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Article

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Optimization strategies for search engines: an analysis based on the data life cycle

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ABSTRACT

Introduction: In the digital era, Search Engine Optimization (SEO) techniques are essential to ensure the visibility and relevance of online content. With the exponential increase in data shared on the internet, managing the Data Life Cycle has become crucial. This study explores how each stage of the Data Life Cycle – from collection, through storage and retrieval, to disposal – can impact the practices and effectiveness of SEO techniques. Objective: To investigate the relationship between the Data Life Cycle and SEO techniques and practices, aiming to understand how each stage of this cycle, along with associated cross-cutting factors, allows for the analysis of the effectiveness and efficiency of search engine optimization strategies. Methodology: The study adopts a descriptive methodological approach focused on SEO, discussing data access by optimization experts within the context of search engines. Results: The results present the connections between the phases of collection, storage, retrieval, and disposal through the cross-cutting factors present in all phases of the Data Life Cycle in relation to SEO techniques. Conclusion: Finally, the strategic integration of the Data Life Cycle and SEO techniques is essential for successfully navigating the digital environment. By considering each phase of the Data Life Cycle through the lens of Search Engine Optimization, organizations can not only improve their online presence but also ensure that their content is valuable, accessible, and compliant with ethical and legal standards.

KEYWORD

Search engines. Web content management. Data.

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Estratégias de otimização para mecanismos de busca: uma análise a partir do ciclo de vida dos dados

RESUMO

Introdução: Na era digital, as técnicas de Search Engine Optimization são fundamentais para garantir a visibilidade e a relevância do conteúdo online. Com o aumento exponencial de dados e compartilhados na internet, a gestão do Ciclo de Vida dos Dados torna-se decisivo. Este estudo explora como cada etapa do Ciclo de Vida dos Dados – desde a coleta, passando pelo armazenamento e recuperação, até o descarte dos dados – pode impactar as práticas e a eficácia das técnicas de SEO. Objetivo:

Investigar a relação do Ciclo de Vida dos Dados com as técnicas e práticas de SEO, visando compreender como cada etapa desse ciclo, bem como os fatores transversais associados, permitem analisar a eficácia e eficiência das estratégias de otimização para mecanismos de busca. Metodologia: Possui uma abordagem metodológica descritiva centrada em SEO, discutindo o acesso a dados por especialistas de otimização no cenário dos mecanismos de busca. Resultados: Como resultado apresentam-se as conexões das fases de coleta, armazenamento, recuperação e descarte, por meio dos fatores transversais presentes em todas as fases do Ciclo de vida dos dados com as técnicas de Search Engine Optimization. Conclusão: Por fim, a união estratégica do CVD e das técnicas de SEO é essencial para navegar com sucesso no ambiente digital. Ao considerar cada fase do Ciclo de Vida dos Dados através da lente do Search Engine Optimization, as organizações podem não apenas melhorar sua presença online, mas também assegurar que seu conteúdo seja valioso, acessível e em conformidade com as expectativas éticas e legais.

PALAVRAS-CHAVE
Mecanismo de busca. Gestão de conteúdos na web. Dados.

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1 INTRODUCTION

In the current digital era, effective data management has emerged as a central pillar for enhancing digital presence through Search Engine Optimization (SEO) techniques. The relevance, integrity, and quality of data play a fundamental role in this context—not only as factors that influence online visibility but also as the foundation for a thorough analysis of SEO strategies. In this scenario, a detailed understanding of the Data Life Cycle (DLC) offers valuable insight, allowing for investigation into how data is collected, processed, stored, and eventually discarded, and how these stages impact the effectiveness of SEO strategies.

Proposed by Sant'Ana (2016), the DLC model places data at the core of attention, addressing its various stages from inception to disposal. Rooted in the principles of Information Science, this model highlights the challenges and opportunities present at each stage of the cycle, providing crucial insights for improving SEO techniques. As the connection between the DLC and SEO is explored, it becomes clear that the efficiency of search optimization strategies is intrinsically linked to how the underlying data is managed throughout their life cycle.

Recognizing data as a vital strategic resource, this study aims to delve into the intersection between the DLC and SEO practices. Through this analytical lens, we investigate how each phase of the DLC, from collection to disposal, can shape and enhance the efficiency of SEO techniques. In addition, we consider the cross-cutting factors that permeate the DLC, seeking to understand how they influence keyword selection, content optimization, and performance monitoring, which are fundamental to a successful SEO strategy. Thus, a DLC-based analysis opens new avenues for assessing the quality and effectiveness of SEO, emphasizing the importance of robust and conscious data management. In this scenario, a fundamental question arises: How do the different phases of the Data Life Cycle, from collection to disposal, influence the efficiency and effectiveness of SEO techniques?

Accordingly, the present study aims to investigate the relationship between the Data Life Cycle and SEO techniques and practices, seeking to understand how each stage of this cycle, along with associated cross-cutting factors, allows for the analysis of the efficiency and effectiveness of search engine optimization strategies.

To this end, this study adopted a qualitative and descriptive approach, focusing on the theoretical and conceptual articulation between the principles and practices of SEO and the DLC model, as proposed by Sant'Ana (2016). The analysis began with a discussion of SEO and the DLC phases, with the aim of constructing an interpretative model that would highlight the correspondence between each phase of the DLC—collection, storage, retrieval, use/dissemination, and disposal—and search engine optimization techniques.

2 SEARCH ENGINE OPTIMIZATION PRINCIPLES

Search Engine Optimization, known by the acronym SEO, is a fundamental digital strategy in today's information landscape. In an online universe overflowing with content, ensuring that a page or article is easily found by search engines is vital for its visibility and relevance. SEO combines techniques, tactics, and best practices with the purpose of raising a website's position in organic search results, increasing its accessibility to the desired audience and, thus, maximizing its traffic and online recognition.

The definition of SEO is indeed broad and diverse. While Gandour and Regolini (2011) see it as a set of techniques, McVittie (2012) approaches it as a practice. Jones

(2008) describes SEO as a process, and Ledford (2015) considers it a science. On the other hand, Lieb (2009) defines it as an art. Regardless of the approach, the central objective, according to Lieberam-Schmidt (2010), is to improve both the volume and quality of users in digital environments through organic search results.

In this perspective, the concept of SEO stands out in the work, based on the idea of how these techniques can contribute to improving visibility and organic traffic in digital information environments (Camossi; Rodas, 2023b).

