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Mobile Readiness Assessment of U.S. Public University Websites: A Google PageSpeed Analysis

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ABSTRACT
The rapid evolution of mobile communication technologies over the past decade has fundamentally reshaped user engagement with digital content. The widespread adoption of smartphones and tablet computers, driven by their superior portability and ease of use, has led to a significant shift in user preference away from traditional laptop computers. Consequently, organizations that rely on websites to disseminate critical information must strategically reassess and redesign their digital interfaces to accommodate this drastically increased population of mobile device users. This paper critically examines the mobile readiness of official websites belonging to public universities in the United States. The performance of a web page for mobile devices is quantitatively assessed using the Google PageSpeed Insights tool, which conducts a systematic analysis of a page's content and generates a performance report. This report specifically evaluates the degree to which a page adheres to established best common practices for mobile optimization. The findings of this investigation reveal a substantial need for improvement in the mobile optimization of the majority of U.S. public university websites. These results underscore the imperative for these institutions to undertake significant modifications to enhance the experience of their growing mobile user base.

Keyword: PageSpeed Insights, mobile readiness, smart phone, mobile devices, the U.S. public university websites, webpages for mobile device

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I. INTRODUCTION

Since Schwab (2016) declared the advent of the Fourth Industrial Revolution (4IR) at the World Economic Forum, it has been defined by the convergence of disruptive technologies, including the Internet of Things (IoT), quantum computing, artificial intelligence (AI), autonomous vehicles, and blockchain. Mobile computing technology is widely recognized as one of the fundamental pillars of 4IR, maintaining a continuously disruptive effect on both personal life and the broader business landscape.

Current data reflects this pervasive shift: a substantial majority of U.S. adults now own mobile devices. According to recent surveys, approximately 98% of Americans own a cellphone, 91% possess a smartphone, and around 64% own a tablet computer (Pew Research Center, 2024; U.S. Census Bureau, 2024). Furthermore, due to the ubiquity and ease of use of smartphones and tablets, an increasing number of U.S. adults—upwards of 85%—report going online almost every day (Pew Research Center, 2024).

The operational landscape for public universities has been significantly impacted by several major factors post-pandemic, including the Supreme Court ruling on affirmative action, evolving student mental health needs, and the rapid integration of Generative Artificial Intelligence (AI) across curricula and administration (Hanover Research, 2024; InsideTrack, 2024). These challenges, coupled with the need for enhanced personalized recruitment and enrollment strategies, underscore the critical role of the university website as the primary digital gateway for prospective students, faculty, and the public. It is thus imperative that organizations that rely on their websites to communicate with users and provide important information continuously reassess their digital presence to ensure optimal performance for a drastically increasing mobile device user base.

This paper examines whether the U.S. public university websites are mobile-ready. For this purpose, the universal resource locator of each university was systematically analyzed. Physical and technical elements of the websites were collected and subjected to empirical analysis. The tools utilized, the types of data collected, and the specific methodology are explained in detail in the following section, and the research results and implications are discussed prior to the conclusion.

II. LITERATURE REVIEW

Mobile technology has continued its steady growth and integration across numerous sectors in recent years. Its applications are now central to business (Palanivelu et al., 2023; Sharma & Kaur, 2023), education (Adedoyin & Soykan, 2023; Ma et al., 2023), construction (Wang et al., 2023; Yang et al., 2023), and healthcare (AlSohaimi & Almutairi, 2023; Tausend & Böhmer, 2023).

Despite the pervasive adoption and increasing utilization of mobile technology, the field continues to experience rapid evolution. This dynamic environment often results in a lack of definitive, universally accepted guidelines for optimal mobile web design and mobile interface development. However, amidst various considerations, the following factors are consistently deemed the most critical for achieving truly mobile-friendly websites and provide an optimal user experience in the dynamic mobile environment.

Responsive Web Design (RWD)

Responsive Web Design (RWD) is defined as "an approach to web design that makes web pages render well on a variety of devices and window or screen sizes" (W3C, 2023). Specifically, RWD entails the automatic resizing and reorganization of web components—including layout, images, text font, and navigation—to ensure a consistent and acceptable user experience across diverse computing viewports, such as desktops, laptops, tablet computers, and smartphones, all utilizing the same underlying HTML code (Lynch & Horton, 2020; Preece et al., 2023).

