RACEF
Revista de Administração, Contabilidade e Economia da **Fundace**

FUNDACE

Ribeirão Preto, Janeiro de 2026
Edição: v. 17, n.1 (2026)

ANALYSIS OF THE WEBSITES OF THE TECHNOLOGY TRANSFER OFFICES OF BRAZILIAN FEDERAL UNIVERSITIES

ANÁLISE DOS WEBSITES DOS NÚCLEOS DE INOVAÇÃO TECNOLÓGICAS DAS UNIVERSIDADES FEDERAIS BRASILEIRAS

DOI: HTTP://DX.DOI.ORG/10.13059/RACEF.V17I1.1266

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Data de envio do artigo: 19 de Maio de 2024.
Data de aceite: 07 de Novembro de 2025.

Abstract: One of the main communication channels between a Transfer Technology Office (TTO) and its audience is through websites; however, there are few studies addressing their development in terms of architecture, content, and usability. The present study is the first to analyze the websites of NITs at all Brazilian federal universities and presents findings that can enhance their quality. A panel of experts defined 47 criteria and their respective weights, ranking the websites from both academic and business perspectives. It was found that most websites do not offer information on the legal possibilities of contracts with companies; are heavily focused on patents; do not follow good usability practices and have incomplete content; thus, this study provides a diagnosis and suggests practical improvements for the enhancement of TTO websites.

Keywords: Technology Transfer Offices; Websites; Universities; Technology Innovation.

Resumo: *Um dos principais canais de comunicação entre um Núcleo de Inovação Tecnológica (NIT) e seu público se dá por meio de websites, no entanto há poucos trabalhos abordando o desenvolvimento dos mesmos em termos de arquitetura, conteúdo e usabilidade. O presente estudo faz uma análise dos websites de NITs de todas as universidades federais brasileiras, e apresenta descobertas capazes de aprimorar a qualidade dos mesmos. Uma comissão de especialistas definiu 47 critérios e seus respectivos pesos, ranqueando os websites na perspectiva acadêmica e empresarial. Descobriu-se que a maioria dos websites não oferecem informações sobre possibilidades jurídicas de contratos com empresas; são fortemente direcionados para patentes; não utilizam boas práticas de usabilidade e possuam conteúdo incompleto; de modo que esse trabalho faz um diagnóstico e sugere melhorias práticas para o aperfeiçoamento dos websites de NITs.*

Palavras-Chave*: NIT, Websites, Universidades, Inovação Tecnológica.*

1 INTRODUCTION

In accordance with Brazilian Innovation Law (Brasil, 2004), TTOs (Technology Innovation Centers or Technology Transfer Offices) are structures established by STIs (Scientific, Technological, and Innovation Institutions), with or without their own legal personality, whose objective is to manage the institutional innovation policy. In detail, TTOs are responsible for managing intellectual property and technology transfer from STIs and aim to promote innovation and entrepreneurship in academic, business, and social spheres. To achieve these objectives, it is imperative that the services, processes, and projects developed by TTOs are efficiently communicated to interested audiences (Singh et al., 2020).

Garett et al. (2016) shows that one of the main communication channels between a TTO and its audience is through websites; and according to York and Ahn (2012) the quality and structure of a TTO's website are directly linked to improvements in managerial processes, specifically the facilitation of technology commercialization, partnership engagement, and the administrative handling of technology transfer agreements. However, there are few studies addressing how these websites should be structured, as demonstrated by Table 1. Addressing this gap, this study examines: What are the key shortcomings and improvement opportunities in the websites of TTOs at Brazilian federal universities, considering both academic and business perspectives?

Overall, the article aims to characterize the websites of TTOs at Brazilian federal universities and construct an ideal website model, encompassing the observed best practices. To this end, the study investigates and develop criteria and weights to rank the best websites, discuss findings related to the content and usability, and finally provides practical insights to improve TTOs websites.

The article is structured as follows: Section 2 covers the literature review; Section 3 describes the methodology; Section 4 encompasses the results and discussions, including graphical

analyses, ranking of the TTO websites, and proposition of an ideal website model; and Section 5 comprises the conclusions.

2 LITERATURE REVIEW

Proper website design is a critical element for engaging users; however, little research has been conducted to define the specific elements used in the effective design of websites and mobile applications (Garett et al., 2016). Singh et al. (2020) identified difficulties TTOs face in communicating with the market, noting that the university websites studied did not provide detailed information about the services offered, their target audience, and especially the main technical competencies the institution has to offer.

Table 1 - Feature of related studies

Citations	Publication type	N	Rank	Group	Area
Jacob, V. C. (2010)	Final Paper/Thesis	1	no	no	Library
Gillespie, *et al.* (2011)	International Journal	1	no	no	TTOs
York and Ahn (2012)	International Journal	48	no	no	TTOs
Youngblood (2012)	International Journal	144	no	no	Government
Grützmann *et al.* (2013)	International Conference	148	no	no	Companies
Sa and Cunha (2015)	National Conference	3	yes	no	Cultural Centers
Fung *et al.* (2016)	International Journal	3	no	no	Library
Muenchen *et al.* (2016)	National Conference	1	no	no	Economic Sciences
Silva (2017)	Final Paper/Thesis	52	yes	no	TTOs
Li *et al.* (2017)	International Journal	3	no	yes	Hotels
Medeiros *et al.* (2019)	International Conference	20	no	no	TTOs
Medeiros and Souto (2019)	National Conference	20	no	no	TTOs
Lee and Lee (2019)	International Journal	1	no	no	Government
Nascim. and Ti-radentes (2020)	International Conference	20	no	no	TTOs
Rocha and Aganette (2021)	National Journal	1	no	no	Project Company
Neto *et al.*, (2022)	National Conference	1	no	no	Library
Current paper	National Journal	62	yes	yes	TTOs

Source: Own elaboration (2024)

Tables 1 and 2 summarize the characteristics, contributions, and limitations of studies published over the past 15 years that focus on information architecture, evaluation, and analysis of websites, including design and user engagement. The searches mechanisms used were Google Scholar, Scopus and Web of Science with the keywords: technology innovation center websites; websites of technology transfer offices; university technology transfer offices; website design and user engagement; usability assessment. These same tables help to contextualize the present study within the related literature.

