
Investigating a JavaScript Single Page Application Framework for improving Usability/User Experience of Web Applications

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Abstract

This project proposal is a research and development initiative for Single Page Applications (SPAs) – specifically using the JavaScript library ReactJS. The key purpose of the research project is to create a proof of concept React SPA to improve usability / user experience. To identify shortcomings, an existing app or website will be investigated, and pre-usability tests will be conducted to evaluate the usability/user experience. A Single Page Application will then be implemented to overcome the flaws, based on the testing results.

The research discusses improving usability/user experience with React and related findings. The theory component covers key reasons for improving usability/user experience of web applications, and the best practices to be used in the creation of the Single Page web application.

1. Introduction / Background to the Proposed Research

1.1. Introduction

Modern web applications have a complex software structure as a result of functionality they provide within the user interface. Owing to the complexity of the whole application, writing software code manually will result in inconsistent content and poor quality within the application. It is more challenging to manage applications which are built this way. For this purpose, web apps are often built with the use of various frameworks. A framework enables software script writing to be standardised and more consistent, thereby facilitating the development of web applications. There are various frameworks which may be used for various parts of an application when developing web applications [1].

React is a popular JavaScript front-end open source framework that was created by Facebook [2]. Due to its usability and simple yet efficient development process, React is widely popular among developer communities. React makes Interactive User Interfaces simpler to build and may be used as a framework to create Single-Page Applications (SPAs).

1.2. Literature Review

The nature of the modern web has evolved significantly in the past decade, with the generalisation of high-speed Internet connectivity in many nations, both at home and at work [3].

As a result, users expect website response time (RT) to be lower [4] and abandon websites when the real RT fails to meet their anticipated average RT, including websites which are known for high levels of customer satisfaction and outstanding results – such as Google [5] or Amazon [6]. Google claims that the traffic reduces by 20 percent when half a second is added to the search results, [5]. Google has stated [7] that it considers the response time in its page ranking algorithm, which determines the position of a website in the search results.

The performance of a website has become a crucial factor in assessing customer satisfaction and, ultimately, a deciding factor in how a customer purchases or otherwise returns to a website. At the same time, users often want websites to deliver improved user experience (UX) than before, richer and more fluid [8].

ReactJS uses a virtual DOM that is updated by the reconciliation process, which ensures that only the DOM components with changes can be re-rendered. This makes the speed and performance of the network application better than multipage architectures [9] [10] [11].

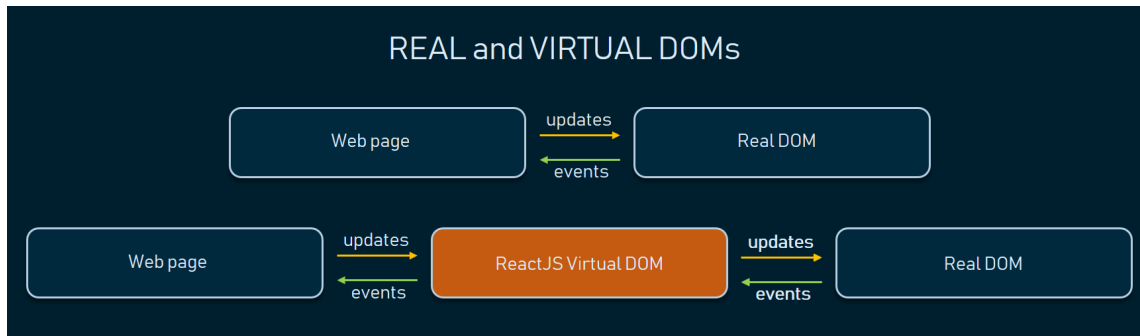


Figure 1: Real vs Virtual DOMs [12].

The virtual DOM means Single Page Applications have an almost instantaneous response time between pages after the initial loading time. It is for this reason why a variety of websites have embraced the SPA approach, converting their multi-page websites to an SPA interface [13].

Usability is closely connected to user interactivity [14]. Human-computer interaction describes user interaction as the degree to which end-users can engage proactively in the communication process, exchanging roles in their mutual discourse [15].

ReactJS is dedicated to creating an interactive user interface. The browser is an event-driven programme and all that the end user does in the browser triggers an event, from dragging the mouse or just hovering over an item.

