TRENDS IN STEM AND CAREER AND TECHNICAL EDUCATION IN THE UNITED STATES OF AMERICA

TENDÊNCIAS EM EDUCAÇÃO EM CIÊNCIAS E MATEMÁTICA E EM EDUCAÇÃO PROFESSIONAL E TÉCNICA NOS ESTADOS UNIDOS DA AMÉRICA

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ABSTRACT

This paper offers a portrait of educational trends affecting the practice of career and technical education in the United States of America. It argues that through a combination of governmental agenda, accountability discourse on legislation, and pressure from state governments and businesses alike, teachers have been having to make evident how their technical courses contribute to the achievement of academic parameters in mathematics. The interplay between the need for legitimation of their programs and for maintaining the authority over their courses has led teachers to focus on convincing authorities that their technical courses already teach a great amount of mathematics and science. Conversation with the socio-political strand of mathematics education literature is suggested as a catalyst for future research and action.

Keywords: career and technical education, college and career readiness, STEM education, accountability, governance in American education;

RESUMO

Esse artigo oferece um panorama de tendências em educação que vêm afetando a prática da educação profissional e técnica nos Estados Unidos da América. Argumenta que por uma combinação de planos governamentais, discurso legislativo de accountability e pressão de governos estaduais e empresas, professores vêm tendo que evidenciar como seus cursos técnicos contribuem para o alcance dos parâmetros acadêmicos em matemática. A necessidade de legitimar seus programas e ao mesmo tempo manter a autoridade sobre seus cursos tem levado professores a concentrar seus esforços em convencer as autoridades de que seus cursos técnicos já ensinam muita matemática e ciências. É sugerido que, como um catalisador de futuros estudos e práticas, estabeleça-se uma conversa com a literatura sobre aspectos sócio-políticos da educação matemática.

Palavras-chave: educação profissional e técnica, prontidão para carreira e universidade; educação em ciências, tecnologia, engenharia e matemática; governança na educação estadunidense.

Vocational education in the United States, which since 2006 has been referred to as Career and Technical Education (CTE)[1], has been shaped in the recent history by a confluence of governmental agendas of different presidencies, federal legislation concerning funding for CTE programs, as well as state and local level priorities. In this paper I will argue that two of these priorities have been particularly influential in the professional activity of CTE educators: the role attributed to Science, Technology, Engineering, and Mathematics (STEM) in the country's economic growth and the push towards academic standards and preparation for college. In order to provide a view of these trends that intertwine STEM and CTE, I will first offer a brief description of the American education system and its governance. I will then characterize CTE and situate it in relation to the other modalities of education. In the development of my argument, I will offer an account of the emergence of governmental reports, educational agendas, and federal legislation have contributed to impose onto CTE professionals the need to account for how their programs and courses contribute to students' attainment of academic proficiency in mathematics and science.

1 Federalism and state sovereignty in American education

It is often surprising, even to US citizens, that the federal constitution of that country does not dwell on education. That is, education is not a constitutional right in the United States of America. Provisions for education appear in state constitutions, and vary from state to state. Some state constitutions explain the foundations of their educational systems; others use more vague language and leave the details for the legislature. Some common differences between state constitutions concern religious restraints, education of people with special needs, student age groups, length of the school year, and higher education systems (Parker, 2016). For Stone III, "this means that public education in the United States is not just one system but 50 different state systems and thousands of district systems". (Stone III, 2012, p. 231)

It is the communities, as well as public and private organizations of all types, that establish schools and colleges, develop curricula, and determine the requirements for enrollment and graduation. The funding structure for education reflects this predominant role of state and local governments. At elementary and secondary levels, almost 90 percent of the funds come from non-federal sources. The federal role in education is characterized as a sort of "emergency response system", a means of filling gaps in state and local support for education when national critical needs arise (U.S. Department of Educaton, 2012).

Despite the emphasis on state sovereignty, the federal government has ways of influencing educational policies. One of them is to allocate funds only to districts that follow certain federal guidelines. Another is to influence the conceptions and ideologies of the population and those who really have the power to make concrete changes in the education system (states, counties, communities, parent associations, etc.)

