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Research Article

An entrepreneurship education ecosystem's analysis, based on a case of a Brazilian public institution

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Abstract

Purpose: to analyze the entrepreneurial education ecosystem (EEE) of a Brazilian public teaching and research institution. **Methodology**: case study of the Federal Center for Technological Education of Minas Gerais (CEFET-MG), according to the following stages: survey in 2017, participatory observation in 2018 and another survey in 2019. **Findings**: the analysis (which embraces the policies, structure, resources, actors and culture realms) indicates the configuration of the main EEE components and their possible consequences on the institution, thus showing the need for institutionalizing educational processes that comprise entrepreneurship in curriculum, co-curricular and research activities, as well as making available resources and structures that contribute to stakeholders' engagement and to the entrepreneurship culture development. **Theoretical/methodological contributions**: this paper advances the understanding of EEE, by proposing methods triangulation for the application of the framework of analysis, and contributes by analyzing a unique teaching and research institution, relevant for its institutional design and for the orientation towards technological education. **Originality/value**: this paper (a) identifies possible analytical and suggestions for intervention, based on the interactions of the Triple Helix, in order to develop EEE, and (b) approaches the teaching and research institution as the unit of analysis itself (and not the territory, usually found in the field). **Practical implications**: suggestions for decision-making on institutional policies and for increasing participation in actions in the territory are made for similar institutions.

Keywords: Entrepreneurial Education Ecosystem. Triple Helix. Entrepreneurial Universities Ranking. Federal Center for Technological Education of Minas Gerais.

Resumo

Objetivo: analisar o ecossistema de educação empreendedora (EEE) de uma instituição pública brasileira de ensino e de pesquisa. **Método**: estudo de caso do Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG), perfazendo três fases: survey (2017), observação participante (2018) e outra survey (2019). **Resultados**: a análise (que abarca dimensões políticas, estrutura, recursos, atores e cultura) indica a configuração dos principais elementos do EEE e seus possíveis reflexos na instituição analisada, evidenciando a necessidade da institucionalização dos processos educacionais que contemplem o empreendedorismo nos componentes curriculares, extracurriculares e de pesquisa, bem como disponibilizar recursos e estruturas para contribuir com a articulação dos atores e a formação de uma cultura empreendedora. **Contribuições teóricas/metodológicas**: o artigo avança na compreensão dos EEE, propondo a triangulação de métodos para a aplicação do framework de análise; e contribui com a análise de uma instituição de ensino e de pesquisa singular, relevante pelo seu desenho institucional e pela orientação à formação tecnológica. **Originalidade/Relevância**: este artigo (a) identifica possíveis caminhos analíticos e sugestões de intervenção, fundamentados nas interações da Hélice Tríplice, para desenvolver EEEs; e (b) aborda como unidade de análise a própria instituição de ensino e de pesquisa (e não o território, usualmente abordado no campo). **Contribuições para a gestão**: são propostas sugestões para a tomada de decisão sobre políticas institucionais e para o aumento da participação em ações do território por parte de instituições similares.

Palavras-chave: Ecossistema de Educação Empreendedora. Hélice Tríplice. Ranking de Universidades Empreendedoras. Centro Federal de Educação Tecnológica de Minas Gerais.

INTRODUCTION

Some conceptual frameworks – such as the "linear model", the "Mode 2" and the "Triple Helix" (Mowery & Sampat, 2005; Ruffoni et al., 2021) – have allowed us to understand the relationship between universities, the production of knowledge and innovations, so necessary to the so-called "information society", "network society" or "economy of knowledge and innovation" (Bell, 2006; Castells, 1999).

Increasingly emphasizing collaboration between universities and other institutions is one of the contributions of these models, particularly the Triple Helix, which even proposes variations in the roles of teaching and research institutions, as they articulate with industry and the government to promote, through innovation and entrepreneurship, the economic and social development (Etzkowitz & Zhou, 2017).

This context reinforces the need to develop the entrepreneurial education ecosystem of such institutions (Dorion et al., 2015; Lima et al, 2015; Nabi et al., 2017). The attention that public policymakers, educators, researchers and practitioners have given to topics such as entrepreneurship and entrepreneurial education in teaching and research institutions is reflected in the growing number of publications in indexed journals in the fields of Economics, Management, Education, Social Sciences and others. In this sense, according to Johann et al. (2018), over a period of ten years, approximately 2.5 thousand scientific articles were published on the Web of Science, which is an important scientific journals database.

This reaffirms the relevance of understanding, in practice, what entrepreneurship education ecosystems are (Belitski & Heron, 2017; Brush, 2014), and how to develop them in the context of traditional teaching and research institutions. In this regard, for Gimenez (2017), it is necessary to elucidate and understand the difficulties in planning and implementing policies, programs and practices related to entrepreneurship, among other aspects.

Belitski e Heron (2017) clarify that the entrepreneurship education ecosystem aims to develop collaborative links between its three main stakeholders: government, universities and entrepreneurs. Through the joint work between universities' technology transfer offices and entrepreneurship centers, this ecosystem thus reaches the local business community and policy-makers. For the authors, assuming entrepreneurship education on the surface should be avoided, that is, it is necessary to create a highly attractive campus experience for all its participants, including local policy-makers, current and future entrepreneurs, students, scientists and companies.

Ribeiro e Plonski (2020), on the other hand, indicate that it is necessary to go beyond the excessively focused analysis on institutional aspects, and seek a vision that comprises the students' experiences in the teaching environment.

In this sense, the purpose of this article is to analyze the entrepreneurship education ecosystem of a Brazilian public, centennial and multicampus teaching and research institution - the Federal Center for Technological Education of Minas Gerais (CEFET-MG) -, given the complexity of its institutional design and its orientation towards technological training.

Therefore, below (Section 2), we discuss the concepts and main analytical categories for understanding an entrepreneurship education ecosystem; we describe the methodological approach used in the CEFET-MG case study (Section 3); and we present the findings and discussion of their implications (Sections 4 and 5, respectively).

This research contributes to the expansion of the literature in this field by combining analytical categories and suggestions of intervention relevant to entrepreneurship, from the point of view of the teaching and research institutions themselves, and by identifying possible pathways to establish or favor the decision-making to foster entrepreneurship education ecosystems.

ENTREPRENEURSHIP EDUCATION ECOSYSTEM

Recent literature has drawn attention to the need to differentiate terms such as "entrepreneurship ecosystem", "business ecosystem" and "innovation ecosystem" (Martins & Olave, 2020). In this article, differently, we focus on the term "entrepreneurship education ecosystem", which is a topic that needs to be further explored by researchers (Ratten, 2019). Recent studies in this regard are noted, such as those by Fetters et al. (2010), Brush (2014), Hayter (2016), Belitski and Heron (2017), Maritz and Foley (2018), e Wraae and Thomsen (2019).

These authors build their views of the entrepreneurship education ecosystem from the Triple Helix model (Etzkowitz, 1983) and the entrepreneurial ecosystem itself (Isenberg, 2011; Spigel, 2017; Stam & Spigel, 2016). In contrast to theories that emphasize the role of government or companies in innovation, the Triple Helix focuses on teaching and research institutions as a source of entrepreneurship, technology, innovation, as well as critical research, education, and preservation and renewal of cultural heritage (Etzkowitz, 1983; Etzkowitz & Zhou, 2017).

Innovation increasingly takes shape in Triple Helix relationships and in the types of actors that enable different interactions (Silva, 2017), contributing to a new role for universities – of being "entrepreneurs" (Guerrero & Urbano, 2012). Among the new actors, the mechanisms for generating enterprises (incubators, accelerators, coworking spaces, living labs and others) and innovation environments (scientific and technology parks, fablabs, innovation districts and others) stand out (Audy, 2017).

On the other hand, for Belitski e Heron (2017, p. 10), the concept of entrepreneurial university (Guerrero & Urbano, 2012) is superimposed by entrepreneurship education ecosystem, due to the ambitious agenda established for universities, entrepreneurs, government and industry, actors prominently involved in the local and national business environment. In addition, this ecosystem incorporates the university-industry-government collaboration, and has it as an important boundary condition for its performance (Belitski & Heron, 2017).

An entrepreneurship education ecosystem can be understood as a set of "*strategic and collective actions of various organizational components [...] in order to maximize both the entrepreneurial and innovative contributions of universities*" (Hayter, 2016, p. 2). It is, then, a dynamic and complex system of collaborative links at different levels, between the main stakeholders (teaching institution, companies, local government, students and researchers, etc.), with several interrelated elements, which can help or hinder the knowledge transfer, made

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possible by the university-industry-government partnership (Belitski & Heron, 2017; Ratten, 2019).

