The role of mathematics in vocational education curricula: a comparative study

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Summary

In the study reported in this paper, the authors take a comparative framework to study, compare, and contrast legislations, guidelines, and programs of Career and Technical Education in the United States of America and programs of Professional and Technological Education in Brazil. The study seeks to answer the question: How do the educational goals and aims of the different curricula shape the role of mathematics education in the curriculum? The main official legislations analyzed were the American Perkins IV and the Brazilian National Guidelines for Technical and Professional Education at the Secondary Level. The methodology used was the development and application of a criterion for comparison, using a four-stage process to produce comparative hypotheses that can be used in future typologies. Preliminary results suggest that, although the American system is concerned with preparing students for postsecondary education as well as career, this emphasis is not found in the Brazilian case.

Key Words: education, mathematics, vocational education, curriculum integration, comparative education.

Introduction

Vocational education has been defined differently in different countries. The legislations governing such segment of education are diverse, as are the social, economic, and cultural factors that affect them. Nonetheless, in today's globalized world vocational education systems face many of the same challenges in different countries, and have the general mission of preparing students careers and jobs, by focusing on the development of occupation-specific knowledge and skills.

In the context of mathematics education, the contextualization of mathematics in realistic situations (realistic mathematics education), the use of mathematical modeling as a teaching strategy, and an interdisciplinary approach to mathematics education has been a focus of research and recommendations for many decades (Barbosa, 2001, 2004; Lozada, 2011).

The connections between vocational education and mathematics education take then an obvious dimension, since we are led to ask if vocational education, with its focus on occupation-specific knowledge and skills, wouldn't be a context where mathematics appears integrated, par excellence, into aspects of the real world and into meaningful problems.

A previous work by Gonçalves, Dias and Peralta (2014) indicates that this connection might not be so obvious, or does not occur to a great extent. The study investigated the conceptions that teachers in an institution of secondary vocational education in Brasil (an institution of *Educação Profissional Técnica de Nível Médio*, as the segment is coined in Brasil) have concerning the integration of mathematics into vocational-specific courses. That study describes structural aspects indicated by the teachers as obstacles to an integration of mathematics into vocational curricula.

The connection between mathematics education and vocational education, which theoretically makes a lot of sense, has also caught the attention of North American researchers. Nkata (2013) posits that the search for relevance in STEM (Science, Technology, Engineering, and Mathematics) suggests that we should look for more sinergy between STEM education and Career and Technical Education (the term used in the United States for the formerly so-called vocational education).

Still in the context of American Career and Technical Education (CTE), Meeder and Suddreth (2012) affirm that, even in CTE programs, the integration of real world contexts with academic content are almost non-existent.

> Effective career and technical education (CTE) programs have an inherent advantage because they are modeled closely after real careers that students may one day enter. They can readily demonstrate the answer to questions such as "How am I ever going to use this?" and "Why should I learn this?" Reading, written communications, listening, speaking and mathematical reasoning (with problem solving) are embedded in careers — especially in the middle- and high-skills careers that lead to family-supporting wages and benefits. And given that the majority of those middle- and highskills jobs require some education and training beyond high school, the link between the academic preparation and the technical preparation for careers becomes even stronger. (p. 4)

Despite this argumentation, Meeder and Suddreth affirm that career preparation and academic preparation remain in two separate "silos".

In 2012, the investigators involved in this project wrote a series of three research articles in which they delineate the history of professional education in Brazil. (Gonçalves et al., 2013a, 2013b, 2013c). With the aim of advancing such studies towards an international perspective, in 2013 the group sought the formalization of an agreement between the institutions to which they are affiliated. In 2014, a Memorandum of Understanding between the Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP) and Central Michigan University (CMU) was signed. The agreement foresees, among other things, the formation of collaborative research teams and the development of collaborative research projects involving the two universities.

In the study reported in this paper, the authors take a comparative framework to study, compare, and contrast legislations, guidelines, and programs of Career and Technical Education (CTE) in the United States of America and programs of Professional and Technological Education (PTE) in Brazil[1]. The study seeks to answer the question: How do the educational goals and aims of the different curricula shape the role of mathematics education in the curriculum?

Methodology

The Theoretical Basis for Comparative Research into Vocational Education

In face of the global "new economic order", vocational education systems are affected by what goes on internationally (Gordon, 2014). Many governments compare their states' curricula with international models when seeking new initiatives and when trying to boost international competitiveness.

