

**CURRICULAR INTEGRATION IN VOCATIONAL EDUCATION AND TRAINING: AN ANALYSIS OF MATHEMATICS FAIR PROJECTS IN BRAZIL**

INTEGRAÇÃO CURRICULAR NA EDUCAÇÃO PROFISSIONAL: UMA ANÁLISE DE PROJETOS DE FEIRAS DE MATEMÁTICA NO BRASIL

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ABSTRACT

Mathematics Fairs have been held in Brazil for more than thirty years and have become increasingly an environment for the training of teachers and students, since they play a role in encouraging new meanings for mathematics teaching and learning. Considering the expansion of the math fairs in the federative units, this work aims to continue the studies on the integration of curricular components of the middle level vocational education, from experiences with math fairs projects. We have adopted as theoretical assumptions the concepts of integrated curriculum and the proposal of mathematics research projects to analyse practices presented by students of vocational technical courses integrated to high school during the IV National Mathematics Fair in 2015. We concluded that math fairs are shown as spaces where experiences are communicated in interaction with the areas of science and technology of Vocational Education and Training. Thus, we agree that the formal organization of the curriculum requires knowledge to be organised in a disciplinary format, but we conclude that the interdisciplinarity identified in the projects analysed contributes to the relationship between concepts originated from different disciplines.

Keywords: Mathematics Fair; Vocational Education and Training; Integrated Curriculum.

RESUMO

As Feiras de Matemática já são realizadas no Brasil há mais de trinta anos e, cada vez mais, têm se constituído de um cenário para formação de professores e alunos, visto que desempenham um papel de

provocar novos sentidos para o ensinar e o aprender Matemática. Considerando a expansão das Feiras de Matemática nas unidades federativas, o texto em tela dá continuidade aos estudos sobre a integração de componentes curriculares da Educação Profissional de Nível Médio, a partir de experiências com projetos de Feira de Matemática. Adotamos como pressupostos teóricos as concepções de Currículo Integrado e a proposta de projetos de Investigação Matemática para analisar práticas comunicadas por estudantes de Cursos Técnicos Integrados ao Ensino Médio durante a IV Feira Nacional de Matemática, em 2015. Concluímos que as Feiras de Matemática se apresentam como espaços onde são comunicadas experiências com interação com as áreas de ciências e tecnologia da Educação Profissional. Destarte, concordamos que a organização formal do currículo exige a organização dos conhecimentos em formas de disciplinas, mas concluímos que a interdisciplinaridade identificada nos projetos analisados contribui para a relação entre conceitos originados a partir de disciplinas distintas.

Palavras-chave: Feira de Matemática; Educação Profissional; Currículo Integrado.

## 1. Introduction

Vocational Education and Training<sup>1</sup> (VET) has been gaining reputation in the Brazilian educational system in recent years. According to the school census of the national Ministry of Education, in 2016, Brazil had 1.9 million enrolments in VET, including concurrent and subsequent technical courses integrated to the regular high school, to high-school level teacher training (normal), integrated to EJA, *Projovem Urbano* course and elementary, middle and concomitant initial and continuing education courses (Brasil, 2017). To make a comparison, in a decade, the number of students in professional education increased by more than 155% (Brasil, 2007; 2017). With regard to enrolments in technical courses integrated to high school education, at which level we will focus our research, in 2016, we had 506,538 Brazilian students in the public school system and 25,233 in the private sector (Brasil, 2017). That is, approximately 29% of the VET students are in integrated technical courses, as we can observe in Table 1.

**Table 1** - Number of enrolments in Brazilian VET, by educational network and type of course.

	<i>Public network</i>	<i>Private initiative</i>	<i>Total</i>
Technical course concomitant or subsequent to high school	495,682	714,921	1,210,603
Technical course integrated to high school	506,538	25,233	531,771
Others	95,253	21,377	116,630
<i>Total</i>	<i>1,097,473</i>	<i>761,531</i>	<i>1,859,004</i>

Source: Adapted from the Brazilian School Census of Basic Education, 2016.

Studies of Mathematics Education Focusing on Professional Education (Gonçalves & Pires, 2014) also point to a lack of specific research in the area. As an example, the former SBEM Working Group no.3, Mathematics Education in High School, aimed to develop "research on the roles and effects of mathematics education in the different modalities of teaching - such as teaching integrated to *Vocational Education and Training*, youth and adult education, rural education, indigenous education, quilombola education". However, among the proceedings of the WG in the previous editions of the International Seminar for Research in Mathematics Education - SIPEM, only four papers discussed this modality, one in the third (2006) and three in the fourth edition (2009).

