students learned valuable content for carrying out the project rather than focusing on more abstract academic concepts. Notice that students were expected to learn and think about characteristics that make up a successful team (Unit 1), as well as research strategies on how to use Boolean operators and evaluate sources (Unit 2).

The research team read through and coded each unit’s description, objectives, required assignments, and suggested assignments for elements meeting the NGSS science practices and project-based learning criteria discussed above. Additionally, the assessed standards were coded for Common Core math practices. Each research team member coded all three course outlines for one of the standards or criteria; in other words, one researcher was responsible for looking for alignment with Common Core math practices, the second researcher was responsible for looking for alignment with NGSS, and the third researcher was responsible for looking for alignment with project-based learning criteria. This way of coding can be referred to as hypothesis coding. In this method, researchers are testing hypotheses and using a pre-determined list of codes (Saldaña, 2013). In this project, the codes were directly derived from the mathematics standards, science standards, and project-based learning criteria, and the researchers sought to identify whether the AGL curriculum would incorporate many, even all, of the practices required by the California’s high school mathematics standards, the state’s high school science standards, and project-based learning criteria informed by project-based learning research. As the research team examined the written curricula and did not observe student behaviors directly in the classroom, the research team only reported on the existence of the opportunities at the unit-level (1 for yes, the opportunity exists; 0 otherwise).

Below is a snapshot of the coding process.

Figure 4. Snapshot of coding process



This snapshot shows the beginning section of Unit 4 of the Global Logistics course. The researcher’s process was to identify segments in the course’s description, objectives, and required assignments that met Common Core mathematics practices. Only curricular segments that aligned with the codes were coded and included in this report

2.3 Limitations of the Project

As a preliminary investigation of the AGL curriculum, only the course outlines provided by the teachers were examined. Additional course materials, such as textbooks or assignments, were not studied. Implementation of the curriculum, or how the teachers taught the course content, went beyond the scope of the project. An additional limitation of the project is that, as a preliminary investigation, the researchers only examined their respective criteria. Cross checking the coding completed by individual researchers did not take place at this stage of the project. Lastly, with regards to meeting project-based learning expectations, although Sun and colleagues (2016) included authentic assessments as an important factor of STEM project-based learning, the research team did not adopt this recommendation since the project intended to determine whether the AGL curriculum included mathematics and science practices, not whether students had learned mathematics and science concepts through the project-based learning teaching method.

3. Findings

3.1 Connections to Next Generation Science Standards

In the Global Logistics course, the researcher identified that students were expected to engage in “obtaining, evaluating, and communicating information” most frequently (12 out of 18 units). This was followed by “constructing explanations and designing solutions” (10 out of 18 units). Students were also expected to engage in “analyzing and interpreting data” and “using mathematics and computational thinking” (7 out of 18 units). In contrast, there was no evidence of students being expected to engage in “planning and carrying out investigations” (0 out of 18 units).

In the Supply Chain course, the researcher identified that students were expected to engage in “obtaining, evaluating, and communicating information” and “developing and using models” in every unit of the course (9 out of 9 units). Students were also expected to engage in “analyzing and interpreting data” often (8 out of 9 units). However, as in the Global Logistics course, there was no evidence of students being expected to engage in “planning and carrying out investigations” (0 out of 18 units).

In the Capstone course, the researcher identified that students were expected to engage in “obtaining, evaluating, and communication information” most often (6 out of 9 units). This was the only course where students were expected to engage in “planning and carrying out investigations” (1 out of 9 units). This is not surprising due to the course’s focus on students working in teams to tackle hypothetical business situations.

Across the three courses, the practice that students were expected to engage in the most frequently was “obtaining, evaluating, and communicating information” (27 out of 36 units). The practice that students were expected to engage in the least frequently was “planning and carrying out investigations” (1 out of 36 units). The wide range of engagement (and lack thereof) in NGSS science practices is possibly due to science placing a greater emphasis on hypothesis testing and the carrying out of experiments to determine whether one’s hypothesis is supported or not more so than a business/finance curriculum would.

3.2 Connections to Common Core Mathematics Standards

In the Global Logistics course, the researcher found evidence that students were expected to “reason abstractly and quantitatively the most frequently” (14 out of 18 units). Students were expected to frequently engage in other mathematical practices as well: “construct viable arguments and critique the reasoning of others” (13 out of 18 units), “model with mathematics” (12 out of 18 units), and “look for and express regularity in repeated reasoning” (12 out of 18 units). Unexpectedly, there were no mathematical practices that were not expected in any unit. The least frequent mathematics practice students were expected to engage in was to “look for and make use of structure” (7 out of 18 units).

In the Supply Chain course, the research found evidence of students being expected to engage in all of the practices, and frequently, with four of the practices being expected in every unit: “make sense of problems and persevere in solving them,” “reason abstractly and quantitatively,” “model with mathematics,” and “look for and make use of structure.” Three additional practices were expected in 8 of the 9 units: “construct viable arguments and critique the reasoning of others,” “use appropriate tools strategically,” and “attend to precision.” The last practice, “look for and express regularity in repeated reasoning,” was the least expected practice in this course (6 out of 9 units).