2 The place of Career and Technical Education in the structure of the American education system

The public education system in the United States comprises elementary, intermediate or middle school, secondary or high school and higher education. The American system of higher education displays a variety of programs, certifications and institutions. Besides universities,

[1] Accordingly, in this article I will use the term vocational education when writing about legislation and vocational education systems in the United States prior to 2006 or in more generic contexts. I will use the term Career and Technical Education or the acronym CTE to refer to that segment of education from 2006 to the present.

there are *4-year colleges* or *liberal arts colleges* — which offer programs with humanist curricula —, *community colleges* and *2-year colleges*, which generally confer *associate degrees* — a degree at tertiary level, but lower than a bachelor's degree.

Career and Technical Education is offered across various levels of education, as well as various types of institutions. CTE is mainly pre-baccalaureate, that is, conferring degrees at the associate level or lower (Zirkle, 2012). These are offered at post-secondary level through a variety of institutions, including technical institutes, community colleges, university campuses offering two-year courses, or private schools.

It seems pertinent to offer a little more detail about the American community colleges, since, from an outside standpoint, "the American community college may appear as a somewhat peculiar, idiosyncratic institution" (Schmidtke, 2012, p. 52). Even for Americans, there seems to be some confusion:

> Especially in the technical education arena, it is thought by many not to be part of higher education, yet it is not part of secondary education either. It sits astride the two systems and reflects a market-driven response to the supply and demand of the labor market. (Stone III, 2012, p. 244)

The way Stone III (2012) views CTE at the various educational levels is that secondary CTE assumes more a role of "an introduction to the workplace in lieu of preparation for the work place", whereas "community (or technical) two-year colleges are expected to assume a larger role in occupational preparation". (p. 244)

A distinguishing characteristic of the American case seems to be that United States does not have a separate vocational education system, but offers Career and Technical Education intertwined with the other modalities of education. King (2012) gets to the point of calling it a "patch-work nonsystem" (p. 24).

> This nonsystem is overloaded with ad hoc fixes, like so many freight cars on a train, each connected to what is in front or behind it by only one or two points of contact; each at risk of being disconnected and sidelined at any moment—as key segments have been after only a few years of under-nourished experimentation. (King, 2012, pp. 24-25)

Also, Hoffman (2011) explains how different from other countries' vocational education systems CTE is:

> One piece of data that may surprise U.S. readers is that when the OECD charts the proportion of students across countries engaged in vocational education and training as opposed to academic general education, the United States is not on the chart. (...) The United States would show up as having no VET or career and technical education (CTE) at all. This is because while about one in five high school students concentrates in an occupational area, the course requirements are a small proportion of the high school diploma. (Hoffman, 2011, p. 6).

The role of company-based training provided by companies to their employees independent of government or educational connections is also significant in the United States. In fact, Stone III (2012) states that most occupational training and certification for workers takes place within business-based systems.

US CTE takes place in a public education system largely limited to high school; community or technical colleges serving a wide range of public needs; various government programs; a miniscule apprenticeship system; and a large business-based training system disconnected from all of the others. (Stone III, 2012, p. 233)

In the remaining of this article, I will concentrate in the public, secondary, CTE programs. According to data from the National Center for Education Statistics (NCES), of all U.S. high schools, 67.5% are regular high schools; 3.7% are career/technical high schools; and 28.7% are other special focus high schools — special program emphasis schools (such as science or mathematics schools, performing arts schools, talented or gifted schools, and foreign language immersion schools), special education schools, alternative schools, and other types of schools that do not fall into these categories (National Center for Education Statistics, 2008). Data from 2012 indicate that 66.9% of all high school students attend either CTE schools or schools that utilize shared-time or regional CTE schools (National Center for Education Statistics, 2012). These data include non-occupational CTE (courses that prepare students for roles outside the paid labor market, for example family and consumer sciences education), general labor market preparation (courses that teach general employment skills such as word processing and introductory technology skills) and occupational education, which teach skills required in specific occupations or occupational clusters. Using this classification, the NCES is able to say that 96.6% of U.S. high school graduates earn credits in CTE. If we consider only those who have taken three or more credits as CTE courses, that percentage falls to 61.5%. Note that these data also include CTE courses offered by regular high schools (Bradby, 2007).

