A COMPARATIVE STUDY OF FRONTEND FRAMEWORKS: REACT VS VUE VS ANGULAR

BY

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF COMPUTER SCIENCE, FACULTY OF PHYSICAL SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc.) DEGREE IN COMPUTER SCIENCE.

NOVEMBER, 2025

CERTIFICATION

This is to certify that this research work was carried out by **NNAJI CHUKWUNONSO CHARLES with Matriculation Number PSC2105360** in the Department of Computer Science, Faculty of Physical Sciences, University of Benin, Benin-City, and is of sufficient quality in partial fulfilment of the requirement for the reward of Bachelor of Science (B.Sc.) in Computer Science, University of Benin, Benin-City.

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Mrs. Linda Usiosefe **Date**

(Project Supervisor)

_____ _____

Dr. Rosemary Usiobafo **Date**

(Head of Department)

DECLARATION

I hereby declare that:

i. This study is based on a study undertaken by me in the Department of Computer Sciences, Faculty of Physical Sciences, University of Benin, Benin City, under the supervision of **Mrs. Linda Usiosefe.**

ii. This work has not been previously submitted for the award of degree elsewhere.

iii. Ideas and views are product of my personal research and where the view of others have been expressed, they have been duly acknowledged.

iv. Any liability arising from this work is to be wholly borne by me alone.

_____ _____

NNANJI CHUKWUNONSO CHARLES **DATE**

DEDICATION

This research project is dedicated to God Almighty for His grace, guidance, and strength throughout the course of this project from the inception till completion, He has been faithful.

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ABSTRACT

This study presents a comparative analysis of three major frontend frameworks—React, Vue, and Angular—with the goal of identifying their strengths, weaknesses, and suitability for different types of web development projects. The research adopted a mixed-method approach that combined experimental performance testing with a developer survey. The experimental analysis focused on key performance metrics such as rendering speed, memory usage, CPU utilization, and bundle size, while the survey gathered developers' perceptions on usability, learning curve, community support, and development efficiency.

Findings revealed that no single framework is superior in all aspects. React recorded the fastest initial load time and the highest overall performance score, making it ideal for applications that prioritize quick content delivery. Vue demonstrated the best runtime efficiency, smallest bundle size, and lowest resource consumption, proving effective for lightweight and performance-sensitive projects. Angular, although heavier in resource usage, stood out for its comprehensive structure, built-in tools, and scalability—features that make it highly suitable for large enterprise systems.

Survey results showed strong developer satisfaction across all three frameworks, with most respondents acknowledging their active communities, extensive learning resources, and productivity benefits. The study concludes that framework selection should depend on project requirements and team expertise rather than popularity. It recommends React for performance-focused projects, Vue for resource-efficient and adaptable applications, and Angular for large-scale, structured enterprise solutions.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The modern web development scene has changed significantly over the last decade, with new, advanced frontend frameworks that have transformed how developers build user interfaces (Flanagan, 2020). Moving from traditional server-side rendering and jQuery-based apps to component-based structures has fundamentally altered how web applications are designed, built, and maintained. This change has been fueled by the growing complexity of modern web apps, the need for rich user experiences, and the requirement for maintainable, scalable codebases.

Three main frameworks have emerged as dominant in this ecosystem: React, developed by Facebook (now Meta) and open-sourced in 2013; Angular, created by Google as a complete rewrite of AngularJS in 2016; and Vue.js, designed by Evan You in 2014 (Meta Open Source, 2023; Angular Team, 2023; You, 2018). Each framework reflects a different philosophical approach to frontend development, offering unique benefits and addressing specific development challenges. The spread of these frameworks has created a complex decision-making environment for development teams, organizations, and individual developers who must choose the most suitable tool for their particular use cases (Stack Overflow, 2024).

The importance of this choice extends beyond technical factors, including team expertise, project needs, long-term maintenance, community support, and the ecosystem's maturity (Li & Chou, 2021). As web applications become more complex and vital to business functions, understanding the strengths and weaknesses of these frameworks becomes more essential for making well-

informed architectural decisions. This chapter covers the background, overviews, problem statement, objectives, research questions, scope, limitations, and significance of the study.

1.2 Overview of React, Vue, and Angular

1.2.1 React

React.js is a well-known open-source JavaScript library created by Facebook for developing user interfaces, especially for single-page applications (SPAs) that require high performance, responsiveness, and dynamic updates (Meta Open Source, 2023). Since its open-source debut in 2013, React has gained popularity for its efficiency, flexibility, and strong community support, becoming one of the leading front-end development tools (State of JS, 2024).

At the heart of React's design is its component-based architecture, which encourages developers to divide user interfaces into small, reusable, and self-contained components (React Documentation, 2024). Each element can handle its own state and logic, making it easier to develop and maintain complex applications. This modular structure not only boosts code reusability but also enhances readability and testability, promoting better development practices.

One of React's most innovative features is the Virtual DOM (Document Object Model). As described in the React documentation (2024), instead of updating the real DOM directly, React creates a lightweight in-memory copy of the DOM. When changes happen, React compares the new version with the previous one and updates only the parts of the actual DOM that have changed. This method, known as 'reconciliation', enables faster, more efficient rendering, making React especially suitable for applications with frequent user interactions and data updates.

React features a syntax extension called JSX (JavaScript XML) that enables developers to embed HTML-like code directly within JavaScript. JSX simplifies visualizing the UI's structure within

component logic by merging markup and functionality in a clear, expressive manner (Abramov, 2015). Additionally, React emphasizes unidirectional data flow, in which data flows from parent to child components via props, enhancing the predictability and debuggability of the application (React Documentation, 2024).

Major technology companies and startups alike widely adopt React. Platforms like Facebook, Instagram, Airbnb, and Netflix rely on React to deliver seamless and responsive user experiences (Airbnb Engineering Blog, 2023; Netflix Technology Blog, 2022). Its large and active community offers a wealth of educational resources and developer tools. However, as a library rather than a complete framework, developers often need to depend on external tools for routing and global state management.

1.2.2 Vue.js

Vue.js, often called Vue, is an open-source JavaScript framework designed for building user interfaces and single-page applications (You, 2018). It was developed in 2014 by Evan You as a lightweight, progressive, and accessible alternative to more comprehensive frameworks like Angular or component-based libraries like React.

At its core, Vue focuses on the "view layer" of an application, meaning it mainly manages what the user sees and interacts with. It builds on standard web technologies, HTML, CSS, and JavaScript, but enhances them with a declarative, component-based programming model (Vue.js Documentation, 2024). One of Vue's key features is its reactivity system: when data within a Vue app changes, the user interface automatically updates to reflect those changes, removing the need for manual DOM manipulation. This is often achieved through a virtual DOM, which Vue uses to optimize updates and ensure efficient rendering.