In this work, we will resume the contribution of researchers who investigate the theme and will encourage reflections in order to explore possibilities of curricular integration

<sup>1</sup> In Brazil, the VET modality is called Educação Profissional e Tecnológica (EPT, in English: Vocational and Technological Education).

from the projects of math fairs. The project to which this text is associated aims to analyse the mathematics education of students of high school integrated VET courses, during their participation and exhibition of works in mathematics fairs (Sá & Silva, 2016; Turi & Sá, 2017), which have been carried out in Brazil for more than thirty years and have increasingly become an environment for the training of teachers and students, as they "play a role in evoking new meanings for teaching and learning mathematics" (Hoeller *et al.*, 2015, p. 4), as will be seen below.

## 2. A brief history of Mathematics Fairs in Brazil

During the decades of 1980 and 1990 there were several post-graduation courses for mathematics teaching in Brazil. The origin of the math fairs happened precisely in this context. In 1983, when invited to coordinate one of the multidisciplinary postgraduate courses, Professor José Valdir Floriani, with the support of a colleague from the mathematics department, Professor Vilmar José Zermiani (Zerminani, 2003), reformulated its curricular matrix to introduce didactic subjects. From this reformulation, several materials were produced, as well as several projects, among which we highlight the mathematics fairs, whose essence is "in the intertwining of ideas, in the results from studies and experiences in regular classes, favouring mathematics education in particular, and education in general" (Biembengut & Zermiani, 2014, p.47).

Under the coordination of Prof. Floriani and Prof. Zermiani, the first math fair of the state of Santa Catarina took place in 1985, in the city of Blumenau, with the general principle: "a program to encourage students (in all levels of education) both to study and research under teachers' guidance in school spaces and terms, and to socialise these studies and research with the community through an exhibition" (Biembengut & Zermiani, 2014, p.52). Since then, the event has been held place annually in Santa Catarina, and has gradually expanded to other federation units.



Figure 1 - Poster of the 1st Catarinense Math Fair.

Source: FURB Collection, 1985.



Figure 2 - I National Math Fair, in Blumenau (SC).

Source: FURB Collection, 2010.

In addition to a space to socialise classroom practices, Silva (2014, p.189) states that mathematics fairs are "a space for the training of teachers and students, insofar as the participants conceive works, elaborate, execute and present them, explaining in them and through them the conceptions that govern their school practices". They reveal their conceptions also at the moment they write the expanded abstract (mandatory for the submission of the work in the event since 2014) and when they review qualitatively the

work of other colleagues (since 2014, the guiding teachers are invited to participate as reviewers of the oral presentations at the fair).

By involving players and diverse contexts, the fairs have undergone a series of changes. But an essential characteristic remains strong, that is, its public nature and its network management format, in a collective/collaborative work in favour of non-meritocracy. "The publications concerning the math fairs never mention that the objective of the fair is to compete, but rather, it is to cooperate, to socialise knowledge, and to rally students from all levels of education..." (Oliveira *et al.*, 2013, p. 2).



Figure 3 - Visitation at the VI National Math Fair, in Rio Branco (AC).  
Source: Researchers' collection, 2018.

The fact that it is an event that prioritises the participation of players from basic education is one of the differentials of this event. But, from our perspective, what makes math fairs an extremely important event for mathematics education is that "[T]he mathematics fair must enable to display to the external public the mathematics activities normally undertaken in or outside the classroom by the internal public of the school" (Floriani & Zermiani, 1985, p.1). That is, the works are not developed for the fair. Currently, the works are presented by at most two exhibitors, under the guidance of a teacher (with the exception of special education and early childhood education, which may have two guiding teachers). They can present the results of activities developed in the classroom (with the whole class) or extraclass (with a group of students).

As an opportunity to socialise a practice that actually occurs naturally in the classroom, mathematics fairs are organized into eight categories (special education, early childhood education, first years of elementary school, middle school, high school, higher education, teacher and community), according to the level of schooling that students were attending at the time the experiment was completed. In relation to the special education category, works developed in spaces specialised in attending students with disabilities (specific institutions or multifunctional resource rooms) can be submitted. Occasionally, works developed in class but not focused on the curriculum are also presented; if it is focused on the syllabus of the series/year the student is attending, the work must be enrolled in the relevant category. In terms of modalities, we have:

**I) Materials and/or educational games:** this modality comprises studies about the use of some materials that allows to study concepts and mathematical properties. In this case, materials and games are educational resources through which, through exploration,

discussion and analysis, concepts are elaborated, conclusions are drawn, and mathematical knowledge is constructed. In the following figure, we have, as an example, the work "The Mathematics in the Shopping Trail", carried out by special education category students.