3 Governmental reports, educational agendas, and federal legislation

Despite the decentralized character of career and technical education in the United States, federally supported investments in school reform have been a driving force behind many of the practices in secondary-level CTE. In this section I trace the history of federal CTE policy since the beginning of the 20th century. Following Popple and Leighninger (2007), I use a descriptive model detailing relevant policies and the background context in which they were originated, trying to map the driving forces behind the big picture of CTE in the United States.

3.1 A Nation at Risk?

At the end of the 1970s and beginning of 1980s, the American economy went through what came to be known as *stagflation* — a combination of high inflation and stagnation of the economic growth. In 1980, Ronald Reagan was elected president, and appointed a commission to examine the quality of education. His intention was to provide justification to close the Department of Education, which had been one of his campaign promises. As a result, in 1983 the National Commission of Excellence in Education published its report, entitled *A Nation at Risk* (National Commission on Excellence in Education, 1983). The report did not lead to the extinction of the Department of Education, but it triggered a sentiment that a supposed low quality of education was the cause of the country's economic problems for not producing skilled workers and professionals in the STEM fields. Some have argued that this conclusion had not support on data (Conley, 2015) and that there had not been an analysis of the link between education and economy that could justify these claims (Stone III & Lewis, 2012). In particular, the document's rhetoric was permeated by the notion that the country needed to prepare more scientists and engineers because there was a deficit of professionals in these areas, and because that would be the preventing the U.S. to be competitive at the international level. This discourse is still common today. However, Stone III and Lewis (2012), although agreeing with the importance of STEM, argue that these alarming claims do not have base on reality, and that there is actually three times more graduates from STEM university courses than there are job openings in those areas.

Notwithstanding these facts, which the majority of the population ignores, the impact of the *A Nation at Risk* in the country's ideology is suffered to this day, and has led to a series of

educational policies and agendas. The document alarmed the population, suggesting that the American educational system was not capable of preparing youth for work as well as competitors.

The award-winning best-seller *Thinking for a Living: Education and the Wealth of Nations* (Marshall & Tucker, 1992) argued that there was a massive imbalance between the resources available for the education of managerial, technical, and professional workers on the one hand, and line workers on the other, and that this threatened the United States' economic survival. The authors called for school reform that would follow the principles that America's leading industrial organizations used raise productivity without increasing costs. The book features a one-paragraph review by President Bill Clinton on its back cover. Not everybody agreed with this analysis, however. Noble (1994) reviewed the book and highlighted that there seemed to be "precious little connection between worker skill, training and education, on one hand, and the availability of secure, high-wage employment, on the other." (p. 16) He also pointed out that there was little reason to believe things would improve, so long as multinational corporations could shut down plants, go offshore, bust unions, and de-skill or automate jobs without constraint. For Noble, this stance was equivalent to "choosing a dubious high-tech patriotism over an ominous workplace realism" (p. 16), and meant blaming the victims—workers and students—for the nation's economic malaise, while ignoring more obvious explanations, such as corporate abandonment of the social contract with the complicity of the government.

Along the same lines, in 1989, the National Center on Education and the Economy (NCEE) — a non-profit organization dedicated to policy development and analysis based in Washington — formed the bipartisan Commission on the Skills of the American Workforce. A year later the commission published its report *America's Choice: High Skills or Low Wages* (Commission on the Skills of the American Workforce, 1990). According to the report, with changes in the nature of work and technology, workers would be forced to take greater responsibility and to exercise decision making and other higher forms of reasoning. This would require a change in the repertoire of knowledge, skills, and attitudes that workers would need to display upon entering the job market. The report identified the lack of clear parameters for vocational education as one of the many barriers the United States faced in obtaining a highly skilled workforce. According to the document, only with a strong system of standards and subsequent evaluation would vocational education and other workforce development efforts be able to adjust to the expectations and needs of employers.