According to Wraae e Thomsen (2019), this ecosystem – seen as an impeller of regional and economic development – is based on the university, depending on its performance towards the internal community, in which the actors do not compete directly with each other; and it mainly facilitates the development of academic spin-offs, the employability of students, the commercialization of knowledge, and the university's involvement with external actors (Belitski & Heron, 2017).

A well-developed entrepreneurship education ecosystem generates tangible outcomes, such as venture creation, entrepreneurial orientation, technology transfer, among others (Maritz & Foley, 2018). More specifically, Nabi et al. (2017) emphasize the creation of startups, the survival rates, the performance of created businesses, and the social contribution as resulting from such ecosystems.

Brush (2014), based on Fetters et al. (2010) and in studies consistent with the topic, emphasizes the articulation of the roles that the university can play in the development of its own entrepreneurship education ecosystem, corroborating the fact that teaching and research institutions are at the center of economic progress, by providing infrastructure, resources and ways to develop entrepreneurial communities.

The literature, in this sense, indicates the need for the analysis of entrepreneurship education ecosystems to comprehend aspects that include from the curriculum and structures, to interactions with external actors, passing through the tangible and the intangible, as will be observed below.

Dimensions of an entrepreneurship education ecosystem

Brush (2014) suggests the analysis of entrepreneurship education ecosystems, based on two broad categories: (1) dimensions, raised from Fetters et al. (2010), which include infrastructure, culture, stakeholders and resources; and (2) domain, indicated on the basis of Alberti et al. (2004) and Kuratko (2005), which embraces curriculum, co-curricular activities and research.

The creation and expansion of the ecosystem requires the assessment, by the university, of the strengths and weaknesses of these dimensions and domain, determining the role played in entrepreneurial education. Thus, the extent of the domain's activities, to which the institution is closely connected and aligned, and the degree of its commitment to the dimensions must be verified.

One point highlighted by Belitski e Heron (2017), is that entrepreneurship education is at the heart of these ecosystems. As a primarily practice-based approach, entrepreneurial education allows students and researchers to better understand market opportunities. The favorable environment promoted by an entrepreneurship education ecosystem can contribute to learning and knowledge creation, not only for students, but also for other actors involved (Wraae & Thomsen, 2019).

In Brazil, the Brazilian Micro and Small Business Support Service of Minas Gerais (Sebrae/MG) has developed an ecosystem approach to entrepreneurial education, based on the practice of applying its Entrepreneurial Education Program, comprising of five dimensions: policies, structure, resources, actors and culture (Sebrae/MG, 2018) (Table 1).

Table 1

Dimensions of an entrepreneurship education ecosystem

Dimension	Description	Authors
Policies	Factors related to all possibilities of formalization, integrated articulation and institutionalization, which will guarantee the continuity and effectiveness of the application, and the development of an entrepreneurial culture	Brush (2014); Davari et al. (2018); Dorion et al. (2015); Neck et al. (2014); Ratten (2019); Wraae e Thomsen (2019).
Structure	It includes all spaces and initiatives available inside and outside the teaching institution, capable of contributing to a favorable environment for the generation, development, application, and sharing of ideas and projects	Audy (2017); Belitski e Heron (2017); Brush (2014).
Resources	It represents the economic and financial sources available to implement projects and actions that promote the dissemination of an entrepreneurial culture	Davari et al. (2018); Ribeiro et al. (2018); Rossano et al. (2019).
Actors	People or institutions that directly or indirectly contribute to and are involved in the process of implementing, developing and disseminating the entrepreneurial culture	Bischoff et al. (2018); Brush (2014); Davari et al. (2018); Dorion et al. (2015); Neck et al. (2014); Ribeiro et al. (2018); Rossano-Rivero e Wakkee (2019); Wraae e Thomsen (2019).
Culture	As a backdrop to all elements of the entrepreneurship education ecosystem, culture (which is constantly changing) demonstrates, influences and directs the way in which actors act	Brush (2014); Ribeiro et al. (2018).

Notes: For the first dimension, Sebrae/MG uses the term "public policies". In this article, considering that the concept of entrepreneurship education ecosystem concerns institutional policies of public or private teaching institutions, as well as the ruling policies in the territory, we chose to use the term "policies".
Elaborated by authors based on data from Sebrae/MG (2018).

Although these dimensions of Sebrae / MG were inspired by the broader view of the entrepreneurial ecosystem by Isenberg (2011) – which includes, among others, human capital (teaching institutions), policies (government) and market (companies) - such dimensions dialogue with the aspects identified by Belitski e Heron (2017), Brush (2014) and other researchers on the topic under discussion here.

In a period with still little research on entrepreneurship education ecosystem, in order to analyze the case of CEFET-MG, we adopted the Sebrae/MG approach, which seeks to develop the entrepreneurship education ecosystem from the point of view of the reference institution. This approach proposes a territorial analysis of the institution's surroundings as a promoter of economic and social development and seeks to promote practices and experiences to generate learning and an entrepreneurial attitude in students and educators, in line with what Neck et al. (2014) propose.

The "policies" dimension embraces normative and institutionalization aspects of ecosystem components, including territorial and institutional policies – i.e. internal, formal and informal organizational aspects, which will contribute to the constitution of capacities and strategic resources (Davari et al., 2018), with a direct impact on the outcomes of an entrepreneurship education ecosystem (Maritz & Foley, 2018; Mukesh & Pillai, 2020). The "policies" dimension also involves educational processes (Brush, 2014; Wraae & Thomson, 2019), which should focus on the curriculum itself (set of courses and content), co-curricular activities and research.

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As for the curriculum, Neck et al. (2014) propose that knowledge-based learning should be oriented towards the formation of an entrepreneurial mindset – which requires a look beyond the disciplines of entrepreneurship, integrating practical experiences and traditional teaching (Ratten, 2019). Teaching entrepreneurship requires a method, assuming a way of thinking and acting in the face of a reflexive and intentional pedagogical practice (Neck et al., 2014). Thus, the importance of developing pedagogies that respect local specificities (Dorion et al., 2015).

Co-curricular activities are those non-degree bearing activities that enrich learning, contributing to the formation of an entrepreneurial culture; and research must be seen as theoretical and applied in a broad scope, but related to the entrepreneurial process and other entrepreneurship and business issues (Brush, 2014).

The "structure" dimension includes not only the physical aspects of the campus, such as buildings, living areas and equipment, but also the infrastructure of information and communication technologies. For Brush (2014), a cohesive and functional physical structure favors the connection between the actors and the implementation of programs, as well as the execution of courses, research and other activities. The use of structure by actors in the ecosystem can be one of the aspects aimed at facilitating knowledge transfer (Belitski & Heron, 2017), that is, spaces available for the generation, development, application and sharing of ideas and projects (Audy, 2017). Entrepreneurship centers, incubators, research and experimentation laboratories are aspects analyzed in this dimension. It is worth noting that the use of the structure concerns both that of the teaching institution and that of other organizations in the territory.

The "resources" dimension comprises the economic and financial sources to make feasible projects and actions that support student initiatives and promote the dissemination of an entrepreneurial culture, including informal institutional factors and organizational capabilities and resources (Davari et al., 2018), such as human, financial and social capital (Mukesh & Pillai, 2020). The existence of unique resources – such as a professors and staff with qualifications in certain areas of knowledge, for example – can contribute to the creation of an entrepreneurship education ecosystem also unique.

In addition to internal sources, resources can come from partnerships with other actors in the territory, due to physical proximity (Rossano-Rivero & Wakkee, 2019), or even from development agencies at national and international levels. In this sense, Ribeiro et al. (2018) highlight the importance of financial support for materials and personnel in projects supported by the Massachusetts Institute of Technology (MIT), regarded as an international reference in entrepreneurship.

In relation to the "actors" dimension of the entrepreneurship education ecosystem - students, educators, staff, institutional supporters, alumni, students' parents, service providers, people from the external community, external public and private organizations - there must be a dialogical relationship between them, in that one influences the other (Brush, 2014; Wraae & Thomsen, 2019).

In the aforementioned perspective, there is a view of connections that extend from the institution's "internal" ecosystem to the entrepreneurship ecosystem as a whole (Bischoff et al., 2018; Isenberg, 2011). Thus, the students should have the opportunity to develop entrepreneurship competencies to make the articulation work (Davari et al., 2018; Ribeiro et al., 2018), which, therefore, denotes the role and involvement of professors as essential. The experience in the labor market and the entrepreneurial attitude of these professionals can contribute to the formation of external networks, allowing access to key resources for conducting actions within the ecosystem (Rossano-Rivero & Wakkee, 2019).

