MATHEMATICS AND THE WORLD OF THE WORK: A HISTORICAL RELATIONSHIP

A MATEMÁTICA E O MUNDO DO TRABALHO: UMA RELAÇÃO HISTÓRICA

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Antonio Henrique Pinto

ahp.mat@gmail.com

Federal Institute of Espírito Santo

ABSTRACT

In this work, we weave the strings of memories of the Federal Technical School of Espírito Santo, in the 1960s, to highlight the important and complex relationship between mathematics and vocational education. Our goal is to show that, throughout history, the development of mathematics and its teaching walked side by side with the scientific and technological development, which enabled people to create techniques and technologies to solve problem situations of their reality. Thus, in the context of the mid-twentieth century, mathematics teaching has become a very important element in the school curriculum and in vocational education, enlightening the historicity and the contradiction of the relationship between work and education. Thus, we conclude that the presence of mathematics in the curriculum of vocational education sheds light on human existence, evidenced in the experiences that configure the conceptions of education, work and human kind.

Keywords: Mathematic Education; Professional Education; Technology; World of the Work; Curriculum.

RESUMO

Neste trabalho entrelaçamos os fios da memória da Escola Técnica Federal do Espírito Santo nos anos 1960, para enfatizar a relação importante e complexa entre matemática e educação profissional. Nossa meta é mostrar que, através da história, o desenvolvimento da matemática e seu ensino tem caminhado lado a lado com o desenvolvimento tecnológico e científico, o que possibilitou que as pessoas criassem técnicas e tecnologias para resolver situações problema de sua realidade. Assim, no contexto da metade do século XX, o ensino da matemática se tornou um importante elemento no currículo escolar e na educação profissional, iluminando a historicidade e a contradição da relação entre trabalho e educação. Desta forma, concluímos que a presença da matemática no currículo da educação profissional lança luz sobre a existência humana,

evidenciada pelas experiências que configuram as concepções de educação, trabalho e gênero humano.

Palavras-chave: Educação Matemática; Educação Profissional; Tecnologia; Mundo do Trabalho; Currículo.

1. Introduction

Since ancient times, the development of mathematics has walked side by side with scientific and technological development, providing brilliant inventions. In recent decades we have witnessed the increasing use of technology in people's daily lives, a factor that impacts on social relations and the way people live and work. In this context, mathematical knowledge has become a necessary tool for the training of workers, qualifying them for the various branches of professional activities. This makes it essential to teach this discipline in the school curriculum and in vocational education.

Intertwining the threads of the memories of the Escola Técnica Federal do Espírito Santo (ETFES) in the 1960s, this paper analyses the complexity that the curricular construction represents in vocational education, in a context marked by the massive presence of technologies. Thus, we assume that the school institution is constituted from the historicity and contradictions present in the relation work and education, aspect that makes the school curriculum a stage where the issues of human existence are outlined, evidenced in the unique experiences that mingle mathematics and society.

2. Mathematics and the world the work

Brynjolfsson and McAffe (2014) emphasise that mathematical knowledge has enabled incredible technological inventions, especially in this age of intelligent machines, and this has transformed forms of work and social relations. In the researchers' opinion, this process has induced proposals for reforms in the school curriculum, especially for high school. They state that the presence of digital technologies in various spheres of society has provided:

- new ways of communication and interaction in society, especially among young people;

- new forms of material production, with the growth of the service sector and flexible production, replacing the Taylorist-Fordist standardisation;

- the need to articulate, in the curriculum, the world of work and the cultural, scientific and technological spheres.

In this sense, we highlight the relevance of a question that crosses the history, that is, the curricular integration based on the mathematical knowledge, in the perspective of the human formation that has on the tripod work, science and culture the axes of the curricular organisation.

Miorim (1998), when analysing the historical course of mathematics education, reports how the concern with the teaching of mathematics went parallel to the development of this science, in a cut that goes from ancient times to the twentieth century. The author highlights, for example, that, in the late nineteenth and early twentieth centuries, this concern led many mathematicians to organise the first "international reform movement for mathematics teaching", led by Félix Klein, a German professor and mathematician, who sought to articulate the approach of a theoretical teaching of non-professional schools to the teaching of vocational schools, characterised by being more practical and interested in solving problem situations. This articulation and integration made it possible to break with the "old separation between a classical and a technical formation, that one destined for those who would continue their studies, this one for those who should only work" (Miorim 1998, p. 71).