A study was conducted by Hock Hai Teo et al. [16], which states a higher degree of user interaction has a direct beneficial impact on users' satisfaction, performance, effectiveness and attitude pertaining to a website.

Despite the web's popularity, web apps often suffer from inferior interactivity and responsiveness compared with native apps. Due to the multi-page design model, classic web applications had to update the whole interface before single page applications (SPAs) existed. SPAs seek to improve the user interface of web apps by optimising the interaction and responsiveness of the UI.

1.3. Rationale for the Research Study

The project is an exploratory research analysing how Single Page applications improve usability and user experience of web applications.

Little research has been conducted to identify why there is greater user experience and usability in Single Page Applications compared to multiple-page applications and even less research has been conducted to show how the use of React can improve user experience/usability [17].

The author chose this project as React JS has become one of the most used JavaScript frameworks and its use is growing rapidly. React JS is widely used by Facebook, Netflix, PayPal, and Apple. Facebook first started using React in 2011. Due to React's useful features and easy adaptability, most web development companies now create interactive Web applications with React JS. This is the reason it has recently become one of the most sought-after web skills.

React JS is a declarative and scalable JavaScript application allowing user interfaces to be flexibly created. It makes it enjoyable and uncomplicated to create interactive UIs. Within the code, you can easily build simple views for different states, and when your data changes, React can automatically update and make only the right components.

For this research project, the author wanted to investigate why ReactJS is such a popular framework and whether it can be used to improve UIs.

1.4. Aims and Objectives

Research Aim: To investigate the use of a JavaScript Single Page Application (SPA) Framework for improving the usability/user experience of Web Applications.

Objectives:

- Research performance of a JavaScript Framework on a Single Page Web application (SPA) for the purpose of improving usability/user experience by October 2020.
- Investigate rigorously an existing app or website, aiming to improve the usability/user experience, conducting pre-study tests by November 2020.
- Design and develop a proof of concept Single Page Application to improve usability/user experience by March 2021.
- Evaluate the performance of the Single Page Application in comparison with the existing website based on testing results by April 2021.

1.5. Deliverables/Outcomes

- Project proposal – Research title and proposed project description and introduction
- Project Plan – Gantt chart
- Weekly progress sheets
- Design of the React SPA components – Wireframe,
- Proof of Concept Single Page Application using ReactJS.
- The research on usability
- Survey/questionnaire/interview/focus group results
- Software performance results
- Document containing graphs showing comparison of results of the performance of the two websites – pre-study compared to post-study results.
- A report which understands the results of the investigation.
- The extent to which the aims have been achieved.
- Recommendations for future work
- A final project report:
 - Specifying the degree to which the objectives have been accomplished
 - Summarising the key conclusions, results or details found in this study
 - Identifying shortcomings and providing suggestions for future research in the field of JavaScript frameworks and libraries

- Highlighting the importance or usefulness of the SPA research.

2. Research and Development Methods

2.1. Research philosophy and approach

2.1.1. Positivism or phenomenology?

Positivism is well adapted for the study of natural world aspects and phenomenology for studying the social world, that is, the world of people, the organisations and community structures [18].

Håkansson [19] provides a model to enable a research method to be selected. A plan for undertaking the research is needed to achieve the goals and outcomes of a project and needs to be applied during the project.

The quantitative methods are claimed to have their intellectual basis in the positivist and realistic paradigms, while the qualitative methods have their intellectual basis in the paradigms of interpretivism, constructivism and naturalism [20].

Philosophical principles provide assumptions about legitimate and acceptable methods of analysis [19]. It is Computer Science's function to provide valid solutions that adhere to the internal conditions of computer systems and is therefore a positivistic approach. The positivist statement it is usually used in experimental character projects and is appropriate for this project where the performance of Single Page Application (SPA) using the ReactJS framework will be tested. The hypotheses for this project needs to be measured with quantifiable data usually involving large sample sets and using statistics to provide objective results [19].

A parallel qualitative-quantitative approach could be used to overcome the disadvantages of a positivistic approach. This has the benefit that it helps to recognise both qualitative and quantitative data's measurement issues and methodological artefact, because the same people are interviewed using different techniques [21]. The qualitative component of the project analysis can be used to overcome the disadvantage of positivist as this will provide information which helps to understand statistical relationships, establish explanations, and recognise additional variables.