Related to the promotion of entrepreneurial culture, the "culture" dimension proposes effective changes in the way of thinking about entrepreneurship, expanding it to how to act in the face of challenges and opportunities. This includes symbolic and normative aspects, values, and traditions of the teaching institution that, according to Brush (2014), are infused into the curriculum, co-curricular activities and research (components of the "political" dimension).

In this context, the ecosystem is structured with mechanisms capable of developing entrepreneurial initiatives (interdisciplinary projects and entrepreneurship journeys, for example), implemented inside or outside the institution, in order to favor differentiated and contextualized experiences. Thus, these are components of entrepreneurial learning: academic leagues, junior companies, competition teams, events (such as hackathons and lectures), open classes, mentorships, research projects, network, among others (Brush, 2014; Ribeiro et al., 2018).

Based on the dimensions mentioned above, a model of entrepreneurship education ecosystem, such as the one proposed by Sebrae/MG (2018), makes the teaching institution an important protagonist (with its own and individual system) in the connection with other actors, in line with the Triple Helix model and the purpose of fostering economic development and entrepreneurial capital in its territory.

METHODOLOGY

We adopted the case study strategy in this research, as it allows an in-depth examination of contemporary phenomena in their real context (Creswell, 2010; Yin, 2005); and involve quantitative and/or qualitative methods with different views (Godoi et al., 2010). Therefore, we opted for mixed methods (Creswell, 2010), due to the existence of a theoretical perspective that integrates the investigation of quantitative and qualitative data; and because they are suitable to respond to the type of problem proposed, promoting the understanding of the phenomenon, from the epistemological-pragmatic point of view.

Choosing the CEFET-MG case is justified, in principle, by the recognition of the region in which this institution operates (the state of Minas Gerais), in terms of innovation in products and processes. According to the 2017 Pintec Innovation Survey, the innovation rate in Brazil was 33.8%, and in Minas Gerais, 32.3%, therefore, close to the national rate (IBGE, 2020). In addition, in this region, there are three universities (Federal University of Minas Gerais, Federal University of Itajubá and Federal University of Viçosa) among the ten most "entrepreneurial" in the country (Brasil Júnior, 2019); and potential to generate technology-based ventures and startups, as shown by a mapping at national level

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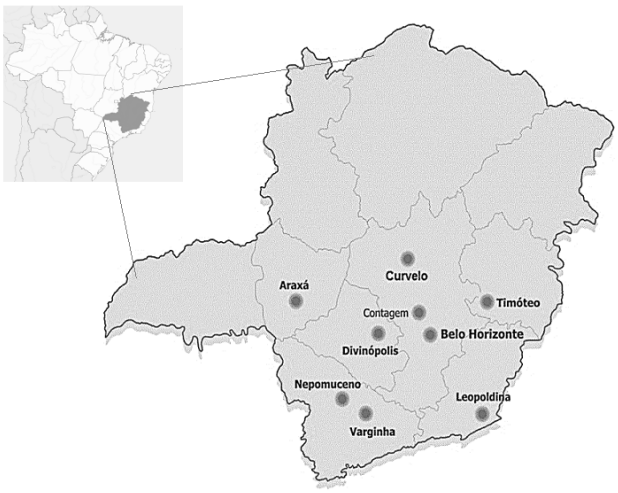
(Distrito, 2020), which counted 782 startups in Minas Gerais, only behind São Paulo, with 2,677.

The option for CEFET-MG was also pertinent, due to the institution's relevance in the communities where it operates. That is, it is a Federal Institution of Higher Education, public and centennial, with campuses in the following cities/regions of Minas Gerais: Araxá (Alto Paranaíba); Belo Horizonte, Contagem and Curvelo (Central); Divinópolis (Midwest); Leopoldina (Zona da Mata); Nepomuceno and Varginha (South of Minas); and Timóteo (Rio Doce) (Figure 1).

Figure 1

CEFET-MG campuses in the state of Minas Gerais, Brazil



Nota: CEFET-MG Institutional Development Plan (2016).

As a special regime autarchy, linked to the Ministry of Education, CEFET-MG operates in the fields of teaching, research, outreach and administration, in the mold of a technological university. According to the 2019 Annual Report (2020, p. 15), the institution's mission is:

> to train and qualify professionals in the field of technological education, at different levels (technical, undergraduate and graduate) and teaching modalities (face-to-face and distance), for the various sectors of the economy, as well as to conduct applied research and promote the technological development of new processes, products and services, in close articulation with the productive sectors and society, especially of local and regional range, offering mechanisms for continuing education.

CEFET-MG operates in the following educational stages and respective admission numbers: technical high school (8,776); and higher education, in undergraduation (6,122), lato sensu post-graduation (216), master's degree (1,363) and doctorate (239). Its guiding principles, objectives, programs and goals, for the period from 2016 to 2020, are disposed in the Institutional Development Plan of CEFET-MG (2016) (Annex 1).

The methodological pathway of this research involved, sequentially, the stages: survey, in 2017; participant observation, in 2018; and, again, survey, in 2019, as described below.

Surveys in 2017 and 2019

The surveys (Babbie, 1999) aimed to provide an overview of the dimensions of the entrepreneurship education ecosystem, from the point of view of the participating students. Although they are also the target audience of the questionnaire applied, professors and staff (technical-administrative servants) did not have their perceptions reported here, due to the insufficient amount of valid responses, which made the analysis and discussion of the obtained results unfeasible.

It is noteworthy that CEFET-MG was invited to participate in a pilot, in 2017, of the Ranking of Entrepreneurial Universities (Brasil Júnior, 2017) to analyze the applicability, in institutions other than universities, of the following factors: entrepreneurial culture (student's, professor's and staff's entrepreneurial attitude, and entrepreneurship disciplines); outreach (networks and extension projects); innovation (research, patents and proximity between the institution and companies); infrastructure (quality and technology park); internationalization (exchange program, publications and international citations); and financial capital (budget and funds) (Brasil Júnior, 2017; 2019).

Table 2 compares population and sample between the 2017 and 2019 surveys, regarding gender and race variables. Data were extracted, respectively, from the Nilo Peçanha Platform (Ministry of Education) (Brasil, 2020) and the databases of the Ranking of Entrepreneurial Universities. According to the Kolmogorov-Smirnov and Shapiro-Wilk tests, the results indicate the multivariate normality of the data for all variables.

Table 2

Comparison between population and sample of the survey stages

Variable	2017		2019	
	Population (%)	Sample[1] (%)	Population (%)	Sample[1] (%)
Gender				
Female	33.6	40.85	33.2	45.62
Male	66.4	58.54	66.8	54.16
Racial group				
White	42.83	–	41.69	50.56
Brown	39.06	–	36.75	36.52
Black	5.77	–	6.75	7.98
Yellow	3.85	–	3.27	1.35
Indigenous	0.05	–	0.02	0.22
Not declared	8.44	–	11.52	3.37
Total	6,122	164	6,728	890

Notes: [1] The samples calculated for 2017 and 2019, respectively, were 250 and 262, with a confidence level of 95% and a margin of error of 5%. Due to the smaller number of valid questionnaires in 2017, the actual margin of error was 7.55%; and, in 2019, 2.32%. Elaborated by authors based on data from Nilo Peçanha Platform of the Ministry of Education, for population data (Brasil, 2020), and Ranking of Entrepreneurial Universities (Brasil Júnior, 2017; 2019), for the sample data.

In 2017, the survey was conducted as a pilot, and involved 164 respondents with valid questionnaires, with 59% male and 41% female. In 2019, in turn, the sample was expanded to 890 respondents with valid questionnaires, with 54% male students and 46% female.

Sociodemographic data on race and income were only available in the 2019 survey, even so it was only possible to make the comparison concerning the racial group, since the scale of declared income differed between the data sources. The proportion of respondents who declared themselves white and brown matches the population of the year in question.

In relation to the courses, most students (84% in 2017; and 70% in 2019) were majoring in administration, and in some engineering (mechanical, electrical, environmental and sanitary, civil production, and computing, principally). It is noteworthy that: (a) the technical level was not included in this survey, due to the fact that the collection instruments of the Entrepreneurial Universities Ranking do not yet allow the processing of data for

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this type of respondent; and (b) it was not possible to indicate in the questionnaires which campus the student belonged to, which made more detailed analyzes of these specific realities unfeasible.

The selection of variables (Appendix 1) was based on Brush (2014), Wraae e Thomsen (2019) and other authors mentioned above (Table 1), with the majority following the Likert scale from 1 (totally disagree) to 5 (totally agree). It is noteworthy that only those variables corresponding to the dimensions of entrepreneurship education ecosystems (Table 1 and included in the Entrepreneurial Universities Ranking methodology were considered. Thus, of the 170 variables raised by the 2019 survey, 60 met the objectives of this article (Brasil Júnior, 2019).