Significantly, Google has continuously updated its search algorithm to prioritize mobile-friendly websites, a strategy that evolved substantially beyond the initial 2015 "Mobilegeddon" update. This commitment to mobile performance culminated in the Mobile-First Indexing strategy, making the mobile version of a website the primary basis for indexing and ranking in search results (Google Search Central, 2024; Sze, 2023). Consequently, website owners are compelled to re-architect their digital interfaces to adhere to RWD principles to maintain search visibility and site ranking (Alabsi et al., 2022).

Key Design Elements of Mobile Responsive Websites

Leading researchers and practitioners (Budiu & Nielsen, 2023; Shneiderman et al., 2023; W3C, 2023) emphasize that effective mobile responsive design must incorporate the following critical elements:

- Fluid Layout and Flexible Grid: Utilizing a flexible grid system that enables a website to scale seamlessly to the full width of the browser. This technique is crucial for mobile web presentation, as it effectively accommodates users who frequently toggle between portrait and landscape orientations based on their content viewing needs.
- Flexible Media and Image Optimization: Implementing images and media that are either fluid (resizing relative to the container) or controlled via overflow mechanisms. Modern RWD also prioritizes image file optimization and the use of responsive image tags to load appropriate image sizes based on the user's device.
- Media Queries: Employing CSS Media Queries to precisely optimize the design for different viewing contexts and to resolve specific rendering issues or "bugs" that may emerge across distinct resolution ranges and breakpoints.

Page Loading Speed (Performance)

Mobile users often rely on cellular data connections, making speed crucial. Key performance indicators (KPIs) include 1) optimizing images: compressing images and using next-gen formats, 2) minimizing code: compressing HTML, CSS, and JavaScript files, 3) leveraging browser caching: storing common elements locally to speed up subsequent visits, and 4) server response time: ensuring the server delivers content quickly.

Usability and Navigation

The interface must be intuitive and easy to use on a small screen:

- Tap Targets: Buttons, links, and other interactive elements must be large enough and sufficiently spaced to be easily tapped with a finger (often requiring a minimum size of 48px x 48px).
- Simplified Navigation: Using concise menus (often hamburger icons) and minimizing the number of steps required to reach important information.

- Minimal Scrolling: Prioritizing key content above the fold to reduce unnecessary vertical scrolling.

Legibility and Readability

Content must be easily consumed on a smaller screen:

- Font Size: Using sufficiently large font sizes (generally at least 16px base font for body text) to ensure readability without zooming.
- Viewport Configuration: Correctly setting the viewport meta tag, specifically $ <meta name="viewport" content="width=device-width, initial-scale=1.0"> $, to control the page's dimensions and scaling.
- Contrast: Ensuring high contrast between text and background colors.

Technical Compliance and Compatibility

Websites must avoid elements that are incompatible with mobile operating systems:

- Avoiding Flash: Historically, websites using Flash were inaccessible on many mobile devices; modern sites should use HTML5 instead for animation and video.
- CSS and JavaScript Rendering: Ensuring that CSS and JavaScript are loaded and executed correctly to render the page as intended.

These factors directly influence user satisfaction, bounce rates, and ultimately, the ability of an organization (such as a public university) to effectively communicate and engage with its mobile audience.

III. RESEARCH METHODOLOGY

This research employed a Google tool, PageSpeed Insights (PSI), to measure the mobile readiness of the U.S. public university websites. As shown in figure 1, the PSI analyzes the contents of a web page and generates a performance report that shows whether a page utilizes best common practices. The PSI generates an overall performance score with the following three categories: 1) slow (between 0 to 49 points: red color) – the page is not optimized and most likely delivers a delayed rendering, 2) average (between 50-89 points: yellow color) – the page uses some common performance best practices but misses some optimizations that may result in a slow rendering, and 3) fast (between 90 and 100 points: green color) – The page uses the most common best practices and should deliver a good user experience.