For D'Ambrósio (1996), mathematical knowledge has a practical dimension associated with people’s socio cultural context. In the educator's opinion, in all societies people produce skills and knowledge that can be understood as techniques to solve problems derived from their social cultural context. Each culture systematises this experience in a certain way, according to its language and mode of expression of the relationships between a human being and their fellow human being, and with the world around them. In this way, we find mathematics "[...] in handmade works, in artistic manifestations and in commercial and industrial practices" (D'Ambrósio, 1996, p. 10).

In the preface to *Conceitos fundamentais da Matemática*, Caraça (1989) develops an interesting argument in favour of a mathematics, understood from an imbrication between the practical knowledge of the real world and the disinterested knowledge of that reality:

> Beyond dispute, mathematics has its own problems, which have no immediate connection with the other problems of social life. But there is no doubt also that its foundations plunge as much as any other branch of science in real life; both of them share the same mother. (Caraça, 1989, p. XIV).

Davis and Hersh (1985), in *A experiência Matemática*, analyse the relationship between mathematics and philosophy, making a historical-epistemological approach, emphasising mathematical knowledge by pertinence to solving problem situations. In this way, as problem-situations become more complex over time, these researchers understand that mathematical knowledge develops cumulatively throughout history.

For Davis and Hersh (1985), the vigour and vitality of this science creates, establishes, and explains the relations of quantity and space and their importance from ancient times to the present day, demonstrating their practicality in solving problems, and their applicability to other branches of science.

3. Mathematics and its relation with human formation

In the 1960s, the expansion of people’s schooling was driven by economic development, in a context in which a large part of the youth demanded a professional qualification. For Souza (2008), the idea that a new society emerged in that context of the 1960s caused the emergence of values and behaviours appropriate to the urban-industrial-technological world by "[...] the displacement of the humanities to the scientific culture" (Souza, 2008, p. 285). In this context, high school had a humanistic identity, aimed at formatting an elite.

Silva's analysis (1960) on mathematics teaching in the 1960s highlights some guidelines that determined the way didactics developed in the classroom. In that context, the teaching of mathematics should develop in the student:

- the capacity for judgment;

- the habit of conciseness;

- intuition;

- agility of action and reasoning;

- attention and readiness to understand, retain and elaborate.

According to Silva (1960), these aspects were highlighted by the National Committee on Mathematical Requeriments, a commission of the American government that analysed and proposed changes to the teaching of mathematics in that country. Following those guidelines regarding the objectives of mathematics teaching, the author classifies them into three categories:

1. *Automatism:*
   a. habits - of study, of accuracy, of rigor, of precision, of order, of clarity, of correction of language, of concision, of persistence in work, of cleanliness, and of verification of results;
   b. specific skills - in measuring, comparing measurements, calculating, consulting charts and tables, organising and interpreting graphs, constructing charts and tables, mastering symbology and mathematical terminology, recognising geometric figures, associating geometric curves with algebraic equations and vice versa, organising forms, and so on.
2. *Ideative elements*: information and knowledge of mathematics about its concepts, its scientific methods, the development of its reasonings, its postulates and theorems.
3. *Emotional elements*: the taste for problem solving, the aesthetic appreciation of geometric forms, the perception of the identity of the methods and procedures employed in different branches, often in apparent interrelationships.
   (Silva, 1960, p. 17).

Regarding the purposes of mathematics, the author suggests adopting a unifying vision, avoiding the temptation to separate what is utilitarian from what is academic, and what is practical from what is theoretical (Silva, 1960, p.18). For this, she refers to Félix Klein for a view of a mathematical knowledge linked to the needs of the social environment and the ends of education, aspects that vary for each age and culture.