According to Camossi and Rodas (2023a, p. 6):

> [...] Search Engine Optimization is the fusion of techniques and technologies that aim to improve the visibility and traffic of a digital information environment in organic search engine results, with the ultimate goal of improving its ranking in Search Engine Results Page (SERP). To achieve this, it is necessary to use metadata and other optimization techniques to help search engines better understand the content of the website and rank it in a relevant way for users' search queries.

The SEO process is outlined in four phases, which can evolve over time, highlighting its dynamic and adaptive nature. The traditional steps are: Keyword/phrase research and selection, On-page SEO, Off-page SEO, according to Malaga (2008), and finally, Monitoring and Reporting, as highlighted by McVittie (2012).

2.1 On-page SEO

On-page SEO refers to the content and structure of a website, as pointed out by Shahzad et al. (2020). This approach involves selecting and incorporating keywords in strategic positions, as well as defining relevant page titles for each section of the website, to provide relevant content (Dover; Dafforn, 2011).

This technique encompasses both the content and the HTML source code of a page that requires optimization, as noted by Patil and Patil (2018). According to Ellis (2022), while On-page SEO focuses on the content and HTML source code of a page that can be optimized, Off-page SEO concerns links and other external indicators.

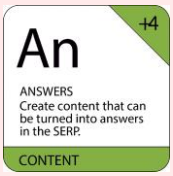
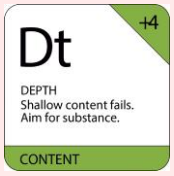
The application of SEO techniques can significantly boost a website's traffic and improve its presence in search engine results. According to Patil and Patil (2018), some of these techniques, categorized as on-page SEO, include:

a) **Meta Tag**: Essential for many on-page SEO efforts. The meta tag provides search engines with information about the web page, boosting its visibility in SERP results;
b) **Title Tags**: These define the theme of the pages. They represent what the user sees in the search engine and are crucial in helping search engines understand the website's content. In addition, they are the first impression the user gets when finding the website through an organic search;
c) **Meta Description**: Provides a summary of the page content for the user. Although it does not directly impact ranking, it can affect the click-through rate (CTR) in SERPs, indirectly influencing a page's position;
d) **Heading Tags**: Using tags (such as H1, H2, H3, etc.) in the HTML structure can enhance the visibility of the page;
e) **Keyword**: Incorporating relevant keywords into the content is strategic for increasing visibility in search results;
f) **Image Optimization**: When inserting images into content, it is recommended to include target keywords in the alternative text (Alt) and assign a unique title to each image. This practice can improve relevance in search results, attracting more qualified traffic to the website.

Since the main goal of SEO is to optimize the position of websites in search results, several key factors are considered or even required by search engines to achieve this. As pointed out by the Search Engine Land portal (Search..., 2023c), vital signs include content, user signals, website architecture, and reputation. These ranking criteria must be harmonized to achieve better results.

In the Content set, the focus is on the depth and high quality of the material presented. Content should be at the center of SEO strategies. Quality content is evaluated by the degree of engagement, the relevance of the information, and the support offered to the website's target audience. This criterion emphasizes the need to produce authentic and valuable material to ensure visibility in search engines. According to the Search Engine Land Framework, the Content set consists of the items presented in Chart 1.

Chart 1. Components in the content group

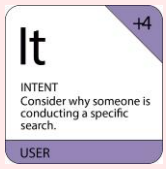
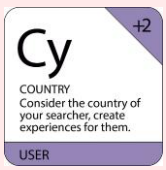
Symbol	Name	Recommendations
	Quality (Qu)	Pages must provide users with substantive, useful, and unique content that compels them to stay on the pages, building familiarity and trust. Content is the cornerstone of SEO efforts. Creating and investing in a clear content strategy is critical to SEO success, as nearly all other factors depend on content quality.
	Research (Rs)	Researching the keywords (the search terms your target audience is using) is perhaps the most important SEO factor after creating good content. It will help you develop content that "answers" what people are searching for. Keyword research can also carry benefits beyond ranking for those queries. Keyword research can provide you with insights into the nature of your audience's pain points and needs, whether that is navigational, informational, or transactional.
	Answers (An)	There is tremendous value in explicitly answering users' questions on your pages. For one, you are creating content specifically designed to meet your audience's needs. Two, search engines are increasingly trying to show direct answers in the search results. If you answer questions well enough, your page may be displayed as a featured snippet or returned as a voice search result on Google Assistant.
	Depth (Dt)	The content on your site should be deep enough to answer the user's question in a substantial, complete, or comprehensive manner. You should provide more value than your competitors, but that does not necessarily mean you should throw more words at it to achieve an arbitrary word count. Some queries, such as "what is the fastest land mammal," have a relatively straightforward answer, whereas other questions, like "why is the cheetah the fastest," may warrant a more in-depth explanation.
	Keywords (Kw)	After you have researched the keywords your audience is using to find you, include those keywords within the body of your content, your subheads, and your titles, as this will help you rank higher in search engines. Always keep in mind that you are writing for users first and that search engines are getting much better at understanding natural language.

	Freshness (Fr)	Pages must contain timely, up-to-date content. Google has also long applied what it calls Query Deserved Freshness (QDF)[1] as a content ranking factor for certain types of queries.
	Multimedia (Mn)	Text is the foundation on which the internet is built, but that does not mean it is universally the best medium for your content. Other formats can also provide added exposure in the search results. Consider using images, video, audio, or other formats that appeal to your audience and set your brand apart from competitors. Regardless of the format you choose, you will still want to use descriptive text to supplement your content and provide context for both search engines and users. If it is a video or a podcast, you can add a transcript. If it is an image, use alt text and captions. You can also mark up your multimedia content with structured data to increase the chances that it will be returned as a rich result.

Source: Camossi (2022).

The user experience group notes that search results for a specific query may vary slightly between different users, even though they share a common basis. These variations are due to user signals. While a search may present a standard listing to several individuals, certain results are shaped by the user's geographic location, personal connections, and browsing history. Additionally, search engines strive to align results with the user's underlying search intent. Google advises SEO professionals to develop content with the audience in mind first and foremost (Search..., 2023b).