In order to analyze the survey results, we used descriptive statistics and comparative techniques of statistically significant mean differences - t-test, chi-square test and analysis of variance (ANOVA) for independent samples - between the research rounds 2017 and 2019.

Participant observation

The participant observation stage (Creswell, 2010) consisted of semi-structured data collection and recording by the first three authors of this article, through a consulting project by Sebrae/MG, conducted in four eight-hour meetings (two in August, and two in October), in 2018. At the meetings, whose agendas included the sequence presented below (Table 3), we discussed about the entrepreneurship education ecosystem, the diagnosis of problems and the proposal of actions to the development of this ecosystem (policies, structure, resources, actors and culture) at the territorial level.

Therefore, all local entrepreneurship and innovation coordinators were brought together; some participants with outreach coordination functions on each campus; directors and representatives of the board; in addition to members of the CEFETMINAS Foundation (FCM), which is the foundation supporting CEFET-MG's outreach and research & development activities, totaling 32 professionals (Table 4), identified by their functions and positions in the central organizational structure and in the respective campus.

Tabela 3

Modules from Sebrae/MG consulting project at CEFET-MG

Modules and dates	Discussion guidelines on entrepreneurial education
Module 1 Aug. 2, 2018	Entrepreneurship, the entrepreneur and entrepreneurial education Entrepreneurial teaching institution Entrepreneurial Mindset Entrepreneurial characteristics and attitudes Entrepreneurial professor
Module 2 Aug. 3, 2018	The entrepreneurship education ecosystem Dimensions of the ecosystem Connections map Entrepreneurial Action Planning
Module 3 Oct. 1, 2018	The ideation process for entrepreneurial education Design thinking Creative process Action plan for entrepreneurial education Assumptions of the entrepreneurial education project
Module 4 Oct. 2, 2018	The entrepreneurial education project Project structuring steps Validation Implementation

Note: Elaborated by authors based on data from Sebrae/MG (2018).

The composition of this group is in line with Wraae e Thomson (2019), who suggest the involvement of institutional actors capable of connecting to favor the development of the entrepreneurship education ecosystem. Thus, there was a diversified participation, including people at executive levels, responsible for normative aspects (coordinators); team members on campuses in Belo Horizonte; two professionals from each campus; and representatives of the supporting foundation that has CEFET-MG as one of its founders.

Local pairs of mobilizers and representatives of the coordination (subordinate to the board of each campus) of entrepreneurship, innovation and outreach, and/or technical-administrative servant linked to the incubator, were appointed by the local coordinators to favor the constitution of the entrepreneurship education ecosystem on the campuses. However, this mobilization was difficult to perform during and after the consulting process; therefore, we cannot say that the

Table 4

Participants of the consulting process, by location and function

Location	Function and acting in the organizational structure
Belo Horizonte CEFET-MG	Adjunct Director (Community Outreach and Development Board), "sponsor" of the consulting process Director (Professional and Technical Education Board) General coordinator (Technology Transfer), responsible for the incubator and entrepreneurship actions at the institutional level Coordenador de ações (Política Institucional de Padronização de Processos e Serviços) Docente e coordenadora das empresas juniores Professor and coordinator (Núcleo de Inovação Tecnológica, NIT), responsible for typical attributions of a Technology Transfer Office Professor (Business Administration Course), responsible for Entrepreneurship disciplines Professor and coordinator of the Professor Training Program (Department of Education) Professor and coordinator of the Distance Education Center, with projects and research in entrepreneurial education Professor and coordinator (Center of Engineering Applied to Competitions) Technical-administrative servant and coordinator of actions (Institutional Policy for Standardization of Processes and Services) Technical-administrative servant to articulate actions of the Undergraduate Board Technical-administrative servant, working in the incubator and in entrepreneurship actions, at the institutional level Technical-administrative servant (Community Outreach and Development); professor and coordinator of junior companies)
Belo Horizonte CEFETMINAS Foundation	President, communications advisor and Presidency consulting advisor
Araxá	Professor and local coordinator (Entrepreneurship and Innovation); and Professor appointed to help with local mobilization
Contagem	Professor and local coordinator (Entrepreneurship and Innovation); and Technical-administrative servant appointed to help with local mobilization
Curvelo	Professor and local coordinator (Entrepreneurship and Innovation); and Technical-administrative servant appointed to help with local mobilization
Divinópolis	Professor and local coordinator (Entrepreneurship and Innovation); and Professor appointed to help with local mobilization
Leopoldina	Professor and local coordinator (Entrepreneurship and Innovation); and Professor appointed to help with local mobilization
Nepomuceno	Professor and local coordinator (Entrepreneurship and Innovation); and Technical-administrative servant appointed to help with local mobilization
Timóteo	Professor and local coordinator (Entrepreneurship and Innovation); and Professor appointed to help with local mobilization
Varginha	Professor and local coordinator (Community Outreach and Development); and Professor and NIT local coordinator

Nota: Elaborada pelos autores com base nos dados da pesquisa (2018).

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propositions of the actors involved in 2018 have impacted the results of the 2019 survey variables.

The participant-observers noted the activities and perceptions of the participants in the consulting process (Table 4), guided by the dimensions of the entrepreneurship education ecosystem.

Data analysis and interpretation proceeded with the following steps (Creswell, 2010): (a) typing of field notes, in order to organize and prepare them for analysis; (b) reading of all data to verify the general perception of the information; (c) data codification, with reference to the dimensions of the entrepreneurship education ecosystem (policies, structure, resources, actors and culture); (d) description, identification and connection of analysis categories; (e) extraction of the data meanings, derived from the comparison between the results and the literature.

RESULTS AND DISCUSSION

This section is organized according to the dimensions (policies, structure, resources, actors and culture) of the analysis model proposed by Sebrae/MG (2018) (Table 1) and in line with the theoretical discussion on entrepreneurship education ecosystems. It approaches data from the institutional context of the analyzed case; the evidence obtained through surveys conducted in 2017 and 2019, and the main results of the participant observation.

As highlighted in the methodology, the survey data come from responses by CEFET-MG students to the perception questionnaire of the Entrepreneurial Universities Ranking (Brasil Júnior, 2017; 2019). Participant observation, in turn, was conducted during the meetings that discussed the dimensions of the entrepreneurship education ecosystem.

Policies

This subsection aims to show the articulation and constitution of the entrepreneurship education ecosystem of CEFET-MG, with regard to institutional policies. The CEFET-MG mission, informed in the case description (Section 3), is closely linked to the Triple Helix model (Etzkowitz, 1983; Etzkowitz & Zhou, 2017).

Institutional aspects have evolved, over time, towards this model (Triple Helix), so much so that, in 2008, the Community Outreach and Development Board (DEDC) was created, including in its scope: involvement of internal and external public in cultural actions; student social development; the promotion and practice of outreach activities, together with teaching and research; and support for entrepreneurship and technological innovation.

CEFET-MG has been implementing institutional programs that are essential to the entrepreneurship education ecosystem (Brush, 2014), such as the Nascente Technology-Based Impact Business Incubator, the Support Center for Junior Companies, the Coordination of Innovation and Entrepreneurship (which embraces the attributions of the Technology Transfer Office (Núcleo de Inovação Tecnológica, NIT), and the outreach programs aimed at entrepreneurship (Engrena, for example).

However, more contemporary mechanisms for the generation of enterprises are absent, such as accelerators and coworkings (Audy, 2017), even though they are included in the ongoing plans (the creation of an idea lab on the Gameleira campus, located in Belo Horizonte, is an example of this).

In the interaction of the internal community with external initiatives, we observed the execution of lectures, competitions involving technology and innovation, and the participation of students and professors in challenges and acceleration programs, among other co-curricular activities, as suggested by (Brush, 2014; Neck et al., 2014; Wraae & Thomson, 2019).

In 2018, following the changes brought by the New Legal Framework for Science, Technology and Innovation (Law n. 13.243, 2016; Decree n. 9.283, 2018),), the internal Innovation Policy was created. Approved by the Board of Directors, in Resolution CD-027 (2018) of CEFET-MG, this Policy encourages the dissemination of an entrepreneurial culture and outreach actions aimed at technological innovation, as well as internally regulates the processes of intellectual protection and technology transfer.