Table 1 shows, in this order, the type of publication, the number of evaluated websites, whether the work presented a ranking for the evaluated websites, whether the evaluation was carried out by a group of experts and/or users, and the area of the studied website. Although the literature review

focused on TTOs, only four articles analyzing TTO websites were found, highlighting a gap in the specific literature. The other works, despite not involving TTOs, were selected because they address the topic of information architecture and website usability, included in the scope of this study. It is noticeable that the works are relatively well distributed among all publication types. It is noted that 10 out of the 17 works evaluate multiple websites; and the vast majority of the articles do not rank the websites or perform the evaluation by a group of experts and/or users. The application areas are diverse, including libraries, companies, government websites, and TTOs.

Table 2 summarizes the main contributions and limitations of the related works. Most contributions focus on identifying anomalies on websites and suggesting improvements; while limitations generally refer to small samples and vague conclusions. The following paragraphs provide more details on the context of these studies and specific examples of problems identified on websites from different areas that may also occur on TTO-related websites.

Gillespie, et al. (2011) state that creating a single website location for finding information such as patent, patent applications, and marketing summaries for trans-portation technologies with market potential. York and Ahn (2012) showed that websites are an important differentiator between TTOs which can enhance the es-tablishment of 'virtual proximity' with potential collaborators if the websites are per-ceived as highly usable (e.g., easy to navigate, content amount and variety and re-sponsive).

Addressing library websites, Jacob, V. C. (2010) conducted a study to verify if the website of the library of the Federal University of Goiás (UFG) meets the elements of Information Architecture and Usability criteria. Some problems were identified such as: vertical scrolling more than three times; use of expressions like "click here"; there is no site map; long texts; no update date; lack of a layout pattern; among others.

Fung et al. (2016) evaluate the usability of the "mobile" version of the University of Hong Kong Library's website as a case study comparing it with two others, according to the ten usability heuristics developed by Nielsen (1994). Some of the identified issues are: inability to inform users of waiting time, consistency issues in content display, lack of advanced search, and inadequate error message. Still on libraries, Neto et al. (2022) analyze the digital interface of the National Library website in Brazil, identifying issues such as a poor layout utilization, scattered information, disordered menus, confusing nomenclature, and ineffective search system.

Youngblood and Mackiewicz (2012) adapted corporate usability and e-government benchmarks to compare municipal government websites finding issues comprising: lack of a home button in navigation, absence of a logo, non-underlined text links that do not change color after the linked page is accessed, and the need for horizontal scrolling. Grützmann et al. (2013) investigated the use of web technologies by Brazilian companies revealing a lack of content updates, the use of social networks only for advertising or customer service as a replacement for traditional channels such as telephone or email stand out.

Table 2 - Main contribution and limitations of the related literature

Reference	Contributions	Limitations
Jacob, V. C. (2010)	Appropriate design and usability issues.	Evaluation conducted on 1 website.
Gillespie, *et al.* (2011)	Recommendations for Technology Transfer at the ITS TTO.	Focus on transportation systems
York and Ahn (2012)	Importance of TTO websites	Subjective reccomendations
Youngblood (2012)	All municipalities in the state of Alabama had their websites analyzed.	Analysis tools do not provide detailed results.
Grützmann et al. (2013)	The potential for innovation seems to be going to waste.	Focus on a brief qualitative evaluation.
Sa and Cunha (2015)	Website developers need to improve their practices.	Few websites analyzed.
Fung et al. (2016)	Several opportunities for improvement identified.	Few websites analyzed.
Muenchen et al. (2016)	Website as a means of engagement with society.	Tests and possible improvement opportunities were not reported.
Silva (2017)	Identifies Architecture and Usability issues.	Does not include the perception of entrepreneurs and TTO services.
Li et al. (2017)	Complementarity with other communication channels.	Does not delve into the functionalities of the websites.
Medeiros et al. (2019)	Identifies patterns in interfaces.	Sample of 20 websites.
Medeiros and Souto (2019)	Identifies a lack of standardization in the use of concepts.	Sample of 20 websites.
Lee and Lee (2019)	Proposal for a new method to evaluate government websites.	The method not tested in practice.
Nascim. and Tiradentes (2020)	Recommends websites with proactive functionalities and quality search	No significant novelty compared to previous articles by the authors.
Rocha and Aganette (2021)	Identifies anomalies on the website, studies, and makes improvements.	Study limited to a single website, without generalizations.
Neto et al., (2022)	Suggestions for improvements on the researched website.	Study limited to a single website; without group analysis.
Current paper	Suggestions for improvements, ranking, and analysis by group.	Limited to Brazilian federal universities

Source: Own elaboration (2024)

Sa and Cunha (2015) evaluated the usability of three websites of Brazilian cultural centers, finding problems such as misuse of the "Home" key, excessive use of acronyms, lack of an "emergency exit," images with incorrect links, absence of shortcuts, and overly long texts were found. Muenchen et al. (2016) developed a website to disseminate information about the Economics course and area as a means of approaching society but not reporting possible issues. In the hotel industry, Li et al. (2017) investigated the relationship between the quality of economy hotel websites and online booking intentions in China, finding that the dimension 'complementarity with other communication channels' is more relevant than the others (usability, ease of use, entertainment)."