Chart 2. Components in the user context signals group

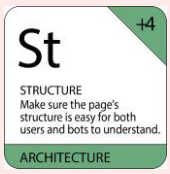
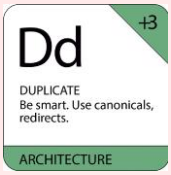
Symbol	Name	Recommendations
	User Experience (Ux)	Search engines not only want to direct users to the most relevant results, but also to pages where they will have a positive experience. User experience (UX) encompasses everything from your site's navigation to the quality of your content, site speed, and more. From a structural standpoint, you will want to make it intuitive for your visitors to find whatever they are looking for.
	Intent (It)	Satisfying users' search intent also has benefits. This is where first impressions matter. Website visitors should not have to guess; instead, they should be able to quickly discern whether the website is offering what they are looking for.
	Locality (Ly)	Search engines must tailor results to match the city or metropolitan area based on the user's location. If you want to appear when someone gets city-specific results, you need to ensure your site is relevant to that city.
	Country (Cy)	Users see results relevant to the country in which they are located. Taking the geography, language, and culture of a region into account will help ensure that your content speaks to users in the areas you serve. If your site is not deemed relevant to a particular country, you have a lower chance of showing up when country personalization occurs.

[1] Query Deserves Freshness is Google's update quotient. Google took this step to promote new content for its users' queries (Sen, 2020).

Source: Camossi (2022).

The next group, website architecture, highlights the importance of a website's structure. The way it is built helps search engines understand the theme of its pages. Additionally, it ensures that when users click on a SERP result, they will find a fast website that is free from threats such as malware. This group covers aspects ranging from URLs, which are visible to users, to loading speed, security, and page traceability. The elements associated with architecture are presented in Chart 3.

Chart 3. Components in the architecture group

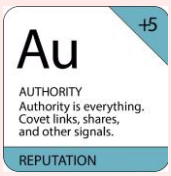
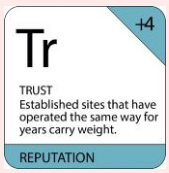
Symbol	Name	Recommendations
	Crawl (Cr)	Search engines use web crawling software — Google's is called Googlebot, and Bing's is called Bingbot — to read your site's pages and compile copies of them within a searchable index. When searchers enter a query, the search engine scans its index to filter and rank the relevant pages. If your site is not crawlable, it will not be included in the index and therefore will not be visible in search results.
	Mobile (Mo)	Mobile-friendly does not just mean that your site is viewable on phones and tablets, it means that your site is built for the humans that own those devices. In March 2018, Google began broadly implementing mobile-first indexing, in which it uses the mobile version of the web as its primary search engine index.
	Structure (St)	Structured data contributes to search engines because it provides an understanding of the content on the page, resulting in improved information about what is available on it.
	Parity (Pr)	The website should provide a consistent user experience regardless of the device being used. This combination with mobile devices helps ensure that, if there are two separate websites, one for mobile devices and one for computers, there will be parity in content and experience for users, including parity in links, navigation, structured data, content, images, and between mobile and desktop user interfaces.
	URLs (Ur)	This is not a major ranking factor, but it is good practice to use descriptive words in your page URLs for search engines and users. Your URLs appear on search results pages, so having an easy-to-understand URL may give searchers a better idea of what is on the other end of the link.
	Duplicate (Dp)	Duplicate or repeated content is content that is copied and pasted in its entirety or with very few changes to other pages. That dilutes the value of trust and authority of those links and paints an inaccurate picture of how valuable and relevant a page may be to searchers.
	Speed (Sp)	Your site should load quickly, whether visitors are viewing it on mobile or desktop. And, since speed is a Google ranking factor, faster sites will have an SEO advantage. Like many other SEO factors, speed is closely tied to the user experience. Maintaining a zippy site may help prevent visitors from bouncing and improve your engagement and conversion rates.

	HTTPS (Ps)	Google has encouraged websites to migrate to HTTPS servers to provide better security for searchers. In 2014, Google started giving a slight ranking boost to secure HTTPS/SSL sites. In July 2018, the Chrome browser began marking pages that do not use HTTPS as not secure, effectively making HTTPS part of a user's experience on your site.

Source: Camossi (2022).

Finally, in the Reputation group, Google adopts the criteria of Expertise, Authoritativeness, and Trustworthiness (EAT) [2] as parameters for evaluating the relevance and value of websites (Grow..., 2024). These criteria are often translated as the "reputation" of the website (Search..., 2023a). Related to reputation, the Search Engine Land Framework lists three fundamental elements, as detailed in Chart 4 below.

Chart 4. Components in the reputation group

Symbol	Name	Recommendations
	Expertise (Ex)	Expertise is associated with the depth of content and topics covered by the website. Content should be written by experts, as they tend to develop reliable content.
	Authority (Au)	Being an authority typically means being a widely recognized leader in your field or business sector, and that is very useful when the goal is to rank well organically. Google primarily assesses authority on a per-page basis; however, sitewide signals may also be used to supplement individual pages. The types of links your pages receive, which may be used as signals for search engines to measure authority, include the words used within and surrounding those backlinks, engagement metrics, and reviews.
	Trust (Tr)	The website needs to be and appear trustworthy to the user. It is necessary to have an SSL security certificate that ensures the user that, when entering the page, they are making a secure connection. There should also be clear information about who the enterprise is and its physical location. The presence of content bait, links to SPAM, or low-reputation websites can be harmful.

Source: Camossi (2022).

Chart 4 emphasizes the importance of expertise, authority, and trust as key pillars for a website's credibility in search engines. Expertise reflects the depth and accuracy of content, while authority is established through recognition in a specific field, contributing significantly to organic ranking. Ultimately, trust is essential for maintaining a safe and trustworthy environment for users.

2.2 Off-page SEO

Off-page SEO aims to increase a domain's authority by acquiring links from other websites. The main factor in this type of SEO is the quantity and quality of backlinks

[2] It is the metric by which Google determines the quality of a website and its ability to rank (Grow..., 2024).