2.1.2. Induction or Deduction

When conducting analysis, appropriate methods are used to draw conclusions and to determine what is true or false. The most popular is inductive and deductive [22]. Inductive approaches construct general propositions on the basis of specific evidence, and the deductive method derives the conclusions from proven premises.

The deductive approach was used for the project as deductive reasoning begins with a statement or inference – SPAs improve user experience/usability, and then checks that it is valid through

observation. The hypothesis is tested experimentally to evaluate different performances of multiple page applications and single page applications to reach a conclusion.

Deductive research is a form of hypothesis testing which is focused. Some opponents would argue, [19] however, that such a strategy does not promote divergent thought. The reach of creativities can also be reduced. Inductive approach produces an explanation from the collected data according to Chris Gratton et al. [23]. It is the opposite of deductive analysis. This disadvantage of deduction can be overcome by using an inductive strategy for the data collection questions and to interpret the data.

The inductive approach could have been used for this project, and a hypothesis used to consider why the SPA behaves the way it does, but this was not the objective of this project.

2.2. Research strategy

Experimental research enables researchers to study a cause and effect relationship between two variables [24]. The method involves dealing with variables, defines the relationship among variables, and determines the causality of relationships. This may change one variable whilst not altering other variables and it may check whether the changes have affected the outcome.

The research strategy used in this SPA project is experimental. This strategy was selected as the project involves looking at an existing website or web application and conducting pre-study usability/user experience testing on it to identify flaws.

The experiment strategy will be used in conjunction with a case study to be selected in the future. This will enable the data from the experiment to represent the real-life SPA.

Software engineering research strategy addresses any aspect of a software development issue by developing and validating a new technique or procedure and undertaking an analysis and discussion of its use. This project would include an element of this when the implementation flaws are fixed [25].

2.2.1. Generalisability, reliability, and validity

Validity and reliability are two significant criteria for the quantitative research to be accepted and validated [26].

Golafshani [27] suggests that the reliability and validity principles synonymous with quantitative research could potentially not be relevant for the use of qualitative research.

Quantitative and qualitative research methods are two research methods used, defining whether the analysis involves numerical or non-numerical data. The SPA project's research questions relate to performance that is usually addressed using quantitative data, and therefore

quantitative analysis approaches have been chosen. The quantitative approach uses experiments and studies in which theories and hypotheses are confirmed or falsified.

Generalizability is considered a significant criterion of quantitative research to determine the quality of a study [28] [29]. For decades, external validity has been a respected concept within the classic validity framework of Cook and Campbell [30]. Generalisability is to what degree the results of research can apply to different people or circumstances. The results from the SPA project will be able to apply to projects researching usability and user experience of websites and projects studying JavaScript Single Page Application Frameworks.

Three validity types were considered for this project to provide relevant information from experiments:

- Internal validity - relates to the relationship between independent and dependent variables and the conclusions drawn which are causal and influenced by one factor [24]. Measures will be taken in the project to decrease other variables. Extraneous variables are any variables you do not deliberately study in this research or experiment. The author will study whether one variable (independent) affects another variable (dependent) while performing the research.
- Validity of statistical conclusion relates to the correct use of statistics when the relation between variables is inferred. For example, whether a true relationship drew the conclusion, or because of chance [24]. The results of statistical tests in this project will be described together with respective error bounds. When any conclusions are drawn, only results with a significant statistic will be considered.
- External validity refers to how to generalise the research results to other conditions other than those examined in the experiments [24]. The author will design the experiments to make the results as generalisable as possible.

2.3. Data Collection

Common methods for collecting data include interviews, questionnaires, observations, document reviews [19]. A series of experiments will be planned and used during this project to gather output data using technology to test the hypotheses.

Data from the website comparisons can be quantified and generated in numerical form, to use mathematically and provide valuable statistics. These quantitative approaches, unlike qualitative processes, will allow use of greater sampling sizes as the data is measurable.

2.3.1. Interviews

A structured interview is one that uses a set of fixed questions - essentially a conversationally administered survey. An unstructured interview allows people to ask questions and have a relevant discussion, but these can be time consuming. The interviewer poses and answers open-ended questions. Most interviews fall between the two extremes [31].

