

# PROJECT PLAN

MANIPULATION AND VISUALISATION OF SELF-  
BALANCING BINARY SEARCH TREES EMPLOYING  
A DOMAIN SPECIFIC LANGUAGE

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# 1 Introduction

This project aims to demonstrate the manipulation and visualisation of self-balancing binary search trees (BSTs) employing a domain specific language (DSL) in the form of a website application, developed to such a standard to be used when teaching or learning content related to BSTs, to further close the gap between students who prefer hands on learning, and students who prefer learning through demonstration.

## 1.1 Background

In recent years there have been an increasing number of studies identifying the key differences and significance between students who prefer to learn through demonstration, and students who prefer to learn hands on “comparing hands-on learning to demonstration at the three points of recall, was statistically significant ( $t [58] = 2.48$ ,  $p = .008$ , with effect size  $d = .648$ ).” (Hearns, Miller and Nelson, 2009).

This report not only emphasises the significance in learning preferences, and how different students benefit from different teaching methods, but it also emphasises the lack in hands on teaching that currently exists when compared to demonstration-based teaching.

The combination of this, the idea of developing an application to the standard of aiding teaching and learning for students of different learning preferences, and the added Research into existing solutions showing that no other BST visualisation websites contain any in-depth hands-on learning tools i.e. DSL for experimentation, outside of inserting and removing nodes and the demonstration of different traversals of a BST, is why I feel the addition of DSL hands on experimentation within my application is a necessary feature, and a key difference between existing solutions and my own.

## 1.2 Implications

The beneficial implications of such a project, are largely targeted towards academic and educational based environments and contexts, as the tool will mostly serve as a teaching tool for teachers to explain concepts with a visual and hands-on aid, but also for students

to better their understanding and experiment with the existing algorithms to see what happens when they change different aspects of each algorithm.

A potentially negative implication of the project comes from incorrectly developing any aspect of the BST logic. This includes insertions, deletions, traversals, rotations and the DSL. Any incorrect logic within any of these areas, once taught or studied, could lead to a potentially lower grade in a university context for the teacher or student using the tool.

Another example of incorrect logic leading to a potentially negative implication, is if an employed software developer attempts to improve their knowledge of BSTs using the tool and it leads to the incorrect implementation of a business project.

## 2 Aims and Objectives

### 2.1 Aims

The aim of this project is to produce an educational tool to help teachers and students when teaching/learning BSTs and to further develop interest into such topics. The project aims to do this through the development and application of a web-based application that allows for the visualisation and manipulation of BSTs employing a DSL for the purposes of experimentation.

### 2.2 In Scope

- Develop a survey to gather target audience expectations and interests for the application
- Develop a web-based application that allows for the visualisation of BST traversals, rotations, insertions, deletions and self-balancing and manipulation of BSTs using a DSL.
- Develop a complete set of unit tests and test suites to cover all functionality of the site
- Publish the software for the University to use in teaching and studying environments for both teachers and students when investigating basic or advanced topics from in order traversals, insertions, and removals, to complex tree rotations and self-balancing algorithms

### 2.3 Out of Scope

- The application will not allow for the visualisation and manipulation of any other data structures e.g. linked lists (excluding an exception where the user creates a constantly ascending or descending BST, as this is technically a singly linked list), arrays of any sort i.e. 2d, 3d, 4d, vectors of any sort, hash maps, dictionaries
- The application will also not include any visualisation or manipulation of any data sorting algorithms i.e., bubble sort, quick sort, merge sort etc.

## 3 Tasks and Deliverables

### 3.1 Deliverables

- End of survey development will produce a survey to be handed out to all students and teachers relevant to the project
- End of basic web-application development will produce a simple working site with minimal functionality
- End of second stage web-application development will produce a further expansion on the existing site, with the inclusion of insertion and removing multiple nodes
- End of third stage web-application development will produce a BST traversal expansion including in-order, pre-order, and post-order traversals
- End of fourth stage web-application development will produce a self-balancing BST algorithm
- End of fifth stage web-application development will produce the final expansion of the application including a domain specific language

### 3.2 Tasks

Develop a basic web app capable of displaying a singular node from a binary tree –

- Research the use of React and JSX elements and how they can benefit the development of more functionally founded projects such as mine
- Develop the JavaScript binary tree logical foundation for the binary tree
- Develop the SCSS/JSX styling to display the nodes in the tree after they're created
- Further develop the app to display a single node
- Further develop the app to allow for the creation and insertion of a singular binary node completely visualised within the app with the desired key and info from the click of a button

Further develop the application to allow for the creation, insertion and viewing of any number of nodes –

- Develop the animation for multiple nodes being added and one node traversing the tree
- Further develop the application to handle multiple node entries while maintaining standard BST rules