In this regard, in the mid-twentieth century context, the growing incorporation of science and technology into the production system imposed a change on the school curriculum, both from the point of view of the contents and from the methodological point of view. In fact, since the 1950s, a change in the teaching of mathematics had been advocated. This transformation was based on international guidance such as the recommendation of the United Nations Educational, Scientific and Cultural Organization (Unesco) when, in 1955, it suggested that "[...] the modern approaches for mathematics teaching proposed by the modern mathematics movement should be adopted" (Unesco, 1955).

In Brazil, the context was of social, political and cultural changes, aspects that provided alterations in the educational legislation. Law Nº 4.024 / 1961 of the Guidelines and Bases of National Education, provided a great appreciation of vocational education, inasmuch as it established the curricular equivalence between high school and technical-vocational education. In 1971, a new change added value to vocational education, since it instituted compulsory vocational training in the high school level (Brasil, Lei 5.692/1971).

In that context, those changes in legislation somehow influenced changes in the school curriculum. In the Technical School of Vitória, for example, it is noteworthy the adoption of the methodological approach advocated by the modern mathematics movement. The teaching program of the course of the Industrial Junior High School (Ginásio Industrial), of 1969, had the curriculum organised from the set theory, as shown in Chart 1:

Chart 1 - Mathematics program of the 1st grade of the Ginásio Industrial Course - 1969

1st Grade
1. Sets a) Conceptualisation and determination - identification of its elements b) Concept of relevance c) Singleton - empty set d) Inclusion relationship e) Union and intersection - properties f) Equality and sets - properties **2. Set of integers** a) Representation and numbering system b) Addition and reverse operation - properties c) Multiplication and reverse operation, properties d) Potentiation and reverse operation - properties. e) Practice of extracting the square root **3. Divisibility** a) Multiples and divisors b) Prime numbers c) Maximum common divisor and minimum common multiple **4. Set of rational numbers (integers and fractions)** a) Representation (fractional and decimal) b) Addition and reverse operation - properties c) Multiplication and reverse operation, properties d) Potentiation and reverse operation - properties 5. Intuitive study of the main geometric figures 6. Decimal measure system a) Decimal system b) Notions about other non-decimal systems in use

Source: Ifes Archive.

In the 1st grade, the contents relate to the theory of numerical sets and their properties. There is no clear evidence that this approach has been adopted among ETFES teachers. Possibly, the mention of those contents that are pertinent to the proposal of the modern mathematics movement can be justified, on the one hand, by the need to attend to the modism of this movement and, on the other, by the reception to the conception of professional formation based on the perspective of a fragmented knowledge, including mathematical knowledge itself.

In the 4th grade, the contents associated to the numerical, algebraic and geometric field are collected, without relating them to each other or to their applications. In all grades, the distribution of topics, the terminology used, and the introduction of the set theory confirm the choice for a "modern mathematics" program, as shown in Chart 2:

Chart 2 - Mathematics program for the 4st grade of the Ginásio Industrial course - 1969

4th Grade
1. Set of real numbers a) First notions of real number and its representation on the line b) Radicals: power with relative rational exponent, operations and properties **2. Second degree equations** a) Generalities, resolution b) Bi-square equations, irrational equations c) Simple system of the second degree of two equations with two variables **3. Functions** a) Linear function and its Cartesian graphic representation b) Graphic resolution of the system of equations c) Second degree trinomial function, graphic representation **4. Similarity** a) Ratio and proportionality of segments. b) Thales's theorem, similarity of triangles, similarity of polygons c) Notion of sine and cosine **5. Metric relations** a) In a right triangle b) In any triangle, the laws of sines and cosines **6. Regular polygons and circumference measurement** a) Inscribed and circumscribed regular polygons b) Construction and metric relationship between square elements c) Notion about circumference measurement and Pi number d) Areas of the main plane shapes

Source: Ifes Archive.