In response to this wave of documents and public pressure, in 1994 Bill Clinton signed a law, *The Goals 2000: Educate America Act* (Public Law 103-227). This bill approved funding for the states and communities to make sure their educational systems were leading their students to reach their full potential. The Act was based in the premise of *outcomes-based education*, that is, that students will achieve higher if more is expected of them. This set the stage for a wave of standards, norms and accountability.

It is important to emphasize that curriculum theorists and education analysts stress that there is a pattern in blaming education for problems of all sort in the United States:

> Historically, the United States reacts with educational reform when confronted with social, political and economic challenges – in the 1930's there was an increase in vocational program to address the high unemployment rate, in the 1950's the curriculum was enhanced with a focus on science and mathematics to respond to the 'space race' and fears created by the launch of Sputnik. (Lafollette, 2011, p. 141)

Cobb (1994) argues that *Goals 2000* was no exception, and originated from economic and political forces outside of education.

Coupled with this discourse that creates the view that education is the solution for all problems in society, the democratic ideal has created a philosophy of college-for-all in the United States. After all, in a democratic society, some may argue, "all students should be given the opportunity for higher education; their college for all policy would mean educating all high school students the same way with one purpose: admission to college" (Stone III, 2012, p. 236)

For Hoffman (2011) the focus of U.S. policy is not even college admission, but postsecondary completion:

> Whatever one concludes about the United States' average performance in the transition to work, the United States is not average or middle-of-the-road in the education strategy it is pursuing—college for all. The United States is currently an outlier in focusing on postsecondary completion rather than on education having as its primary purpose to help young people find a calling or vocation. (p. 14)

The college-for-all phenomenon has another explanation: college degrees had become (and in some ways still are) a synonym for work readiness and employability. "Believing that the high school diploma no longer signifies meaningful achievement, and in the absence of a national system of industry credentials, employers rely on college degrees to ensure they're hiring the right candidates" (Stone III, 2012, p. 240).

The growing emphasis in accountability and the spread of outcome-based and competency-based education led to the development of standards and norms by states and other organizations. U.S. policy focus on college-for-all and the increasing pressure to ensure that all students leave high school *college-ready* led some higher education institutions to investigate what skills and abilities their first-year courses required of their students and thus map out the skills that would define college readiness. This action may be said to have been also influenced by the rise of competence-based pedagogy. The standards and evaluation systems developed were based on "what students should be able to do" — rather than "what subjects they should study" **—** in order to be ready for higher education. The idea was to shift college admission criteria from academic history to competency (Conley, 2015).

The strong push towards academic preparation in the United States has in a way undermined the goals of career and technical education. As Stone III points out, "[t]here is an implicit assumption in the college-for-all philosophy that CTE provides little or no value to participants." (Stone III, 2012, p. 239)

3.2 The birth of the College and Career Readiness agenda

After several attempts to define college readiness, the *American Diploma Project* (ADP) was the first major instance of linking the workplace to post-secondary readiness. It was developed by Achieve — an independent, nonpartisan, non-profit organization created in 1996 by a group of governors and business leaders. The group argued that the high-school diploma had lost its value because its requirements were disconnected from what it takes for graduates to compete successfully beyond high school — either in the classroom or in the workplace. The goal of the project was of determine the English and mathematics skills that high school graduates needed in order to be successful "in college and the workplace" and to help states incorporate those skills into their standards, assessments and high school graduation requirements.

> What will it take to restore value to the American high school diploma? *First*, state policymakers need to anchor high school graduation requirements and assessments to the

> standards of the real world: to the knowledge and skills that colleges and employers actually expect if young people are to succeed in their institutions. *In return*, colleges and employers need to start honoring and rewarding student achievement on state standards-based assessments by using these performance data in their admissions, placement and hiring practices. (Achieve, The Education Trust, & Thomas B. Fordham Foundation, 2004, pp. 3-4)

ADP worked with K–12, postsecondary and business leaders in five states, using market projections for "the most promising jobs" and pinpointing the academic knowledge and skills required for success in those occupations. The project also involved two- and four-year postsecondary institutions to determine the prerequisite English and mathematics knowledge and skills required for success in entry-level, credit-bearing courses in English, mathematics, the sciences, the social sciences and humanities.

