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A DATA-DRIVEN FRAMEWORK FOR EVALUATING AND IMPROVING THE SEO PERFORMANCE OF PAKISTANI UNIVERSITY WEBSITES

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Abstract
Official university websites in Pakistan mainly share basic announcements like admission calls, program info, and research updates. Most universities don't regularly use search engine optimization (SEO) as part of their website upkeep. They often only deal with SEO-related tasks after the website is already built, and even then, it's usually a one-off thing. This research created a structured way to assess websites using a data-driven framework, looking at five key areas: technical SEO, content relevance, website speed, on-page optimization, and the strength of the site's backlinks. We adopted stratified exploratory sampling to select public and private universities across all provinces and regions of Pakistan, and audited several categories of pages from their official websites, including homepages and admissions pages. The findings reveal that all sampled universities' websites share a set of widespread common problems: weak technical foundations, slow loading speeds, failure to meet Core Web Vitals requirements, and poor search visibility for search queries that do not use the university's official name. The research conducted in this paper finds that most universities perform well in their backlink authority. Most high-quality external links are naturally generated from long-established educational domain names, alumni websites, and news websites, while planned link-building work by the universities was not clearly visible. After validating this conclusion through the case of Abbottabad University of Science and Technology, which recorded an improved core search term match rate after completing optimization, we released three types of tools: the university SEO performance index, a page-level prediction method, and a university website optimization cycle.

TABLE I. STRATIFIED AUDIT SAMPLE AND INSTITUTIONAL GROUPING

Region	Older public (≤2000)	Newer public (≥2001)	Older private (≤2000)	Newer private (≥2001)
Punjab	University of the Punjab (1882); UET Lahore (1921)	–	LUMS (1985)	University of Central Punjab (2002)
Sindh	University of Karachi (1951); NED UET (1921)	–	Aga Khan University (1983)	Habib University (2014)
Khyber Pakhtunkhwa	University of Peshawar (1950)	Hazara University (2001); AUST (2015)	GIK Institute (1993)	–
Balochistan	University of Balochistan (1970); BUET Khuzdar (1987)	BUITEMS (2002)	–	Al-Hamd Islamic University (2005)
Islamabad Capital Territory	Quaid-i-Azam University (1967); AIOU (1974)	–	FAST-NUCES (2000)	Riphah International University (2002)
AJK and Gilgit-Baltistan	University of AJK (1980)	MUST (2009); Karakoram International University (2002); University of Baltistan (2017)	–	–

Note: In this paper, universities established up to 2000 are placed in the "older" group, and those established from 2001 are placed in the "newer" group. This grouping is used only for comparison and is not an official ranking.

I. INTRODUCTION

A university website is now one of the first places where a student looks for information. SEO links the website structure, useful content, and web authority with the way people find a page in search results [1], [2]. Links within a website and from other domains are also a basic part of search authority [3]. Earlier studies have shown that accessibility and page performance are still important issues on ordinary websites and also on higher education websites [4]–[7]. Before contacting a university, a student normally checks admission dates, eligibility, fee structure, scholarships, programs, faculty, and campus facilities. If this material is missing or difficult to locate, the student may leave the website. During our review in Pakistan, most sites opened on mobile phones were responsive, but good search performance was not common. Updates were mainly made for an admission notice, job advertisement, or a news item.

We also noticed that part of a university's online visibility comes from outside the official website. When students write about their university, former students share what they're up to, newspapers report on campus happenings, and other websites link to the university's own site, it naturally builds trust. This is especially true for university websites that have been around for a while.. Still, it does not show that the university has its own planned SEO work. In many cases, the exact university name ranked well, while searches without the name, for example "BS Computer Science Pakistan", "university scholarships Pakistan" and "computer science university in Pakistan", gave weak or mixed results. This difference between branded visibility

and planned organic search work is also discussed in search marketing research [1], [2]. For some queries, an HEC page, Wikipedia or an information portal appeared before the actual university program page.

The paper answers seven questions. These are: (1) what is the present SEO condition of Pakistani university websites; (2) which technical and on-page issues occur most often; (3) whether public and private universities have a clear difference; (4) which factors have more effect on search visibility; (5) whether machine-learning models can estimate website performance; (6) whether data-driven changes improve visibility and user acquisition; and (7) how universities perform for non-branded searches about admission, programs, scholarships, faculty and research. The paper checks several pages of each website, not only its homepage.