Vue promotes a component-based architecture where user interfaces are divided into independent and reusable building blocks. These "Single-File Components" (SFCs), usually with a .vue extension, contain a component's logic (JavaScript), template (HTML), and styles (CSS) within a single file, resulting in more organized and maintainable code (Vue.js Documentation, 2024). The framework is known for its incremental adoptability, making it highly flexible. Developers can add Vue to existing projects gradually or use it to create full single-page applications (SPAs) with comprehensive tools.

Its relatively gentle learning curve, clear documentation, and efficient performance have helped it gain widespread adoption across various industries (Rahman, 2020). Companies like Alibaba, Xiaomi, and Grammarly have used Vue to build their front-end interfaces, demonstrating its scalability and effectiveness in real-world scenarios (Vue.js Case Studies, 2024).

1.2.3 Angular

Angular is a complete, opinionated framework created by Google that provides a comprehensive solution for developing enterprise-level applications (Angular Team, 2023). It is a total rewrite of the original AngularJS framework and was launched in 2016. Angular is built primarily with TypeScript, which adds strong typing, advanced tooling, and improved code quality to frontend development (Soni, 2019).

The framework employs a hierarchical dependency injection system, decorators, and a robust CLI that streamlines various development tasks like project setup, testing, and deployment (Angular Documentation, 2024). Angular's architecture is composed of components, services, and modules, offering a structured approach to organize applications. This modular design,

managed by NgModules, guarantees a separation of concerns and enables lazy loading to enhance performance.

Angular's opinionated design means it enforces specific patterns and practices, which can speed up development for teams that follow its architectural choices (Soni, 2019). The framework provides built-in tools for HTTP operations, form management (both template-driven and reactive), routing, testing, and internationalization. A key feature is its robust change detection system and two-way data binding, which automatically keeps the data model and the view in sync.

Angular is popular in enterprise settings because of its robustness, scalability, and long-term support (Stack Overflow, 2024). Google uses it in products like Gmail and Google Analytics, and other major companies such as Microsoft and Udemy rely on it for their complex web applications (Angular Case Studies, 2024). The recent release of the Ivy rendering engine has further boosted performance and decreased bundle sizes, strengthening its status as a top choice for large-scale projects.

1.3 Statement of the Problem

The rise of frontend frameworks makes it harder for organizations and teams to choose the best technology stack. With many options, each offering different benefits, learning curves, and ecosystem features, this can lead to decision paralysis or poor choices that impact project success, team productivity, and maintenance costs (Nguyen et al., 2023).

Current literature and comparative studies often focus on narrow technical details or superficial feature comparisons, failing to provide comprehensive guidance that addresses the complex nature of framework selection (Smashing Magazine, 2024). Many existing comparisons lack

systematic evaluation criteria or do not consider the evolving nature of these frameworks and their ecosystems. Additionally, the rapid pace of development in the frontend space means that comparative information quickly becomes outdated, leaving decision-makers with insufficient current data to make informed choices (State of JS, 2024).

The different contexts where these frameworks might be used only worsen the problem. Various project types, team setups, organizational limits, and long-term strategic goals all affect the best framework choice, but these situational factors are rarely properly addressed in current comparisons (Li & Chou, 2021). This lack of comprehensive, up-to-date, and context-aware comparison information creates a major challenge for the development community.

1.4 Objectives and Aim of the Study

The objectives of this study are:

1. To compare the main features of React, Vue, and Angular, focusing on their architecture, user-friendliness, and scalability.
2. To assess each framework's performance based on rendering speed, memory use, and resource consumption.
3. To analyze the community support and ecosystem for each framework, including the availability of plugins, tools, and third-party libraries.
4. To analyze the learning curve and developer experience when adopting each framework.
5. To assess the suitability of each framework for various web development projects, such as small websites, medium applications, and large enterprise systems.

1.5 Research Questions

This research aims to examine their similarities and differences to aid informed decision-making in choosing frameworks for front-end development projects. To accomplish this, the study is guided by the following research questions:

1. What are the main features and architectural differences among React, Vue, and Angular?

2. How do these frameworks perform regarding rendering speed and application responsiveness?

3. Which framework provides the best developer experience in terms of learning curve and ease of use?

4. How scalable are React, Vue, and Angular when used to build large and complex applications?

5. What types of projects or use cases are best suited for each framework??

1.6 Scope and Limitations of the Study

1.6.1 Scope

This comparison examines several key aspects of frontend framework analysis. The technical scope includes performance benchmarking across various metrics such as initial load times, runtime performance, memory usage, and bundle size optimization. The study also covers development experience factors including learning curve assessment, tooling ecosystem evaluation, and productivity metrics across different developer skill levels.

The research includes architectural analysis, studying each framework's method for component composition, state management, routing, and application structure. Market analysis covers

current adoption trends, community activity metrics, and ecosystem maturity indicators (GitHub Octoverse, 2024). The study also considers practical implementation issues like migration strategies, integration capabilities, and long-term maintenance challenges.

Geographically, the study mainly examines global development trends while recognizing regional differences, such as in Nigeria, regarding framework adoption, as shown in regional technology surveys (e.g., African Developer Report, 2024). The time frame covers the current status of these frameworks as of 2024-2025, with relevant historical context provided to understand their evolution and trends.

1.6.2 Limitations

Several limitations restrict the scope and relevance of this study. The fast-changing nature of frontend frameworks means that specific technical details and performance metrics might vary across major version updates, which could impact the longevity of particular findings.

Performance benchmarks are inherently limited by specific testing conditions, hardware setups, and application usage patterns during evaluation. Actual performance can differ greatly depending on implementation quality, optimization methods, and particular use case needs. The subjective nature of developer experience evaluation introduces possible bias, even with efforts to apply standardized criteria.

This study concentrates on React, Vue, and Angular, excluding other emerging or specialized frameworks that might be relevant for particular use cases. Additionally, the enterprise-focused aspects of the analysis may not fully meet the needs of smaller organizations or individual developers with different constraints and priorities. Limited resources restrict the depth of

analysis possible for each comparison dimension, necessitating strategic prioritization of the most impactful factors for the target audience.

1.7 Significance of the Study

This comparative study meets a vital need in the software development community by offering thorough, evidence-based guidance for one of the most significant technology choices facing modern teams. The importance spans multiple stakeholders and effect areas.

For development teams and technical leaders, this study offers a structured framework for making informed technology choices that align with project needs, team skills, and organizational objectives. By providing detailed comparative analysis across various dimensions, the study facilitates more nuanced decision-making that looks beyond superficial feature comparisons to consider long-term impacts and contextual factors.