Therefore, the existence of important organizational and normative factors (Davari et al., 2018) is noted for the "internal policies" dimension. Like the universities, the institutions that compose the Federal Network of Professional, Scientific and Technological Education (Law n. 11.892, 2008), such as CEFET-MG, operationalize public policies and play a relevant role, whether in the production of knowledge and innovations, or in the training of new professionals. In addition, these entities are close to companies from various sectors, given their origins in labor market-oriented technical and vocational education. As a driving force behind innovative entrepreneurship, universities – or academy – are thus a key link in Triple Helix interactions (Etzkowitz, 1983; Etzkowitz & Zhou, 2017).

In the participant observation, the discussion on the "political" dimension was guided by the following questions: how to act in internal policies to favor the implementation of entrepreneurial education, and how to participate in public policy actions in the territory? The results point to the relevance of revealing information regarding the regulations that govern entrepreneurship and innovation actions, such as the Innovation Policy and the regulation of outreach actions.

The institution must also establish clear and defined processes, as well as increase the engagement of actors, especially professors (Davari et al., 2018; Ribeiro et al., 2018), in the implementation of these instruments.

In addition, it was clear the need for breaking taboos relating to the term "entrepreneurship" in the internal discussions of councils, specialized boards and campuses, as well as collegiate bodies, so that its debate is broad and constant, possibly generating regulations, guidelines and other institutional instruments.

Furthermore, we suggest the gradual inclusion of entrepreneurial education and entrepreneurship themes in institutional development plans, management reports, pedagogical projects, internship regulatory framework, complementary activities, term papers and others.

From the point of view of public policies in the territory, promoting the linkage of CEFET-MG to entrepreneurial education was suggested, increasing its presence in the formulation of public policies for entrepreneurship and innovation (such as the constitution of local or regional committees), as well as the approximation with the legislature and the executive, in the

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campuses regions and at the state level (Wraae & Thomsen, 2019). There was an emphasis on lines such as "breaking down the wall" and "strengthening relationships", in order to allow the exchange of information and knowledge with all territorial agents relevant to the process. One way to do this is to offer technical support to the local government, for the creation of a political plan for entrepreneurship in the territory; another way is the use of a platform to unite supply and demand for technology and innovation projects, promoting interaction between actors.

In order to complete this subsection, the results of Table 5 refer to the variables selected for the "policies" dimension, in the surveys conducted in 2017 and 2019, whose analysis can be made from the means, as a measure of central tendency; and the standard deviations of the selected variables, as a measure of data dispersion as a function of the mean.

Moreover, the results of t-test for each variable are shown, which indicated, for most variables in this dimension, a p-value > 0.05, revealing that the means of the two years (2017 and 2019) are equal in statistical terms.

Table 5

Survey results for the "policies" dimension

Variables	Mean (Standard deviation)		Difer-ence	Signifi-cance[1]
	2017	2019	%	*t*-value
My university's teaching model/methodology helps me to develop entrepreneurial competencies	3.04 (1.28)	3.12 (1.28)	1.6	-1.595^{ns}
The curriculum of my course contributes to the development of entrepreneurial competencies	3.04 (1.37)	3.03 (1.29)	-0.2	0.087^{ns}
My university offers a flexible curriculum so I can engage in co-curricular activities	2.63 (1.44)	2.79 (1.39)	3.2	-1.349^{ns}
The university ecosystem where I study positively influenced the development of my entrepreneurial attitude	3.01 (1.23)	3.14 (1.20)	2.6	-1.238^{ns}

Notes: [1] significance: * = 10% (0.1); ** = 5% (0.05); *** = 1% (0.001) ns = non-significant. Elaborated by authors based on data from Coordination of Technology Transfer, Community Outreach and Development Board of CEFET-MG (2018), in collaboration with Brasil Júnior (2017, 2019).

Still (Table 5), more accentuated disagreements (greater dispersion) (between 1.20 and 1.44) can be perceived, indicating the need, on one hand, to develop an "entrepreneurial journey" (Brush, 2014; Neck et al., 2014); and, on the other, to establish communication of what is already being done for this purpose. For this, both the curriculum must be more flexible, to allow participation in co-curricular activities (Brush, 2014; Ribeiro & Plonski, 2020), and the ecosystem improved, to influence the entrepreneurial attitude at CEFET-MG.

In relation to the entrepreneurship as a curricular component (Brush, 2014), the data collected in the institution's information system (Table 6) in the time frame of this research (2017 to 2019), show a growing offer of disciplines with the term "entrepreneurship" in the title, being six (in 2017), five (in 2018) and seven (in 2019). Entrepreneurship disciplines have been offered in the Bachelor Programs of Administration (mandatory and optional disciplines) and Technological Chemistry (mandatory discipline).

The disciplines offered had a workload between 30 and 60 hours/class, with an average of 66% of the vacancies occupied, by about 30 students/class. Although the annual offer (Table 6) has grown recently, it is small in relation to the size of the institution, which demonstrates the need to include this topic as a curricular component in the most diverse courses (Brush, 2014).

The fact that there are relatively few subjects entitled "Entrepreneurship" obviously does not nullify the adoption of pedagogies aligned with entrepreneurial education (Neck et al., 2014), in other curriculum components. For example, professors who teach Management, or even other disciplines not necessarily related to this field, can play a key role in this process, by relating their contents to entrepreneurship (Davari et al., 2018).

Table 6

Offer of undergraduate entrepreneurship disciplines

Year	Entrepreneurship courses offered			
	Quantity	Workload (class hours)	Average vacancies (unit)	Enrolled (%)
2009	1	60	22	100
2010	2	120	38	78
2011	2	120	44	64
2012	2	120	44	42
2013	2	120	45	93
2014	2	120	44	57
2015	4	240	27	70
2016	2	120	42	37
2017	6	330	31	59
2018	5	300	31	79
2019	7	420	26	59

Note: Elaborated by authors based on data from Coordination of Technology Transfer, Community Outreach and Development Board of CEFET-MG (2018).

Structure

This subsection discusses the main evidence regarding the "structure" dimension of CEFET-MG entrepreneurship education ecosystem, in order to verify the infrastructure available for the institution's advances in terms of innovation, the development of inter-institutional partnerships, technology transfer and promotion of an entrepreneurial culture.

In the 2017 and 2019 survey results, the variables selected for the structure were those that captured the respondents' perception about the quality of research and experimentation laboratories, and innovation environments (Table 7). In 2019, in particular, 51% and 63% of students did not know how to give their opinion, respectively, about the research and experimentation laboratories and innovation environments, that is, a lack of knowledge that may indicate the low insertion of these environments in educational processes (Wraae & Thomsen, 2019).

In any case, there is a more positive view of laboratory infrastructure compared to typical innovation environments, which signals the need to invest more in these spaces, as a way to bring people together and accommodate projects (Audy, 2017; Belitski & Heron, 2017).

Participant observation evidenced discussions aimed at identifying public and private structures in the territories (Spigel, 2017; Stam & Spigel, 2016) necessary to create, generate and develop ideas and projects, or even spaces of the CEFET-MG itself, that could be re-signified.

Common to all campuses, due to the absence of spaces dedicated to entrepreneurship actions, we identified the need for greater use of spaces such as multi-sport courts, auditoriums, gymnasium, computer labs, classrooms, meeting rooms, and even

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the parking lot for the development of actions. Externally, associations, schools and universities, technology parks, partner companies, coworking spaces, event venues, theaters and cinemas, shopping malls, parks and squares were mentioned.

Table 7

Survey results for the "structure" dimension

Variables	Mean (Standard deviation)		Difference	Significance[1]
	2017	2019	%	*t*-value
Quality of infrastructure offered in terms of research and experimentation laboratories	3.51 (0.98)	3.66 (0.90)	3	-1.595[ns]
Quality of infrastructure offered in terms of innovation environments (incubator, coworking, fablabs, hubs, etc.)	–	3.20 (1.19)	–	–

Notes: [1] significance: * = 10% (0.1); ** = 5% (0.05); *** = 1% (0.001) ns = non-significant.
The questions about structure had a scale of 1 (very bad), 2 (bad), 3 (reasonable), 4 (good) and 5 (excellent), considering only the data of those who knew how to give their opinion. The question about innovation environments was introduced in the survey only in 2019.
Elaborated by authors based on data from Coordination of Technology Transfer, Community Outreach and Development Board of CEFET-MG (2018), in collaboration with Brasil Júnior (2017, 2019).

Resources

As for the "resources" dimension, the results of the participant observation show the search, on one hand, for partnerships to develop an entrepreneurial culture; and, on the other hand, greater convergence among projects, activities and resources already available at CEFET-MG. For example, 195 outreach actions were implemented in 2019, 40 of which were financed with resources in the order of two-hundred thousand reais, through internal calls for funding programs, projects, courses and events. About 6% of these actions that year were framed under the theme "labor and entrepreneurship", which highlights the pressing need to encourage more outreach actions to provide co-curricular activities (Brush, 2014).