The main objectives were to check technical SEO, content, on-page work, performance and authority; prepare a combined SEO index; compare sector, province and university-age groups; identify important visibility factors; describe suitable prediction models; apply selected changes at AUST; and give practical guidelines for higher education institutions. Where reliable search data were available, the purpose was also to measure the change. In this way the audit can show both the problem and the order in which work may be done.

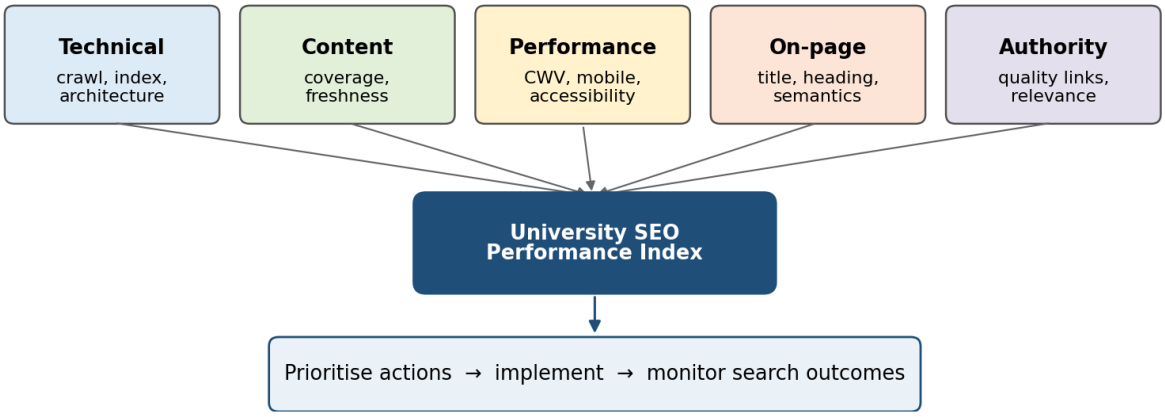


Fig. 1. Proposed data-driven SEO evaluation and improvement cycle.

II. RESEARCH DESIGN AND DATA

A. Sampling and Page Selection

Purposive stratified sampling was used. The sample included public and private universities, different provinces and territories, general and specialized institutions, older and newer universities, and websites of different sizes. HEC recognition was checked from the recognized-university list while preparing the sample [8]. The groups are given in Table I. University age was included because an old institution may have many years of brand searches and backlinks. A recently established university may have a newer website, but it usually has less time to build this authority.

The homepage alone was not considered enough for the audit. Where the pages were available, we checked the homepage, admission page, academic program page, department page, faculty profile, scholarship or financial-aid page, news page, research page and contact page. Crawling and performance checking were kept within one observation window so that website changes would have less effect on the comparison. Admission notices were also reviewed, as many university websites become more active during the admissions period. Earlier research also shows that the condition of institutional pages and prospective-student pages can be different [6], [7].

B. Research Hypotheses

Based on the issues noticed during the website audit, eight hypotheses were prepared. The first

hypothesis, H1, examines the relationship between website performance and organic search visibility. H2 focuses on whether useful content and proper coverage of academic topics can attract more non-branded traffic. The effect of backlink authority is examined through H3. In H4, we check whether websites having fewer technical SEO problems receive better visibility scores. H5 compares the SEO performance of public and private university websites, while H6 considers mobile usability and engagement from organic visitors. H7 examines changes in clicks, impressions, CTR, and search position after applying the proposed SEO improvements. Finally, H8 checks whether a model combining all SEO areas gives better predictions than a model based on only one area. Previous studies conducted in different countries have also identified problems in the accessibility, usability, content and maintenance of public and private university websites [9]–[15]. Where Search Console or Analytics data were not available, the findings were reported as provisional. No p-value was presented without having the required numerical data.