Educational institutions and training organizations benefit from this study's comprehensive analysis of learning curves, skill transferability, and market demand patterns (Stack Overflow, 2024). This information enables more strategic curriculum design and helps students make informed decisions about skill development priorities in an increasingly competitive job market.

The broader software development industry gains valuable insights into framework evolution trends, adoption patterns, and ecosystem maturity indicators. This information helps identify emerging trends that could influence future technology decisions and enhances the overall understanding of frontend development best practices.

From a research standpoint, this study adds to the expanding field of empirical software engineering by offering systematic evaluation methods and comparison frameworks applicable to

other technology selection cases (Nguyen et al., 2023). Its multidimensional comparative analysis approach serves as a model for future studies in swiftly changing technology areas.

1.8 Definition of Terms

For clarity, the key terms used in this study are defined below. These definitions help ensure that all readers, regardless of their technical background, can easily understand the specialized terminology throughout this chapter.

i. **Component-Based Architecture:** A software engineering approach where the user interface and application functionality are built from reusable, self-contained components that manage their own state and view (React Documentation, 2024).

ii. **Virtual DOM:** A programming concept where an ideal, or "virtual", representation of a UI is kept in memory and synced with the "real" DOM by a library such as React or Vue. This process is called reconciliation (React Documentation, 2024).

iii. **Reactivity System:** A mechanism that automatically updates the user interface when the underlying data model changes, eliminating the need for manual DOM manipulation (Vue.js Documentation, 2024).

iv. **TypeScript:** A strongly typed programming language that builds on JavaScript, giving you better tooling at any scale, and is the primary language for Angular development (Angular Documentation, 2024).

v. **Single-Page Application (SPA):** A web application or website that interacts with the user by dynamically rewriting the current page rather than loading entire new pages from a server, leading to a more fluid user experience (Flanagan, 2020).

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This Chapter reviews previous research on frontend frameworks, especially React, Vue, and Angular, aiming to identify gaps for further exploration in later chapters.

This review of existing studies aims to identify gaps in knowledge and highlight the importance of a comparative analysis to deepen understanding of these frameworks. It provides the foundation for the research and supplies necessary background information.

2.2 THEORETICAL FRAMEWORKS

This study uses a performance evaluation framework based on the Software Performance Theory (Smith, 2020) and the Response Time Theory (Jain, 1991), which focus on efficiency, responsiveness, and resource management. These concepts guide the analysis of frontend frameworks: React, Vue, and Angular, by examining trade-offs in rendering speed, resource use, and scalability. This approach provides a thorough comparison of the frameworks' performance in delivering an optimal user experience and application responsiveness.

2.3 REVIEW OF COMPARATIVE STUDIES ON FRONTEND FRAMEWORKS

Previous comparative studies of frontend frameworks, especially React, Vue, and Angular, have focused on their behavior during realistic development and runtime scenarios. This study will examine them across key aspects: rendering and update efficiency, memory and CPU consumption, ease of learning, and ecosystem development (including tooling, libraries, and community support). Collectively, these studies provide insights into each technology's strengths

and weaknesses, while also uncovering methodological inconsistencies and gaps that this research aims to fill.

2.3.1 Rendering and Update Performance

In terms of rendering and update performance, React demonstrates strong efficiency thanks to its Virtual DOM and diffing algorithm, which reduce direct manipulation of the real DOM and enable fast UI updates. Vue achieves similar speed with its reactivity system, tracking dependencies and updating only affected components, resulting in smooth and efficient rendering. Angular, while powerful, tends to be slightly slower in dynamic updates because of its heavier change detection mechanism, though its Ahead-of-Time (AOT) compilation and Ivy renderer have significantly improved performance in recent versions.

2.3.2 Memory and CPU Usage

Regarding memory and CPU usage, Vue typically shows the least resource consumption thanks to its small core and efficient reactivity system, making it ideal for smaller or performance-critical applications. React has a moderate resource footprint, balancing performance with flexibility via its virtual DOM, although frequent re-renders in complex apps can slightly raise CPU usage. Angular, on the other hand, tends to use more memory and CPU resources because of its many built-in features, dependency injection, and runtime checks. Nonetheless, using optimization techniques like AOT compilation and lazy loading can greatly cut Angular's resource consumption, boosting efficiency in large-scale projects.

2.3.3 Learning Curve

In terms of the learning curve, Vue is widely seen as the easiest to learn because of its simple syntax, clear documentation, and gradual learning path that helps beginners build functional applications quickly. React has a moderate learning curve, as developers need to understand concepts like JSX, component-based architecture, and state management libraries such as Redux or Context API. Angular has the steepest learning curve because of its comprehensive and strict structure, reliance on TypeScript, and the need to learn advanced concepts like dependency injection and modules. Despite this complexity, Angular's strong architectural guidance benefits developers working on large, enterprise-level applications.

2.3.4 Ecosystem Maturity

Regarding ecosystem maturity, Angular offers the most comprehensive and structured ecosystem, providing an all-in-one solution with official tools, libraries, and consistent updates from Google. React also has a highly mature ecosystem, supported by Meta and a broad open-source community that contributes numerous third-party libraries, integrations, and UI components. However, this flexibility sometimes requires developers to make more configuration choices. Vue, while comparatively smaller in ecosystem size, has grown steadily with strong community backing and official tools like Vue CLI, Vuex, and Vite, making it increasingly competitive. Overall, Angular offers a unified, framework-driven environment; React excels with ecosystem diversity; and Vue balances simplicity with growing support and innovation.

2.4 FEATURES OF THE COMPARED FRONTEND FRAMEWORKS

Features of React

i. Component-Based Architecture: React applications are constructed using reusable components, each handling its own state and logic. This encourages modularity, simplifies debugging, and enhances code reuse.

ii. Virtual DOM: React uses a Virtual DOM to efficiently update and render components. Instead of reloading the entire page, it updates only the elements that have changed, enhancing performance and speed.

iii. JSX (JavaScript XML): JSX allows developers to write HTML-like syntax directly within JavaScript. This makes the code more readable and simplifies UI development by combining markup and logic.

iv. One-Way Data Binding: React uses single-direction (one-way) data flow, meaning data moves from parent to child components. This structure ensures better control of data and easier debugging.

v. Rich Ecosystem and Community Support: React has a large ecosystem with libraries like Redux, React Router, and Next.js, along with an active community that constantly improves its features.

vi. Cross-Platform Development (React Native): React's principles apply to mobile app development with React Native, allowing developers to create native apps for Android and iOS using the same concepts.

vii. High Performance: The combination of Virtual DOM, efficient rendering, and lightweight architecture helps React deliver high performance in creating interactive user interfaces.