In relation to high school, the mathematics program of the technical course gives to mathematics teaching a deeper understanding of the concepts of algebra, geometry, arithmetic and trigonometry. These courses were created with the purpose of providing the workers with a technical-scientific qualification that would be adequate for the development of the technologies used in the industries. In this sense, the perspective of curriculum integration and articulation with the applications demanded in the workshops and laboratories constituted a principle of the vocational education. The teaching program is shown in Chart 3:

Chart 3 - Program of the 1st grade of the Técnico Industrial course (1961)

1st Grade
I) Algebra 1. Progressions 2. Logarithms 3. Exponential equations **II) Trigonometry** 1. Proportional lines. Similarity. Scale between the sides of a triangle 2. Basic formulas of trigonometry. Functions of the 30- and 60-degree angles 3. Trigonometric functions of complementary angles. Natural trigonometric tables. Rectangle resolution 4. Circle Equation 5. Trigonometric functions of supplementary arcs, of arcs that differ from 180 degrees or whose ends are on the same diameter 6. Arc operations: sum, subtraction, multiplication and division. Logarithmic transformation 7. Theory of logarithms. Using tables 8. Resolution of triangles using the logarithmic-trigonometric tables 9. Trigonometry applied to practical cases

10. Evaluation of areas of irregular shapes. Simpsom's formula and Poncelet's formula

Source: Ifes Archive.

The 1st grade starts with the study of numerical sequences, followed by the study of trigonometry, which is very emphasised. This emphasis could be justified by the applicability of this subject in the various technical courses the school offered. Questions about the concept of logarithm, use of problem solving and the articulation with workshop activities, among others, are not clear enough. The only item that comments on "applying trigonometry to practical cases", does not clarify the nature of these applications.

The program of the 2nd grade is even more synthetic, bringing contents related to algebra and geometry, without any methodological indication, references to teaching objectives or articulation with other contents of mathematics or other disciplines. The program of the 3rd grade presents contents related to algebra and analytical geometry, with the beginning of mathematics topics of higher education, such as differential and integral calculus, as shown in Chart 4:

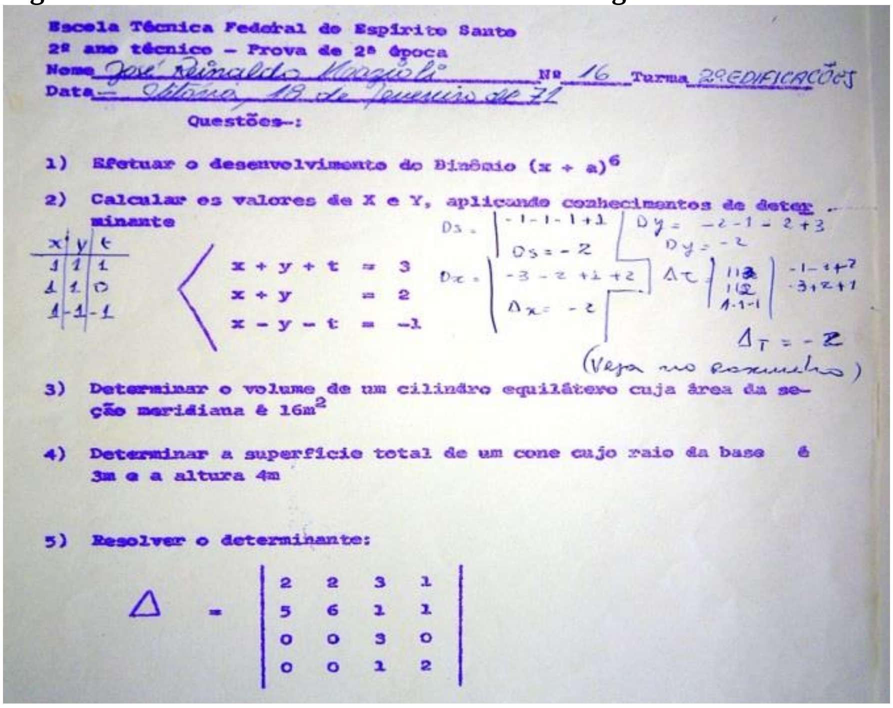
Chart 4 - Program of the 3st grade of the Técnico Industrial course (1961)

3rd Grade
I) Algebra 1- 2nd degree trinomial 2- Real and Complex Numbers 3. Functions 4- Limits 5- Derivatives 6- Immediate Primitive 7- Polynomials 8- Introduction to the theory of equations **II) Analytical geometry** 1-Cartesian coordinates 2- Important problems 3- Linear function and the straight line 4- Classical problems of the line 5- Circumference

Source: Ifes Archive.