C. Collection Tools and Limitations

Screaming Frog was used to collect crawl-based technical and on-page information. PageSpeed Insights and Lighthouse were used to check how well the site performs, its accessibility, best practices, and basic SEO. Moz, Ahrefs, and SEMrush were used to estimate backlink authority and public visibility. Scores from different authority tools were not mixed because DA, PA and similar measures are calculated in different ways. A crawler makes a large website easier to inspect in a repeatable manner, but the output still needs manual checking, particularly for low-quality and unusual pages [16], [17].

For technical SEO, we recorded HTTPS, HTTP status codes, broken internal and external links, redirect chains, XML sitemap and robots.txt availability, canonical tags, indexability, duplicate URLs, repeated titles and descriptions, orphan pages, URL structure, crawl depth, internal linking, structured data and hreflang where it was relevant. JavaScript rendering and large or unoptimized images were also checked. The on-page review covered titles, descriptions, H1 use, heading order, keyword relevance in the title and content, image alt text, anchor text, content length, thin or duplicate content, readability, freshness, semantic coverage, internal links and schema markup.

Accessibility was reviewed with WCAG 2.2 principles [18]. PageSpeed Insights [19] and the Lighthouse scoring method [20] were used in the same way for the selected pages. The Google SEO Starter Guide was used for crawl, metadata, internal-link and structured-data checks [21]. A Lighthouse result is affected by the device, network and test conditions [20]. Therefore, the score was treated as an observation for comparison and not as a permanent value of the website.

TABLE II. DATA GROUPS USED IN THE AUDIT

Group	Main variables
Technical	HTTPS; status codes; broken links; redirects; sitemap; robots.txt; canonical; indexability; duplicates; orphan pages; URL depth; rendering; images; internal links
On-page/content	Title and description; H1 and hierarchy; keyword relevance; alt text; anchors; length; thin/duplicate content; readability; freshness; semantic coverage; schema

Performance	Performance, accessibility, best-practice and SEO scores; FCP; LCP; INP; CLS; TTFB; Speed Index; TBT; mobile usability
Authority/search	Referring domains; relevant backlinks; authority score; branded and non-branded rankings; ranking pages and SERP coverage

We did not have login access to Google Search Console or Google Analytics for the selected universities. Because of this, clicks, impressions, CTR, query-level average position, device, country, search appearance, organic sessions and admission conversions could not be collected in the same form for every university. This study used crawl logs, public web directories, third-party monitoring tools, and manual checks. This approach has a big limitation because external tools can only estimate data; they can't replace a university's own Search Console or Analytics information. The definitions used for clicks, views, click-through rates, and average ranking follow Google's Performance report guidelines[22], [23].

D. University SEO Performance Index

The University SEO Performance Index (USPI) merges five domains and provides a rating ranging between 0 and 100. Positive variables are changed to a common scale by the min-max formula in (1). For an error variable, such as the number of broken links, the normalized score is reversed. Therefore, a higher value is favorable for every part of the index.

$$x'_i = (x_i - min(x)) / (max(x) - min(x)) \quad (1)$$

$$USPI = 0.25T + 0.25C + 0.20P + 0.15O + 0.15A \quad (2)$$

In (2), T represents technical SEO, C content and topical relevance, P performance and mobile experience, O on-page optimization, and A backlink authority. Technical and content factors have the largest weights because a page must be crawlable and must answer the student's question. Performance receives 20%, while on-page work and authority each receive 15%. This weighting prevents an old domain from getting a high total only because it already has many natural links. Inside the performance score, more attention is given to LCP, INP and CLS, which cover loading, responsiveness and visual stability [24].

TABLE III. USPI WEIGHTS AND INTERNAL EMPHASIS

Dimension	Weight	Internal emphasis
Technical (T)	25%	crawl/index 10; architecture 6; canonical/metadata 5; security/schema 4
Content (C)	25%	topical coverage 10; completeness 6; freshness 5; readability/language 4
Performance (P)	20%	Core Web Vitals 12; mobile usability 5; accessibility/best practice 3
On-page (O)	15%	title/headings 5; semantics 5; images/anchors 3; page schema 2
Authority (A)	15%	link quality 8; relevance 4; natural growth 3