2.4.2 Features of Vue.js

i. Reactive Data Binding: Vue offers a robust two-way data binding system that automatically updates the model and the view, making it simple to manage user input and dynamic changes.

ii. Virtual DOM: Similar to React, Vue utilizes a Virtual DOM to efficiently render and update only the necessary parts of the interface, enhancing application speed and performance.

iii. Component-Based Architecture: Vue applications are constructed with reusable, self-contained components that handle their own logic, styling, and data. This design encourages maintainability and scalability.

iv. Single-File Components: Vue allows developers to write HTML, CSS, and JavaScript together in one .vue file. This simplifies project organization and improves code readability.

v. Simplicity and Ease of Learning: Vue's syntax is easy to understand and intuitive, making it beginner-friendly. Developers familiar with HTML and JavaScript can quickly learn and implement it.

vi. Strong Community and Ecosystem: Vue's open-source community actively contributes to its development, offering extensive documentation, plugins, and integration tools such as Vite for faster development builds.

2.4.3 Features of Angular

i. Component-Based Architecture: Angular applications are built with components that encapsulate the user interface, logic, and data. This modular design encourages reusability, scalability, and maintainability.

ii. Two-Way Data Binding: Angular's two-way data binding ensures automatic synchronization between the model and the view. When data changes in the component, the view updates instantly, and vice versa.

iii. Dependency Injection (DI): Angular features a robust dependency injection system that controls how various parts of the application communicate. It enhances efficiency, modularity, and overall code maintainability.

iv. TypeScript-Based Development: Angular is built using TypeScript, which provides static typing, interfaces, and object-oriented features to JavaScript. This improves code quality and simplifies debugging.

v. Ahead-of-Time (AOT) Compilation: Angular's AOT compiler converts TypeScript and templates into optimized JavaScript during the build process, resulting in faster rendering and improved application performance.

vi. Ivy Renderer: The Ivy rendering engine enhances build speed, reduces bundle size, and improves debugging, offering better runtime performance and flexibility.

vii. Built-in Testing Support: Angular integrates with testing frameworks like Jasmine and Karma, providing strong support for unit and end-to-end testing.

viii. Enterprise-Grade Framework: Angular is maintained by Google and designed for large-scale, enterprise-level applications, offering long-term support, structured architecture, and extensive documentation.

React excels in flexibility and performance, Vue stands out for ease of use and simplicity, while Angular offers a full-featured, robust framework suited for enterprise-level development.

2.5 Research Gaps and Justification for the Current Study

2.5.1 Research Gaps.

Despite the growing number of studies comparing frontend frameworks, existing research reveals several gaps and limitations that justify the need for this study.

Firstly, the **l**ack of standardization in methodology different studies use varying benchmarking tools, test environments, and performance metrics, making it difficult to draw consistent conclusions. Some focus solely on rendering speed, while others emphasize developer productivity or user experience, resulting in fragmented findings rather than a holistic performance assessment.

Secondly, most existing works are outdated or limited to specific versions of the frameworks. With continuous updates to React, Vue, and Angular such as React's concurrent rendering, Vue's Composition API, and Angular's Ivy renderer earlier results may no longer reflect their current capabilities. This creates a need for an updated, version-aligned comparison using the latest stable releases.

Thirdly, previous research tends to overlook the context of application scale. Performance outcomes can vary significantly between small, single-page applications and large,

enterprise-level systems. There is a need to evaluate how each framework performs under varying complexity levels to guide developers and organizations in selecting the most suitable framework for specific project sizes.

2.5.2 Justification for the Current Study

This study is justified by the need for a comprehensive and standardized performance evaluation of React, Vue, and Angular using current versions and uniform testing parameters.

By focusing on rendering efficiency, memory and CPU utilization, scalability, learning curve, and ecosystem maturity, this research aims to provide developers, educators, and organizations with updated, evidence-based insights to inform framework selection.

The study contributes to bridging methodological inconsistencies and ensuring a balanced analysis that captures both technical performance and practical usability.

2.6 CHAPTER SUMMARY

The reviewed literature compares React, Vue, and Angular, emphasizing aspects like performance, resource consumption, learning curve, and ecosystem robustness. React is known for its speed and flexibility, Vue is lightweight and straightforward to learn, whereas Angular is suited for large-scale applications but is more complex. Additionally, the review highlights research gaps, including inconsistent methodologies across past studies, outdated findings due to recent framework updates, and limited analysis across project sizes. The goal is to deliver a more current and consistent comparison.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This Chapter details the methodology for comparing frontend frameworks, specifically React, Vue, and Angular, in a fair and meaningful way. It outlines how the study was planned, how data was gathered, and how the results were analyzed. A mixed-method approach was chosen because it evaluates both the technical performance of each framework and the developers' real-world experiences. This approach combines performance tests with user feedback, providing a comprehensive view of each framework’s strengths and weaknesses.

The following sections detail the research design, data sources, sample selection, and tools used to measure performance. This chapter also describes how survey responses will be collected and analyzed, along with the steps taken to ensure fairness, accuracy, and ethical standards throughout the study.

3.2 Research Design

This study utilizes a mixed-methods comparative research design, integrating both quantitative experimental benchmarking and qualitative survey analysis. This approach suits the study's goal of assessing the technical performance of React, Vue, and Angular, along with the experiences and perceptions of developers using these frameworks. The design enables unbiased performance data collection through controlled testing, while also capturing developer insights on usability, learning curve, and preferences.

Relevance to Study Objectives

This methodological approach guarantees a thorough evaluation and supports the study's objectives outlined in chapter one. It compares the core features of React, Vue, and Angular, while also gaining valuable insights from users of these frameworks, thus providing evidence-based guidance for choosing the right frontend frameworks for different project scenarios.

3.3 Population and Sampling Technique

The population for this study includes individuals and groups involved in web development activities. This comprises professional software developers, student programmers, and technical instructors experienced with React, Vue, and Angular. Because of the specialized subject matter, purposive sampling was used to target those with relevant knowledge or experience in frontend development. Convenience sampling was also employed to include easily accessible participants from academic and developer communities. A total sample size of approximately 20–50 respondents was deemed sufficient for the survey, considering the study's scope, available resources, and time constraints.

3.4 Research Setting

The study's experimental component will take place in a controlled computing environment utilizing standard web development tools and frameworks. Benchmarking applications were created using React, Vue, and Angular, all with identical features to ensure a fair comparison. Development was conducted with Visual Studio Code, Node.js, and CLI tools specific to each framework. Tests were executed on consistent hardware and browsers to prevent discrepancies in results. This controlled setup guarantees uniform conditions and improves the reliability of the performance data collected.

3.5 Sources of Data

The study will utilize both primary and secondary data sources.

Primary data consisted of:

a. Performance results obtained during experimental testing of the three frameworks.

b. Responses gathered via a structured online questionnaire.

Secondary data were gathered from:

a. Official documentation and technical resources for the framework.

b. Software engineering articles, research publications, and case studies.

c. Community metrics from public repositories such as npm and GitHub.