Lee and Lee (2019) developed an evaluation model focused on government agency websites, both from the government's and citizen's perspectives, including specific criteria for assessing

transparency, service quality, and user engagement. Regarding private companies, Rocha and Aganette (2021) analyzed the usability of a website of a project management administrative company, based on user observation during navigation and execution of their tasks.

The literature search sought to find works related to TTOs, identifying four publications. Silva (2017) analyzes the architecture and usability of information on 52 TTO websites of federal universities using Nielsen's heuristics (1993; 1999). Problems such as excessive menus, logical errors, display of false links and buttons, blank pages, inappropriate shortcuts, and lack of user assistance were identified. Medeiros et al. (2019), Medeiros and Souto (2019), and Nascimento and Tiradentes (2020) sought to characterize, from the perspective of Interaction Design, technological showcases on the web of 20 Brazilian public ICTs. Four categories of websites were identified based on the characteristics and patterns presented. There was a great divergence in the names assigned to the websites and also differences between the information provided in the showcases and that of patent databases.

The present work complements Silva (2017), which focused on analyzing Information Usability using Nielsen's heuristics and Information Architecture, using a form to evaluate the Organization, Navigation, Labeling, and Search System of websites, with the results of the article mainly usable by website developers to prevent problems such as inadequate translation, link redirection errors, menu layouts, inappropriate shortcuts, presence of a site map, etc. This article delves into evaluating the quality and completeness of content offered by websites regarding the inherent services of TTOs such as invention notification and registration, computer program programs; legal instruments such as "Research, Development, and Innovation Partnership Agreements" and "Provision of Specialized Services", technological showcases, incubators, subsidiary companies, among other services. The results of the article can be used by TTO staff to direct the content to be made available on the websites and allow better use of their services by internal and external users of the institution. Other differences are:

- Websites are analyzed not only from the perspective of the academic audience but also from the business audience.
- It doesn't focus solely on intellectual property but also includes possibilities for partnerships with the private sector as outlined in Federal Decree No. 9283/2018.
- The websites are not analyzed by a single individual but by a group of TTO professionals.
- For website ranking, a simple average is not considered; instead, weights have been created for each of the evaluation criteria.
- Based on the analysis conducted, the characteristics of an "ideal website" for TTOs are suggested.

The present study, by evaluating all 62 websites of federal universities, established evaluation criteria, defined weights for these criteria, collectively applied the evaluation criteria, ranked the websites, analyzed differences, and learned about positive and negative characteristics of the websites in order to consolidate best practices for achieving an ideal website.

3 METHODOLOGY

The study conducts an applied, explanatory, and quantitative research (York & Ahn, 2012; Silva, 2017) analyzing websites of all federal universities' NITs, suggesting best practices for user interaction. Initially, website characteristics were defined from literature and preliminary analysis of top 10 innovative universities (RUF, 2023).

Subsequently, a survey was conducted to identify the quantity, names, and websites of all federal universities in Brazil, and then the sectors or administrative units of each university related to NITs were identified. An open search on Google was also conducted using the keywords

"innovation" and the "name of the university" under study.

Among the 69 universities, no websites related to NITs were found for seven institutions: UFAPE, UFDPar, UFAC, UNIR, UFRR, UFNT, and FURG. To verify, emails were sent to the universities, and UFAPE, UFRR, and FURG responded to the emails, confirming the absence of a website for their NITs. The other four universities did not respond to contact, and a specific investigation for these institutions did not find websites.

The previously identified characteristics were used as evaluation criteria for the websites and were measured by four analysts familiar with the topics of innovation and entrepreneurship. In preparation for the website evaluation, a meeting was held among the evaluators to standardize the understanding of each of the criteria and the measurement scales to be adopted. To reduce the workload, given the analysts' time constraints, the website evaluation was divided among them in approximately the same proportion.

Once the evaluation was completed, to ensure the coherence of the results due to the presence of different analysts, a cross-evaluation was conducted in which all analysts evaluated a sample of websites. Since the results from different analysts were similar, the research proceeded. Weights were assigned to the criteria, descriptive statistics were generated and analyzed, website ranking was conducted, and finally, best practices capable of improving website quality and that should be present in an "ideal website" were analyzed.

4 RESULTS & DISCUSSION

The following are the criteria used for website evaluation, data analysis, and the obtained learning.

4.1 EVALUATION CRITERIA

Tables 3 to 8 describes the criteria used in the research, with their respective identification numbers (ID), criterion family, variable type, description, and weights. There are 47 criteria divided into 6 families: Introd uction (related to general aspects of the website); Services (criteria directly related to the services provided by a TTO), Disclosure (website profile, technological showcase, indicators), Entrepreneurship (incubator, junior and subsidiary companies), Companies (means for companies to identify researchers' profiles/specialties), and Community (services for the community external to the university).