Figure 4 - Presentation of work in the modality: Materials and/or educational games.  
Source: Researchers' collection, 2018.

**II) Applied Mathematics and/or interrelationship with other disciplines:** in this modality, mathematics is seen as a tool to obtain concrete results within a context, through algorithms and methods. Below, we have a record of the work "Mathematics, Life and Health Related to the Body Mass Index", presented in this modality by middle school category students.



Figure 5 - Work in the modality Applied mathematics and/or interrelationship with other disciplines.  
Source: Researchers' collection, 2018.

**III) Pure Mathematics:** brings together works that deal with mathematics concepts, operations and properties. An example of experiences of this modality is "Mathematics - the Moment of Beauty", performed by high school category students.



Figure 6 - Presentation of work in the Pure Mathematics modality.  
Source: Researchers' collection, 2018.

Thus, if the works displayed in the mathematics fairs present reports of practices developed in the classroom, we believe that this is an interesting space to investigate how the experiences of institutions of VET actualises curriculum integration and promote interdisciplinarity. More specifically, we focus on productions presented in the "Applied Mathematics and/or Interrelationship with Other Disciplines" modality that articulated basic and professional core subjects.

### 3. Mathematics Education and VET: some approximations

According to Resolution No. 6/2012 of the National Council of Education, which defines the National Curricular Guidelines for VET in the Middle School, the principles of this modality include "interdisciplinarity ensured in curriculum and pedagogical practice, aiming at overcoming the fragmentation of knowledge and segmentation of the curricular organisation" (Brasil, 2012, Art. 6º, subsection VII). CNE Resolution No. 6/2012 also recommends the contextualisation and interdisciplinarity in the use of educational strategies, because they are "favourable to the comprehension of meanings and the integration between theory and the experience of professional practice, involving the multiple dimensions of the technological axis of the course and of the sciences and technologies that are linked to it" (Brasil, 2012, Art. 6º, subsection VIII). The modality of high school integrated with VET has as one of its aims to provide a connection between the general educational processes with specific technical learning in the same curriculum. According to Ciavatta and Ramos (2011, p. 31):

The first sense we attach to integration expresses a conception of human formation that advocates the integration of all dimensions of life - work, science and culture - into the formative process. Such a conception can guide both general and Vocational Education and Training, regardless of how they are offered.

When it comes to school curriculum in a technical course integrated to high school, the articulation between the general formation and the professional formation is what characterises this course modality. For this formation, the political, social, professional, historical and cultural aspects are considered, as Ciavatta (2005, p. 84) points out:

In the case of integrated training or high school integrated to technical education, we want general education to become an inseparable part of the Vocational Education and Training in all fields where there is education for work: whether in productive processes or in educational processes as initial

training, whether in technical, technological or higher education. It means that we seek to focus work as an educational principle, in order to overcome the dichotomy manual work/intellectual work, to incorporate the intellectual dimension into productive work, to train workers capable of acting as leaders and citizens.

Complementing the above, we mention Saviani (2008) to point out that whereas the presentation of scientific concepts (intellectual work) unrelated to practice is configured as contemplation, the reciprocal practice - unrelated to theory (manual work) - is spontaneity. It is important, then, that theory illuminates practice as much as practice gives meaning to the theory. "It is a movement that is primarily practical, but theoretically grounded, feeds on theory to clarify meaning, to give direction to practice" (Saviani, 2008, p. 142). In this sense, it is necessary to go beyond the simultaneity between disciplines of general formation and of the professional nucleus, the two formations have to be worked in an integrated way. But how can we achieve these goals in mathematics? How to get the activities closer to the professional reality of the students?

From the point of view of mathematics education, we have found different Brazilian research works focusing on VET, including the history of education (Pinto, 2006), the production of didactic material (Freitas, 2010), the integrated curriculum (Gonçalves, 2012) and teacher training (Jordane, 2013).

Pinto (2006) investigated the memories of the *Escola Técnica de Vitória* (vocational technical school) from 1942 to 1990. The researcher mapped the school practices that were constituted in the pedagogical actualisation of mathematics education in the daily life of the institution, emphasizing its continuities and discontinuities. This research is relevant for our study, because it reveals that mathematics education practices outweighed the stigma of a school as a correctional agent through work, adapted from the English model of *workhouses*, moving to a vocational school that cultivates science and technology.