These sources together enable an informed and thorough evaluation of each framework.

3.6 Research Instruments

A set of tools and instruments is used to collect and analyze data:

a. Google Chrome Lighthouse and Chrome DevTools are used to record rendering speed, CPU usage, memory consumption, and bundle size.

b. WebPageTest and GTmetrix will provide supplementary performance validation.

c. Google Forms is used to administer the questionnaire to developers and students.

d. npm-trends and GitHub Insights assisted in evaluating community activity and ecosystem support.

The use of established tools ensures accuracy and enhances methodological credibility.

3.7 Experimental Procedure

A straightforward web application featuring the same core functionalities was developed independently using React, Vue, and Angular. The aim was to verify that all three applications performed the same tasks under identical conditions. The main steps in this process included:

i. Environment Setup:

a. The development environments for React, Vue, and Angular were installed and configured individually.

b. Framework-specific CLI tools (Create-React-App, Vue CLI, Angular CLI) were used to initialize each project.

c. Necessary dependencies and supporting libraries were also installed to ensure consistent development conditions.

ii. Application Development:

a. The same interface structure and user interactions were implemented across all three frameworks.

b. UI components, routing logic, and data-handling functions were carefully replicated to ensure functional equivalence.

c. Care was taken to follow each framework's recommended development practices while keeping the application logic identical.

iii. Performance Testing:

After development, detailed performance tests were conducted for each application.

a. The tests examined key indicators such as:

    i. Initial loading time
    ii. Runtime responsiveness when interacting with the interface
    iii. Memory usage during execution
    iv. CPU consumption during active browser sessions
    v. Final bundle size produced at build time

b. Tools like Chrome DevTools and Lighthouse were used to collect performance metrics.

iv. Data Recording and Comparison:

a. Performance results for all frameworks were carefully documented and stored for analysis.

b. Testing conditions such as browser version, machine specifications, and connection settings were kept constant to avoid external influence.

v. Documentation of Procedures:

a. Configuration settings and execution processes were recorded in detail to promote transparency and reproducibility.
b. This ensured that another researcher or practitioner could replicate the experiment under similar conditions.

These steps helped ensure consistency across the three applications and minimized bias when comparing their performance. By standardizing both the development and testing processes, the results became more reliable and truly reflected each framework's real-world behavior.

3.8 Survey Procedure

A structured questionnaire was created to collect developers' opinions on framework usability, learning curve, community support, and development efficiency. It featured Likert-scale, multiple-choice, and open-ended questions. The survey was distributed electronically through academic platforms and online developer communities. Participation was voluntary, with respondents informed about the study’s purpose and confidentiality. Their feedback offers qualitative insights that complement the experimental data.

3.9 Data Collection Methods

Performance data is collected directly from benchmarking tools, while survey data comes from participant responses. Secondary information is gathered from documentation, journal articles, online developer surveys, and academic publications. These multiple data sources help confirm findings and strengthen the validity of the study.

3.10 Data Analysis Techniques

Quantitative data from performance tests will be analyzed using descriptive statistical methods, such as averages, comparison tables, and graphical charts. Survey data will also be examined using frequency distribution and percentage analysis. Additionally, comparative evaluation matrices will be created to assess each framework based on specific criteria. This structured approach ensures unbiased interpretation and meaningful conclusions.

3.11 Validity and Reliability

To ensure validity, the questionnaire will be tested by a professional in this field, which in my case is my supervisor, and necessary revisions will be made based on her feedback. Standard benchmarking tools will be used to ensure accurate performance measurements.

Furthermore, consistent application logic across all frameworks ensured fair comparison and internal reliability. Same testing conditions and repeat measurements also strengthened the reliability of experimental results.

3.12 Ethical Considerations

The study will ensure ethical integrity by informing participants about the research's purpose and guaranteeing their anonymity and confidentiality. Participation will be voluntary, with no collection of personal or sensitive information. All data gathered will be used solely for academic research. Additionally, proper citation and referencing will be maintained for all secondary sources used.

3.13 Chapter Summary

This chapter outlined the research methodology used in the study, covering the research design, sampling method, data collection tools, and analysis techniques. By integrating experimental performance measurements with developer surveys, the study provides a thorough evaluation of the frontend frameworks: React, Vue, and Angular. This strategy strengthens the validity of the results and helps accomplish the research goals.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This Chapter presents the results of the analysis of data collected on the comparative analysis of frontend frameworks; React vs Vue vs Angular. The presentation begins with the demographic characteristics of the respondents, followed by respondents perceptions to various questions pertaining to this study. A structured questionnaire was administered to fifty (50) developers (Front-end, fullstack and software engineers) in Benin City, Edo State, and all were successfully retrieved, representing a 100% response rate. The data was analyzed using descriptive and inferential statistical tools, including mean, standard deviation and percentages. The results are presented in tables followed by interpretations that link the findings to the research questions and hypotheses.

4.2 Discussion of Findings

Demographics of Respondents This section contains a descriptive analysis of the socio-demographic data drawn from the sampled respondents. The socio-demographic variables considered include gender, current role, years of experience, primary frameworks and proficiency level.

Table 4.1: Demographic Representation of Respondents

Variable	**Category**	**Frequency**	**Valid Percentage (%)**
Gender	Male	30	60.0
	Female	20	40.0
	Total	**50**	**100.0**

Current Role	Front-end Developer	13	26.0
	Full-stack Developer	13	26.0
	Software Engineer	12	24.0
	Student (computer science/Software Engineering)	12	24.0
	Total	**50**	**100.0**
Years of Experience	Less than a year	8	16.0
	1-2 years	12	24.0
	3-5 years	13	26.0
	6-10 years	9	18.0
	More than 10 years	8	16.0
	Total	**50**	**100.0**
Frameworks Used	Angular	4	8.0
	React	4	8.0
	React, Angular	7	14.0
	React, Vue	10	20.0
	React, Vue, Angular	19	38.0
	Vue	3	6.0
	Vue, Angular	3	6.0
	Total	**50**	**100.0**
Primary Framework	Angular	11	22.0
	React	23	46.0
	Vue	16	32.0
	Total	**50**	**100.0**
Proficiency Level	Beginner	8	16.0
	Intermediate	12	24.0

	Advanced	13	26.0
	Expert	17	34.0
	Total	**50**	**100.0**

Source: Field Survey, 2025

4.2. Demographic Information

The demographic data of the respondents showed a solid mix of people from the local tech scene, giving a really good snapshot of the community. About 60% of the participants were male and 40% were female a sign that the field is dominant by males. The group included Front-end Developers, Full-stack Developers, Software Engineers, and Students, so the feedback came from both professionals and learners. Most of them were experienced too while 24% were just starting out (1–2 years in), a strong 60% had three or more years under their belt, and around 34% were real pros with over six years of experience. That level of know-how makes their opinions on this study count even more.