> In some ways, ADP anticipated the discussions to come about the role of career readiness and addressed them with the option of viewing career readiness as a component of college readiness, at least to the degree that the opinions of employers helped specify the ADP standards. (Conley, 2015, p. 5)

The new catchphrase became then *College and Career Readiness*. For Stone III, the new slogan is predicated on the assumption that if a student is college-ready, he or she is also career-ready. (Stone III, 2012) Conley (2015) is more optimist and writes that models of college and career readiness had the premise that readiness for success in tertiary studies requires more from students than simple academic knowledge — factors such as the ability to apply academic content in complex contexts outside the discipline in which content was learned, the mentality that effort is more important than aptitude, self-management, the ability to succeed in an organizational context, among others (Conley, 2015).

But what was *career readiness*? The definition of career readiness imposed a new set of modeling challenges. In that initial vision of the American Diploma Project, career readiness was seen as a component of readiness for higher education. Whether one is a subset of the other or whether the two are separate things remained a point of debate. The American College Testing (ACT), which is one of the two large companies that have their large-scale assessments used for admission to universities, developed a study on the levels of reading and mathematical knowledge required for entry into some jobs and institutions and concluded that the same level of knowledge was needed in both contexts (ACT, 2006). This led many educators and policy makers to assume that this meant that college readiness and career readiness were essentially the same thing. This has had some negative impact on the creation of CTE courses because it was believed that if students were only to take academic courses, they would be prepared for the job market.

Another stream of curricula and prescriptions claimed that the focus should not be on what competencies were needed for the first job, but that students should be prepared for continuing education and to be always studying and acquiring the skills needed to advance in their careers of choice. Several studies have sought to identify the knowledge and skills necessary not only to enter a career, but to progress in it. Although recognizing that each career has its own demands, this approach sought to identify elements of career readiness that would be generic, such as self-management, impulse control, work ability, ability to work with others, communication skills, ambition, and personal goal setting (Conley, 2015).

Regardless of differences in philosophical views, aims, and goals, the push towards *College and Career Readiness* as a whole was responsible for introducing a concern with academic

preparation into CTE in the United States. In other words, CTE programs are increasingly held accountable for providing college preparation as well as career preparation.

3.3 Federal Legislation regarding CTE

Federal investment in secondary vocational education began with the passage of the *Smith-Hughes Act of 1917* (Public Law 64-347). The Smith-Hughes Act represented a compromise between various societal groups, and turned out to promote a segregated curriculum, with agricultural and industrial segments separated from academic programs (Braz Dias, 2017). The next most significant year in the legislative history of vocational education since 1917 was 1963, when the *Vocational Education Act* (Public Law 88-210) was signed into law by President Lyndon B. Johnson. (Gordon, 2014). The *Vocational Education Act of 1963* (Public Law 88-210, 1963) and its 1968 and 1976 Amendments expanded the provision of vocational education to people of all ages in all communities, including funding for programs for academically and economically disadvantaged and disabled students (Imperatore & Hyslop, 2017).

In 1984, the *Carl D. Perkins Vocational Education Act* was signed as a new amendment to the 1963 law, and replaced its previous amendments (Public Law 98-524). It began a series of legislative acts known by the name of Perkins, the 1984 one being now known as Perkins I.

Perkins II was signed into law by President George H. W. Bush in 1990, and had the meaningful name of *Carl D. Perkins Vocational an Applied Technology Education Act* (Public Law 101-392). This signaled the increasing importance of applications of technology in society. It also changed the scope of vocational education to all segments of the population. This represented a major shift from the way vocational education had been delineated before, in isolation from mainstream education. The new Act provisioned not only the integration of academic and vocational education, but also the articulation between different segments of education and a closer link between school and work (Gordon, 2014).

Two other major changes happened with Perkins II: one has to do with accountability, which will be further explored in the next section, and the other is the bypassing of state agency decision makers and the removal of all discretion of distribution of funds from state officials. Funds were allocated directly to local education agencies. Thus, the need for accountability: states were explicitly required to develop systems of performance measures and standards for the segment.