Freitas (2010) has carried out the analysis of the collaborative productions of a group of mathematics teachers of the Programa Nacional de Integração da Educação Profissional com a Educação Básica na Modalidade de Educação de Jovens e Adultos - Proeja (national program of integration of the Vocational Education and Training with basic education in the modality of youth and adult education) in the campus of Vitória, of Ifes. The theoretical framework of this study includes the critical communicative methodology, youth and adult education and critical mathematics education, the latter being common to the project I propose. The researcher showed that the didactic material produced and the curriculum elaborated by the group have great potential regarding the collaboration with the mathematical learning of the Proeja young or adult student. Furthermore it contributes in a significant way with the process of curricular integration.

Jordane (2013) also explored Proeja but from the perspective of Ifes teachers' own experience. The epistemological path of the researchers goes through the theoretical basis that supports Proeja and the theory of the communities of practice to understand the constitution processes of the integrated curriculum. Agreeing with the author, among the most significant questions we have: the dialogical perspective, which seeks to involve students at all times; special attention to the experiences lived by the students, so that the teachers encourage and create situations conducive to the development of the students' autonomy; the use of activities that encourage students to explore new paths and territories, ensuring continuity of the process so that they can develop shared practices;

and, finally, the consideration that the main protagonists of the integration process are the students themselves.

Another noteworthy research in this scenario is Gonçalves's (2012), focusing on the teaching of mathematics at high school integrated to Vocational Education and Training (Educação Profissional Técnica de Nível Médio - EPTNM). The research was developed based on a documentary approach, which considers the historical frameworks of Brazilian VET and an analysis of the prescribed EPTNM curricula, as well as curricula shaped by teachers of the Federal Institute of São Paulo. On the occasion, Gonçalves (2012) observed two important aspects: first, a certain difficulty in making possible to integrate the VET with high school; second, that the curricular documents analysed do not present specific guidelines regarding the teaching of mathematics.

Our Research Group has also been dedicated to the interface between these two fields of research, which has already culminated in different studies and the publishing of two books (Sá, 2017; Sá, Arpini & Santos, 2018). In this work we seek to analyse the mathematics fair projects from the *learning milieus* defined by Skovsmose (2001). These milieus are presented as possible answers to the challenge of practicing critical mathematics education in the classroom. In a total of six, they are the result of the combination of three types of reference (pure mathematics, semi-reality, real-life situations) with two paradigms of classroom practices (tradition of exercises and landscapes of investigation), as illustrated below.

Table 1 – Milieus of learning.

	Tradition of exercises	Landscapes of investigation
References to pure mathematics	1	2
References to semi-reality	3	4
Real-life references	5	6

Source: Skovsmose (2001).

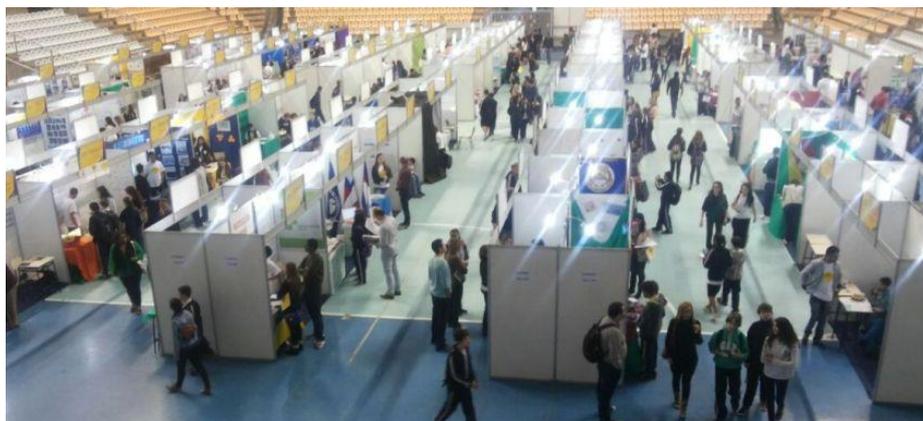
Pure Mathematics refers to primitive concepts, operations and exclusively mathematical procedures. The Semi-Reality associates mathematics with hypothetical situations based on real situations. Reality, in the strict sense of the word, refers to real situations. In the exercise paradigm, the **(1)** refers to pure mathematics exercises and can be exemplified by math exercises, the statement command of which is "find the value of X" or "solve according to the model". The learning milieu **(3)**, with reference to the semi-reality, deals with problems contextualized by hypothetical situations and that present an objective resolution. For example, the exercise of calculating the height of a pole from the height measures of a person and the shadows of the person and the pole. Finally, type **(5)**, with reference to reality, can be represented by a mathematics class in which exercises are carried out with true data and information conveyed by the media.