Regarding access to resources via external partnerships, which are so important to the integration between the entrepreneurship education ecosystems and entrepreneur (Rossano-Rivero & Wakkee, 2019), participant observation data denoted that is necessary an approximation with: companies; other incubators and technology parks (technical aspects); national and international development agencies, such as the Minas Gerais Research Funding Foundation (Fapemig), Funding Authority for Studies and Projects (Finep), Coordination for the Improvement of Higher Education Personnel (Capes) and the National Council for Scientific and Technological Development (CNPq); investment funds, banks and angel investors; Sebrae and external acceleration programs such as Fumsoft Acelera MGTI, Lemonade and BioStartup Lab (methodologies and training); municipal, state and federal governments (resources from parliamentary amendments); NGOs, third sector, unions, regional development agencies; Association of Minas Gerais Municipalities; commercial, community and industrial associations; entities such as regional class councils, Federations of Junior Companies, Minas Gerais Innovation Network (RMI), Minas Gerais Innovation System (Simi); National Association of Entities Promoting Innovative Enterprises (Anprotec); Minas Gerais Intellectual Property Network (RMPI). We suggested, a greater role for the supporting foundation in making the execution of projects viable to facilitate these approaches.

We also noticed the importance of converging entrepreneurship and innovation actions to promote greater optimization of the use of internal resources. In this sense, there are works associated with entrepreneurship being developed in: Tutorial Education Programs (PET), Junior Companies, competition teams from the Center of Engineering Applied to Competitions (Neac), Distance Education Center (Nead), several research and outreach projects, research groups, FCM and actions on campuses (such as EmpreendaTec, in Araxá), in addition to the NIT itself and the Nascente incubator. In addition, workshops for professors and technical-administrative servants, symposia and activities scheduled during the Specific Exhibition of Works and Applications (Meta), the Science and Technology Week, and other periodic events can provide opportunities for making activities aimed at better articulation of the entrepreneurship education ecosystem.

Therefore, it is necessary to increase the coordination of actions, find synergies and collaborate to leverage results, optimizing resources and promoting the engagement of everyone involved.

Actors

The "actors" dimension considered the analysis of people or institutions that, directly or indirectly, contribute to and are involved in the entrepreneurship education ecosystem.

Concerning people, the entrepreneurial attitude of students and professors (Davari et al., 2018; Ribeiro et al., 2018) is characterized in the survey results. The means (Table 8), located between the third and fourth points of the scale, indicate the need to develop this attitude in students. The experience of professors in other roles, such as working for public and private organizations, is also evidenced as a key aspect for the creation of networks (Rossano-Rivero & Wakkee, 2019).

In relative terms, it is interesting to observe that self-assessment was superior to the assessment of the other, with regard to the entrepreneurial attitude; and, in absolute terms, the respondents' perception is more positive for the variables "professors' experience in the labor market" (means of 3.88 in 2017; and 3.77 in 2019) and "entrepreneurial attitude" of the respondents themselves (means of 3.70 in 2017; and 3.55 in 2019).

Table 8

Survey results for the "actors" dimension

Variables	Mean (Standard deviation)		Difference	Significance[1]
	2017	2019	%	*t*-value
I believe I have an entrepreneurial attitude	3.70 (0.98)	3.55 (1.10)	-3.0	1.567[ns]
The students of my university have an entrepreneurial attitude	3.32 (1.01)	3.35 (0.98)	0.6	-0.318[ns]
The professors of my university have an entrepreneurial attitude	3.05 (1.14)	3.24 (1.10)	3.8	-1.908[ns]
The professors of my university have experience in the labor market	3.88 (1.06)	3.77 (1.11)	-2.2	1.115[ns]

Notas: [1] significance: * = 10% (0.1); ** = 5% (0.05); *** = 1% (0.001) ns = non-significant.
Elaborated by authors based on data from Coordination of Technology Transfer, Community Outreach and Development Board of CEFET-MG (2018), in collaboration with Brasil Júnior (2017, 2019).

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It was not possible to identify a statistically significant difference between the results obtained by the 2017 and 2019 surveys for the analyzed variables; however, even so, the data collected and analyzed reveal perceptions about individual characteristics capable of favoring entrepreneurial intention – identified as typical among Brazilian students (Lima et al., 2015).

The means of the variables related to entrepreneurial competencies (Davari et al., 2018; Ribeiro et al., 2018), in 2017 and 2019, refer to the perception of students about their own entrepreneurial competencies, those of other students and those of professors (Table 9). It is noteworthy that, in the case of the rankings used, such competencies refer to characteristics and behaviors that result in an entrepreneurial attitude.

In this regard, statistically significant differences between 2017 and 2019 can be noted in Table 9 of 19 variables, out of a total of 27, the majority concerning the respondent's perception of other students and professors.

Thus, there is a positive and above average perception, for all groups (about themselves, others and professors, from the respondents' point of view), of the variables: curiosity, ability to achieve, ease to communicate ideas, and sociability.

Aspects that should be further developed, specially through institutional policies and programs, to encourage entrepreneurship are: courage to take risks (3.7 – in both years); non-conformity with reality and willingness to transform it (4.0 – in both years); and support for entrepreneurial initiatives (4.3, in 2017; and 3.2, in 2019). This last aspect deserves to be highlighted, since the vision of an entrepreneurial ecosystem and institutional action integrated to the Triple Helix must start from interdependence, interactions and connections between actors (Etzkowitz & Zhou, 2017; Isenberg, 2011). Therefore, supporting entrepreneurial initiatives is a key aspect to translate the actor's level of engagement (Wraae & Thomsen, 2019).

As for the participant observation of the "actors" dimension, the group discussions focused on the issue of how to involve, engage and maintain the engagement of internal and external actors, so that the entrepreneurial competencies of students can be developed, as indicated by Ribeiro et al. (2018).

Among the suggestions of the participants, which embrace initiatives with common applicability to the reality of each campus, are: (a) creating new communication strategies, such as web-radio, portal, YouTube channels, pitches about developed actions and social networks; (b) executing periodic events, with a specific agenda for entrepreneurship and innovation, providing moments of interaction between participants; (c) presenting an overview of the entrepreneurship education ecosystem to the internal and external communities of CEFET-MG; and (d) inviting alumni to share entrepreneurial experiences and maintaining a relationship with them, through mentoring and guidance.

The participants also suggested the use of departmental assemblies and informal meetings to improve awareness of the entrepreneurship theme for the engagement of professors and technical-administrative servants.

Maintaining the engagement of all actors, according to the above mentioned suggestions, can be achieved by clearly defining the actions purposes and assessing their results.

Table 9

Entrepreneurial competencies, in the perception of student respondents

Variables		Mean (Standard deviation)		Difer-ence	Signifi-cance[1]
		2019	%	*F*-value	2019
Non-conformity with reality and willingness to transform it	themselves	4.0	4.0	0	0.001
	other students	3.2	3.7	10	24.671***
	professors	3.1	3.6	10	24.416***
Vision for opportunities	themselves	4.0	3.9	-2	0.185
	other students	3.5	3.8	6	7.279**
	professors	3.4	3.9	10	19.058***
Innovative and creative thinking	themselves	3.8	3.9	2	0.652
	other students	3.6	3.9	6	11.196**
	professors	3.3	3.7	8	18.887***
Ability to achieve	themselves	4.2	4.2	0	0.091
	other students	3.8	4.0	4	8.596**
	professors	3.8	4.0	4	6.737**
Courage to take risks	themselves	3.7	3.7	0	0.372
	other students	3.3	3.6	6	4.996**
	professors	3.0	3.4	8	15.455***
Curiosity	themselves	4.5	4.4	-2	3.972**
	other students	3.8	4.1	6	13.43***
	professors	3.5	3.8	6	9.654**
Ease to communicate ideas and sociability	themselves	4.0	3.9	-2	0.248
	other students	3.8	4.0	4	3.868*
	professors	3.7	3.9	4	4.578**
Activities planning	themselves	4.2	4.1	-2	1.713
	other students	3.5	3.7	4	5.135**
	professors	3.7	4.0	4	12.719***
Support for entrepreneurial initiatives	themselves	4.3	3.2	-22	113.471***
	other students	3.5	3.6	2	1.282
	professors	3.3	3.6	6	9.64**

Notes: [1] significance: * = 10% (0.1); ** = 5% (0.05); *** = 1% (0.001) ns = non-significant. Elaborated by authors based on data from Coordination of Technology Transfer, Community Outreach and Development Board of CEFET-MG (2018), in collaboration with Brasil Júnior (2017, 2019).