Develop the app to include three traversals –

- Implement the JSX logic for traversing the tree in order
- Implement the SCSS styling to show the tree being traversed
- Implement the JSX logic for traversing the tree post order
- Implement the SCSS styling to show the tree being traversed
- Implement the JSX logic for traversing the tree pre order
- Implement the SCSS styling to show the tree being traversed

Develop a complete set of unit tests and test suites to cover all of the functionality of the site –

- Develop unit tests to cover the functionality of singular and multiple node insertions
- Develop unit tests to cover the functionality of a basic and complex removals
- Develop unit tests to cover the functionality of basic and complex tree rotations
- Develop unit tests to cover the functionality of user entered domain specific language commands

## 4 Gantt Chart

For visual representation of the following information, refer to appendix item **Figure 1. Gantt Chart.**

### 4.1 Milestones

MILESTONE	DATE
FYP RP2	03/12/21
End of Research	19/11/21
FYP RP3	04/02/22
End of Development	22/03/22
End of Testing	29/03/22
FYP Submission	22/04/22

### 4.2 Tasks and Deliverables

DELIVERABLE	DATE
FYP RP2	03/12/21
FYP RP3	04/02/22
FYP Submission	22/04/22
TASK	DATE
Initial Research	DATE
Research existing solutions to determine appropriate aims and objectives and to support the justification behind my application	12/11/21
Create a survey to be given out to classmates and my FYP supervisor/advanced software engineering lecturer Dr Neil Sculthorpe	17/11/21
Gather findings from created survey by handing it out during classes to help determine what the application should cover	19/11/21



<b>Development</b>	<b>DATE</b>
Develop basic web application	06/12/21
Develop application to include multiple nodes	25/01/22
Develop application to include tree traversals	08/02/22
Develop application to include self-balancing algorithm	23/02/22
Develop application to include domain specific language	22/03/22
<b>Testing</b>	<b>DATE</b>
Test singular node insertion and deletion	07/12/21
Test multiple node insertion and deletion	27/01/22
Test binary search tree destruction	28/01/22
Test tree traversals	14/02/22
Test tree rotations	02/03/22
Test self-balancing algorithm	09/03/22
Test domain specific language	29/03/22
<b>EXTERNAL DELIVERABLE</b>	<b>DATE</b>
Advanced Analysis & Design Report + Code	14/03/22
Artificial Intelligence Lab 1	04/02/22
Service Centric & Cloud Computing Demo + Report	23/02/22
Advanced Analysis & Design Demo	18/02/22
Advanced Software Engineering Report + Code	25/02/22
Artificial Intelligence Lab 2	28/03/22

## 5 Resources

### Resources –

- Windows OS – Required for installing software and performing computing tasks
- Visual Studio Code – Required for application development
- JSX – Programming language to develop the logic of the application
- SCSS – Programming language to develop the styling of the application
- React – Framework allowing the use of SCSS and JSX
- Typescript – Aids in reducing user error while developing
- Laptop – Hardware required to run Windows OS
- Internet connection – Required to run the application
- Microsoft Word – Required for report documentation
- Microsoft Project – Required for project scheduling
- NTU NOW – Required for access to university schedules of all relevant module deadlines and exams and access to my emails.

### Sources –

- University Library – Required for researching articles supporting my project
- Research Papers related to developing tools for educational purposes – Required to better understand teaching and learning standards
- Research Papers related to JavaScript development of binary trees – Required to better understand the foundation of my project
- Research Papers related to developing a domain specific language – Required to better understand domain specific languages and how to implement it
- Google Scholar – Required for general article research to support the project
- Advanced Software Engineering Tutor/Personal Tutor/Final Year Project Supervisor
- Advanced Software Engineering class surveys – Aids software development
- University Binary search tree content – Aids software development

## 6 Risks

Please refer to the appendix **Table 1. Risk Assessment Matrix** to better contextualise the impact, probability, and rating values.

RISK	IMPACT	PROBABILITY	RATING	MITIGATION
<b>TECHNICAL</b>				
Loss of source code	10	3	30	Physical backup of data in the form of hard drive/USB or backup data to the cloud.
Physical damage	6	4	24	Avoid using or leaving hardware in potentially at-risk areas i.e. on the edge of a desk or near a door.  Take appropriate precautions when traveling with hardware e.g. carrying a laptop inside a laptop case.
Incorrect binary tree logic from a poor choice of source	9	4	36	Complete in-depth testing of produced source code and spend time ensuring each source chosen appears accurate and reliable.
Incorrect development of the application leads to students	10	3	30	Develop in-depth testing of produced source code to ensure the quality of every scenario developed is correct and up to standard.

learning incorrect logic				
Not achieving the aims discussed in the project	5	7	35	Ensure the application is developed following an agile methodology, allowing for on- going unexpected adaptations of the application
<b>NON-TECHNICAL</b>				
Unforeseen illness	3	7	21	Manage time well and account for unexpected delays by extending expected delivery dates.
Delayed progress due to external modules deadlines	6	6	36	Manage time well and account for external module deadlines and exams
Extension of a local or national lock down preventing access to university equipment.	5	7	35	Ensure all required data to continue project progress is stored or backed up locally or via the cloud and ensure all required hardware to continue progressing the project are accessible from home e.g. virtual desktop.