Table 3 - Evaluation criteria for "Introduction" family websites

ID	Criteria	Variable Type	Description	Weight 1 (Acad.)	Weight 2 (Buss.)
1	Nomenclature	Text	The name of the innovation and entrepreneurship sector is TTO	1.75	2.75
2	Introductory page	Likert	Information about mission, vision, values, target audience, and services provided.	5	4.75
3a	Team size	Integer	Indicates the number of employees	2.75	3
3b		Integer	Indicates the number of interns	1.25	1.25
4a	Innovation policy	Binary	Presence of innovation policy	4.75	4.5
4b		Year	Year of innovation policy update	3.75	3.5
5a	Social media	Binary	Presence on social media	4.5	4.5
5b		Text	Description of social media used	NA	NA
5c		Binary	Verification of social media update in 30 days (posting frequency)	4.5	4.5

Source: Own elaboration (2024)

Table 4 - Evaluation criteria for the "Services" family websites

ID	Criteria	Variable Type	Description	Weight 1	Weight 2
6a	Services provided	Likert	Information about the types of services provided by TTO.	5	5
6b		Text	Description of the types of services provided.	NA	NA
7a	Invention notification	Nominal	Presentation of procedures via text, flowchart, or both.	NA	NA
7b		Likert	Quality/clarity of the procedure description and ease of access through the website.	5	3.67
8a	Software notification	Nominal	Presentation of procedures via text, flowchart, or both.	NA	NA
8b		Likert	Quality/clarity of the procedure description and ease of access through the website.	4.67	3.67
9a	Partnership agreements	Nominal	Presentation of procedures via text, flowchart, or both.	NA	NA
9b		Likert	Quality/clarity of the procedure description and ease of access through the website.	4.75	5
10a	Specialized service provision	Nominal	Presentation of procedures via text, flowchart, or both.	NA	NA
10b		Likert	Quality/clarity of the procedure description and ease of access through the website.	5	5

Source: Own elaboration (2024)

For the ranking analysis, which will be addressed in Section 4.3, the criteria were classified by variable type (binary, integer, year, and Likert), and weights were also defined for them. It is noteworthy that weights were not adopted for criteria of the text and nominal type to avoid redundancy since they complement quantitative criteria. Finally, it is highlighted that weights 1 and 2 in Table 3 refer to the relevance of the specific criterion from the academic and business perspectives, respectively. In structuring the table, it was chosen to categorize the criteria into families for future analyses and to use IDs to facilitate the construction of graphs.

Table 5 - Evaluation criteria for "Entrepreneurship" family websites

ID	Criteria	Variable Type	Description	Weight 1	Weight 2
16a	Business incubator	Binary	Information about the business incubator and its activities.	4.5	4.5
16b		Binary	Information about companies incubated in the last year.	3.5	3.5
16c		Year	Year of the last incubation notice issued.	3.5	3.5
17	Junior companies	Likert	Quality of information about junior companies.	4.75	5
18	Spin-off companies	Likert	Quality of information about spin-off companies.	4.5	4.75

Source: Own elaboration (2024)

Table 6 - Evaluation criteria for the "Companies" family

ID	Criteria	Variable Type	Description	Weight 1	Weight 2
19a	Laboratory portfolio	Likert	Quality of information about laboratory portfolio (infrastructure and services).	3.5	3.75
19b		Year	Year of update.	3	3.25
20	Research groups and areas	Likert	Quality of information about research groups and areas.	4.5	4.75

Source: Own elaboration (2024)

Table 7 - Evaluation criteria for the "Community" family

ID	Criteria	Variable Type	Description	Weight 1	Weight 2
21a	Courses and events	Binary	Provision of training and courses on innovation and entrepreneurship.	4.5	4.5
21b		Binary	Verification of event organization in the last year.	3.75	3.75

Source: Own elaboration (2024)

It is noteworthy that the criteria weights were established through prior evaluation by four analysts with experience in the fields of innovation and entrepreneurship. Individually, the analysts assigned each criterion a score from 1 to 5, representing the weight, where the value 1 represents low importance and 5 represents high importance. If the information does not exist on the website, the assigned value was 0. Then, the arithmetic mean was calculated among the four analysts, resulting in the weight values indicated in the table above. Situations where a significant difference in weights among analysts was observed for a given criterion were discussed within the group to level understanding and reduce assessment dispersion.

According to the weight table, it is inferred that the most relevant criteria, from the analysts' perspective, are those related to the services provided, the technological showcase, and the website quality from the perspectives of students, researchers, and companies, demonstrating the importance of these topics in the construction of TTO websites.

Table 8: Evaluation criteria for the "Promotion" family websites

ID	Criteria	Variable Type	Description	Weight 1	Weight 2
11	Own website	Binary	Existence of a website with its own domain.	3.75	4
12a	Perspectives	Likert	Researcher's perspective on clarity, usability, and quality of information.	5	5
12b		Likert	Student's perspective on clarity, usability, and quality of information.	5	5
12c		Likert	Company's perspective on clarity, usability, and quality of information.	5	5
13a	Technological showcase	Likert	Assessment of clarity, organization, and information provided on the site.	5	5
13b		Binary	Information about the number of patents deposited.	4	4
13c		Binary	Information about the number of patents granted.	3.5	3.5
13d		Binary	Information about the number of registered software.	3.75	4
13e		Binary	Information about the number of R&D partnership agreements.	3.5	3.75
13f		Binary	Information about the number of technology transfer contracts.	4	4.25
13g		Year	Year of the last update of the technological showcase.	4.5	4.5

Table 8 — continued

ID	Criteria	Variable Type	Description	Weight 1	Weight 2
14a	Innovation announcements	Likert	Quality of the dissemination of internal innovation announcements by the institution.	4.75	4.75
14b		Likert	Quality of the dissemination of external innovation announcements.	4.75	4.75
14c		Year	Year of update of the announcements.	4.25	4.25
15a	Indicators and reports	Likert	Quality of information in performance reports.	3.5	3.33
15b		Nominal	Presentation of indicators and reports, via text, dashboard, or both.	NA	NA
15c		Text	Key indicators.	NA	NA
15d		Year	Year of update.	3.25	3.25

Source: Own elaboration (2024)

4.2 Ranking

The universities were ranked based on the weights established for each criterion, considering both academic and business aspects. Table 9 shows the results for the top 10 universities with the highest scores in the website evaluation. A table with the complete ranking can be found in the Appendices section.