E. Keyword Visibility and Predictive Analysis

Queries were first separated into branded and non-branded groups. Non-branded queries covered admission, such as "undergraduate admissions Pakistan" and "fall admissions Pakistan"; programs, such as "BS Computer Science Pakistan" and

"MBA programs"; and also scholarships, fees, location, faculty and research. Equation (3) gives a rank-weighted visibility score. In this equation, r_k is the observed position of keyword k and q_k is the For machine learning, one audited page is treated as one observation. Technical, content, performance, on-page and authority values form X, while visibility, clicks or organic sessions form Y. Linear regression is used as a simple baseline. Random forest, gradient boosting, XGBoost and support vector regression are then suitable for relationships which are not linear. These methods are based on the established work in [25]–[28]. Backlink counts should be log-transformed, and continuous inputs should be scaled where the algorithm needs it. Missing values are filled only from the training data. All pages of one university must remain in the same cross-validation fold; otherwise, the model can learn the university identity and give an over-optimistic result. A model can be called reliable only if it performs better than a mean-prediction baseline on universities not seen in training. R^2, MAE and RMSE can be used for this test. The method supports H8, but we do not report made-up accuracy values because complete numeric data were not available.

III. RESULTS AND DISCUSSION

A. Overall SEO Condition

The overall SEO condition was not satisfactory. We repeatedly found wrong or duplicate page titles, missing or unrelated descriptions, no clear keyword focus, thin pages, orphan pages, and weak heading order. Many universities' WordPress sites still

importance assigned to it. A query outside the tracked range receives zero.

$$V = 100\ [\Sigma(q_k / r_k)] / \Sigma q_k \quad (3)$$

retain demo pages and dummy metadata pre-included with their templates. Internal links across all core site sections are severely lacking, leaving visitors unable to navigate the sites easily. Research on higher education institutions in Asia, Europe, Africa, and the Gulf region has all confirmed that this is a common, widespread flaw affecting university websites globally [4], [6], [9]– [15].

A widespread misunderstanding exists across the industry that websites built with responsive themes qualify as compliant mobile-friendly sites. Findings from the observations of this study show that while most tested sites can load on mobile devices, they universally suffer from four common problems: overly long menus, deeply buried key information, poor adaptation of button text for small screens, and large-sized resources that slow down page loading. The results of the PageSpeed test demonstrate that the majority of websites represented by this category had a low result and did not meet the Core Web Vitals criterion. Therefore, in order to illustrate that the actual loading, rendering, and quality of the page as experienced by the user are significantly more important than choosing a responsive template, an example of a website that failed the test can be provided. A similar conclusion can be found in the Core Web Vitals documentation as well as research conducted by the world's leading universities in recent years [5], [19], [20], [24].

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TABLE IV. CONSOLIDATED OBSERVED RESULTS

Area	Observed result
Branded search	Generally good for exact university names; acronym ambiguity can reduce relevance.
Non-branded search	Weak and inconsistent; HEC, Wikipedia or information portals often appear before program pages.
Technical SEO	Weak heading structure, metadata, redirects, broken links, orphan pages and leftover template content.
Content	Admission notices updated; faculty, scholarship, campus service and evergreen program content updated rarely.
Performance/mobile	Responsive design common, but speed, Core Web Vitals and mobile usability remain weak.
Authority	Moderate to good for many older educational domains; much of the link growth is natural rather than planned.

B. Public, Private, Regional and Age Comparison

The descriptive comparison of this study did not identify a clear gap in core advantages between public and private universities. The long-established public institutions Quaid-i-Azam University and Allama Iqbal Open University have built up strong brand authority. Some private universities feature a more modern presentation style, but suffer from technical and content flaws. Only Hazara University has attempted to improve its search visibility, and this approach has not become a widespread model across the higher education industry.

This study's review finds that long-established universities, which have long operating lifespans and long periods of being linked to by external sites, hold advantages in SEO authority. Some newly founded universities have more concise, faster-responding websites. Neither a university's founding duration nor its affiliated province can guarantee strong SEO performance. The four core influencing factors include website governance and three others were more important in the review. Restricted by data limitations, this study only carries out descriptive comparison, and does not claim that a statistically significant difference exists between public and private universities.