The interviews for the research project will contain a combination of:

- Structured questions to gather quantitative data which will consist of closed questions.
- Open ended questions for gathering qualitative data to enable the conversation to be more spontaneous by requesting more information when such information seems relevant

It is essential to interview people who are in the target market; otherwise the outcomes might be uninformed and misleading.

2.3.2. Surveys

Surveys often return with data which is incomplete [31]. By contrast, direct contact with users in interviews and focus groups can provide more comprehensive feedback and more thorough, thoughtful responses. However, due to the complete anonymity of a survey, personal information can be provided which would not be provided in a face-to-face interview so both will be used for the project.

The project's website usability survey will contain questions where users give views on the usability of the website. The survey will be completed after the people undertaking the survey have experienced using the website. Answers should indicate which features perform well, and what needs to be changed.

The surveys will have a format comprised of:

- Multiple-choice questions for gathering quantitative data,
- Open-ended questions to gather quantitative data where respondents can provide the answers in their own words.

Only a small number of open-ended questions would be included, as the data would be more difficult to process.

2.3.3. Sampling

It can be helpful even to gather a small number of survey responses. It is easier to design from some details than to design from none. Nevertheless, in a small sample, it is crucial not to be overconfident. To achieve statistical significance, it is essential to consider the size of the sample and the number of responses to each question.

Fewer than 10 returned surveys are unlikely to be useful and a good target would be 50 returned surveys. More surveys could be done but 50 would be sufficient for this project [31]. This could be done online using survey software such as Survey Monkey or paper surveys.

The author would use social media, students, friends, family, and lecturers to complete the survey. It is necessary to have a wide range of ages and computing abilities.

When the survey results are obtained, it is important to factor in any limitations regarding which target groups completed the survey to have confidence in the results obtained.

2.4. Development Methods and Techniques

A UML diagram can be created to plan as it is a simple way to picture a system's design. React is an object-oriented language and a class diagram is generally used to model object-oriented programs as these UML diagrams are the only ones which can be mapped directly to object-oriented languages [32].

2.4.1. Wireframe

A wireframe will be used for the project to display the SPA web application's basic structure. It serves as a blueprint which highlights the layout and functionality of key elements on a website. The wireframe will help organise the content of the website. Creating a wireframe will allow the author to make the correct choices from a UX and information-hierarchical point of view, and it can be built based on it. Planning it helps avoid mistakes later. However, if the wireframe is too complicated, it will be too time consuming and therefore counterproductive. It will only be used as a simple outline of the website.

2.4.2. Storyboards

Storyboards will be used since they are a low-fidelity prototyping tool which helps visualise the experience of the user using the SPA and how the user will interact with the SPA. However, only a basic storyboard will be used as to make it detailed would be time consuming and restrictive.

2.4.3. Diagrams

There are several types of diagrams that can help picture different aspects of the redesigned web app, which in turn can help refine the SPA.

2.4.3.1. Mind Maps

Mind maps may assist in visualising the system's structure. They will be used to build the concept and define the different elements that make up the product.

Customer journey maps will help visualise how users can interact through various touchpoints with the product. Like storyboards, customer journey maps can help better understand the user.

2.4.3.2. Flow Charts

Flow charts will be used to represent system flows or user flows. Flowcharts are a simple way to document programmes. However, it is difficult to show too many branches and loops but will be used to provide a basic plan of the code.

2.4.4. Interactive UI Mock-up

A UI mock-up is a variant of the wireframe which is more fleshed out. It reflects the colour schemes, typography, and other visual elements chosen for the finished SPA.

This will enable the look and the feel of the website to be developed before writing the code.

2.5. Risks, Limitations, Ethical and Legal Issues

2.5.1. Risks

Risks were identified that could affect the success of the research project.

R1. Risk Description – Project does not gain ethical approval.

Probability – Low

Impact – High

Strategy to mitigate – Study the ethical guidelines and integrity code of practice.

R2. Risk Description – Ill-defined goals and methods making the project challenging.

Probability – Low

Impact – High

Strategy to mitigate – Ensure the aims and methods are well designed.

R3. Risk Description – Surveyed sample change their responses as they know they are being studied.