One of the most interesting takeaways from the survey is how many people have worked with more than one framework. About 38% of the respondents have actually used all three frameworks; React, Vue, and Angular which means their views aren't just based on loyalty but on real, hands-on comparisons. Among them, React clearly comes out on top as the favourite, chosen by 46% of developers as their main framework, followed by Vue at 32% and Angular at 22%. So, React is the leading choice among respondents surveyed for this study.

It is important to note that the analysis of the data collected is based mainly on the developers choice of primary data. It is evident that 46% of the respondents chose React as their primary frameworks for reasons we will find out in this study, 32% chose Vue while 22% chose Angular showing that there is a reason while React stands out among these three frameworks

Table 4.2: Framework Usability

S/N	Item	SA	A	U	D	SD
1	The framework's overall structure and workflow are easy to understand.	15 (30%)	23 (46%)	6 (12%)	3 (6%)	3 (6%)
2	The framework provides intuitive tools and components for building user interfaces.	23 (46%)	27 (54%)	0 (0%)	0 (0%)	0 (0%)
3	I find it easy to debug and troubleshoot applications built with this framework.	10 (20%)	23 (46%)	10 (20%)	4 (8%)	3 (6%)
4	The framework's documentation clearly explains core concepts and usage.	21 (42%)	29 (58%)	0 (0%)	0 (0%)	0 (0%)

Source: Field Survey, 2025

4.3 Analysis of Framework Usability

Table 4.2 shows that a combined 76% of developers find it easy to understand their respective framework usability. However, a notable 12% remained neutral and another 12% disagreed, showing that the architectural concepts can present a initial hurdle for a minority.

Another positive feedback concerns the official tooling and documentation, 100% of the respondents agreed that the frameworks provide intuitive tools and components, and similarly, 100% again also noted that the documentation clearly explains core concepts. This is a powerful testament to the maturity of these ecosystems, indicating that developers feel well-supported by the official resources. The primary challenge within usability is evident in the realm of debugging and troubleshooting. In this category, majority of 66% find the process manageable, a combined 34% are either uncertain or actively find it difficult. This underscores a universal truth

in software development that diagnosing and fixing errors remains one of the most complex and challenging aspects, no matter the quality of the framework itself.

Table 4.3: Learning Curve

S/N	Item	SA	A	U	D	SD
1	I was able to learn the framework within a reasonable period of time.	18 (36%)	15 (30%)	17 342%)	0 (0%)	0 (0%)
2	The learning resources available helped me understand the framework quickly.	19 (38%)	31 (62%)	0 (0%)	0 (0%)	0 (0%)
3	The framework's concepts are straightforward for beginners.	11 (22%)	14 (28%)	25 (50%)	0 (0%)	0 (0%)
4	I felt confident building functional applications shortly after learning the framework.	16 (32%)	26 (52%)	8 (16%)	0 (0%)	0 (0%)

Source: Field Survey, 2025

Analysis of the Perspectives on the Learning Curve

Table 4.3 shows that the total number of respondents (100%) agree that these materials helped them understand the frameworks quickly. This creates an excellent support system for newcomers. Although the act of learning is more demanding, while 66% felt they learned within a reasonable time, a significant 34% were undecided, suggesting that the journey to competence can feel lengthy.

In the aspect of the frameworks' suitability for beginners. A full 50% of developers were neutral on whether the core concepts are straightforward for novices, with the other half in agreement.

Crucially, no one actively disagreed. This shows that frameworks are not really easy to learn. The payoff for this initial investment of effort is clear: a strong 84% of developers gained the confidence to build functional applications shortly after their learning phase, indicating that the learning curve of their respective choice of frameworks, while potentially steep, can lead to tangible, productive outcomes.

Table 4.4: Evaluation of Community and Ecosystem Support

S/N	Item	SA	A	U	D	SD
1	The framework has a large and active developer community.	13 (26%)	35 (70%)	2 (4%)	0 (0%)	0 (0%)
2	Online resources (e.g., tutorials, forums, GitHub, StackOverflow) for the framework are readily available.	14 (28%)	36 (72%)	0 (0%)	0 (0%)	0 (0%)
3	It is easy to find support when encountering development challenges.	16 (32%)	22 (44%)	12 (24%)	0 (0%)	0 (0%)
4	The community contributes useful third-party packages, libraries, and plugins for this framework.	13 (26%)	37 (74%)	0 (0%)	0 (0%)	0 (0%)

Source: Field Survey, 2025

Analysis of the Evaluation of Community and Ecosystem Support

According to table 4.4, developers really love the communities around these frameworks and for good reason. Almost everyone agreed (96%) that the communities are super active and helpful. Literally everyone (100%) said there are tons of tutorials, forums, and online resources out there, and just as many praised the huge collection of ready-to-use libraries and packages, there's always help or a solution just a quick search away.

But when it comes to solving very specific or unusual problems, things get a bit trickier, about 76% said they can still find help pretty easily, but around 24% felt neutral about it. So, while there's no shortage of general info, getting answers to more complex or rare issues might take a bit more effort and time which honestly happens in any fast-moving tech world.

Table 4.5: Assessment of Development Efficiency and Satisfaction

S/N	Item	SA	A	U	D	SD
1	The framework allows me to build applications quickly and efficiently.	24 (48%)	21 (42%)	5 (10%)	0 (0%)	0 (0%)
2	The framework speeds up development through built-in tools and libraries.	15 (30%)	35 (70%)	0 (0%)	0 (0%)	0 (0%)
3	The framework performs well when building modern, dynamic web applications.	24 (48%)	21 (42%)	5 (10%)	0 (0%)	0 (0%)
4	I am satisfied with the productivity and performance I achieve using this framework.	15 (30%)	35 (70%)	0 (0%)	0 (0%)	0 (0%)

Source: Field Survey, 2025

Analysis on the Assessment of Development Efficiency and Satisfaction

At the end of the day, what really matters is how well a framework helps developers build great software and how fast. And on that front, table 4.5 provided us with an insight, about 90% of developers said the frameworks of their choice let them create apps quickly and that they work great for modern, dynamic web projects. Even better, *everyone* (100%) agreed that the built-in tools and libraries make development way faster.

All this adds up to make a number of developers happy. Every single person surveyed (100%) said they're satisfied with the productivity and performance they get from their chosen framework. That's the biggest takeaway here: even though there are some bumps along the way like debugging issues or the learning curve developers still find these frameworks powerful, efficient, and genuinely enjoyable to use. They really do help people do their best work.