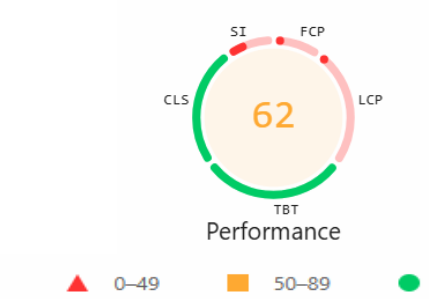

Figure 1. An Example of Web Performance of Google PageSpeed Insights (Source: https://developers.google.com/speed/pagespeed/insights/)

In addition to the overall performance measure, PSI provides the following six more useful insights on a web page.

1) First Contentful Paint (FCP), which measures how long it takes the browser to render the first piece of DOM (document object model) content after a user navigates to your page (see figure 2). If it takes more than 4 seconds, it is considered slow. If it takes between 2 and 4 seconds and between 0 and 2 seconds, it is considered average and fast respectively. Obviously, faster times are more likely to keep users engaged.

2) Speed Index, which measures how quickly content is visually displayed during page load. A video of the page loading in the browser is first captured and the visual progression between frames is computed. After that,

a Speedline Node.js java script module is utilized to generate the Speed Index score. Speed Index is categorized as slow: over 5.8 seconds, average: between 4.4 and 5.8 seconds, and fast: between 0 and 4.3 seconds.

3) Time to Interactive (TTI), which measures how long it takes a page to become fully interactive (see figure 2). A page is considered fully interactive when: The page displays useful content, which is measured by the first contentful paint, event handlers are registered for most visible page elements, and the page responds to user interactions within 50 milliseconds. Time to Interactive is categorized as slow: over 7.3 seconds, average: between 5.3 and7.3 seconds, and fast: between 0 and 5.2 seconds.

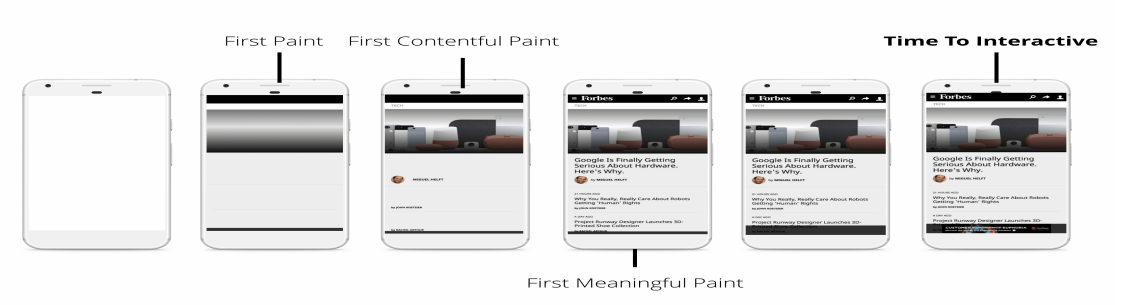

Figure 2. Illustration of First Contentful Paint, First Meaningful Paint, and Time to Interactive (Source: https://developers.google.com/speed/pagespeed/insights/)

4) First Meaningful Paint (FMP) measures when the primary content of a page is visible to the user (see figure 2). The raw score for FMP is the time in seconds between the user initiating the page load and the page rendering the primary above-the-fold content. FMP essentially shows the timing of the paint after which the biggest above-the-fold layout change happens. FCP and FMP are often the same when the first bit of content rendered on the page includes the content above the fold. However, these metrics can differ when, for example, there's content above the fold within an iframe. FMP registers when the content within the iframe is visible to the user, while FCP does not include iframe content.

5) First CPU Idle (FCI) measures how long it takes a page to become minimally interactive. A page is considered minimally interactive when: Most—but not necessarily all—user interface elements on the screen are interactive, and the page responds, on average, to most user input in a reasonable amount of time.

6) First Input Delay (FID) measures the time from when a user first interacts with your site (i.e. when they click a link, tap on a button, or use a custom, JavaScript-powered control) to the time when the browser is actually able to respond to that interaction. The input delay (or input latency) happens because the browser's main thread is busy doing something else, so it cannot respond to the user. One common reason this might happen is the browser is busy parsing and executing a large JavaScript file loaded by your app. While it is doing that, it cannot run any event listeners because the JavaScript might tell it to do something else. It is important to make a good first impression because a good first impression can make the difference between someone becoming a loyal user or them leaving and never coming back.