Pilz (2012a) explains the need for research into comparative vocational education and training. In his argument, made from several examples of current events in vocational education and training, he makes clear that different countries may be facing different challenges, but that they are related in important ways, and that an international and comparative approach is necessary for a comprehensive understanding and improvement of any particular system. This is not an easy task. In Pilz's view, "[a]voiding ethnocentrism is important but also perhaps the most serious challenge in moving forward." (p. 2)

Pilz (2012b) raises the point that because vocational and technical training is defined in fundamentally different ways in an international context, we need elaborate on how we can "compare apples to oranges". He cites Hörner (in Pilz, 2012b, in his own translation from the German) to argue that the key point is how the comparison is framed: "In contrast to popular belief, apples can be compared with oranges or pears, provided there is a meaningful criterion for comparison (their juice content, for example) or a criterion for establishing difference, such as the shape of the fruit." (p. 563).

As examples of criteria for comparison in comparative vocational training research, Pilz (2012b) cites a) the relative value of general and vocational education; b) the permeability of education and training systems; c) different forms of certification assigned by vocational education; d) the costs of a vocational education or training; and d) the extent to which such education has currency on the labor market. Another much used criterion for comparison in the field is how attractive vocational education is in each context.

In this paper we will compare the American and the Brazilian vocational education systems in relation to how their educational goals and aims shape the role of mathematics education in the curriculum.

Pilz (2012b) also points out that the selection of countries to be compared is also relevant

[1] Education for careers and work take different names in different countries and at different times. At the present, the United States use the term "Career and Technical Education" (CTE), whereas the equivalent in Brazil is "Professional and Technological Education" (PTE). At the secondary level, the Brazilian educational segment is termed Educação Profissional Técnica de Nível Médio, or Professional and Technical Education at the Secondary Level. In the past, both countries used terms including the word "vocational", which has been avoided now in these two countries. In Europe, the term "Vocational Education and Training" (VET) is being used. In our writing, most of the time we will use the term that is used in the original context – place or time.

to the second aspect, that of access. The choice of countries to be the contexts of investigations should entail not only worthwhileness to the field, but also a pragmatic dimension. It is imperative that researchers are fluent in the language of the countries, so as not to rely on translations of the literature and documents produced by a country. This pragmatic justification of convenience and possibility of access can definitely aid the justification of a comparison between Brazilian Professional and Technical Education at the Secondary Level and American Secondary Career and Technical Education.

Data and Methods

For the development and application of a criterion for comparison, a four-stage process has been applied, based on the framework developed by Pilz (2012b). The initial stage involved observation and description of the two cases (the *descriptive* stage). In this initial phase, we conducted a study of the planned curricula of the two countries by describing and analyzing policy documents and official curricular prescriptions in each nation. A theoretical interpretation for the observations constructed in the first phase is sought next (the *explanatory* stage) and presented as preliminary results in this paper. Subsequently, a *juxtaposition* stage will offer a side-by-side analysis, and a final *comparative* stage will produce comparative hypotheses that can be used to assess relationships between countries with reference to the criterion for comparison.

The data used in this study consist mainly of documents that were obtained from the websites of government offices, associations, and educational institutions. The official legislations analyzed were the Carl D. Perkins Career and Technical Education Act of 2006 (United States Congress, 2006) and the *Lei de Diretrizes e Bases da Educação Nacional* (LDB - Lei nº 9394/1996), the *Diretrizes Nacionais para Educação Profissional Técnica de Nível Médio*, Resolution CNE/CEB number 06/2012.

A content analysis of the data is being performed, coding, categorizing, and scaling relevant textual units and applying interpretative abstraction to the text. As a first method, a computer program was used to find the mentions of the words *mathematics*, *integration*, and *STEM* in the referenced texts.

Preliminary results and discussion

Seeking information for understanding the relationship between mathematics teaching and professional education in the American literature we could not help but notice an effort to assess how participation in CTE courses was reflected in enrollment and degrees in disciplines in the exact sciences, particularly mathematics in higher education. This finding led us to conjecture a basic difference between the American case and the Brazilian case, since this seemed to be a non-issue in the Brazilian case. In looking for an explanation for this observation, we conjectured that the difference came from the different goals of Career and Technical Education in the United States and the Professional and Technical Education in Brazil. In the next phase of the study we tried to verify our conjecture by examining planned/prescribed curricula as they were found in major legislations in each country – the Carl D. Perkins Career and Technical Education Act of 2006 (U. S. Congress, 2006) and the *Lei de Diretrizes e Bases da Educação Nacional* (LDB - Lei nº 9394/1996), the *Diretrizes Nacionais para Educação Profissional Técnica de Nível Médio*, Resolution CNE/CEB number 02/1997 and the amendments made by the resolutions numbers 01/2005 and 04/20005.