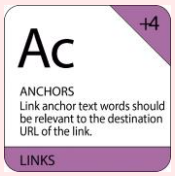
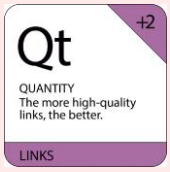
directed to the website in question. This criterion emphasizes the production of unique and valuable content, which naturally attracts external links (Patil; Patil, 2018). Off-page SEO encompasses practices carried out outside the website's pages, aiming not only to optimize its ranking but also to establish trust in it among users, experts in the field, other websites, and search engines. This degree of reliability is commonly referred to as authority level (Ratcliff, 2015). Several techniques can be used to leverage this trust and attract more visitors. These are some of the strategies associated with off-page SEO (Patil; Patil, 2018):

a) **Shareable Content**: Creating relevant and useful content is fundamental for search engine optimization, as it generates additional backlinks;
b) **Guest Blogging**: Many blogs accept guest posts, providing an excellent opportunity to obtain links from other websites—an important factor in Google's ranking algorithm;
c) **Social Media Engagement**: Interacting on social media platforms can increase website traffic, as these platforms are frequently used to promote products and services;
d) **Social Bookmarking**: Similar to adding a website to a browser's favorites, this practice facilitates user access and helps boost traffic;
e) **Link Baiting**: A strategy focused on attracting backlinks by producing compelling content that increases the likelihood of other websites linking to it;
f) **Classified Submission**: Posting classified ads can generate instant traffic and potential leads, increasing a website's online visibility;
g) **Profile Creation**: Listing businesses on multiple platforms expands reach. This is a valuable link-building technique that involves creating profiles on various sites, whether personal, corporate, social networks, or forums;
h) **Blog Commenting**: Participating in or enabling comment sections on blogs fosters the exchange of ideas and opinions on specific topics or posts, thereby attracting more traffic;
i) **Article Submission**: Publishing articles in directories to encourage backlinks is essential in digital marketing campaigns aimed at reaching the target audience.

Search Engine Land (Search..., 2023c) points out that links were the first off-page SEO ranking criterion adopted by search engines. With the introduction of the PageRank algorithm by Google in 1998, the relevance of links in evaluating a website's performance became evident. Three main elements stand out in this group: quality, quantity of links, and anchors. These are detailed in Chart 5 below.

Chart 5. Components in the link group

Symbol	Name	Recommendations
	Link Quality (Lq)	The higher the quality of the link and the more relevant the websites linking to your website, the better it will be for your SEO. Links from trustworthy, high-quality websites that are relevant and reputable in your industry are likely to carry more weight.

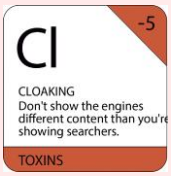
	Anchors (Ac)	Anchor text refers to the clickable text used in a hyperlink. Search engines see the words used in the anchor test as the way a website describes the content or site it is linking to. They inform search engines about their content and provide context to users, as they indicate to the user what content they are about to click on.
	Quantity (Qt)	The more links pointing to a website, the better. These links send signals to search engines, indicating the relevance and quality of your content. You should avoid comment spam, buying links, guest posting schemes, and link exchanges, as your website may be penalized by search engines if caught using these or other tactics known as "black hat."

Source: Camossi (2022).

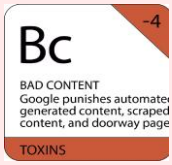
Within the context of off-Page SEO strategies, it is essential to discuss Black Hat SEO[3]. Although it can offer effective results in the short term, this approach is controversial and can have adverse consequences in the long term. This technique refers to practices that are often penalized by search engines, as it aims to manipulate algorithms to achieve higher positions in search results.

These practices, considered dubious or harmful to search engine optimization, are referred to as toxins by the Search Engine Land portal (Search..., 2023c). In the past, these shortcuts or strategies could ensure high rankings due to the simplicity of search algorithms at the time. However, with the evolution and sophistication of mechanisms, these tactics today tend to be more harmful than beneficial. According to Search Engine Land, there are eight elements categorized as toxins, as shown in Chart 6.

Chart 6. Components in the toxins group

Symbol	Name	Recommendations
	Cloaking (Cl)	Showing search engine crawlers something different than what you present to users is called "cloaking," and it can potentially be used to trick users into visiting irrelevant or harmful pages. Unlike some of the other toxins, cloaking is not something that can happen by accident — it is a deliberate attempt to manipulate search results, and if you are caught doing it, you can expect a hefty penalty.
	Schemes (Sc)	Seeking backlinks is an essential aspect of SEO, but the rules change when money is involved. Paying for links that pass link equity violates both Google and Bing's guidelines, and doing so can have dire consequences for your organic visibility. Schemes are not just limited to buying links, either: large-scale guest posting services with keyword-laden anchors, link exchanges, blog spamming, and other illicit practices may also result in penalties from search engines.

[3] Black Hat SEO refers to techniques that are not tracked and approved by search engines to reduce the impact rate of search engine tactics (Sial *et al.*, 2022).

	Bad Content (Bc)	Copying content from the internet, besides being morally questionable, is easily identifiable by Google and punishable if content from other sites is published on your pages repeatedly. This technique ends up being ineffective, as the search engine ends up favoring the oldest publication in its ranking (CAMARGO, 2019).
	Malicious Behavior (Mb)	Behaviors such as phishing, Trojans, and malware are considered malicious and ultimately harm the website's indexing.
	Stuffing (Sf)	You might assume that the more times a keyword shows up on a page, the more relevant search engines will consider the page to be to the query, but that is not true. Inserting keywords more often than is natural or useful to users is called "keyword stuffing." It is one of the oldest spam tactics out there, and it can still get you penalized. You should not repeat keywords over and over again in your headings, copy, footers — anywhere — to try to improve your rankings.
	Hiding (Hi)	Site owners who stuff keywords into their pages may also attempt to obscure these efforts by hiding the text. Whether it is by matching the font color to the background, positioning text off screen, decreasing font size to zero or any other method of concealment, hiding text is a violation of Google's Webmaster Guidelines and can result in a penalty. Links may also be styled in a way to make them invisible to users, which some site owners might do to visually obscure paid links while attempting to pass link equity. Whatever the reason, hiding elements is not something that users benefit from and is unlikely to improve your SEO.
	Piracy (Ar)	Ripping off someone else's intellectual property — an article, song, graphic, photo, video, etc. — and passing it off as your own is illegal. That is not the only reason why it is bad for SEO, though: users generally want the original source of the content, and search engines want to provide it for them. Google's 2012 "Pirate" update took aim at sites infringing on copyright law. Sites are subject to Digital Millennium Copyright Act (DCMA) takedown requests. Plagiarizing or hosting plagiarized or illegal content can get you delisted from search results.
	Intrusive (Iv)	A large number of ads or other intrusive elements can prevent users from finding what they are looking for. This can harm the user experience and organic visibility, and is now a common feature of the mobile user experience. In 2017, Google rolled out the mobile intrusive interstitial penalty to discourage site owners from abusing such elements.