Perkins III was signed during Bill Clinton's presidency, in 1998, and again changed the nomenclature associated with vocational education, being entitled *Carl D. Perkins Vocational and Technical Education Act of 1998* (Public Law 105-332). But the present terminology Career and Technical Education was introduced by Perkins IV, the *Carl D. Perkins Career and Technical Education Improvement Act of 2006* (Public Law 109-270), signed by President George W. Bush. The main themes associated with Perkins IV were secondary-postsecondary connections, links to rigorous academic standards, greater accountability, and stronger focus on business and industry (Gordon, 2014).

In July of the current year President Donald Trump signed *The Strengthening Career and Technical Education for the 21st Century Act* (Public Law 115-224), which will go into effect July 1, 2019. Although it doesn't carry Carl D. Perkins' name in its title, it is being known as Perkins V (U.S. Department of Education, 2018).

3.4 Accountability and Integration

Another way in which the call for strong academics has interfered with the aims of CTE is through the increased accountability demands for meeting academic standards imposed to its programs.

In the Smith Hughes Act of 1917 there was no mechanism to evaluate who would receive funding for CTE. The Vocational Education Act of 1963 introduced accountability in relation to equitable access for population of low economic status and for those with disabilities. Call for accountability increased with the Perkins I. Damon (2010) argues that with occasional disputes over the need to allocate financial resources for vocational education, subsequent reauthorizations of the Perkins law have increased demands to justify the financing of CTE programs. In order to investigate this claim, I analyzed the discourse of the legislation, which I present in what follows.

The first Perkins Act (Public Law 98-524 of 1984) establishes that:

> "SEC. 403. (a) The Secretary shall conduct a national assessment of vocational education assisted under this Act, through independent studies and analysis by the National Institute of Education. The assessment shall include descriptions and evaluations of — (…)
> (5) the impact of vocational education programs on the achievement of academic skills and employment opportunities of students;"

That is, the law states that there should be a national evaluation of the programs that receive funds under this legislation, through independent studies and analysis by the National Institute of Education. Such evaluation should include, among other items, the impact of vocational education programs in obtaining academic skills and employment opportunities for students.

The Carl D. Perkins Vocational and Applied Technology Education Act Amendments of 1990, Public Law 101-392, known as Perkins II, has the following text:

> "(a) GENERAL AUTHORITY. — Each State board receiving funds under this Act shall develop and implement a statewide system of core standards and measures of performance for secondary and postsecondary vocational education programs. (…)
> "(b) REQUIREMENTS. — Each system developed under subsection (a) shall include —
> "(1) measures of learning and competency gains, including student progress in the achievement of basic and more advanced academic skills;
> "(2) 1 or more measures of performance, which shall include only —
> "(A) competency attainment;"

In this reauthorization the requirement for state creation of parameter systems and performance measures for vocational education programs at secondary and higher levels is already present. Moreover, these systems should not only measure the acquisition of basic academic skills but also "more advanced" skills.

Perkins III (Public Law 3105-332) continues to require eligible agencies to identify performance indicators in state plans and to include measures of the degree to which students have achieved "challenging" proficiencies, both academic and vocational and technical:

> ‘‘(2) INDICATORS OF PERFORMANCE. —
> ‘‘(A) CORE INDICATORS OF PERFORMANCE. — Each eligible agency shall identify in the State plan core indicators of performance that include, at a minimum, measures of each of the following:
> ‘‘(i) Student attainment of challenging State established academic, and vocational and technical, skill proficiencies."