IV. RESEARCH RESULTS AND DISCUSSION

Table 1 shows the basic statistics on the tested items. The first column represents the wide range of performance of a web page for mobile devices with the minimum score 1 and maximum score 96, average 43.31, and standard deviation 26.17. All other PageSpeed Insights measures are in seconds except for the First Input Delay which is in millisecond. Except for the Performance column, the smaller the better.

Table 1. Basic Statistics of Test Items

	Google PageSpeed Insights						
	Performance (0-100)	First Contentful Paint (second)	Speed Index (second)	Time to Interactive (second)	First Meaningful Paint (second)	First CPU idle (second)	First Input delay (millisecond)
Min	1	0.9	1.3	1.1	0.9	1.1	20
Max	96	22.8	28.4	91.5	18.6	26.8	6130
Average	43.31	4.24	7.53	12.13	4.72	7.92	430.87
STD	26.17	2.50	4.78	9.37	2.53	3.82	624.11

As shown in figure 3 and table 2, only 10 universities (3.2%) are in fast zone, 118 universities (37.7%) are in average, and 185 universities (59.1%) are in slow zone from the PSI performance test. This means that the majority of universities have not applied industry best practices suggested by Google PageSpeed Insights including optimizing browser caching, removing render-blocking JavaScrit/CSS, and using small-sized images and compressions. It is also considered that 185 universities that turned out to be in poor performance can give a user possibly bad experience. Figure 4 also shows that most used components among the HTML, CSS (Cascading Style Sheets), JavaScript, and images are images in 221 universities. This indicates that most universities are not using images efficiently with suggested optimization techniques.

Table 2. Performance Score

Measurement	Performance	# of Univ.	Percentage
Fast	>90	10	3.2
Average	50<=Per<=89	118	37.7
Slow	0<=Per<=49	185	59.1
Total		313	100.0