Table 9 - Ranking of websites

Position	Academic	Business
1	UFSCar	UFSCar
2	UFPR	UFPR
3	UFABC	UFABC
4	UFJF	UFJF
5	UNIFESP	UNIFESP
6	UFS	UFS
7	UFTM	UFSM
8	UFSM	UFTM
9	UFG	UFG
10	UNIFAL	UFAM

Source: Own elaboration (2024)

In both analyses, with weights referring to academic and professional perspectives, the top 6 TTOs remained in the classification. The universities UFTM, UFSM, and UFG are present in both rankings, while UNIFAL is only located in the academic ranking, at position 10, and UFAM only in the business ranking, at position 8. Compared to Silva's (2017) ranking, only UFSCar and Unifal also appear in the top 10, demonstrating that the inclusion of additional criteria beyond usability, such as quality and completeness, influences the results.

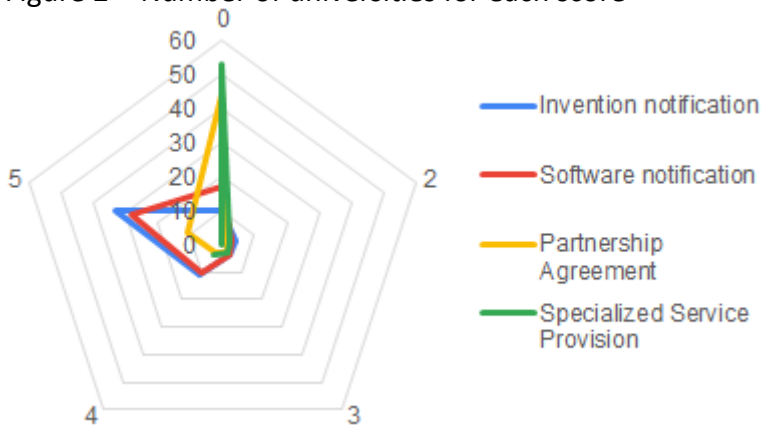
It is also learned that the best websites from one perspective are also better in the other, which demonstrates a maturity of these institutions in understanding the scope of the services provided, not limited to the academic environment.

4.3 Graphical Analysis

4.3.1 Information about invention disclosure

Figure 2 is a radar chart that relates, on the axis starting from the center, the quantity of universities, and at the vertices, the scores, on the Likert scale, of the quality of information for criteria 7b, 8b, 9b, and 10b.

Figure 2 - Number of universities for each score



Source: Own elaboration (2024)

Through the lines representing “Specialized Service Provision” and “Partnership Agreement,” it is observed that most universities do not have information (score 0) regarding the procedures for specialized service provision and partnership agreements. From these results, it is inferred that, despite partnership agreements and specialized service provision being legal instruments mentioned since 2016 in the New Legal Framework for Science, Technology, and Innovation (Brasil, 2016), they are still underutilized. The prevalence of patent-focused content (Fig. 2) reflects a critical gap, as Swamidass & Vulasa (2009) had already warned about this imbalance; and Singh et al. (2020) also identified TTOs’ difficulty in communicating other services, such as partnership contracts.

In this sense, due to this low utilization, the Permanent Chamber of Science, Technology and Innovation (CP-CT&I) of the Federal Attorney General’s Office (PGF), an organ of the Attorney General’s Office (AGU), developed in 2020 model documents for the mentioned legal instruments to facilitate the use of this instrument in partnerships between universities and companies.

On the other hand, the graph highlights a significant number of universities that are well evaluated in the criteria for invention and software disclosure, characterizing the presence of relevant information on these criteria. This can be attributed both to the historical factor of legislation on the topic and to the university’s vision as a knowledge generator. In the first aspect, it is noted that patent registration was introduced through Law No. 9,279/96 and software registration, or computer program, through Law No. 9,609/98, being about 20 years older than the Legal Framework. Thus, the historical factor of legislation influences the knowledge and application of these instruments. In the second aspect, historically, appreciation and encouragement for the publication of patents and software have become ingrained in the internal culture of the university, especially in the teaching community. From this encouragement, the processes of invention and software disclosure become part of the daily life of the university community, being studied and disseminated more vigorously.

Miranda et al. (2023) draw attention to the fact that in Brazilian universities, the current technology transfer rate has not kept pace with the growth in the number of patents and also suggest that TTOs start using, in the evaluation of an invention, not only the three formal patentability criteria

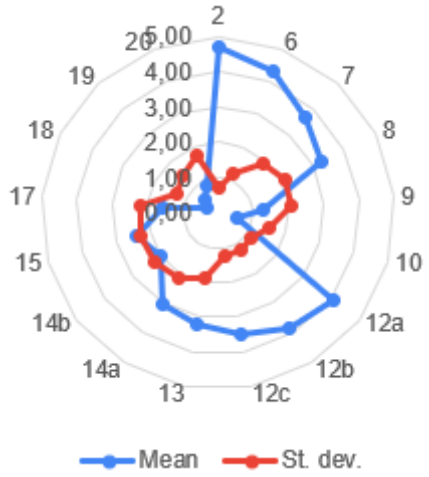
adopted by INPI, but also a fourth evaluation criterion focused on the commercial potential of the invention, to increase the chances of the technology being transferred to the market.

4.3.2 Descriptive statistics

It is important to perform a global analysis of Likert-type criteria in order to analyze the mean and dispersion of the data. In Figure 3, the central axis refers to the scores obtained from the analysis, and the radial axis represents the criteria.