Source: Camossi (2022).

Chart 6 discusses harmful SEO practices that can compromise a website's integrity and visibility on search engines. These techniques, ranging from cloaking to keyword stuffing, are known strategies that violate search engine guidelines, resulting in severe penalties. Adopting these practices can attract penalties ranging from a drop in ranking to complete exclusion from search results. In the context of the DLC, effective

data management involves practices that ensure data quality, security, and compliance with legal and ethical standards.

3 DATA LIFE CYCLE

Research in information science has focused on studying new ways of organizing and structuring digital information environments, with the aim of contributing to the access, use, and reuse of data. The application of SEO techniques is particularly noteworthy, as it assists in the structuring of digital environments. This strategy provides an organization that favors better positioning in search results (Camossi; Rodas, 2023b).

Sayão and Sales (2016, p. 68) highlight that "the intensive use and generation of data [...] create an urgent need for management and technological infrastructure that dynamically handles the data life cycle—from planning to reliable archiving [...]".

Therefore, information science has a fundamental role to play in improving the current scenario of access and intensive use of data. It can help identify and analyze elements that promote a balance among all participants in the process and ensure the optimal use of data (Sant'Ana, 2016).

This process addresses, in different stages, various elements such as: required competencies, understanding of the context and the user, as well as resources and methods. Recognizing the urgency of particularities requires defining the scope of these stages, aiming to integrate them. This occurs even considering limitations, such as the overlap of certain factors or actions that would originally take place at separate times (Sant'Ana, 2016).

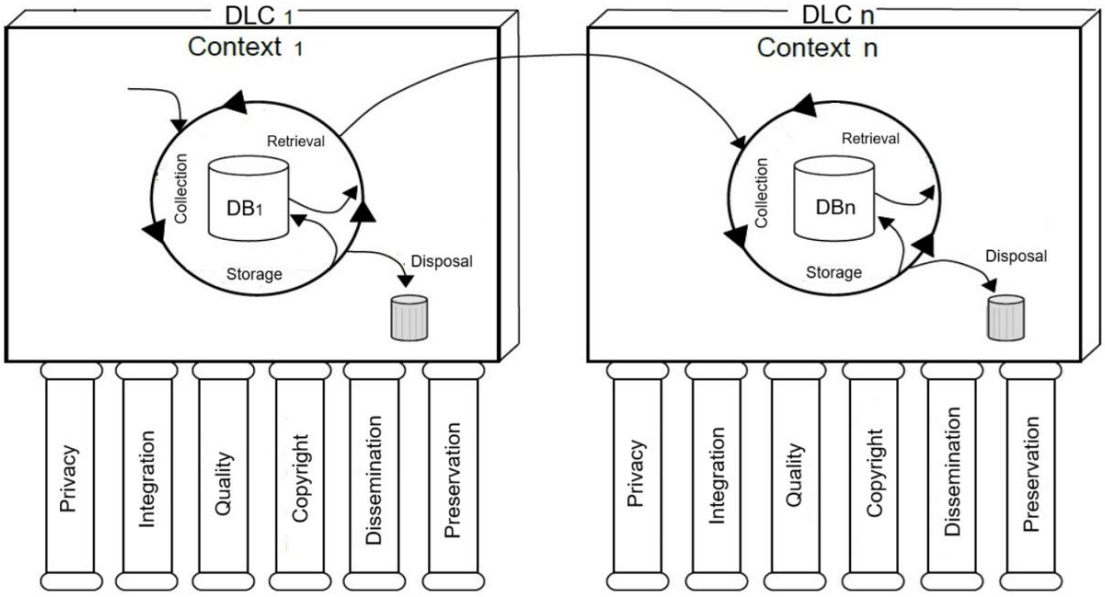
The vast volume of digital data raises concerns about the proper management and preservation of information, ensuring that it remains accessible and can be used and reused in the present and future (Araújo *et al.*, 2019).

In this scenario, information science has the potential to bring a renewed, data-focused perspective and help improve the DLC. This strengthens the connection between users and the information they need (Sant'Ana, 2016).

3.1 Phases of the Data Life Cycle and cross-cutting factors

In the context of SEO, when optimizing the visibility and accessibility of online content, it is important to consider the collection, storage, retrieval, and disposal phases that are part of the DLC. For effective implementation of this perspective, not only in other areas of SEO, it is essential to understand that these phases are shaped by six factors: privacy, integration, quality, copyright, dissemination, and preservation, as described by Sant'Ana (2013).

Figure 1. Data Life Cycle and cross-cutting factors



Source: Sant'Ana (2016).

Therefore, for proper planning of SEO strategies and data management, it is essential to understand the stages of the DLC and consider the associated factors, ensuring more comprehensive and efficient optimization.

The DLC phases proposed by Sant'Ana (2016) are detailed and offer a logical and sequential structure for data management. Below is a revised version to ensure clarity and conciseness:

a) **Collection**: Data acquisition phase, tailored to a specific demand. Aspects to be considered include scope, expected results, data source and formats, processing for use, privacy, potential for integration with other data sets, integrity, copyright, and future identification and retrieval;
b) **Storage**: Refers to the conservation of acquired data for later use. It is essential to recognize the data obtained, determine which will be preserved, the storage structure to be adopted, and ensure the durability of the data. In addition, aspects such as privacy, quality, and findability are crucial to ensure long-term usefulness;
c) **Retrieval:** After collection and storage, the preserved data needs to be retrieved for access, interpretation, and use. This phase requires decisions about which stored data will be retrievable, definitions of target audience, scope, access or creation for retrieval, update frequency, access levels and rights, and integration potential;
d) **Disposal**: Based on the previous phases, it is necessary to determine which data is no longer needed and should be removed. The decision to dispose of data should consider whether the data has been maintained, whether duplicates exist, and ensure effective disposal. In addition, it is necessary to assess the impact of this action on related data and the entire environment, as well as the consequences for future retrieval and access.

The author emphasizes that all stages are influenced by the following factors: privacy, integration, quality, copyright, dissemination, and preservation (Sant'Ana, 2013; 2016). Each stage requires specific competencies from fields such as information science and computer science.