The contents, the methodological approach and the evaluation process begin to identify with the propaedeutic model, moving away from an integrative and articulated conception and from the effective application in the workshops and laboratories, evidencing a process of academicism of technical education, characterised by conceptual rigor centered on a formal and axiomatic perspective, as well as the propaedeutic style of high school:

Figure 1 - Mathematics examination for the 2nd grade of the technical course (1971)


Escola Técnica Federal do Espírito Santo
2º ano técnico – Prova de 2ª época
Nome José Reinaldo Margioli Nº 16 Turma 2º EDIFICAÇÕES
Data – Oitavo, 18 de Janeiro de 71

Questões–:

1) Efetuar o desenvolvimento do Binômio $(x + a)^6$

2) Calcular os valores de X e Y, aplicando conhecimentos de determinante

$$\begin{cases} x + y + t = 3 \\ x + y = 2 \\ x - y - t = -1 \end{cases}$$

3) Determinar o volume de um cilindro equilátero cuja área da seção meridiana é $16m^2$

4) Determinar a superfície total de um cone cujo raio da base é 3m e a altura 4m

5) Resolver o determinante:

$$\Delta = \begin{vmatrix} 2 & 2 & 3 & 1 \\ 5 & 6 & 1 & 1 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 1 & 2 \end{vmatrix}$$

Source: Ifes Archive.

As shown in Figure 1, the mathematics teaching at the Federal Technical School was closely related to the teaching of other non-vocational schools. In that context, a great valorisation of the mathematical knowledge was attributed to the training and qualification of workers.

With the new Law of Guidelines and Bases of National Education (Brasil, Lei 9.394/1996), the secondary education, as it was conceived before, gave way to high school, configured as the last stage of basic education.

4. Final considerations

The enhanced development of science in the twentieth century created the need to expand schooling to meet the demand for labour in an urban-industrial society. This process determined epistemological conceptions in mathematics education, influencing training and pedagogical practice of the teachers of this discipline. This led to a concern with the selection of content and methodological approaches that were closer to the reality of the vocational education, characterised by the development of competencies and skills that allow the resolution of problem situations inherent to the world of work.

In this context, the Federal Technical School of Espírito Santo, an institution characterised for preparing for vocational and technological training throughout most of the twentieth century, developed a mathematics teaching tensioned by two conceptions of knowledge: a training that takes as its axis the resolution of problems and that conceives practice as an epistemological principle and, conversely, a teaching centered on axiomatisation and formalism, which unlinks mathematical knowledge from the context of its application and problem solving.

The present mathematical experience has similarities with the movement started by Félix Klein in the beginning of the twentieth century. A professor at the *Technische*

Hochschue, in Zurique, Klein idealised a mathematics teaching that integrated theory and practice, breaking with the separation between the classic and the technical training.

In this way, mathematical knowledge was appropriated in the cultural artefacts and technologies applied to the world of work, highlighting the way in which the school culture weaves meanings and senses to human activity, and shedding light on the relationship between education, mathematics and the world of work.

In this regard, we emphasise that the challenge for the school curriculum lies in its perspective of intertwining the issues that affect youth with the issues that are put to school and the world of work. This integration allows young people to broaden their horizons, constituting themselves as subjects capable to read the world around them and act on reality.

Thus, for young people entering high school, what usually happens at 14 years of age, the perspective of life is revealed, showing the possibilities and limits of a formative journey that will put them in a position to make choices about the future or, conversely, will lead them away from the wider social processes, removing them from full citizenship, either by the right to decent work or by schooling in higher education.

For many of these young people, a formative phase in the basic school ends, opening the perspective of a future that points to the continuity of studies in higher education and entry into the world of work. This aspect constitutes the core of the relationship established between youth, school and work, elements that configure the curriculum organisation in high school.

Finally, by linking mathematics education and vocational education, we elucidate singular aspects of this "mathematical experience" constructed by humans throughout history. We show the dimension of a knowledge that establishes views of the world, education, training for work, education conception, science and technology.

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