From the perspective of Skovsmose (2001), learning milieu **(2)** referring to pure mathematics, deals with a problem with several possibilities of approach and resolution, involving arithmetic, algebra or geometry, but without contextualization or application in other areas beyond mathematics. Type **(4)**, with reference to the semi-reality, represents a problematisation to be explored based on a hypothetical situation, and that does not have a unique resolution. In this milieu, interventions and questions are valued, but may be limited to speculative hypotheses, since it is a fictional situation. And type **(6)**, with reference to reality, differs from **(4)** with regard to the context of the problematisation to

be investigated, considering that in this environment contextualization is not a hypothetical situation. And it is in this learning milieu (6) that we guide our research work, since we seek to provide the young students with possibilities to know the course and area of action beyond the description of the curricular components, so that they can overcome the dualism high school - vocational school, building an integral education.

#### 4. Methodological paths

Regarding the methodological format, we developed a research of qualitative nature, of the exploratory type. We analysed practices presented by students of VET courses integrated to high school during the IV National Math Fair, held in Jaguará do Sul (SC), in 2015.



*Figure 7 - Visitation at the IV National Math Fair, in Jaraguá do Sul (SC).  
Source: Researchers' collection, 2015.*

As it is an investigation based on the works published in the procedures of the event, our research can be characterized as bibliographical (Fiorentini & Lorenzato, 2006). The stages included conducting a preliminary survey, reading the material, making notes on the reading, organizing the subject and writing the text (Gil, 2008).

In relation to the preliminary survey, forty out of the one hundred and fifty works registered in the fair were produced by high school students. Twenty-nine of them were allocated in the modality Applied Mathematics and/or Interrelationship with other Disciplines, associating mathematics with art, physics, etc. As we intend to discuss the curricular integration of basic core and professional core subjects, we only analyse the seven papers in which there was mobilization of propaedeutic and technical contents, representing about 4.67% of the works present in the event.

Five out of seven papers selected for analysis were from VET federal institutions, and two from a private institution. Among the public institutions are the Federal Institute of Acre (Ifac), Baiano Federal Institute (IFBaiano) and Federal Institute of Espírito Santo (Ifes). In the second group, we have two productions of the Escola Família Agrícola de Jaboticaba, Bahia. Resuming the organization foreseen in the National Catalogue of Technical Courses (Brasil, 2016), we identified participation of the courses belonging to the technological axes called "Industrial Production" (technical course in biotechnology), "Management and Business" (technical course in administration) and "Natural Resources" (technical course in agroecology and in agriculture).

## 5. Results and analysis

In "The Advantages of Planting *Cupuaçu* in the Northern Region", Nobre, Rodrigues and Dall'Agnol (2015), students and teacher of the Technical Course in Agroecology of Ifac - advanced campus Baixada do Sol, carried out projections of the productivity of *cupuaçu* and its impact on the financial income of small producers in the Amazon region. For the project, they investigated the greatest number of *cupuaçu* trees that could be planted in an area of one hectare and the quantity of fruits produced per tree; they also analysed the average time each *cupuaçuzeiro* takes to mature and to produce the fruits. Considering that one of the attributes of the technician in agroecology is to implement agroextractivist production systems and techniques of organic systems of production and that the field of activity of this professional comprises the properties, cooperatives and rural associations (BRASIL, 2016), we identify evidences of Skovsmose's (2001) learning milieu (6), since we had a research landscapes of investigation with reference to the professional reality of the students.

With the project "Revealing the Volume of Rainfall through a Rain Gauge (pluviometer)", Lima, Andrade and Corrêa (2015) constructed a rain gauge to verify, tabulate and understand rainfall frequency data in the municipality of Xapuri (AC). The initiative started from a work developed in the discipline "Pollution and Environmental Impact", from the vocational nucleus of the Technical Course in Biotechnology Integrated to High School offered in Ifac. In this experiment, the students carried out a work to investigate the impacts of a flood that reached the municipality in 2015. Thus, in addition to resuming concepts such as hydrological cycle, students created a rain gauge to measure the volumetric capacity in a temporal space, and in this way, they could understand, through mathematical calculations, the volume of water that could lead to a possible flood. From Ramos's definition (2005, p.116), we see how this approach can favour students' understanding of concepts:

Interdisciplinarity as a method is the reconstitution of the totality by the relation between the concepts originated from distinct cuts of the reality; that is, of the various fields of science represented in disciplines. This aims to enable the understanding of the meanings of the concepts, the reasons and the methods by which the real can be known and appropriated in potential for the human being.