Below is a brief explanation of each phase and factor of the DLC in the context

of SEO, as proposed by Sant'Ana (2016). In SEO, the collection stage is of paramount importance. The cross-cutting factors mentioned emphasize the need for SEO specialists to analyze the source of data to ensure its accuracy and relevance (quality aspect). The identification and validation of metadata and keywords that resonate with the target audience are essential activities, underscoring the importance of integration in data management. This in-depth analysis serves not only to ensure the relevance of the content but also to align SEO strategies with user expectations and needs. Careful organization of the collected material, aimed at maximizing its visibility and accessibility in search engines, reflects a commitment to long-term effectiveness, covering both current demands and anticipating future trends.

As indicated by Sant'Ana (2013), the dissemination stage within the DLC is intrinsically linked to the ability of content to be found and valued in search results. This connection highlights the importance of data management that extends beyond simple collection, encompassing a holistic approach that integrates quality, relevance, and SEO strategy from the outset. Through this analytical and proactive approach, it is possible not only to meet immediate visibility needs but also to build a solid foundation for adaptability and continued success in an ever-evolving digital environment. In the current context of SEO, the integration of ethical and legal practices, particularly with regard to copyright and data privacy, has become a cornerstone for the success and sustainability of search engine optimization strategies. Content originality is not only valued as a competitive differentiator; it is required by search engine algorithms, which actively penalize plagiarism and content duplication. Thus, strict adherence to copyright transcends ethics, positioning itself as a decisive element in optimizing online visibility and relevance.

At the same time, data privacy is emerging as a pillar of trust and security for users. Compliance with global regulations, such as the General Data Protection Regulation (GDPR) in the European Union and the Brazilian General Data Protection Law (LGPD), reflects not only a legal obligation but also a proactive strategy to strengthen user trust. Websites that ensure data security and privacy not only avoid significant penalties but also tend to improve key SEO metrics, such as time spent on the page and bounce rate, by promoting a safer and more reliable online environment.

In this context, conscious consideration of copyright and privacy throughout all stages of the Data Life Cycle highlights an SEO strategy that is both responsible and effective. This integrated approach ensures that, from data collection to dissemination, practices are aligned not only with optimization goals, but also with user expectations and rights. Thus, data management that incorporates these ethical and legal principles not only improves a website's position in search results, but also builds a solid foundation of credibility and trust among users.

The DLC storage phase, within the context of SEO, presents a unique opportunity to reinforce the foundation upon which optimization strategies are built. At this stage, meticulous attention to the various components of data storage becomes imperative to ensure the integrity, accessibility, and compliance of content with search engine guidelines and relevant legislation.

Metadata management plays a decisive role in this stage, facilitating correct interpretation and indexing by the search engine, which is essential for content integration and quality. In addition, effective management of sensitive information is critical to maintaining data reliability and protection, highlighting the importance of quality in information security.

For effective dissemination, data must be readily accessible and locatable, while preserving the anonymity of sensitive information, thus ensuring personal data protection. Strict compliance with copyright, emphasizing the legislative dimension, ensures that content not only respects intellectual property, but also avoids penalties that could

negatively affect online visibility.

The long-term preservation of information relevance and decipherability is another critical aspect, ensuring that data remains accessible and useful for future SEO strategies. Finally, strict access control underscores the pillar of privacy, protecting information from unauthorized access and maintaining user trust.

As explained by Sant'Ana (2013), integrating these practices during the storage phase not only strengthens the database for SEO, but also promotes data management aligned with the principles of quality, accessibility, legal compliance, and privacy. Thus, by adopting these strategic measures, it is possible to optimize the visibility and effectiveness of SEO strategies, establishing a virtuous cycle of continuous improvement in digital data management. Proper preparation and management of stored data to ensure its easy accessibility, location, and future reuse is a critical element in the ongoing optimization of SEO strategies. This ability to adapt data to meet new needs is essential not only for operational efficiency but also to maximize online visibility potential.

In the retrieval phase, the priority is to ensure fast loading and clarity in the display of material, aspects that are directly related to quality and user experience. This focus on agility and clarity significantly contributes to improving the website's performance in search engines, underscoring the importance of a well-planned data infrastructure.

The reintegration of data into new content streams or page updates highlights the scale of dissemination, allowing content to remain dynamic, relevant, and engaging. This practice not only improves the user experience but is also vital to maintaining the relevance of the website in the face of constant changes in search algorithms. Clearly defining terms of use and data applications ensures compliance and prevents potential disagreements, reflecting the need for data management that respects legal aspects, including copyright and privacy regulations. Adapting to technological innovations and ensuring that information remains decipherable and relevant over time emphasizes the importance of preservation for the long-term effectiveness of SEO strategies.

Finally, careful management of personal or sensitive data, emphasizing the concealment and protection of such information, is critical to maintaining user privacy. This practice not only aligns SEO strategies with privacy guidelines, such as the GDPR and the LGPD, but also reinforces user trust in the website, a vital component for long-term success in competitive digital environments, as highlighted by Sant'Ana (2013). The process of disposal of obsolete data and content plays a role in the continuous optimization of a website, ensuring its relevance and alignment with the expectations of the target audience and search engine standards. The careful elimination of outdated or inappropriate information not only simplifies navigation for visitors but also facilitates efficient indexing by search engines, contributing significantly to the maintenance of a clean and contemporary online environment.

Although accumulating a wide variety of data and materials can provide a broad basis for content selection and optimization, it is essential to implement strategic guidelines during the storage phase to identify and discard content that no longer serves the strategic objectives of the website or has lost its relevance. This balance between collection and elimination helps avoid overinvestment in optimization and storage of unnecessary content, as well as the risk of having an insufficient volume of relevant material that requires extensive revisions or the creation of new content.

Careful planning for disposal is essential to maintain website integrity and user experience. Avoiding broken links and content disorganization are key aspects of preserving the clarity and structural logic of the website. In addition, it is essential to properly manage discarded URLs, either through correct redirects or removal, to prevent 404 error pages from occurring, which can harm the user experience and overall SEO effectiveness.

This approach emphasizes the importance of content management as a continuous and dynamic process that requires constant attention to changes in user demands and search algorithms. By ensuring that the discarding process is carried out with due diligence, websites can maintain their relevance and optimization, promoting a superior user experience and better positioning in search results, as pointed out by Sant'Ana (2013).