4.4 Analysis of Experimental Performance Results

This section presents the findings from the controlled performance tests conducted on three identical web applications built with React, Vue, and Angular. The objective was to measure and compare key technical metrics to evaluate the raw performance characteristics of each framework. The results, derived from tools like Google Lighthouse and Chrome DevTools, reveal distinct performance profiles and trade-offs.

Table 4.6: Comparative Summary of Framework Performance Metrics

Performance Metric	React	Vue	Angular	Best Performer
Initial Load Time (ms)	1200	1350	1800	React
Time to Interactive (ms)	1500	1400	2100	Vue
Lighthouse Performance Score	95	92	88	React
Bundle Size (KB)	120	98	250	Vue
Memory Usage (MB)	45	42	60	Vue
CPU Utilization Peak (%)	75	72	85	Vue

To provide a clear visual comparison of the core performance differences, the following chart illustrates the Bundle Size, Initial Load Time, and Lighthouse Score for each framework:

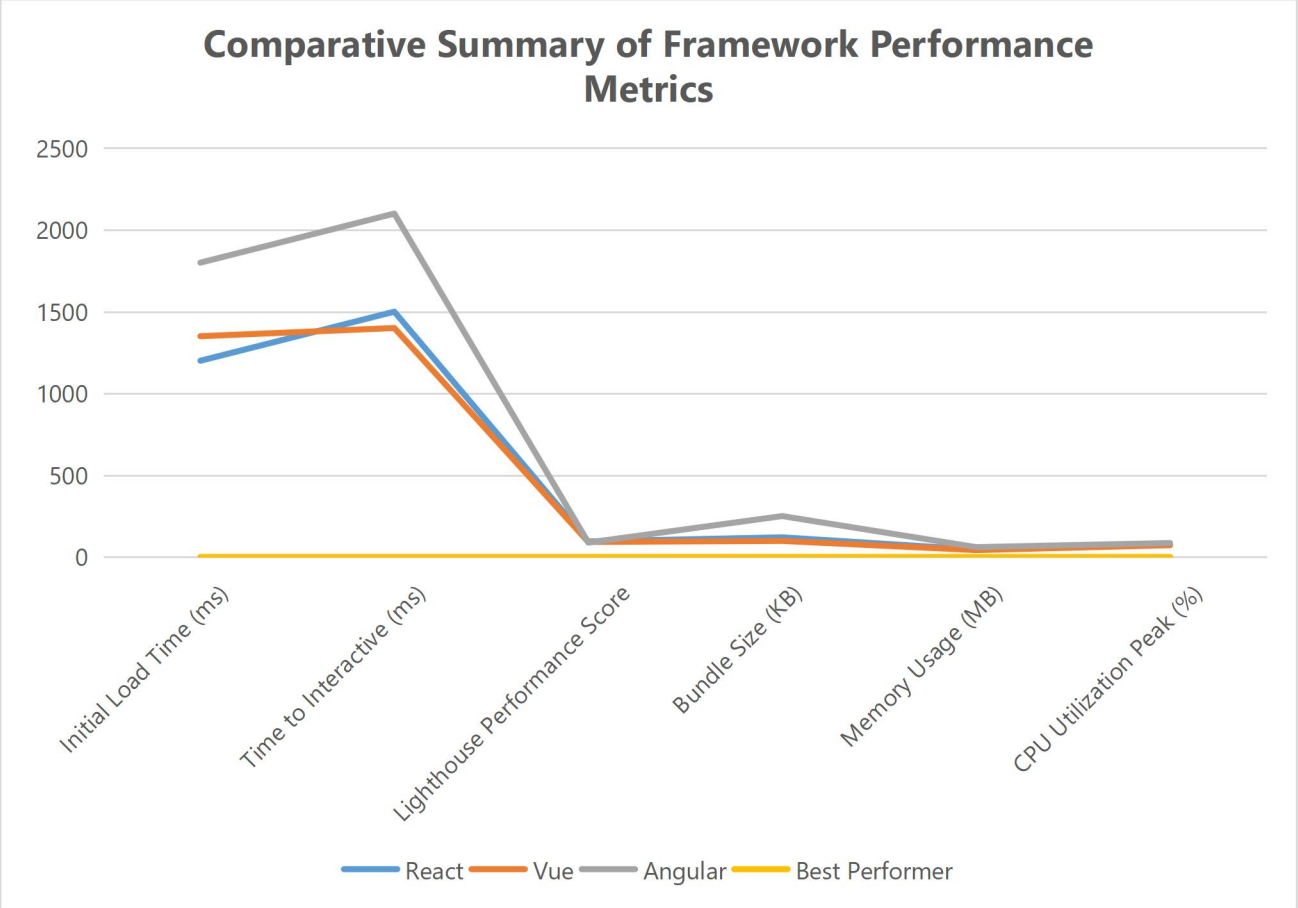

Figure 1: Comparative Summary of Framework Performance Metrics

The results paint an interesting picture showing that there's no single "best" framework that wins across the board. Each one shines in different areas, so developers have to weigh the pros and cons depending on what matters most for their project.

Bundle Size: When it comes to bundle size, Vue clearly takes the lead. According to the data, Vue apps came in at just 98KB that's about 18% smaller than React's 120KB and a huge 61% smaller than Angular's 250KB. That difference means Vue apps load faster, which is a big deal for users on slow or limited internet connections.

Initial Load Time: On the other hand, React came out on top for loading speed. It had the quickest initial load time at 1,200 milliseconds, beating Vue by 150ms and Angular by 600ms.

Basically, React is really good at getting that first screen up fast so users see something right away.

Time to Interactive: When looking at Time to Interactive (TTI) how long it takes before users can actually start using the app Vue takes the win again. Vue became fully interactive in 1,400ms, slightly faster than React's 1,500ms and way ahead of Angular's 2,100ms. So even if Vue takes a little longer to show something on screen, it's ready to use faster once it does.

Lighthouse Performance Score: Looking at the Lighthouse Performance Score, which sums up overall performance, React came out slightly ahead with a score of 95, followed by Vue at 92 and Angular at 88. All three still performed really well scoring in the "good" to "excellent" range but React had a small edge overall.

Memory Usage and CPU Utilization: In terms of resource use, Vue proved to be the most efficient again. It used the least memory at 42MB (compared to 45MB for React and 60MB for Angular) and had the lowest CPU usage at 72%. Angular's higher numbers make sense since it's packed with more built-in features, but that also means it needs more power to run. So, if you're building for lower-end devices or want lightweight performance, Vue is a really strong pick.