Also in the biotechnology area, Vieira, Souza and Vieira (2015) developed the project "Applied Mathematics in Renewable Resources" to evaluate the economic impact of the use of renewable fuels through concepts built in the vocational core disciplines. To do so, they ran an experiment using hydrogen and oxygen fuel cells, resulting in electrical energy. In these two examples, the problems of rainfall volume and renewable fuels as starting points have reverted to teaching contents, systematised both in a vocational core discipline (pollution and environmental impact, for example) and in a component of the general training (mathematics), getting closer to Ramos's integrated curriculum ideas (2005).

According to the National Catalogue of Technical Courses, the technician in agriculture:

Drives *in a sustainable way* soil fertility and natural resources. Plans and executes projects related to irrigation and water use systems. Selects, produces and applies inputs (seeds, fertilizers, pesticides, pastures, concentrates, mineral salts, medicines and vaccines). Develops *strategies for animal feeding and water reserve*. Carries out activities of seed and seedling production,

transplanting and planting. Carries out harvesting and post-harvesting. Carries out work in the agroindustrial area. [...] (Brasil, 2016, p. 229, emphasis added).

Many of the skills required to the practice of an agricultural technician were observed in the works of the IV National Math Fair. The ideas of sustainability, for example, were practiced in "Mathematics Applied to the Rational Use of Water in Irrigation", when Cerqueira, Nunes and Júnior (2015) estimated the amount of water stored in soils present in the Jacuípe River basin in Bahia, seeking to contribute to the water savings used in irrigation by family farmers. The experiment was carried out in the organic garden space of the Escola Família Agrícola de Jaboticaba-BA, where the saturation conditions, field capacity and wilting point of soil samples were determined. With these data, the percentage of moisture was calculated, and then applied to the storage needs of soil water for different crops.



Figure 8 - Sample of saturated soil, in field capacity and at wilt point.  
Source: Cerqueira, Nunes & Júnior, 2015, p. 411.

In the same perspective of Cerqueira, Nunes and Júnior (2015), Melo and Mendes (2015), student and teacher of the Baiano Federal Institute, with the project "Mathematical Modelling: the Influence of the Incidence of Sunlight on Agriculture", produced a software in a spreadsheet editor, from which it was possible to identify days of high sun, proposing subsidies for the rural producers to protect their production through specific techniques. The strategies for feeding reserve, highlighted in the citation above, were observed in the project "Mathematics as a Cost-Raising Tool: Palm Planting x Number of Animals", in which Rios, Matos and Silva (2015) analysed the palm supply for cattle feeding through surveys with producers and traders. In this experiment, the data collected were organized and analysed with the help of spreadsheet editing software to calculate the most economical way to obtain such a product.

Representing the technological axis denominated "Industrial Production", we have a work presented by students of the Technical Course in Administration Integrated to High School of Ifes. In "An Analysis of the Presence of the Golden Ratio in Logos of Organizations Acting in Brazil", Stocler, Malavasi and Sá (2015) carried out a study on the presence of the golden ratio in logos of organizations operating in Brazil, mainly in Espírito Santo, highlighting the relationship between mathematics and advertising and aesthetic concepts, subjects studied in the curricular components of the professional core of the course.

## 6. Conclusion

The math fairs are characterized as events designed to socialise classroom practices that differ from other kinds of fairs due to its free, public nature, as well as its network management format, in a collective and collaborative work. We believe that such characteristics make math fairs a unique event within mathematics education.

We concluded that the math fairs are actually presented as spaces where experiences are communicated in interaction with the areas of science and technology of VET. Thus, we agree that the formal organization of the curriculum requires knowledge to be organised in disciplinary forms, but we conclude that the interdisciplinarity proposed in the projects of math fairs has promoted the reconstitution of the totality by the relation between concepts originated from different disciplines.

Through this, we try to foment the reflection about the mathematics school work with students of the Vocational Education and Training at high school level. We hope that the mathematics teaching plans of different courses can be updated to further explore the existing relationships between mathematics and the world of work, evidenced in this text from the production of mathematics fair works.

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