4 METHODOLOGY

This is a qualitative, descriptive, and theoretical-conceptual study. The research focused on analyzing and articulating bibliographic frameworks related to Search Engine Optimization (SEO) and the Data Life Cycle (DLC), with the aim of identifying conceptual convergences and structural relationships between these two fields.

The interpretation model was structured based on an analytical reading of scientific and technical studies published between 2010 and 2024, selected for their conceptual relevance. The correspondences between the stages of the DLC and SEO practices were systematized in analytical tables and complemented by practical examples, aiming to offer an applied and potentially replicable overview of the integration between these domains.

According to Gil (1999), descriptive research aims to portray characteristics of a given phenomenon and establish connections between variables. For Selltiz, Wrightsman, and Cook (1965), this approach is particularly useful for understanding current phenomena and detailing their specificities. Thus, this research does not aim to test hypotheses, but rather to interpret and correlate concepts based on the available literature.

The content is anchored in the perspective of information science, detailing the DLC phases and discussing its applicability in the context of search engine optimization strategies. These strategies were analyzed in terms of their role in increasing visibility, structuring information, and improving user experience.

Therefore, this study proposes a reinterpretation of the DLC model, according to Sant'Ana (2013), in light of SEO practices, analyzing how these manifest themselves from data collection to disposal, including aspects of storage, retrieval, dissemination, and preservation of digital content.

4 RESULTS

In the current digital marketing context, SEO is an indispensable tool that permeates all phases of the DLC. This deep integration between SEO and the DLC enhances an organization's ability to not only be found online, but to maintain a meaningful and influential digital presence. When applied meticulously from data collection to disposal, SEO strategy can serve as a powerful competitive differentiator, ensuring that content not only reaches its target audience, but also engages and converts.

Data collection is the starting point, where the application of SEO techniques directly influences the quality and relevance of the content to be developed. At this stage, careful keyword selection and search trend analysis are essential to align content with the needs and interests of the target audience. This initial step is crucial to establishing a solid foundation for all subsequent SEO activities. As you move on to data structuring and storage, SEO practices guide the organization of content to maximize its indexing and retrieval by search engines. The implementation of appropriate metadata, tag optimization, and logical URL structuring are examples of how SEO can positively influence the accessibility and visibility of stored content.

During the content usage and dissemination phase, SEO techniques are effective in ensuring that content is delivered to the audience efficiently through fast page loads, responsive content, and an optimized user experience. Additionally, distributing content through SEO-optimized channels, such as blogs, social networks, and publishing platforms, increases its visibility and engagement.

A practical example of this phase can be seen in the publication of scientific articles on academic institutional blogs that adopt on-page SEO practices. For example, a university may publish a recent study through a blog post structured with relevant keywords in the title and subheadings, correctly filled metadata (title, description, keywords), images with descriptive alternative text (alt text), and a clean and meaningful URL. These elements contribute to the efficient indexing of content in search engines, offering a responsive and optimized user experience on both mobile devices and desktops. In addition, republishing this content on institutional social networks with optimized snippets (such as the correct use of open graph for Facebook and Twitter) enhances its engagement with different audiences. This type of strategy not only increases the visibility of scientific content but also contributes to its appropriation and reuse in different informational contexts.

Ultimately, the careful disposal of obsolete data and content, guided by thorough SEO analysis, ensures that the website remains up-to-date and relevant. Strategically removing old content or updating it to reflect more recent and accurate information can boost overall SEO effectiveness, improving user experience and the website's search engine ranking.

Chart 7 extends the relationship between the DLC phases and SEO techniques, offering observations that highlight the importance of each technique in its respective phase.

Chart 7. Relationship between DLC phases and SEO techniques

Data Life Cycle Phases	SEO Techniques	Considerations
Collection	Keyword search Competitive analysis	When collecting data, identifying relevant keywords and topics is crucial to ensure that the content is relevant and meets user demands. Competitor analysis can guide data collection more strategically and efficiently.
Retrieval	Indexing On-page SEO Sitemaps	In order for data to be easily retrievable, it is essential that search engines properly index it. Refining internal content elements, such as titles and meta descriptions, is important for effective retrieval. A well-structured sitemap helps search engines understand and index content efficiently.
Storage	File optimization URL structuring HTTPS implementation	Optimized files, especially images, ensure shorter loading times and a better user experience. A clear and logical URL structure is essential for indexing and user comprehension of content. The security of stored data is vital; HTTPS ensures data protection and website reliability.
Disposal	301 redirects Removal of broken links Sitemap updates	When content is discarded, redirects ensure that users do not encounter error pages. Broken links can harm both the user experience and the website's authority; therefore, they should be identified and corrected. When discarding pages, the sitemap should be updated to reflect the current website structure.

Source: Prepared by the authors.

The detailed analysis in Chart 7 highlights the effective interconnection between DLC phases and SEO techniques, revealing a coherent narrative about the importance of integrating SEO practices into each phase of the DLC to amplify online presence. This synergy between the DLC and SEO is a testament to the complexity and need for a digital marketing strategy that is both comprehensive and meticulously executed. Below, we unfold this relationship, also considering the influence of cross-cutting factors of the DLC on SEO techniques.

During the collection process, keyword search and competitive analysis are of paramount importance. These techniques not only guide the collection of relevant information aligned with the audience's search preferences but also highlight areas of opportunity within the market. Accurate keyword identification and a thorough understanding of the competitive environment are pillars for creating content that resonates with the target audience and stands out in the vast digital landscape.

As an example applied to the collection phase, SEO techniques can be used to structure online forms and data capture pages in an optimized manner. Academic institutions and research groups often create pages for recruiting participants or collecting data via questionnaires. By applying strategies such as clear and objective titles with relevant keywords, informative metadata, and page responsiveness, these pages are more easily found by potential respondents in search engines. In addition, the inclusion of structured markup with vocabularies such as Schema.org can indicate to search engines that this is an academic research or registration form, improving semantic indexing and increasing perceived reliability. This practice enhances both the reach of the target audience and the response rate, thereby significantly contributing to the efficiency of data collection.

Retrieval emphasizes the need for proper indexing and on-page SEO, including effective sitemaps. These practices ensure that content is not only accessible and easily retrievable by search engines, but also provides a smooth and satisfying user experience, elements that are crucial for online visibility and SEO efficiency.