In the Capstone course, the researcher found evidence of students being expected to engage in all of the practices, and regularly as well. All of the practices were expected in every unit or in 8 of the 9 units. This could be because the Capstone course has the densest lesson plan of the three courses.

Across all three AGL courses, the Common Core practice that was the most present was “reason abstractly and quantitatively” (32 out of 36 units). The two practices that were expected of students the least frequently were “attend to precision” and “use appropriate tools strategically” (24 out of 36 units). This is likely due to differences in expectations of precision and what tools are considered when learning mathematics when compared to business/finance.

3.3 Connections to Project-Based Learning

In the Global Logistics course, the coding showed students were expected to “come up with solutions through exploration” explicitly in 12 out of 18 units. Students also had many opportunities to “conduct research” (14 out of 18 units). There was a difference in the number of times students engaged in these behaviors because some research efforts were not to find a solution. For instance, Unit 3 set out to develop an understanding of time zones. The existence of time zones is not itself a problem requiring a solution. Later, in Unit 6, time zones become a factor to consider when students need to find ways to ship goods across the world. Students engaged in “communication,” often in the form of writing, in almost every unit (16 out of 18) in this course. The writing tasks varied from creating checklists and posters to papers and essays. The researcher found no explicit instances where students were expected to “test and refine their own idea” or “engage in metacognition.”

In the Supply Chain course, the coding showed that students engaged in several aspects of project-based learning in nearly every unit: students were presented with “a complex problem” (9 out of 9 units); and they were expected to “identify constraints,” “conduct research,” and “derive solutions through exploration” (9 out of 9 units for each code). This seemed to be due to the nature of the course’s content, as the supply chain is itself a complex problem. There were many “opportunities for communication” as well (7 out of 9 units), with only Units 2 and 4 not explicitly requiring students to communicate their work. In contrast, as seen in the Supply Chain course outline, the researcher found no explicit instances where students were expected to “test and refine their own idea” or “engage in metacognition.”

In the Capstone course, students engaged in “exploration for solutions” often (6 out of 9 units) and were expected to engage in communication in every unit. This was anticipated given that the focus of the course is to complete a team capstone project. This course is unique in two ways. It was the only course that had a unit explicitly providing an opportunity for students to engage in metacognition. Also, although there was no mention of opportunities to test and refine ideas in each unit, the course overview mentioned that students will have “access to consultants from international business industry to offer input and guidance along all the stages of their capstone project.” This indicated that students would be able to discuss their ideas with industry professionals and possibly obtain feedback. However, it was unclear how frequently this would take place, and the feedback’s quality was unknown. As the only course providing opportunities for students to engage in metacognition, and potentially to test and refine their ideas, the Capstone course was complementary to both the Global Logistics and the Supply Chain courses.

Across the three courses, students were expected “to communicate” the most frequently (32 out of 36 units). The least frequent opportunities were “to pursue ideation” (5 out of 36 units), “to engage in metacognition” (1 out of 36 units), and “to test and refine ideas” (0 out of 36 units). The remaining project-based learning criteria were met fairly often, ranging from 11–27 out of 36 units. This is likely due to the nature of CTE, being grounded in exposing students to real-world situations so they can be ready to handle situations that arise in the profession.

4. Connections to Students' Futures

4.1 College Readiness

Examination of the AGL curriculum suggests that students who complete the program are equipped with useful skills for college success. Specifically, when considering the skills practiced across the three courses, AGL students are exposed to conducting research in order to come up with solutions and communicate the arguments they constructed. These are foundational skills required of all college students and that can be applied to different industries.

Additionally, AGL students have many opportunities to utilize and apply the practices of mathematicians and scientists during their time in AGL. This suggests that they may experience fewer adjustment challenges in their foundational mathematics and science courses in college. Many first-year college students struggle with the differences in expectations of college instruction compared to that of high school, with many finding it discouraging and demotivating to have to complete introductory mathematics and science courses that they do not see as relevant to their desired course of study (see Rosenzweig et al., 2020 for interventions targeting usefulness or relevance in college physics). Students who have gone through AGL are likely to have fewer questions regarding the relevance of their mathematics and science college and university courses as they have already been exposed to how the content material connects to industry.

4.2 Career Readiness

Young people entering the workforce are expected to have various soft skills that include communication, critical thinking, and problem-solving (see Kapareliotis et al., 2019 for skills gained in an internship). In this project, the research team showed that AGL, a high school CTE program, embedded numerous opportunities for students to communicate their ideas and their work. Having the chance to practice explaining their knowledge will likely contribute to developing communication skills.

AGL also provided students with numerous opportunities to conduct research, identify constraints when solving problems, and explore solutions. These activities can help students develop critical thinking and problem-solving skills because they give students insight into how decisions are made and the factors to consider when making decisions. In other words, students participate in data-driven decision making. In these significant ways, AGL prepared students for careers.

This level of formal collaboration between the school district and industry, specifically the involvement of a key employer of the community, the Port of Long Beach, with the curriculum creates a feedback loop for the educators to be aware of the kinds of workforce employers are looking for and to prepare students to meet these needs. Young members of the Long Beach community can be ready to pursue these career opportunities.