Probability – Moderate

Impact – Significant

Strategy to mitigate – Emphasise the fact that the survey is anonymous and to answer honestly.

R4. Risk Description – Unrealistic assumptions regarding the skill level of the researcher/author.

Probability – Moderate

Impact – High

Strategy to mitigate – Ask for help/consult experts.

R5. Risk Description – Research subjects breach of confidentiality.

Probability – Moderate

Impact – Moderate

Strategy to mitigate – Ensure the questionnaires do not breach confidentiality.

R6. Risk Description – Falling to meet the milestone targets on Gantt chart.

Probability – Significant

Impact – Significant

Strategy to mitigate – Good time management.

Impact	High	R1 R2	R4		
	Significant		R3	R6	
	Moderate		R5		
	Low				
		Low	Moderate	Significant	High
	Probability				

———— = Tolerance Line

Figure 2: Risk Evaluation Matrix based on impact and probability

2.5.2. Hazards

1. Hazard – Environmental e.g. extreme weather, fire, flood

Probability – Low

Impact – High

Safeguards – Effective backup systems

2. Hazard – Unavailability of facilities/resources for research due to Covid-19

Probability – Significant

Impact – High

Safeguards – Conduct interviews/surveys remotely and find alternative software methodologies

2.5.3. Ethics

The Research Ethics and Integrity Code of Practice [33] define the ethical code of research criteria for the project.

The project will adhere to the BSC Code of Conduct [34].

The results of the research project could enable future web developers to create more websites using JavaScript Single Page Application frameworks as they aim to improve usability/user experience.

Confidentiality often needs to be considered if work includes gathering confidential records.

The author does not consider that the results of the project could be misused in any way.

The author does not consider there are any legal problems that apply to data privacy, code abuse or information freedom.

The author does not consider the project will leading anywhere which may not be for the good of society.

2.6. Methods to analyse the data and evaluate results

IBM SPSS® Statistics is a powerful statistical software platform which can be used to analyse the experimental data obtained in order to understand complex and large data sets of information with sophisticated statistical methods that help ensure high accuracy and quality decision-making [35].

The data obtained from the surveys, questionnaires and focus groups can be analysed using SPSS for quick and accurate statistical data analysis.

There are various factors that need to be investigated while testing the React UI. There are many tools and techniques that can be used for the project to find bugs and functioning errors.

2.6.1. React UI Testing

2.6.1.1. Structural testing

The structural testing will check the code's structure for the ReactJS website. There is specific software available that can be used to test React. A bug would be found if a particular input does not match the output which is expected.

Jest and enzyme are complementary yet separate tools that work well with each other to test React [36]. Both will be appropriate tools to carry out structural testing.

Jest is a testing framework for JavaScript units, and is used by Facebook to test React applications. Jest offers Snapshot testing, the option to create a component's rendered 'snapshot'

and a comparison to a snapshot previously stored. If the two do not compare, then the test will fail.

Enzyme is a React testing tool which makes it simple to assert, control, and traverse the performance of React Components. Enzyme, developed by Airbnb, provides additional resources to render a component (or several components), locate elements, and interact with elements.

2.6.1.2.Interaction Testing

User Interface design is about interacting with the customer. For the project, this will be achieved using UI components, such as buttons, links, and input fields. This involves interaction testing which conducts tests to verify if these components are working. Enzyme will be used in the project for interaction testing.

2.6.1.3.Benchmarking

Benchmarking a website involves identifying a benchmark site from which to collect data – in this case the existing multi-page website.

HTTP Archive [37] provides several statistics that include details such as the overall size of the website by text and the user response time. This will be used in the project to compare the multi-page website with the single page application.

2.6.1.4.T-Test

The t-test will be carried out on the results of the website comparisons to determine how important the variations between the groups are. This will indicate whether any differences may have arisen by chance.