C. Branded and Non-Branded Search

This study retroactively deduces core information architecture flaws in official university websites by analyzing performance discrepancies in Google Search results: Searches using the full, accurate official name of a university produce far better performance, as Google can match the query to the university's official domain name. When the university name is removed from search queries, results for six types of high-frequency student search terms (including admissions) are returned in disordered rankings. This pattern leads the study to further conclude that university program pages fail to align with user search terms, and key information is either stored as PDF files or split across multiple web pages, making it difficult both for students to access and for search engines to identify correctly.

D. Hypothesis Assessment

TABLE V. EXPLORATORY HYPOTHESIS OUTCOME

Hyp.	Outcome	Basis
H1	Provisional support	Poor speed/Core Web Vitals occurred with weak visibility and usability.
H2	Supported	Complete, relevant topical pages showed better non-branded relevance.
H3	Supported with limit	Authority helped branded visibility but did not repair weak content.
H4	Supported	Cleaner crawl/index structure produced stronger visibility conditions.
H5	Not supported descriptively	No systematic public/private advantage was observed.
H6	Provisional support	Usable mobile pages provided better access; responsive theme alone was insufficient.
H7	Supported by AUST case	Structured intervention improved branded SERP relevance.
H8	Method supported; numeric test pending	Combined model covers factors missed by a single score.

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IV. AUST SEO INTERVENTION

Abbottabad University of Science and Technology (AUST) was chosen as the case of improvement. It previously failed in terms of branding in search due to ambiguity of the abbreviation AUST (could be an American/Australian institution). The WordPress theme and described approach utilized for site identity, structure, and branded content continues to be used for a fresh site. We did a manual search and found Abbottabad University of Science and Technology was leading for the branded keyword. This was a significant increase in entity relevance, but exact click and impression data was not available due to the lack of private search data.

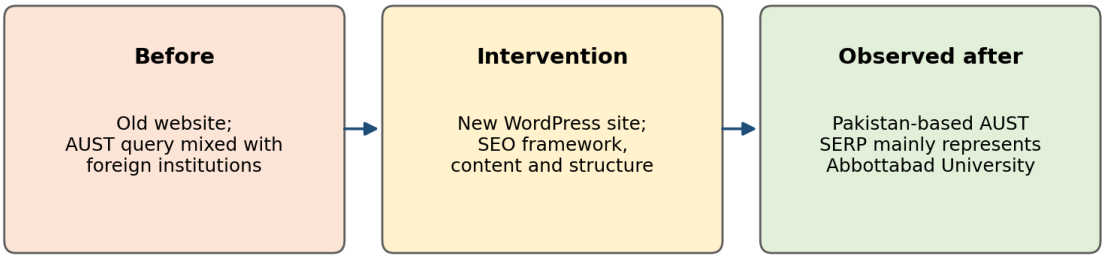


Fig. 2. AUST intervention and observed branded

search improvement.

The AUST intervention is not complete yet. Many of the titles and meta descriptions could also still be optimized, and the web performance can also be enhanced. Furthermore, separate pages must be dedicated to non-branded searches for programs, eligibility, scholarship information, fees, research, etc. and campus services. Percentage change of any outcome M could be expressed in percentage point using (4) in an analysis following the AUST intervention. However, a more powerful analysis would be performed using a difference-in-differences comparison between the original AUST pages and the revised pages before and after the intervention.

$$\Delta M(\%) = 100(Mpost - Mpre) / Mpre \quad (4)$$

Clicks, impressions, CTR, average query position and devices should be recorded by Search Console. Organic sessions, program page engagement, rates of downloading the prospectus and clicking the applying-now link should all be tracked with Analytics. The AUST example also supports the hypothesis H7 with empirical evidence, but it is not possible to claim the increases in percentages until a stable history of performance data (before and after intervention) is retrieved.

V. PRACTICAL DATA-DRIVEN FRAMEWORK

The first step in the implementation process is to audit the data that exists on the website and what is missing. Manual review is required on a page level as there are some webpage elements a crawl can't determine, but those elements are important for determining whether the admissions or academic information is complete. When a problem or issues are identified, the work should be assigned to responsible offices. The web team should take care of redirects, canonical tags, JavaScript errors, big images, and load times. The admission dates, eligibility criteria, fee structure and scholarship information should be attended by admissions office and the program information, faculty information and research information should be addressed by departments. A small group of SEOs should be responsible for organizing the work and focusing on page titles and meta descriptions, internal linking and structured data.