Culture

For the "culture" dimension, the participant observation data indicated people with behaviors and attitudes that favor the entrepreneurial culture; and mapped the experiences, activities and projects to be leveraged (Brush, 2014). In this sense, the participants recognize themselves as key actors in stimulating entrepreneurial culture, hence the importance of mapping other people with the potential to support the entrepreneurship education ecosystem in each campus.

It is also noteworthy the need to sensitize professors (newly hired and already established) about entrepreneurship and innovation, breaking the taboos and encouraging continuing education. Therefore, we suggest the following actions: (a) awareness of the concept of "entrepreneurial education", through the creation of new workshops, in addition to the events already existing at the institution (Science and Technology Week and Specific Exhibition of Works and Applications); and (b) offering disciplines on entrepreneurial education, entrepreneurship and innovation, including in the form of distance education, in order to reach technical-administrative servants (who can obtain training points for progression), professors (who can report academic duties) and students (who can record participation as co-curricular activities).

Regarding the survey results, both rounds of the research indicate about 64% of students involved in activities that develop

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an entrepreneurial attitude, thus favoring the entrepreneurial culture (Davari et al., 2018).

In Table 10 is the percentage of students' participation in activities directly related to entrepreneurship, those associated to research, outreach and other co-curricular activities (Brush, 2014), in addition to those linked to internationalization (Ribeiro et al., 2018). It is noteworthy that, over the years, the participation of students in each of the activities varied a lot, with the exception of variables related to outreach projects, participation in athletic unions and exchange programs.

Table 10

Activities carried out by students who develop an entrepreneurial attitude

Type of activity	Respondents (%) 2017	Respondents (%) 2019	Significance[1] χ^2 value
Directly associated with entrepreneurship			
Junior Company	16,5	8,9	8,813**
Academic League	6,7	2,1	10,470**
Associated with the research			
Scientific Initiation	20,1	28,7	5,074*
Tutoring	18,9	25,6	3,370
Associated with outreach and other activities			
Outreach projects	26,8	26	0,055ns
Athletic Unions	12,2	9	1,658ns
Student Activism	1,2	7	8,019**
Associated with internationalization			
Science without Borders	11,6	2,8	26,664***
Exchange Program	4,9	4,3	0,123ns
AIESEC	1,8	0,4	3,997*
None	37,2	37,2	0,000***

Notas: [1] significance: * = 10% (0.1); ** = 5% (0.05); *** = 1% (0.001) ns = non-significant. Elaborated by authors based on data from Coordination of Technology Transfer, Community Outreach and Development Board of CEFET-MG (2018), in collaboration with Brasil Júnior (2017, 2019).

The data (Table 10) reveal that CEFET-MG, through institutional programs, not necessarily linked to entrepreneurship (notably outreach, scientific initiation and tutoring), and the initiative of professors and students themselves, offers opportunities for the development of activities that can contribute to the formation of an entrepreneurial culture. However, there was a decrease in participation, from one year to the other, in activities directly associated with entrepreneurship: the percentage of students fell from 16.5% to 8.9%, in the variable participation in junior companies; and from 6.7% to 2.1% in the variable participation in academic leagues.

It is noteworthy that most of the activities identified occur under the professors' guidance, while others depend only on student protagonism. Initiatives by students in junior companies, athletic unions and academic leagues provide new experiences (Ribeiro & Plonski, 2020), although there is space for greater involvement and engagement of students, in addition to better institutional coordination.

With regard to outreach activities, we recently noticed the inclusion of the theme "labor and entrepreneurship" in internal calls for fundings to promote outreach programs and projects, allowing, for example, the emergence of initiatives such as "Programa Engrena" and "Entrepreneurship and associativism: social reintegration of prisoners from APAC Nova Lima".

The results discussed here show the importance of continuing to adapt internal policies, structures and resources to favor the entrepreneurship education ecosystem, and obtain greater engagement from actors and the development of an entrepreneurial culture.

In this sense, some actions started in 2018 - e.g. introduction of the Innovation Policy and initiatives by Nascente Technology-Based Impact Business Incubator and Engrena Program - may have already had some effect on the entrepreneurial competencies of students in 2019 (Table 9) – although there may be other causal factors, such as other actions formally implemented by the institution or those that emerge informally (Davari et al., 2018; Guerrero & Urbano, 2012), which are also important for the development of the ecosystem.

CONCLUSIONS

Returning to the objective of this article, we consider the combination of diagnostic actions and periodic interventions essential for the development of an entrepreneurship education ecosystem, based on models such as the Triple Helix, which draws attention to the importance of the joint action of government, university and companies. This interaction, which has the academy/university as a driving force, is necessary to achieve economic and social development goals through entrepreneurship and innovation. Hence the importance of constituting an entrepreneurship education ecosystem, from the point of view of academic institutions, to understand their dynamics in the interaction of actors, policies, structure, resources and culture.

The results of this CEFET-MG case study indicate the need to improve the entrepreneurial attitude of students, although, in some aspects, it is already possible to notice improvements from 2017 to 2019. On one hand, the diagnosis via survey, in collaboration with the Entrepreneurial Universities Ranking, can be a key element for assessments and proposals, that is, as an internal and, eventually, external benchmarking tool, capable of improving decision-making in favor of such ecosystems. On the other hand, participant observation allowed to list several suggestions that, if put into practice, can favor ecosystems and serve as a reference for their implementation in institutions with similar characteristics.

We evidenced the constitution of internal policies to favor entrepreneurial education and participation in public policy actions in the territory as essential. In this sense, we highlight the institutionalization of educational processes - which include entrepreneurship in curricular components, as well as relevant co-curricular and research activities - and the availability of resources and structures, which can contribute to the articulation of actors and the formation of an entrepreneurial culture.

We conclude that the various actions already developed by the studied institution are ways of bringing up entrepreneurship, a taboo topic for some teaching and research institutions. Based on participant observation data, this study shows the need to adapt "thinking about entrepreneurship" to each territory, in order to reflect locally on entrepreneurship ecosystems and align to the needs of internal and external communities.

However, it is worth noting that, while specific actions compete with the workload necessary for students to comply with the mandatory curricular components, in the most diverse courses, it will be difficult to properly activate the transformation that is capable of establishing, in fact, an entrepreneurship education ecosystem. In order to confront this issue, entrepreneurial journeys can be created and effectively

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integrated into the curriculum (Brush, 2014); and communication processes established between internal and external public, to disseminate knowledge about all elements of the ecosystem.

An entrepreneurship education ecosystem must reflect the dynamization, connections and interactions necessary to generate economic and social development, based on innovation and entrepreneurship, sustained by an entrepreneurial education-favorable attitude by ecosystems' actors. Therefore, the teaching institution exerts a strong influence on the development of its territory, by making its entrepreneurship education ecosystem evolve.

This research helps to identify not only the opportunities and challenges encountered, but also possible pathways for inserting the theme of entrepreneurship in teaching, research and outreach activities of other institutions.

As university-industry-government collaboration is essential to the performance of the entrepreneurship education ecosystem (Belitski & Heron, 2017), a limitation of this research was to approach only the teaching and research institution as a unit of analysis for understanding this ecosystem.

It is worth noting that, for each of the variables selected in the two rounds of surveys, the results bring interesting insights that reflect the reality of CEFET-MG, and contribute to understanding the institution's entrepreneurship education ecosystem. However, due to their methodology, the surveys were not able to capture in-depth information, from the perspective of the institution's managers and staff, nor to generate, in this context, decisions and suggestions of actions necessary for the development of this ecosystem - aspects explored in the results of the participant observation.

Participant observation evidenced, on one hand, the difficulties of the entrepreneurship education ecosystem of each campus; while, on the other hand, the willingness of research participants at this stage, mostly coordinators and local mobilizers, as essential actors for developing their ecosystems, based on short, medium and long-term initiatives. It is worth remembering, in this regard, as discussed by Dorion et al. (2015), that universities and technical schools, such as CEFET-MG, are often focused on training for the labor market; therefore, they do not aim precisely to develop entrepreneurial competencies and potential.

As opportunities for future research, in the light of Belitski e Heron (2017) and other authors mentioned here, we suggest to include as much territory actors as possible - among them, business communities, policy-makers, spin-off entrepreneurs and scientists - in the discussion about pillars and criteria for the entrepreneurship education ecosystem. It is also necessary to conduct studies on the impact of pedagogical aspects on the ecosystem (Nabi et al., 2017). In this way, performing qualitative and/or quantitative studies will allow deepening the understanding of entrepreneurship education ecosystems in the dimensions proposed in this research - actors, policies, structure, resources and culture - or even in new dimensions, eventually identified as emerging analytical categories and relevant to the phenomenon analyzed.