Perkins IV (Public Law 109-270) continues to require students to meet "challenging" academic standards developed by the states. The law also requires programs that seek funding to implement professional development programs for teachers and other professionals involved in the CTE. Among the expected responsibilities of teachers, we find the development of "rigorous and challenging" curricula, in which academic subjects appear integrated, to the extent practicable; the development of a higher level of knowledge and skills professional and technical, academic and industry; and the use of applied learning methods that contribute to the student's academic, professional and technical knowledge:

> ‘‘(b) REQUIRED USES OF FUNDS.—The State leadership activities described in subsection (a) shall include —
> (…)
> ‘‘(3) professional development programs, including providing comprehensive professional development (including initial teacher preparation) for career and technical education teachers, faculty, administrators, and career guidance and academic counselors at the secondary and postsecondary levels, that support activities described in section 122 and —
> (…)
> “(D) will support education programs for teachers of career and technical education in public schools and other public school personnel who are involved in the direct delivery of educational services to career and technical education students to ensure that teachers and personnel —
> ‘‘(i) stay current with the needs, expectations, and methods of industry;
> ‘‘(ii) can effectively develop rigorous and challenging, integrated academic and career and technical education curricula jointly with academic teachers, to the extent practicable;
> ‘‘(iii) develop a higher level of academic and industry knowledge and skills in career and technical education; and
> ‘‘(iv) effectively use applied learning that contributes to the academic and career and technical knowledge of the student;

The new Perkins V, actually entitled Strengthening Career and Technical Education for the 21st Century Act of 2018 (Public Law 115-224) continues to emphasize the purpose of “promoting the development of services and activities that integrate rigorous and challenging academic and career and technical instruction, and that link secondary education and postsecondary education for participating career and technical education students” (Sec. 2, 20 U.S.C. 2301).

3.5 The hegemony of STEM education trickles into CTE

Coupled with the precedence given to college readiness, the role attributed to science and mathematics as the pillar of economic growth has put extra burden on CTE programs and teachers to not only prepare students for a career, but also to account for how they are contributing to students’ academic preparation in those disciplines. “Top policy leaders have made STEM central to their platforms, business leaders are calling for more STEM graduates and educators are demanding a greater focus on STEM in the classroom” (Ellner, 2015, p. 44).

All the while, the threat of funding cuts makes it crucial for educators to advocate for the value of CTE. Therefore, in order to defend their “place under the sun”, CTE programs have been having to showcase the STEM applications in their courses. In a true “re-branding” effort, CTE programs have relied on curriculum alignment with state standards for mathematics to

show that they already teach math in their courses. This alternative is preferred to having to require more mathematics credits into the already busy programs of study.

> First, throw out your current class description. The outdated paragraph describing the woodworking class your father took in his youth is no longer relevant, and certainly does not belong in your high school's current class catalogue. It's time to change the way you communicate your subject matter. Today's CTE classes already teach STEM at their core; it's naturally embedded deep within the curriculum. There's no need to overhaul your curriculum—again, it's simply a matter of re-branding. (Ellner, 2015, p. 47)

Publications in professional periodicals show a concern by teachers to actively communicate how their courses contain STEM elements: "Moving forward in this endeavor requires educators to take a purposeful look at CTE, abandoning antiquated perceptions about it as STEM is seamlessly integrated into curricula and experiences" (Geno, 2015, p. 33).

It is evident in CTE educators' discourse the need to not only provide evidence of results and of incorporation of STEM content, but also to be accountable to the needs of the business community: "Securing funding in a highly competitive environment requires a program that addresses the needs of the business community, one that demonstrates results via data and anecdotal information" (Emeagwali, 2015, p. 26).

In a coordinating effort, the National Association of State Directors of Career Technical Education Consortium (2013) has published a brief in which it advances the concept that "CTE is your STEM strategy":

> Simply put, STEM must not be viewed as a separate enterprise from CTE. While a state's CTE programs may not encompass everything within a state's STEM strategy, high-quality CTE programs can provide a strong foundation for and serve as a delivery system of STEM competencies and skills for a broader range of students. (National Association of State Directors of Career Technical Education Consortium, 2013, p. 1)

In a recent project, two collaborators from Brazil and I conducted a comparative study of Brazil and U.S. vocational education systems (Gonçalves, Dias & Peralta, 2018). As part of the project, we conducted fieldwork at a secondary CTE institution in the state of Michigan, and can offer evidence of such curricular integration taking place. The Automotive Technology program offered at that institution prepares students for a certification by the National Automotive Technicians Education Foundation (NATEF). That foundation elaborated, with funding from the ACT Foundation and the National Network of Business Industry Associations, a document highlighting the academic content embedded in the various NATEF tasks and aligning each NATEF task and its related academic content with the Common Core State Standards (CCSS), the academic standards adopted by several American states (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). An excerpt of that curriculum alignment effort is shown in Image 1. Notice that the connections established by NATEF are not based on a series of mathematics topics, but their "math objectives" consist of Automotive Technology measurable student outcomes.