It doesn't need to be a complete redesign of the site to address all problems, but some important elements could be addressed on the existing site. Titles and descriptions of pages and posts should be fixed as soon as possible, and pages or dummy content should be removed from the WordPress templates. The errors of broken links and indexation should be addressed, as well as invalid canonical tags. Unnecessary scripts could be removed for mobile loading speeds, and oversized images should be optimized by compressing. The dedicated pages containing information on the admission criteria, information about the courses etc. must be included for the Core Academic Programs. Faculty details, Scholarships and Campus facilities must also be addressed appropriately. Certain pages where necessary can also be in both English and Urdu languages. It may also be helpful to use structured data to assist

search engines in understanding these pages, such as University, Organization, Course, Breadcrumb. The following steps align with the results from search [21], performance guidelines [19] and [24] and accessibility guidelines [18].

It should not take a new design for the university to start to look at improvements, it should look at them every month. This can be complemented with a basic dashboard which tells more about the metrics covered by the 5 USPI, Core Web Vitals, indexed pages, crawl errors, branded and non-branded search performance, etc. Depending on the availability of data, an analysis of organic landing pages and/or activities around admissions may also be included. It can only help if it lets you know what to do next, such as if a page appears multiple times on search engine results pages but lures few to no visitors to the page, then the title and description of the page should be changed. Likewise, when a page is appearing on top of Google, you can further improve its rank by providing more content or internal links. Sometimes a user browses the pages to admission but does not download the prospectus or click the apply link. The content at the admission page might then require to be clarified and easily accessible.

VI. LIMITATIONS

The major problem experienced during data collection was access to the university's actual search records. Google Search Console and Analytics are private accounts (owned by each institution) and we did not have login details to these. Therefore, we were not able to gather the same data for clicks, impressions, and online traffic for all the universities selected. We had very few university pages to work from, a small amount we went on Google and manually checked, and some information we gathered from third party SEO tools. Care must be taken in handling authority scores. Tools such as Moz, Ahrefs, and SEMrush calculate domain authority and related values using their own formulas. Therefore, a score from one tool was not considered directly equivalent to a score from another tool. Search rankings were another issue, as they could change depending on the testing time, user location, and device. Although universities from different regions and categories were included, the sample did not represent every HEC-recognized university in Pakistan. The division between older and newer universities was made only for comparison and should not be considered a measure of institutional quality. In the AUST case, improvement was observed for the branded search term after changes were made to the website. However, this observation cannot be treated as a controlled traffic experiment. A future study can use saved tool reports, institutional analytics data, and repeated observations during admission and non-admission periods. The proposed prediction models can also be tested through grouped cross-validation when sufficient numerical data become available.

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VII. CONCLUSION

Pakistani university websites usually perform well when a person searches the exact institution name. Their technical condition and visibility for non-branded searches are much weaker. The review showed that weak search performance was not caused by one problem only. In many websites, slow loading was found together with failed Core Web Vitals. Page titles and descriptions were either missing or not properly related to the page. The use of headings was also weak, and links between program, admission, faculty and scholarship pages were limited. Some pages contained very little information, while others had not been updated for a long time. Faculty profiles and information required by prospective students were incomplete in several cases. Keyword planning was also not clearly visible. Older university domains still had reasonable authority because students, alumni, news websites and other sources had created links to them over time. However, the universities were not making full use of this authority to appear for searches about programs, admissions, fees and scholarships.

The USPI was proposed to consolidate these SEO findings into a single framework. It combines technical conditions, content, website performance, on-page work, and authority so that a university can identify which area requires attention first. The AUST case provided an early indication that improvements in website identity, structure, and content can make branded search results more relevant. However, the actual increase in traffic and

user activity cannot be confirmed without complete Search Console and Analytics records. These data will also be required before testing the proposed page-level machine-learning models. The main conclusion of this work is that SEO should not end when a university website is launched. It requires regular checks, content updates, and technical maintenance based on the available data.

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