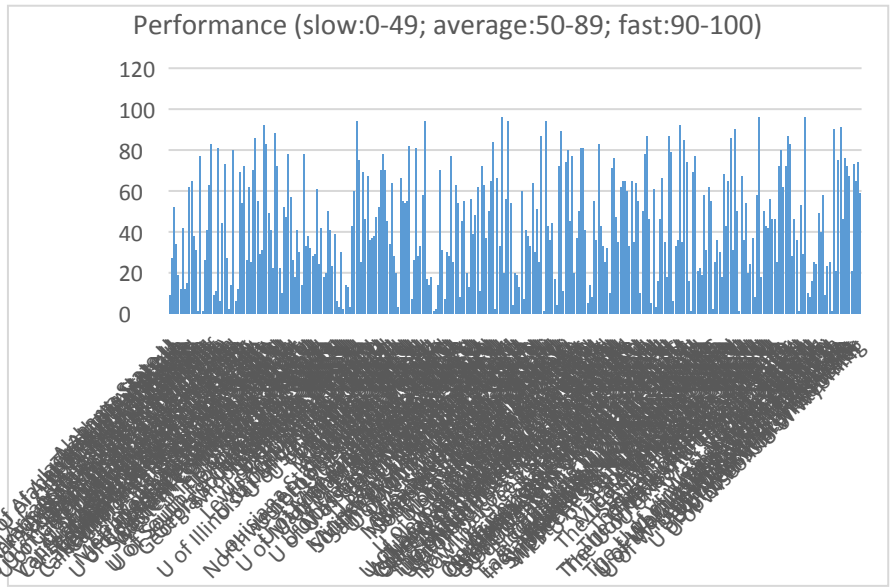

Figure 3. Performance Score

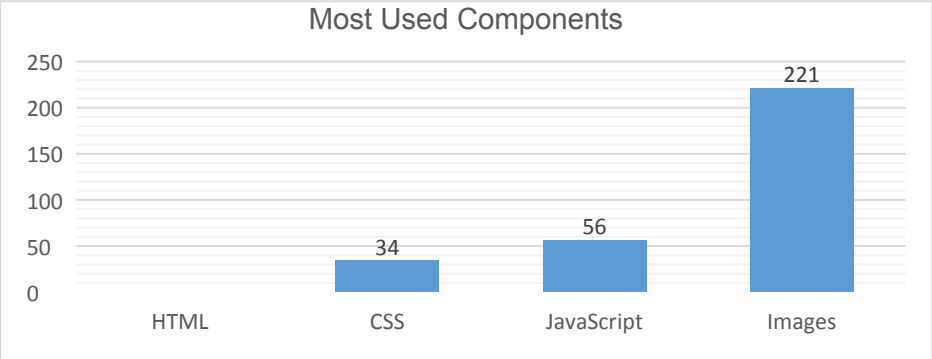

Figure 4. Most Used Components

Figures 5 and 6 depict First Contentful Paint (FCP) and Speed Index respectively. In table 3 FCP table, 29 universities (9.3%) are considered fast, 157 universities (50.5%) are in average, and 127 universities (40.2%) are considered slow. In table 3 Speed Index (SI) table, 82 universities (26.4%) are fast, 63 universities (20.3%) are in average, and 166 universities (53.4%) are slow. These test results reveal that about 40% and more than a half of universities websites are considered slow in FCP and Speed Index category respectively. Obviously, faster times in FCP and Speed Index are more likely to keep users engaged, but more than 90% of universities are not doing well.

Table 3. First Contentful Paint and Speed Index Score

Measurement	FCP	# of Univ.	%
Fast	<=2.0	29	9.3
Average	2.0<FCP<=4.0	157	50.5
Slow	>4.0	125	40.2
Total		311	100.0

Measurement	SI	# of Univ.	%
Fast	<=4.3	82	26.4
Average	4.4<=SI<=5.8	63	20.3
Slow	>5.8	166	53.4
Total		311	100.0