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Conflict of interest statemen

The authors declare that there is no conflict of interest.

Authors' statement of individual contributions

Roles	Contributions			
	Lopes DPT	Silva SA	Almeida CM	Martins LGR
Conceptualization	■	■		
Methodology	■	■		
Software	■			
Validation	■	■		
Formal analysis	■	■		
Investigation	■	■	■	■
Resources	■	■		
Data Curation	■	■	■	■
Writing - Original Draf	■	■	■	
Writing - Review & Editing	■	■		
Visualization	■	■	■	■
Supervision	■	■		
Project administration	■	■	■	
Funding acquisition	■	■		

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Appendix 1

Quadro com a especificação das variáveis

Group of variables	Variable	Scale
Socio-demographic variables	Gender	0 (male) 1 (female) 2 (another)
	Racial Group	1 (white) 2 (brown) 3 (black) 4 (yellow) 5 (indigenous) 6 (not declared)
	Family income (half minimum wage)	1 (up to half – BRL 499) 2 (between half and one and a half – BRL 499.01 to BRL 1,497.00) 3 (between one and a half and three – BRL 1,497.01 to BRL 2,994.00) 4 (between three and five – BRL 2,994.01 to BRL 4,990.00) 5 (between five and ten – BRL 4,990.01 to BRL 9,980.00) 6 (more than ten minimum wages – BRL 9,980.00) 98 (I don't know) 99 (I prefer not to declare)
	Course	[list of courses omitted for space reasons]
Policies	My university's teaching model/methodology helps me to develop entrepreneurial competencies	1 (strongly disagree) 2 (partially disagree) 3 (neither agree nor disagree) 4 (partially agree) 5 (strongly agree)
	The curriculum of my course contributes to the development of entrepreneurial competencies	
	My university offers a flexible curriculum so I can engage in co-curricular activities	
	The university ecosystem where I study positively influenced the development of my entrepreneurial attitude	
Structure	Quality of infrastructure offered in terms of research and experimentation laboratories.	1 (very bad) 2 (bad) 3 (reasonable) 4 (good) 5 (excellent)
	Quality of infrastructure offered in terms of innovation environments (incubator, coworking, fablabs, hubs, etc.)	
Actors	I believe I have an entrepreneurial attitude	1 (strongly disagree) 2 (partially disagree) 3 (neither agree nor disagree) 4 (partially agree) 5 (strongly agree)
	The STUDENTS of my university have an entrepreneurial attitude	
	The PROFESSORS of my university have an entrepreneurial attitude	
	The professors of my university have experience in the labor market	
	Non-conformity with reality and willingness to transform it	
	Vision for opportunities	
	Innovative and creative thinking	
	Ability to achieve	
	Courage to take risks	
	Curiosity	
	Ease to communicate ideas and sociability	
	Activities planning	
	Support for entrepreneurial initiatives	
Culture	Activities directly associated with entrepreneurship - Junior Company	0 (yes) 1 (no)
	Activities directly associated with entrepreneurship – Academic league	
	Activities associated with research - Scientific initiation	
	Activities associated with research – Monitoring	
	Activities associated with outreach and other activities - Outreach projects	
	Activities associated with outreach and other activities – Athletic Unions	
	Activities associated with outreach and other activities - Student Activism	
	Activities associated with internationalization – Science without borders	
	Activities associated with internationalization – Exchange Program	
	Activities associated with internationalization - AIESEC	
	No co-curricular activities	

Note: Adapted from Brasil Júnior (2017, 2019).

Annex 1

Institutional development plan 2016-2020 – CEFET-MG (v. II, **)*

Principles, goals, objectives and general programs

[...] this 2016-2020 IDP has its definitions, in relation to the operation of each of the institutional areas, guided by 20 principles, objectives and general programs that will guide the policies and practices at CEFET-MG, in the period in question. In turn, the principles, objectives and general programs presented below are in line with the educational legislation, the Institution's context and the diagnosis made.

As for the principles, they meet aspects considered essential regarding the characteristics of CEFET-MG as a teaching institution aware of its social function and educational purposes. Thus, there are principles related to: school-society relationship (1 to 5); formative processes specific to higher education institutions, vertical and multicampus, in the area of technological education (6 to 10); treatment of human and material conditions, involving institutional subjects, communication and technological solutions (11 to 15); and institutional administration (16 to 20).

1 – General principles

01. Conception of education as a social right and public good.
02. Commitment to permanent dialogue with integrated action, critically, to local, regional, national and international demands, and to legal determinations, in light of the conditions of environmental, socioeconomic and cultural sustainability and the characteristics of contemporaneity.
03. Commitment to social quality, that is, to the educability of students, professors and technical-administrative servants as socio-historical subjects who can contribute to a more democratic Brazilian social formation and with rejection to forms of exclusion and exploitation, particularly in educational the sector.
04. Improvement of the institution's general conditions, so that it increasingly becomes an institution of excellence for the professional exercise of its servants and the construction of the academic-social trajectory of its students.
05. Valorization of technological innovation as a means to achieve social function and institutional objectives.
06. Valorization of the humanist and technological character of the Institution, in favor of technological education, the promotion of citizenship and social inclusion, with the rejection of exclusionary policies and practices.
07. Formative processes marked by the integration between work, science, technology and culture.
08. Consideration of the plural and contradictory character that permeates the institutional policies and practices of a vertical and multicampus university institution, in teaching, research and outreach, operating in the State of Minas Gerais.
09. Proper articulation of a university institution between the areas of teaching, research, outreach and administration and between the internal components of each.
10. Articulation between high school technical professional education, undergraduate and graduate degrees, strengthening institutional verticalization.
11. Recognition of the subjects' diversity, respecting: the plurality of values and cultural universes; disabilities and special educational needs; and ethnic, gender, sexual orientation and socioeconomic status diversity.
12. Consideration of human and symbolic conditions in the definition and materialization of institutional policy.
13. Valorization of servants, students, culture and knowledge historically built in the centenary trajectory of CEFET-MG as the Institution's greatest heritages.
14. Valorization of the internal and external dissemination of general institutional information, including administrative, academic and technical-scientific, respecting conditions of freedom of speech, intellectual property and information security.
15. Production and use of technological solutions to improve the achievement of institutional purposes and objectives.
16. Democratization and political-administrative transparency of management and continuous institutional self-assessment, with an emphasis on the social quality of institutional operation.
17. Participatory management with respect to collective discussion and deliberative instances.
18. Valorization of the Institution's regional identities, in its policies and practices.
19. Recognition of the importance of physical and academic infrastructure in achieving policies and practices, in organicity with institutional purposes and objectives.
20. Administration guided by the balance between cost-benefit, cost-effectiveness and opportunity cost, in light of the Institution's socio-educational function.

2 – General goals

01. Strengthen the identity of CEFET-MG as a public institution, free of charge and of excellence in the technological education field, and advance in the systematic improvement of indicators that already qualify it as high quality, with the provision of high school-level technical professional education, graduation and postgraduation, by the improvement of their material conditions and academic culture.
02. Achieve, in an organic way, at least 90% of all the goals established in this IDP.
03. Become the Federal Technological University of Minas Gerais: make the presentation of the Law Project, by the Executive Branch, feasible, for approval by the National Congress.

3 – General objectives

01. Strengthen institutional practices (academic and management), its human resources, its technological solutions and its material and academic infrastructure, in a consistent manner with the principles established in this Plan.
02. Consolidate the expansion conducted in recent years and continually take care of the improvement and expansion of institutional operation, with the definition of regulatory frameworks and continuous assessment at all levels and sectors.
03. Strengthen high school-level technical professional education as one of the foundations of institutional verticalization.

It is not too much to say that each of the stated objectives must be carried out, fully respecting the social function, institutional purposes and the 20 general principles explained in this Plan.

4 – General programs

01. Social Inclusion and insertion
02. Development and promotion of the areas of teaching, research, outreach and innovation, and integration between them
03. Innovation, entrepreneurship and technology transfer**
04. International cooperation
05. Organizational development and management of work processes
06. Improvement of information technologies and institutional communication
07. Improvement of infrastructure and distribution of physical space
08. Assessment
09. Cross-sectional programs

* Volume II available at https://www.cefetmg.br/instituicao/plano-de-desenvolvimento-institucional-pdi/

** Acting in the development and execution of an innovation, entrepreneurship and technology transfer policy that involves specific principles to stimulate research, technology generation, protection of creations, licensing and other forms of technology transfer. Such principles come from the Law of Innovation, Law n. 10,973/2004, and the Legal Framework for Science, Technology and Innovation, Law no. 13,243 of January 11, 2016.

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