The Constitution of the United States makes no privison for federal control or support of education (Gordon, 2014). However, the federal government has had an enduring interest in vocational education. Since 1917 there have been a number of legislations concerning vocational education. But it was after the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983) that education reforms have focused on secondary education, as a means of attacking the perceived deficit in the American Educational system.

In 1990, President George H. W. Bush signed into the law the Carl D. Perkins Vocational and Applied Technology Act (Perkins II), which amended and extended the Carl D. Perkins Vocational Eduation Act of 1984. The 1990 Act introduced the new terminology “Vocational and Applied Technology”, which points at the congress’ view that academic and technological skills are necessary, together with vocational skills, for jobs in an advanced society.

In 2006, the language in the Perkins Act was updated from “vocational and technical education” to “career and technical education”, with the Carl D. Perkins Career and Technical Education Improvement Act of 2006 (Perkins IV: Public Law 109-270).

In the hearing held in Washington, DC, in September 20th of 2013, entitled *Preparing today's students for tomorrow's jobs : a discussion on career and technical education and training program*, Deputy Commissioner John Fischer explains that “[t]his transition was more than just a name change. It represented a fundamental shift in philosophy from CTE being for those who were not going to college to a system that prepares students for both employment and postsecondary education.” (United States Congress, 2013, p. 51.)

The term ‘career and technical education’, as defined in the Carl D. Perkins Career and Technical Education act of 2006 (U. S. Congress, 2006) means “organized educational activities that:

> (A) offer a sequence of courses that—
>
> (i) provides individuals with coherent and rigorous content aligned with challenging academic standards and relevant technical knowledge and skills needed to prepare for further education and careers in current or emerging professions;
>
> (ii) provides technical skill proficiency, an industry-recognized credential, a certificate, or an associate degree; and
>
> (iii) may include prerequisite courses (other than a remedial course) that meet the requirements of this subparagraph; and
>
> (B) include competency-based applied learning that contributes to the academic knowledge, higher-order reasoning and problem-solving skills, work attitudes, general employability skills, technical skills, and occupation-specific skills, and knowledge of all aspects of an industry, including entrepreneurship, of an individual.” (p. 4)

The use of terms such as “rigorous content” and “challenging academic standards” embedded career and technical education into the “college and career readiness” national agenda. According to the new paradigm, career and technical education’s aim is not only preparing for jobs and careers, but also for postsecondary education.

According to the new act, State Plans for the use of Perkins grants had to describe:

> "how the eligible agency will—
>
> (A) improve the academic and technical skills of students participating in career and technical education programs, including strengthening the academic and career and technical components of career and technical education programs through the integration of academics with career and technical education to ensure learning in—
>
> (i) the core academic subjects (as defined in section 9101 of the Elementary and Secondary Education Act of 1965); and
>
> (ii) career and technical education subjects;
>
> (B) provide students with strong experience in, and understanding of, all aspects of an industry; and
>
> (C) ensure that students who participate in such career and technical education programs are taught to the same challenging academic proficiencies as are taught to all other students." (U. S. Congress, 2006, Sec. 122(c)(7)).

State leadership activities shall include developing, improving, or expanding the use of technology in career and technical education that may include ''providing career and technical education students with the academic and career and technical skills (including the mathematics and science knowledge that provides a strong basis for such skills) that lead to entry into technology fields, including non-traditional fields". (U. S. Congress, 2006, Sec. 124(2)(B)).

At the 1996 National Education Summit a group of governors and corporate leaders created an organization dedicated to transforming the concept of "college and career readiness "from a radical proposal into a national agenda." (Achieve, 2012) The organization, Achieve, is "an independent, bi-partisan, non-profit education reform organization." (Achieve.org)

In *The Future of the U.S. Workforce: A Survey of Hiring Practices across Industries* (Society for Human Resource Management and Achieve, 2012) it is argued that "all industries are projecting that future jobs will require more skills, education and credentials at all levels, with some variations based on the industry and current levels of education required."(p. 2) The report anticipates higher education requirements for most jobs, and more jobs with more specific technical requirements in the future.