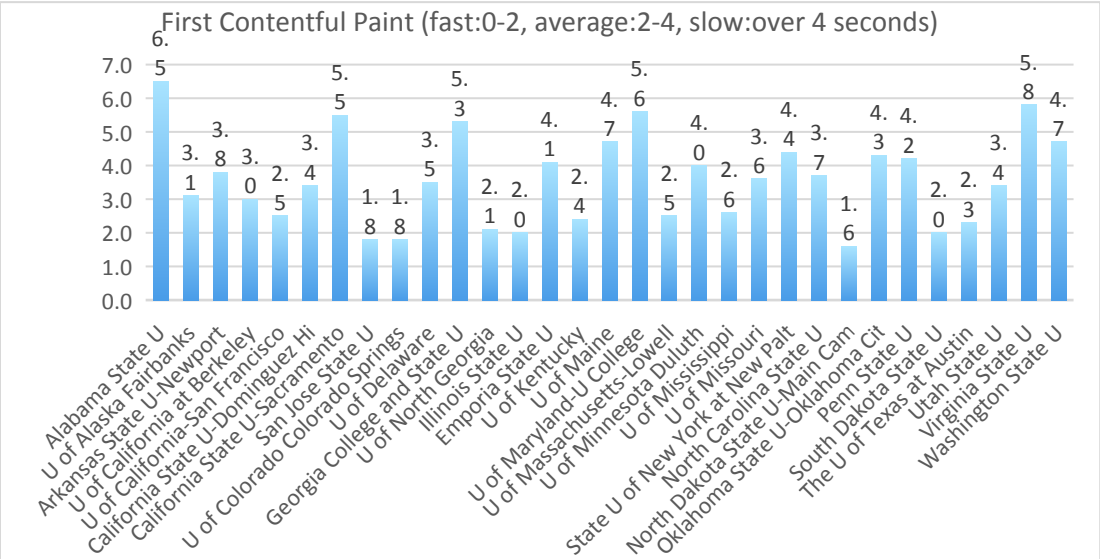

Figure 5. First Contentful Paint

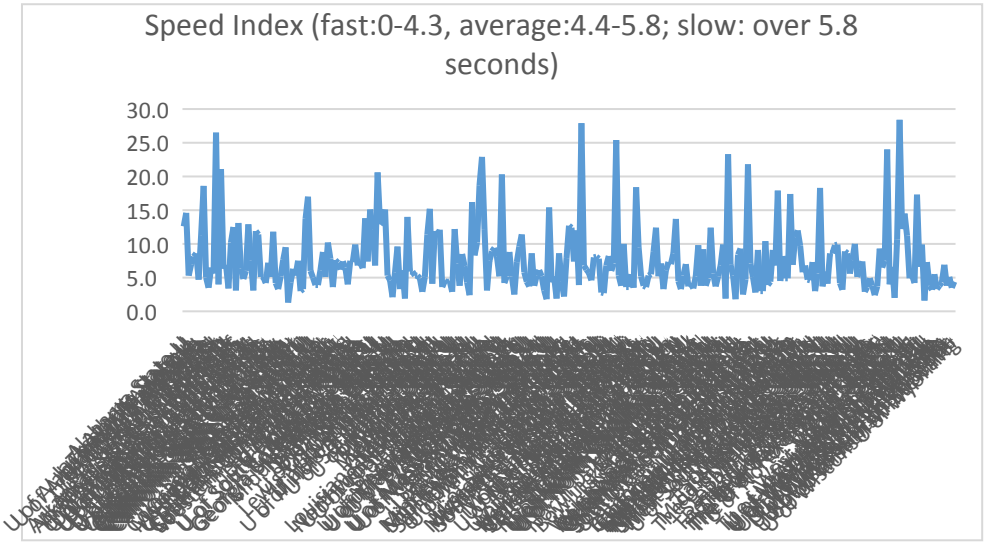

Figure 6. Speed Index

In table 4 Time to Interactive (TTI) and figure 7 indicate that only 40 universities (12.9%) are considered fast, 58 universities (18.6%) are in average, and 213 universities (68.5%) are considered slow. In table 4 First Meaningful Paint (FMP) and figure 8 shows that 17 universities (5.4%) are fast, 135 universities (43.1%) are average, and 161 universities (51.4%) are slow. Both TTI and FMP show that on average most universities are considered not fast enough to give a user good experience.

Table 4. Time to Interactive and First Meaningful Paint Score

Measurement	TTI	# of Univ.	%
Fast	0<=TTI<=5.2	40	12.9
Average	5.3<=TTI<=7.3	58	18.6
Slow	>7.3	213	68.5
Total		311	100.0

Measurement	FMP	# of Univ.	%
Fast	0<=FMP<=2	17	5.4
Average	2<=FMP<=4	135	43.1
Slow	>4	161	51.4
Total		313	100.0