It is noted that criteria 2 (introductory page), 6a (services provided), and 12a (researcher's perspective on the site) are the best-rated in terms of the average. Regarding the first two criteria, the high score is explained by the category of information. Since the information contained in the introductory page and the services provided are considered basic for the functioning of a website, high values for the average were expected. As for the criterion of the researcher's perspective on the site, the positive evaluation is justified by the organizational structure of Brazilian federal universities, whose coordination of sectors related to innovation and entrepreneurship is usually chaired by professors. Thus, it is expected that websites in this sector present a better-developed perspective from the professor's standpoint.

Figure 3 - Score by criteria



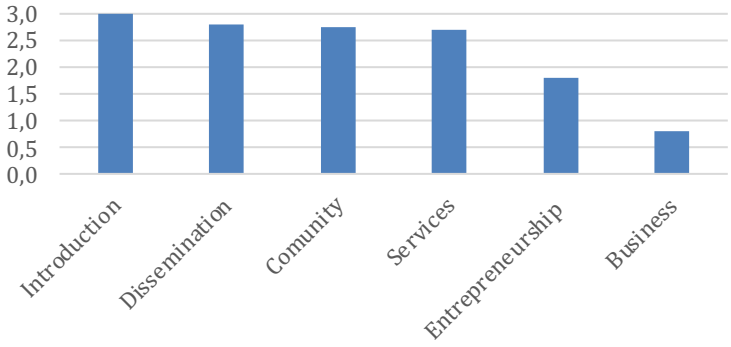
Source: Own elaboration (2024)

In terms of dispersion, the highest standard deviation values are found in criteria 15a (quality of information in reports and indicators), 14b (quality of external notice dissemination), and 17 (information about junior companies). High standard deviation values indicate scattered and heterogeneous information, and consequently, the results become unrepresentative.

4.3.3 Average scores by family of criteria

Figure 4 (next page) is a descending column chart where the horizontal axis shows the criteria families, and the vertical axis reflects the average of the criteria included in each family.

Figure 4 - Scores by families of criteria



Source: Own elaboration (2024)

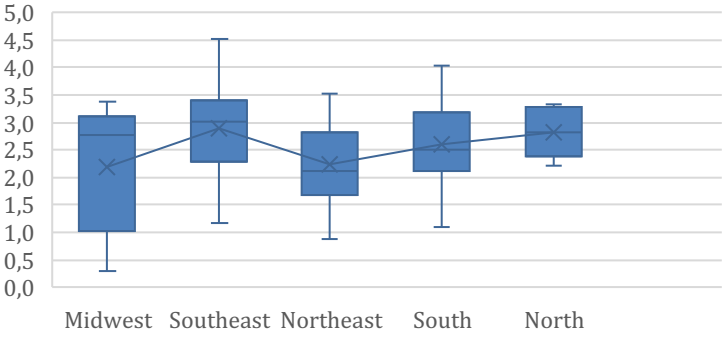
Figure 4 shows that the Introduction and Dissemination families are well-rated, while the Companies family has a low result. Similarly, to the discussion in the previous section, the criteria incorporated into the Introduction and Dissemination families reflect basic information about the TTOs, such as introductory page, social media, and services provided. Thus, the result of these families is high but trivial. On the other hand, the Companies family is the worst-rated, with an average score below 1, reflecting the lack of methodology in building the website, a key feature according to Medeiros et al. (2019). This result also shows the neglect of the entrepreneurship sectors of federal universities regarding dialogues with companies, contradicting the need for virtual proximity with companies demonstrated by York & Ahn (2012).

Together, these factors contribute to the production of an uninformative and non-inclusive website that does not convey the necessary information to all target audiences in the sector.

4.3.4 Average scores by geographical region

The next objective is to study the average score of the criteria according to the geographic regions of Brazil where the TTOs are located. Thus, the graph constructed in Figure 5 is a boxplot, with the horizontal axis representing the geographic regions; the vertical axis representing the average score of the criteria; the “x” symbol inside the box represents the mean of the criteria, and the horizontal line inside the box represents the median.

Figure 5 - Scores by geographical region



Source: Own elaboration (2024)

Figure 5 shows that the Southeast region had better results, with a higher average value (2.89), and with relatively small data dispersion. This result is aligned with the historical development of the Southeast region, with the presence of renowned universities in the areas of innovation,

entrepreneurship, and technology. The Midwest region showed a much larger dispersion than the others, particularly due to the low score of UFJ (0.97) and the high score of UFMT (3.16). The North region showed the smallest dispersion and the second-best average (2.83).

4.4 Ideal Website

This section proposes a discussion regarding the characteristics that should be present in an "ideal website." To evaluate the aspect of quality, the top 10 websites from the ranking were selected, considering the weights for academic and business analysis. Then, for each criterion, the top 3 websites that scored the highest were analyzed. In this way, good practices and relevant information for each criterion were listed.

To assess the relevance of the criteria, a Pareto diagram was created using the weight data for academic and business scopes. Thus, two Pareto diagrams were constructed to classify the criteria representing 80% of a website's performance, providing a total of 28 criteria for each weight (out of the total of 47 criteria). At the end of the classification, it was observed that 26 of the 28 criteria are common to both Pareto diagrams. Therefore, this article explored these 26 criteria for the study of the ideal website. The following describes, for each of these criteria, the characteristic present in the top 10 websites of the ranking:

- 2: Introductory Page - Information about the TTO's mission, vision, and values, as well as internal divisions, team, target audience, regulations, and contact methods, are displayed.

- 4a: Innovation Policy - Availability of the document through a clear and visible link, easily accessible for consultation.

- 5a and 5c: Social Media - Presentation of the technological innovation center's social media networks, along with recent and relevant publications, demonstrating to the public the relevance of the services provided by the TTO.