4.3 Connecting CTE and STEM Learning

This research project contributes to and is in line with research that has been done so far demonstrating the utility of CTE for STEM learning. One example of this research is from the National Research Center for Career and Technical Education (NRCCTE). Starting in 2003, the NRCCTE conducted three research experiments to integrate mathematics, literacy, and science into CTE and to test whether student standardized test scores in these areas can change (Park et al., 2017). For students' mathematics scores, there was improvement among students who were in the CTE course with more mathematics integrated. For students' science scores, there was no overall impact, but the gap between non-white students and their white peers decreased. Park and colleagues (2017) highlight the strength of CTE as being able to provide students with authentic examples of how their mathematics and science knowledge will be utilized. In the experimental studies that the NRCCTE conducted, CTE teachers participated in professional development and integrated mathematics and science content into their CTE courses.

This project found evidence that the AGL curriculum incorporates mathematics and science practices and is likely contributing to student mathematics and science learning. Additionally, the AGL curriculum includes opportunities to build out mathematics and science concepts as well. For example, students are currently expected to calculate the amount of product they could fit in a standard shipping container and examine how much it would cost depending on the means of transportation (algebra). Students were also expected to consider where raw materials or resources are found in the world. There is room to expand such lessons to explicitly investigate other relevant topics in geological science and physics by asking questions, such as why these raw materials are found in specific regions of the world.

Logistics and supply chain as thematic foci allow for the contextualization of STEM learning and the creation of a highly interdisciplinary approach to STEM, including mathematics and science, as well as opportunities for engineering and geospatial and computational thinking. Ultimately, the AGL can be a *STEM for All* (Handelsman & Smith, 2016) environment that includes both CTE and academic pathways. One suggestion for future efforts in connecting CTE and STEM is to consider the overlap across the mathematics and science practices, and even project-based learning, and include explicit discussions on the differences in what is expected in the different fields of study, as well as in postsecondary classrooms when compared to the workplace. By exploring these differences, students will gain opportunities to reflect on their thinking and behaviors in those different situations. This is expected to contribute to the development of metacognition and critical thinking (Chick, 2013).

5. Conclusions

5.1 Recommendations for Policymakers

Currently, the time is right for this examination of the AGL program and its connections to STEM learning. The California Governor’s 2023–2024 budget dedicates \$1.65 billion in advancing workforce development programs. The budget also includes an industrial economic agenda that commits to offering grants for workforce development programs. To respond to the blend of CTE, STEM, and project-based learning needs required to prepare future generations for the technological and socioeconomic megatrends associated with the Fourth Industrial Revolution, programs such as the AGL are essential.

Policymakers can support the growth of programs such as the AGL in two ways: first, by providing funding for additional CTE teachers, especially in schools where CTE programs such as AGL will benefit the local economy as well as the economic development of the state. A second way that policymakers can support this growth is by creating and encouraging programs that develop industry and education partnerships.

5.2 Recommendations for Institutions of Higher Education

The Governor’s budget also emphasizes reinvestment in affordable higher education that improves job pipelines. One recommendation for higher education institutions is to develop partnerships with programs such as the AGL program. Higher education researchers can contribute to this ecosystem of career-development education programs with industry partners by creating a common set of metrics that can assess learning outcomes and student impact. This will create the groundwork for longitudinal studies that can track student outcomes, development in local communities, and industry partners’ growth and success.

5.3 Summary

In this project, the research team examined the curriculum materials of the Academy of Global Logistics (AGL), a high school CTE program that includes courses on global logistics and supply chain management, in order to identify connections between the curriculum and Common Core mathematics and Next Generation Science Standards practices. The research team found that there are many areas where the curriculum provides opportunities for students to engage in mathematics and science.

The research team also examined the ability of the AGL program to provide authentic science and mathematics learning opportunities through project-based learning. Students who had not considered themselves as having the potential to learn science and mathematics may realize that they were missing an explanation of how science and mathematics apply to real-world problems. For example, such a student could be inspired and motivated to pursue a mechanical engineering

degree which may not seem directly related to logistics initially, but this student may do so in order to design energy-efficient, self-driving trucks that will transport products when importing/exporting. One thing to note, in order to create a high-quality project-based learning environment, one must meet all the project-based learning criteria, and the AGL curriculum did not do so, according to project-based learning scholars. There were elements that were missing, the most frequent being the opportunity to engage in metacognition. One way to increase the opportunity for this element would be to create chances for students to revisit their past academic efforts and reflect on what they would do differently. The addition of students reviewing their own progress could provide students a chance to observe their own development.

In addition to a growth in knowledge of global logistics and supply chain, there are opportunities for students to consider their own growth and comfort in mathematics and science because this project ultimately demonstrates that the learning in AGL goes hand in hand with STEM learning. Educators need to think about utilizing programs such as the AGL to expose students not only to logistics and supply chain management, but also to provide quality STEM education. In doing so, educators will have an additional way to strengthen and diversify STEM talent and those who pursue STEM careers.

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