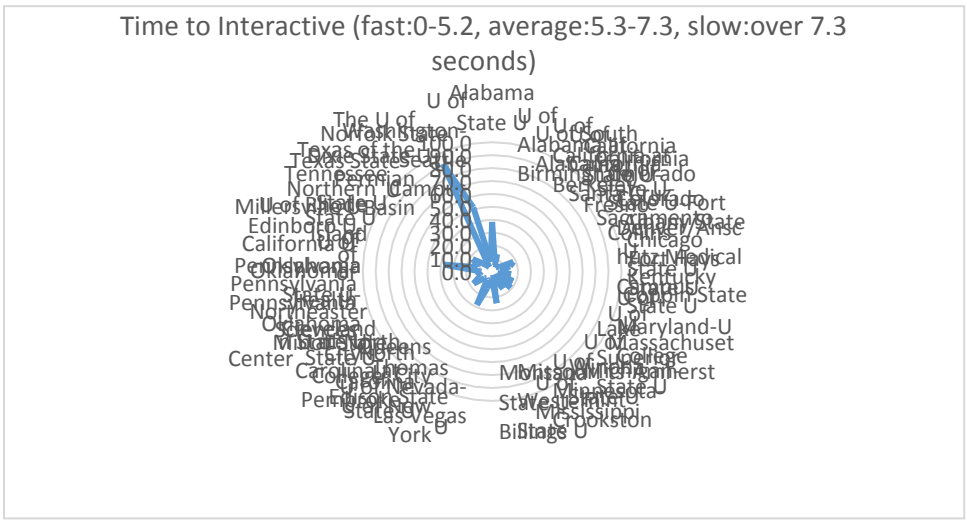

Figure 7. Time to Interactive

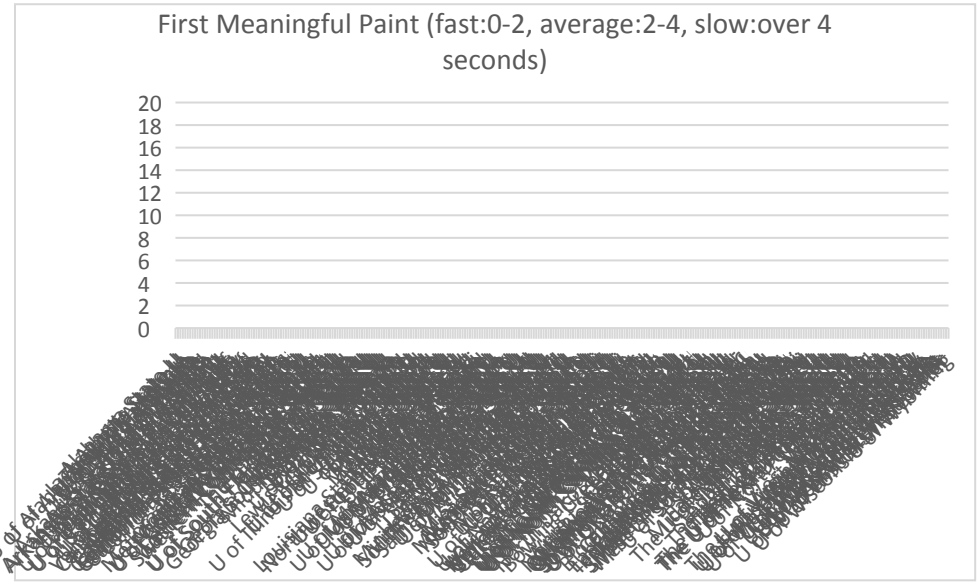

Figure 8. First Meaningful Paint

From table 5 and figure 9, First CPU Idle (FCI), we notice that 57 universities (18.3%) are fast, 71 universities (22.8) are average, and 183 universities (58.8) are slow. Also, from table 5 and figure 10, First Input Delay (FID), which is a user-centric metric for measuring load-responsiveness, we learn that only 30 universities (9.6%) give a user a responsive page. Some of universities' First Input Delays are way too high -more than 2000 milliseconds, which is likely to make an impatient user to leave the website immediately.

Table 5. First CPU Idle and First Input Delay Score

Measurement	FCI	# of Univ.	%
Fast	0<=FCI<=4.7	57	18.3
Average	4.8<=FCI<=6.5	71	22.8
Slow	>6.5	183	58.8
Total		311	100.0

FID	# of Univ.	%
0<=FID<=100	30	9.6
101<=FID<=1000	261	83.9
1001<=FID<=2000	13	4.2
>2000	7	2.3
Total	311	100.0