3. Resources and Planning

3.1. Resources Required

- HTML
- CSS
- React
- A recent version of Node.js installed
- NPM (package manager)
- Visual Studio
- UWTSD Library

3.2. Gantt Chart

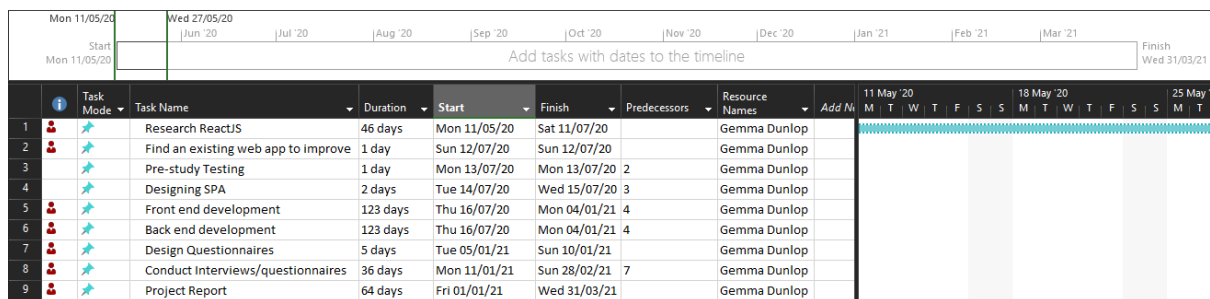


Figure 3: Gantt Chart for the SPA Project.

3.2.1. Resource Usage

Gemma Dunlop	3,208 hrs
<i>Research ReactJS</i>	<i>368 hrs</i>
<i>Find an existing web app to improve</i>	<i>8 hrs</i>
<i>Pre-study Testing</i>	<i>8 hrs</i>
<i>Designing SPA</i>	<i>16 hrs</i>
<i>Front end development</i>	<i>984 hrs</i>
<i>Back end development</i>	<i>984 hrs</i>
<i>Design Questionnaires</i>	<i>40 hrs</i>
<i>Conduct Interviews/questionnaires</i>	<i>288 hrs</i>
<i>Project Report</i>	<i>512 hrs</i>

Figure 4: Resource Usage of SPA Project.

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3.2.2. Network Diagram

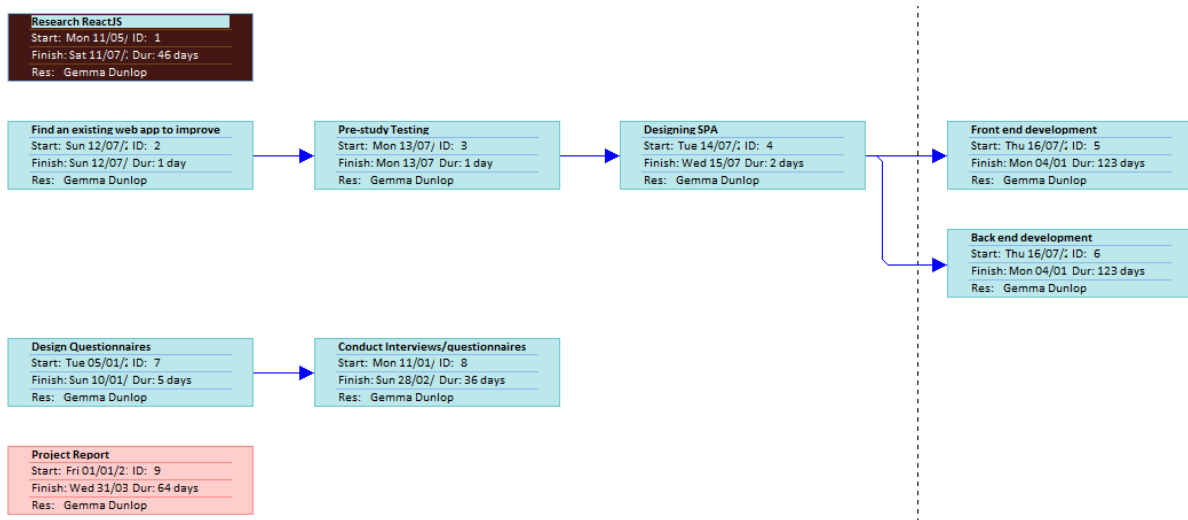


Figure 5: Network Diagram of SPA Project.

4. Conclusion

This project proposal presents a plan of research methods and methodologies which will be used to investigate the usability/user experience of SPAs. The next step will be to evaluate an existing website and identify flaws and build a new website using ReactJS to correct these flaws to improve the usability and user experience.

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