In the retrieval phase, SEO techniques are essential to ensure that digital content is easily found and accessed by users and search engines. A practical example of this phase is the adoption of structured data using vocabularies such as Schema.org in institutional repositories or digital libraries. By tagging scientific publications with properties such as author, datePublished, publisher, about, and identifier, the content becomes semantically richer and more understandable to search engines, which favors display in rich results and improves findability. This practice also enhances interoperability between indexing systems and platforms, thereby facilitating the information retrieval process for researchers, students, and other interested parties. In addition, well-optimized pages with descriptive titles, clear meta descriptions, and user-friendly URLs encourage clicks and user retention, enhancing the information experience.

During storage, file optimization, URL structuring, and HTTPS implementation are essential measures that directly affect website security, accessibility, and performance. User experience and website credibility in search engines are enhanced by data management that prioritizes fast loading and information security.

In terms of storage, a practical example is the adoption of standardized and user-friendly naming conventions for digital files and directories in information management systems or institutional repositories. Using descriptive file names with relevant keywords and directory structures that reflect the content organization logic (by date, subject, author, etc.) facilitates both efficient storage and subsequent automated retrieval by indexing robots. In addition, consistent and structured metadata, even in files stored offline or on local servers, contributes to interoperability between systems and prepares

these information assets for future publication in SEO-optimized environments. Thus, planned storage with a focus on visibility and semantic organization of content promotes the preservation and reuse of information.

At disposal, strategic management of obsolete content through 301 redirects and sitemap updates ensures that the website remains up-to-date, relevant, and error-free. These actions are crucial for maintaining the website's integrity and ensuring an uninterrupted user experience, which directly impacts the website's authority and ranking with search engines.

To illustrate the disposal phase, consider the case of an e-commerce site that decides to remove discontinued products from its digital catalog. Instead of simply deleting the pages for these products, the site manager applies 301 redirects to equivalent pages, such as a new version of the product, a related category, or a personalized purchase suggestion. This practice prevents users from encountering 404 errors, which impair navigation and trust in the website, while also preserving the original URL's authority in search engines. At the same time, the sitemap.xml file is updated to reflect the new site structure, removing deactivated pages and reinforcing the indexing of only active and optimized content. This strategic management of obsolete content contributes to maintaining a clean and consistent architecture, improves user experience, and reinforces the brand's credibility with ranking algorithms.

Cross-cutting factors of the DLC, such as privacy, integration, quality, copyright, dissemination, and preservation, play a decisive role in SEO strategies. Compliance with privacy and copyright regulations, ensuring content quality, and effective dissemination and preservation of data are all elements that underpin ethical and efficient search engine optimization. Chart 8 provides an overview of the relationship between each factor and SEO, complemented by relevant observations that elucidate the ramifications and particularities of this connection.

Chart 8. Relationship between cross-cutting factors of the DLC and SEO techniques

Cross-Cutting Factors	Relevance to SEO	Considerations
Privacy	Personal Data Protection and compliance with regulations such as the GDPR	Ensuring that SEO-optimized websites comply with privacy laws is essential to avoid penalties and maintain user trust.
Integration	Harmonization and connection of data from multiple sources for more accurate SEO insights	Effective integration can improve data analysis, providing better segmentation and customization for the target audience.
Quality	Ensuring that the data used in SEO is accurate, relevant, and up-to-date.	Data quality has a direct impact on the effectiveness of SEO strategies. Outdated or inaccurate data can lead to poor decisions.
Copyright	Use of content and data in a legal manner, preventing plagiarism or misuse of intellectual property.	Copyright violations can result in penalties from search engines and damage to reputation.
Dissemination	The way data is shared and disclosed impacts visibility on search engines.	Effective dissemination can broaden reach and visibility, but must be done ethically and transparently.

Preservation	Ensuring that data relevant to SEO is stored and protected in the long term.	Historical data can be useful for future SEO analysis, so its preservation is essential.

Source: Prepared by the authors.

Chart 8 illustrates the close link between the cross-cutting elements of the DLC and SEO techniques. In terms of privacy, it emphasizes the importance of using HTTPS and having clear privacy policies, ensuring protection and compliance with regulations such as the GDPR and LGPD. Integration highlights the importance of proper structuring through sitemaps and strategically designed URLs, facilitating interpretation by search engines. As for quality, on-page and image optimization is essential for a strong online presence. In terms of copyright, the priority is to establish transparent usage policies and ensure proper citations, preventing violations and strengthening the website's credibility. Regarding dissemination, practices such as link building and content marketing are essential for enhancing visibility and disseminating information effectively. Finally, preservation focuses on the durability and reliability of data through effective redirects and backups, ensuring the continuity of content in the event of unexpected failures or losses.

6 CONCLUSION

The convergence between the DLC and SEO practices represents a milestone in digital strategy, underscoring the importance of an integrated approach to maximize the visibility and relevance of content on the web. This synergy not only facilitates search engine optimization but also promotes data management with a holistic perspective, considering everything from information collection to disposal. By emphasizing the quality, accessibility, and integrity of content, entities can ensure a robust and effective online presence, standing out in a competitive landscape. Increasingly stringent privacy and copyright laws add another layer of complexity to online content management, making it imperative that SEO practices comply with these regulations. Integrating these legal and ethical considerations into SEO strategies is not just a matter of compliance, but an opportunity to strengthen trust and credibility with the public. This responsible approach not only improves search engine rankings but also builds a positive digital reputation.

Furthermore, the interaction between the DLC and SEO highlights the need for continuous adaptability and innovation in content development. As audience preferences and search algorithms evolve, so must the methods for collecting, managing, and optimizing data. This dynamic requires a commitment to constant learning and updating, enabling SEO strategies to remain relevant and effective over time.

The practice of discarding obsolete or irrelevant content, keeping the site up to date and aligned with user expectations, is another decisive aspect of this interaction. This process not only enhances the user experience but also optimizes the site's performance in search engines, underscoring the importance of careful and strategic content management. The ability to identify and remove content that no longer serves the purpose of the website reflects conscious and results-oriented data management.

Ultimately, the strategic combination of the DLC and SEO techniques is crucial for navigating today's complex digital landscape successfully. By considering each phase of the DLC through the lens of SEO, organizations can not only improve their online presence but also ensure that their content is valuable, accessible, and compliant with ethical and legal expectations. As the digital world continues to evolve, this integrated approach will become increasingly vital to achieving and maintaining a sustainable

competitive advantage.

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