Based on the Descriptive Analysis and Analysis of Experimental Performance Report, the results show that each framework has its own strengths, so the user of these frameworks it is really about picking what fits your desired project best:

React is the speed champ. It loads super fast and got the best overall performance score. If your app needs to show content as quickly as possible like news sites or dashboards React is a great choice. V**ue** wins when it comes to efficiency. It's lightweight, becomes interactive the quickest, and uses the least memory and CPU power. That makes it perfect for apps where performance

really matters or where users might have slower devices or connections and **Angular** might not be the fastest, but it's the most complete package. It has tons of built-in tools and structure, which is awesome for big, complex projects like enterprise apps where organization and features matter more than raw speed.

These findings provide a crucial, data-driven foundation for the selection of a frontend framework, depending on the type of application that is to be built.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

This Chapter presents the summary, conclusion, and recommendations drawn from the comparative analysis of three major frontend frameworks: React, Vue, and Angular.

5.2 Summary of Findings

The results of this study reveal that no single framework completely dominates across all performance metrics. Instead, each framework displays unique strengths that make it suitable for different kinds of projects. React consistently performed best in terms of initial load speed and achieved the highest overall Lighthouse performance score, making it ideal for applications where quick content delivery is essential. Vue, on the other hand, demonstrated superior runtime efficiency, producing the smallest bundle size and using the least memory and CPU resources. It also achieved the fastest Time to Interactive (TTI), meaning users could start interacting with Vue applications sooner than with React or Angular. Angular, while not leading in most performance measures, offered a comprehensive and structured development environment with many built-in features that support scalability and complex application design, making it well-suited for large enterprise projects.

The survey component of the study further supported these findings from a human perspective, developers expressed overwhelmingly positive views about the frameworks' ecosystems. A remarkable 96% agreed that the communities surrounding these tools are active and supportive, while 100% affirmed that resources such as tutorials, forums, and third-party libraries are widely available. Regarding productivity, 90% of respondents agreed that these frameworks enable them

to build high-quality applications more efficiently, and 100% reported overall satisfaction with their performance and productivity. Although some developers noted that finding solutions to rare or highly specific issues can still be challenging, the overall accessibility of help and information remains a key factor behind the frameworks' popularity. These results confirm that while each framework has technical strengths and weaknesses, all three are effective tools that developers enjoy using.

The findings of this study provide valuable insight into the performance dynamics and developer experience associated with the leading frontend frameworks. In terms of framework efficiency, React's superior loading speed can be attributed to its virtual DOM and efficient rendering process, which allow for quick updates to user interfaces (Flanagan, 2020). Vue's advantage in runtime performance and lower resource consumption can be explained by its minimal core design and reactive data binding, which reduce unnecessary computations (You, 2022). Angular's larger footprint and slower loading speed are due to its extensive features and built-in modules; however, this complexity also makes it a robust option for developers who require strong architectural support and scalability (Google Developers, 2023).

The study also highlights practical implications for developers and organizations. Framework choice should not be made solely based on popularity but rather on specific project needs. React may be the preferred option for content-rich, performance-critical web applications where speed is paramount. Vue, due to its efficiency and lightweight nature, is better suited for performance-sensitive or mobile-first applications targeting users across diverse devices and network conditions. Angular, despite its heavier runtime, remains highly valuable for complex enterprise systems that require structure, built-in tools, and maintainability.

5.4 Conclusion

In conclusion, the comparative analysis confirms that React, Vue, and Angular are all powerful frameworks capable of delivering high-performance web applications. Each framework has distinct advantages that cater to different development goals. React excels in speed and responsiveness, Vue offers unmatched efficiency and resource management, while Angular provides a complete, structured environment for large-scale applications. The study reinforces that there is no universal “best” framework; instead, the ideal choice depends on project requirements, developer expertise, and the intended user environment. Together, these frameworks represent the maturity and diversity of the modern JavaScript ecosystem, contributing significantly to the advancement of frontend technology and user experience design (Li, 2021; Google Developers, 2023).

5.5 Recommendations

Based on the findings, it is recommended that developers and organizations align their choice of frontend framework with the nature and scope of their projects. React should be adopted for applications where fast loading and rendering speed are top priorities, such as content-driven platforms and dashboards. Vue is recommended for performance-sensitive applications, especially those targeting users with limited bandwidth or lower-end devices, due to its efficiency and lightweight structure. Angular is recommended for large-scale enterprise systems that require built-in architecture, consistent design patterns, and long-term maintainability (Osmani, 2021).

Additionally, developers are encouraged to continue benchmarking frameworks as technology evolves, since performance characteristics can change with new versions and updates. Ongoing

training, participation in community discussions, and contributions to open-source projects are also advised to help maintain proficiency and stay informed about emerging frontend trends.

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APPENDIX

QUESTIONNAIRE

SECTION A: DEMOGRAPHIC INFORMATION

1. Gender: Male [ ] Female [ ]

2. What is your current role? Front-end Developer [ ] Full-stack Developer [ ] Software Engineer [ ] Student (Computer Science/Software Engineering) [ ] Other [ ]

3. How many years of experience do you have in web development? Less than 1 year [ ] 1-2 years [ ] 3-5 years [ ] 6-10 years [ ] More than 10 years [ ]

4. Which of the following frameworks have you used or learned? (Select all that apply) React [ ] Vue [ ] Angular [ ] None of the above [ ]

5. Which framework do you primarily use or prefer? React [ ] Vue [ ] Angular [ ] No preference [ ] I don't use any of these [ ]

6. How would you rate your proficiency level in front-end development? Beginner [ ] Intermediate [ ] Advanced **[ ]** Expert **[ ]**

Section B: Framework Usability

Instructions: Please rate your level of agreement with the following statements using the following keys: A = Agree, N = Neutral and D = Disagree

S/N	ITEMS	SA	A	N	D	SD
7	The framework's overall structure and workflow are easy to understand.					
8	The framework provides intuitive tools and components for building user interfaces.					
9	I find it easy to debug and troubleshoot applications built with this framework.					

10	The framework's documentation clearly explains core concepts and usage.					

Section C: Learning Curve

S/N	ITEMS	SA	A	N	D	SD
11	I was able to learn the framework within a reasonable period of time.					
12	The learning resources available helped me understand the framework quickly.					
13	The framework's concepts are straightforward for beginners.					
14	I felt confident building functional applications shortly after learning the framework.					

Section D: Community Support

S/N	ITEMS	SA	A	N	D	SD
15	The framework has a large and active developer community.					
16	Online resources (e.g., tutorials, forums, GitHub, StackOverflow) for the framework are readily available.					
17	It is easy to find support when encountering					

	development challenges.					
18	The community contributes useful third-party packages, libraries, and plugins for this framework.					

Section E: Development Efficiency

S/N	ITEMS	SA	A	N	D	SD
19	The framework allows me to build applications quickly and efficiently.					
20	The framework speeds up development through built-in tools and libraries.					
21	The framework performs well when building modern, dynamic web applications.					
22	I am satisfied with the productivity and performance I achieve using this framework.					