- 6a: Services Provided - Clear and organized information about the services provided, classified by target audience, such as inventors, companies, and society, or by sector, innovation, and entrepreneurship. Many researchers seek the TTO only to file patent requests; therefore, the website should help to clarify other services.

7b: Invention Notification - Easy access link to the invention notification operational procedure, clear description of steps, responsible parties, informative flowcharts, and important forms.

9b: Partnership Agreement - Easy access link to the legal instrument, publication of information on processing stages, stakeholders, and responsibilities. It is an important legal instrument still underutilized by universities and should be explicitly stated on the website.

- 10b: Provision of Specialized Services - Easy access link to the legal instrument, description of the processing procedure, as well as stakeholders and responsibilities. It is another important legal instrument underutilized by universities, to be more valued on websites.

- 11: Own Website: It is noted that NITs with their own websites have greater autonomy in website development and customization, with their updates being more frequent.

- 12a: Clarity from the Researcher's Perspective - Clear and up-to-date information about services rendered and procedures, going beyond patent registration and computer programs; and encouraging possibilities like the professor-researcher-entrepreneur.

- 12b: Clarity from the Student's Perspective - Information about junior companies, innovation tenders, events, courses, and lectures on innovation and entrepreneurship, organized, clear, and easily accessible.

- 12c: Clarity from the Company's Perspective - Information about legal instruments for partnership agreements and provision of specialized services, technological showcase, technology transfer, portfolio of laboratories, and research groups for partnerships.

- 13a, 13b, 13d, 13f, 13g: Technological Showcase - Clear location of the showcase, with good usability, relevant and attractive information about the product, such as

objective, target audience, functionality, contact for technology transfer, and frequent updates.

- 14a, 14b, and 14c: Internal and External Innovation Project Tenders - Updated information on tenders, such as target audience, registration date, theme, and tender registration link. In addition to tenders from funding agencies such as CNPQ, Finep, and state agencies like Fapesp; there are dozens of companies launching open innovation tenders, so centralizing such information facilitates identification by researchers.

- 16a: Business Incubator: Existence of a business incubator, with calls for applications, incubated companies, and structured content sessions.

- 17: Junior Companies: Information about name, contact, link to social media, and services provided by the junior companies linked to the university.

- 18: Daughter Companies - The website presents name, contact, link to the company's website, and services provided.

- 20: Research Group: Describes research areas, researcher contact, group members, and legal instruments for partnerships.

- 21a and 21b: Community - Availability of training and courses on entrepreneurship, innovation, and technology topics, as well as clear and wide dissemination of them.

In addition to presenting services and content that meet the site's proposed objective, to be deemed "ideal," it must also meet software quality standards such as functionality, reliability, usability, efficiency, maintainability, and portability (Dadkhah et al., 2020). It is important that the content is readable, understandable, attractive, navigable, interpreted, and feedback-driven (Fung et al., 2016). To achieve this, in addition to the previous analysis, the usability of the websites was assessed using the SortSite tool, offered by PowerMapper Software Ltd, capable of evaluating technical usability specifications, compatibility with accessibility devices such as screen readers, loading speed, optimization for search engines, compatibility with different types of devices and browsing software, as well as best practices following the accessibility content guidelines WCAG 2.1 and Section 508, ensuring that the websites align with international accessibility standards. The tool is also capable of identifying broken links, spelling errors, and grammatical problems, providing a comprehensive view of areas that need improvement. At the end of the analysis, a detailed report is produced, offering enhancement recommendations and insights for improvement. The results of this analysis for the TOP 10 websites are presented in Table 10.

Table 10 - Usability assessment

Universities	% Pages with occurrences	% Pages with Usability Issues	Total Pages Verified
UFG	2	3	41
UFABC	9	8	41
UFSM	16	10	42
UFAM	10	11	40
UFSCar	14	13	41
UNIFESP	22	16	44
UFRRJ	20	17	43
UFJF	21	20	41
UFPR	31	30	41
UNIFAL	32	32	89

Source: Own elaboration (2024)

Based on the data from Table 10, it is evident that the TTO website of UFG has a low percentage of pages with unresolved issues or usability problems. For the 10 websites, no serious

usability problems were identified; the most common ones include:

- Broken links. For example, the UFG website refers to the link http://www.funape.org.br/, but it is not accessible.
- Duplicate IDs when referencing HTML programming language elements. This can lead, for example, to a certain font style being applied to an unintended element.
- Figures without alternative text (text appears if the image cannot be loaded, and facilitates search engine crawling).
- Text and background colors lacking contrast, making readability difficult.
- HTML command instructions that may not work in some browsers.
- HTML command instructions that do not follow good programming practices, such as assigning a zero or NaN value to element attributes.
- Existence of links with very long URLs (as they may break when sent via email).
- Omission of HTML height and width attributes for images, causing images to shift position while the site is loading, making readability difficult.
- Link directing to the current tab instead of opening a new tab in the browser, causing the user to lose access to the original site and needing to navigate back through the browser rather than the site itself.
- No use of videos and audio that can complement the user experience.

The prevalence of broken links corroborates Silva's (2017) findings on false links, while poor color contrast echoes Youngblood's (2012) readability critiques. Together, these issues violate core heuristics (Nielsen, 1994; Fung et al., 2016), relating the low business engagement in Figure 4.

In addition to providing quality services and content, it is important for NITs to hire developers who pay attention to these technical issues that can affect the user experience. Finally, we emphasize that the findings of the study were used in the development of the new Innovation Agency website and are available on the website [blind review].