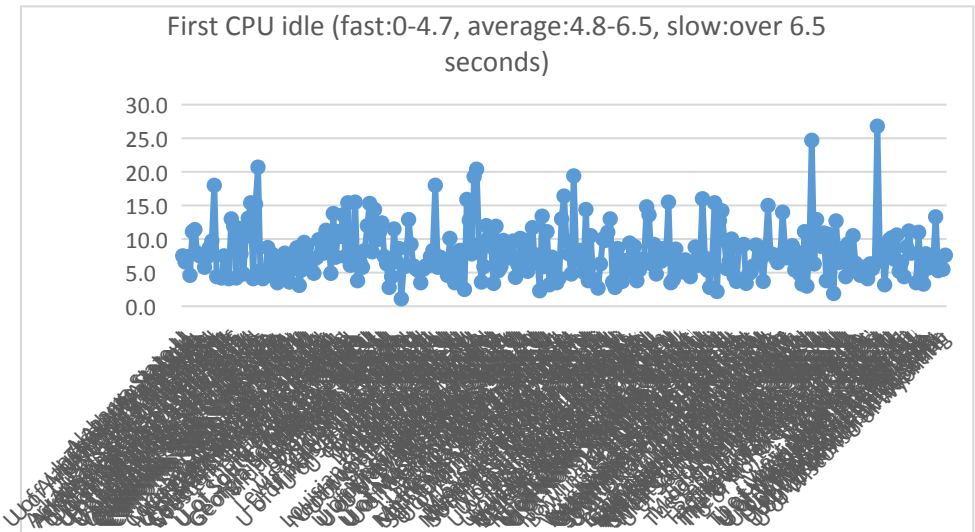

Figure 9. First CPU Idle

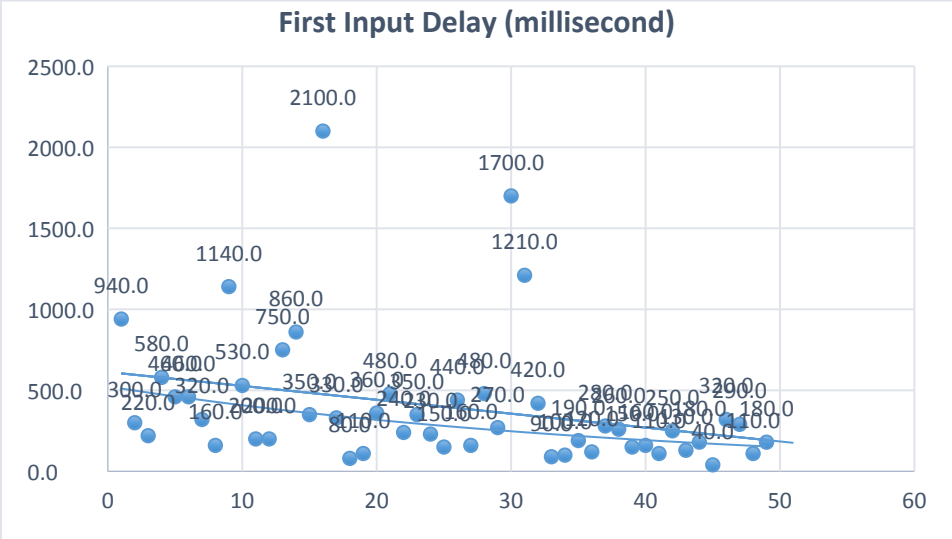

Figure 10. First Input Delay

V. CONCLUSION AND IMPLICATIONS

This paper systematically examines the mobile readiness of official U.S. public university websites. For this analysis, seven user-centered metrics provided by the Google PageSpeed Insights tool were employed to evaluate the efficiency and performance of these websites, specifically assessing their loading speed and optimization for mobile delivery. Despite the profound shifts in higher education's operational landscape, including evolving post-pandemic learning models, intensifying competition for student enrollment, and the imperative for institutions to enhance their digital infrastructure to support both in-person and remote services (e.g., student support, application processes) the study reveals a significant gap.

The findings indicate that more than half of the U.S. public university websites analyzed are not fully mobile-ready. These websites appear to be non-compliant with standard mobile optimization guidelines provided by authoritative bodies such as the W3C (World Wide Web Consortium), Google's PageSpeed Insights, and historical best practices like Yahoo's YSlow. Except for a select group of universities, the study highlights a prevalence of critical technical deficiencies across most institutional websites. These issues directly impair user experience for the majority of their current and prospective mobile audience. The results strongly suggest that public university websites must be urgently re-designed and re-written to align with current industry standards and best practices for mobile delivery, accessibility, and performance.

For future research, it would be valuable to investigate whether there are positive or negative correlations between a university's mobile readiness performance and key institutional characteristics, such as:

- Geographic Location: Categorizing institutions by location (e.g., urban, rural, or suburban) to see if infrastructure access or strategic focus influences mobile optimization.
- Student Enrollment Size: Analyzing whether institutional scale (small, medium, or large enrollment) correlates with resource allocation for website maintenance and modernization.

This correlational study could provide insights into the organizational and environmental factors that either hinder or facilitate the adoption of critical mobile optimization standards in higher education.

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