Under this argument a push has been made for the integration of high-quality academic and technical education programs, further emphasizing that students participating in CTE must meet the same rigorous academic standards as all other students.

In particular, the role of Science, Technology, Engineering and Mathematics education (STEM) has been emphasized.

> "CTE has long been a leader in the integration of high-level academics and technology For example, CTE courses in agriculture, nutrition and health care have always contained strong science, components, in many places earning students core academic credits. During the last decade, however, literally thousands of new cutting-edge, STEM-intensive CTE programs have been launched or expanded in schools across the nation." (Association for Career and Technical Education, 2009, p. 3).

According to the Independent Electrical Contractors (IEC), career and technical education has been succeeding at that. “The national average graduation rate for CTE students is over 90 percent, while the average national graduation rate for all students is less than 74 percent. CTE students are out-performing academic benchmarks.” (In United States Congress, 2013, p. 20). The association provides the indicators in Table 2.

Table 2.

Academic Benchmarks and CTE indicators.

CTE indicator	Target performance	Actual performance
Reading/Language Arts (Secondary	67%	72%
Mathematics (Secondary)	59%	63%
Technical Skill Attainment (Secondary)	68%	75%
Technical Skill Attainment (Postsecondary)	70%	82%

Source: Prepared Statement of John Fischer, Deputy Commissioner, Transformation & Innovation, Vermont Agency of Education. In United States Congress, 2013, pp. 20-21.

In Brazil, the National Guidelines for Technical and Professional Education at the Secondary Level (CNE / CEB No. 06/2012) indicates that the aims of professional and technical education is to provide the student with professional skills and knowledge necessary for professional practice and citizenship. The document emphasizes that the Technical and Professional Education at the Secondary Level should be articulated with secondary education and its different modalities, including Youth and Adults (EJA), and the dimensions of work, technology, science and culture.

According to the guidelines, professional education courses are organized by technological axes contained in the National Catalogue of Vocational Courses, established, organized by the Ministry of Education or in one or more occupations Brazilian Classification of Occupations (CBO). The structuring of the courses must consider: (i) the technological matrix, covering methods, techniques, tools, and other elements of technology relating to the courses; (ii) the common core corresponding to each polytechnic technological hub in the course, comprising scientific, social, organizational, economic, political, cultural, environmental, aesthetic and ethical foundations underpinning technologies and their contextualization in the system of social production; (iii) the knowledge and skills in the areas of languages and codes, humanities, mathematics and natural sciences, linked to basic education should permeate the curriculum of technical secondary courses, according to the specifics of these as essential elements for training and professional development of the citizen; (iv) the relevance, coherence, cohesion and consistency of content, articulated in terms of the work undertaken as an educational principle, contemplating the necessary conceptual and methodological bases; (v) the permanent updating of courses and curricula, structured comprehensive database, research and other relevant sources of information.

The article 14 of the guidelines makes explicit that curricula must provide students: (i) dialogue with various fields of work, science, technology and culture as fundamental references of their formation; (ii) elements to understand and discuss the social relations of production and labor, as well as the historical specificities in contemporary societies; (iii) resources to perform their work with competence, intellectual and technological competence, autonomy and responsibility, guided by ethical, aesthetic and political principles as well as commitment to building a democratic society; (iv) intellectual mastery of the relevant technological axis to enable the ability to build new knowledge and develop new professional skills with intellectual autonomy; (v) occupation-specific tools, grounded in the experience of different practical work situations; (vi) fundamentals of entrepreneurship, cooperatives, information technology, labor law, professional ethics, environmental management, safety, innovation management and scientific research, managing people and managing social and environmental quality of the work.

It is noted that in Brazilian Professional Education the predominance is training professionals to meet the demands of the "world of work", which, although a concept that transcends market positions when it recognizes its egresses as autonomous workers that are ready to act on and transform the reality of their future professions, is very far from the concern with preparing students for college. For careers that require postsecondary education, the Brazilian system has a network of federal institutes of higher education, whose regulamentation is out of the scope of this work.

It seems thus that in this preliminary batch of results we can identify a fundamental difference between the American and Brazilian vocational systems. This can be used as a criterion for the examination of other systems or the development of typologies in the future.

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