5 CONCLUSIONS

The present study analyzes the websites of TTOs from all Brazilian federal universities, identifying best practices to help TTOs improve their websites. The literature review positioned this work among other published studies, and the analysis of 62 TTO websites yielded findings capable of enhancing their quality. Forty-seven criteria were created to assess the quality of website content based on a panel of experts, and weights were defined to differentiate the importance of each criterion; furthermore, analyses were conducted from both academic and business perspectives.

Based on the scores assigned to each criterion for each university, a ranking was conducted, with UFSCar, UFPR, and UFABC standing out in both academic and business perspectives. It was also discovered that the vast majority of TTO websites do not provide information about the legal instruments such "partnership agreement" with private companies, focusing instead on the notification of inventions, not benefiting from all the possibilities opened by the Innovations Federals Lows from 2004 and 2016. On average across universities, the criteria with the highest ratings relate to introductory information and description of services provided. Regarding the averages by criterion families, the best evaluation was for "Introduction", and the worst for "Companies"; highlighting that while basic information is provided, there is a lack of attention in engaging with companies. It was discovered that the Southeast region had the highest average score, and also a small dispersion, while the Central-West region had the lowest average and a large dispersion.

The analysis of the top ten websites has found that the main is: an introductory page with mission and regulations; the innovation policy; social media; description of the services provided by the TTO, among others. The usability of these websites was also analyzed, identifying the most

common errors to be avoided such as: broken links, duplicate IDs, figures without alternative text. It was demonstrated that an ideal website, in addition to quality content, needs to adopt the best programming practices. Therefore, in managerial terms, it would be important that the TTOs had a proper information technology support to develop higher level websites. This study was delimited by investigating the federal Brazilian universities, and for future studies, one could consider learning from world class universities websites.

ACKNOWLEDGMENTS

We are thankful to Fundação de Amparo à Pesquisa do Estado de blind review, project ACN-blind review for the support to the research.

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APPENDIX

The complete ranking of the TTO websites of the universities is shown below. The scores weighted by the criteria were normalized to the scale of 0 (worst score) and 100 (best score).

Ranking – Academic perspective

Pos.	University	Weighted score	Pos.	University	Weighted score	Pos.	University	Weighted score
1	UFSCar	100	22	UFpel	63,78	43	UNILAB	44,93
2	UFPR	88,51	23	UNB	62,3	44	UFRRJ	44,57
3	UFABC	87,38	24	UFMS	61,64	45	UFCSPA	42,93
4	UFJF	79,41	25	UNIVASF	61,5	46	UNI-PAMPA	42,08
5	UNIFESP	79,26	26	UFT	59,75	47	UFPI	41,46
6	UFS	76,33	27	UFMA	58,75	48	UFBA	41,29
7	UFTM	73,55	28	UFCG	57,94	49	UFOP	38,74
8	UFSM	73,03	29	UFF	56,27	50	UFSB	37,96
9	UFG	72,74	30	UFR	55,01	51	UFVJM	36,6
10	UNIFAL	72,59	31	UFRA	54,02	52	UFRB	35,94
11	UFAM	71,83	32	UFRGS	53,71	53	UFERSA	33,01
12	UFRN	71,02	33	UFU	53,15	54	UFAL	32,07
13	UFMG	70,97	34	UFSJ	52,98	55	UFOB	29,8
14	UFPA	70,31	35	UFES	51	56	UFRPE	25,56
15	UFRJ	70,11	36	UFPE	50,92	57	UFGD	21,41
16	UNIFAP	67,77	37	UNILA	50,49	58	UNIRIO	20,78
17	UFMT	67,57	38	UNI-FESSPA	48,99	59	UFFS	18,93
18	UFPB	66,79	39	UNIFEI	46,7	60	UFCAT	15,82
19	UFSC	66,42	40	UFC	46	61	UFCA	13,75
20	UFLA	64,69	41	UFOPA	45,26	62	UFJ	0
21	UFV	64,25	42	UTFPR	44,99			

Ranking – Business perspective

Pos.	University	Weighted score	Pos.	University	Weighted score	Pos.	University	Weighted score
1	UFSCar	100	22	UFV	63,08	43	UNILAB	43,77
2	UFPR	87,96	23	UNB	62,72	44	UFRRJ	43,04
3	UFABC	86,98	24	UFMS	59,96	45	UFCSPA	41,07
4	UFJF	78,59	25	UNIVASF	59,6	46	UFBA	40,21
5	UNIFESP	78,41	26	UFT	57,89	47	UFPI	40,06
6	UFS	74,78	27	UFMA	57,19	48	UNIPAMPA	39,94
7	UFSM	72,8	28	UFCG	56,64	49	UFSB	38,58
8	UFTM	72,52	29	UFF	54,71	50	UFOP	37,99
9	UFG	72,03	30	UFR	52,98	51	UFVJM	37,4
10	UFAM	71,22	31	UFU	52,64	52	UFRB	35,42
11	UFMG	71,13	32	UFRA	52,21	53	UFERSA	32,15
12	UNIFAL	71,07	33	UFRGS	52,21	54	UFAL	30,39
13	UFRJ	70,31	34	UFSJ	51,35	55	UFOB	28,41
14	UFRN	69,67	35	UFES	50,01	56	UFRPE	25,86
15	UFPA	69,07	36	UNILA	49,55	57	UFGD	20,71
16	UFMT	68,05	37	UFPE	49,51	58	UNIRIO	20,69
17	UNIFAP	66,14	38	UNIFESSPA	48,25	59	UFFS	17,83
18	UFPB	65,74	39	UNIFEI	45,89	60	UFCAT	15,59
19	UFLA	65,1	40	UTFPR	45,16	61	UFCA	14,09
20	UFSC	64,78	41	UFOPA	44,16	62	UFJ	0
21	UFpel	63,26	42	UFC	43,96			