MATH OBJECTIVES	COMMON CORE CONNECTION
V. Brakes ***Levers (brake pedal)*** ➢ Classify levers as I, II, or III ➢ Define Mechanical Advantage ➢ Measure and determine Mechanical advantage (i.e. Measure the pedal to fulcrum and from brake pedal travel adjustment to fulcrum to determine the mechanical advantage of the brake pedal) ➢ Identify gain or loss of force and distance based on lever design ➢ Use mechanical advantage to determine force and (distance) travel of levers	*N-Q1* *Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.* *N-Q3* *Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.* *A-REI3* *Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.*

Image 1: Excerpt from the Common Core connections guideline provided as an annex to National Automotive Technicians Education Foundation (2014).

While the pressure is on CTE teachers to account for how they implement the academic standards prescribed by the CCSS, content-area teachers still seem to ignore the opportunities offered by potential engagement with CTE.

To establish a reference point on the current level of CTE involvement in the implementation of the Common Core State Standards, Meeder and Suddreth (2012) conducted a survey with the purpose of determining how state education agencies are including CTE leaders as stakeholders or partners in their CCSS implementation efforts. Their findings suggest a rather substantial gap between the opportunity and need for involvement of CTE and CTE's current level of engagement.

> Not only do nearly half of responding states have no CTE representation on their CCSS implementation teams, but there is also the implication that, in their states, the CCSS are (currently) being viewed as purely an academic initiative, despite interest from CTE leaders to be involved. (Meeder & Suddreth, 2012, p. 7)

The authors concluded that a great divide still separates academic and CTE programs, and call for greater collaboration between academic and CTE teachers. Although collaboration is, in essence, a positive ideal, I however doubt the possibilities for authentic collaboration when one of the parties has more power and legitimacy, as do STEM teachers if compared to CTE teachers. With initiatives for curricular and standards alignment such as the one by NATF and other CTE teachers and association, these professionals may have a clearer shot at showing how CTE courses are beneficial to students without a need for more academic-focused courses.

4 Concluding remarks

In this paper I offered a portrait of vocational education in the United States of America and its place in that country's education system. I have also shown that through a combination of governmental agenda, accountability discourse on legislation, and pressure from state governments and businesses alike, teachers have been having to make evident how their technical courses contribute to the achievement of academic parameters in mathematics. The interplay between the need for legitimation of their programs and for maintaining the authority over their courses has led teachers to focus on convincing authorities that their technical courses already teach a great amount of mathematics and science. This approach can be considered

more engaged then simply changing programs to require more mathematics and science credits from courses taught by mathematics and science teachers in the academic high school. A next step may be for mathematics educators and curriculum theorists to challenge the official discourse that attributes essential importance to mathematics for economic growth, examining if claims for the need for more STEM professionals can indeed be backed by data, and making more precise the general utterances that permeate the official discourse. For example, is the alleged "STEM gap" a gap in the number of STEM workers — which Stone III (2012) suggests not to be true — or a gap in the knowledge of STEM workers? In what career clusters is this gap more noticeable? If a focus on college readiness and academic skills is necessary, how do we explain the fact that the U.S. international competitors said to offer better STEM preparation for their citizens often have vocational education systems with a stronger technical component (Hoffman, 2011)? The "intrinsic goodness" of mathematics and science taken for granted in educational discourse and in the public imagination has been argued by Pais (2018) to be a myth. A conversation between mathematics education curriculists that take a political (mainly critical) approach to their scholarship and the career and technical education community can prove fruitful to unpack the truths and ideologies behind the current push for accountability and the role of STEM in career and technical education in the United States.

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