## 7 Legal, Social, Ethical & Professional Issues

### 7.1 Legal

GDPR is considered the most up to date form of computer legislation to be followed by any software development application and this project will therefore comply.

Right of access by the data subject article 15 specifies that the data subject will maintain the right to confirm the purpose and use of the data being collected from the subject and will always maintain the freedom to access the data collected from the subject.

Right to rectification article 16 also specifies that the data subject will maintain the right to rescind any incorrect or misleading information regarding the data collected from the data subject. It also specifies that the subject can further clarify or update incomplete data at any point during the project by means of providing a supplementary statement.

The project also considers the laws related to applications sold commercially but believes these are not applicable as the application is not being sold commercially and is instead being released for free. However, this does not mean the application will not meet expected accessibility legislations.

MS project would require a license if the product was commercialised

The project will contain a license crediting the author for the creation of the application but will disclose that any future alterations or further developments of the application are not the responsibility of original author.

### 7.2 Social

As the project has no intention of being commercialised, the most significant beneficial social impact of the project is that it's being developed for educational purposes as opposed to monetary or business-based gain. Because of this, the project is not concerned with any monetary or business-related social obligations or drawbacks.

As far as negative social implications are concerned, the most significant impact is if the application is developed incorrectly and a student, teacher or software engineer in the future uses the incorrect logic to further their own understanding of binary search trees. Leading to a lower score in an exam, coursework, or project for a client.

It is also worth mentioning, that the project will have a license crediting the author for the development of the application. However, it will be disclosed that the author will only be credited for the original development of the application, and if an alteration of the application is developed that leads to any negative social implications, the author is not responsible.

### 7.3 Ethical

The only ethical consideration of the project, is informed consent, given the use of surveys as the project progresses. It will be clearly specified that those taking part in the survey will be fully informed of the use of their data, if the data will be used within the report or application, and the deadlines for rescinding any given information.

### 7.4 Professional

This project has considered the professional issues related to integrity and self-awareness in terms of what quantity and quality of work is realistically achievable. However, the project does not consider this an appropriate professional concern given the context of the project being a university dissertation, where the purpose of the project is to go above and beyond your usual standard of work.

The project will act professionally by ensuring all components tested within the site are clearly indicated as so, and any components not tested will be clearly indicated as so.

The BCS code of conduct also specifies that "working together to address issues in your profession and in wider society, you want everyone to have access to IT". The project is enforcing this by making the application accessible to everyone with access to the internet, especially those within the educational system.

## 8 Bibliography

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<<https://journals.sagepub.com/doi/pdf/10.3928/15394492-20090825-01>> [Accessed 4 November 2021].

## 9 Appendix

### 9.1 Risk Assessment Matrix

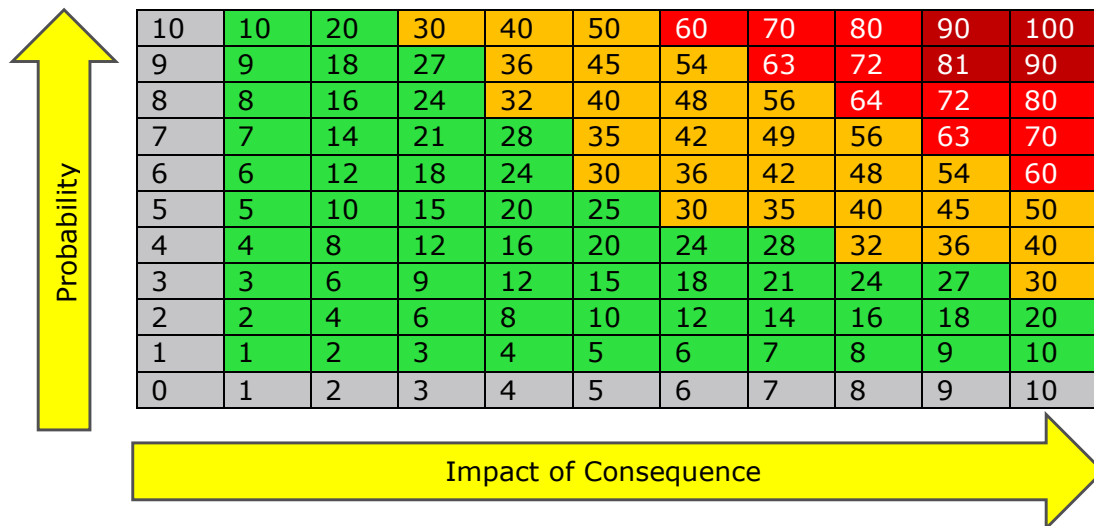


Table 1. Risk Assessment Matrix



## 9.2 Gantt Chart

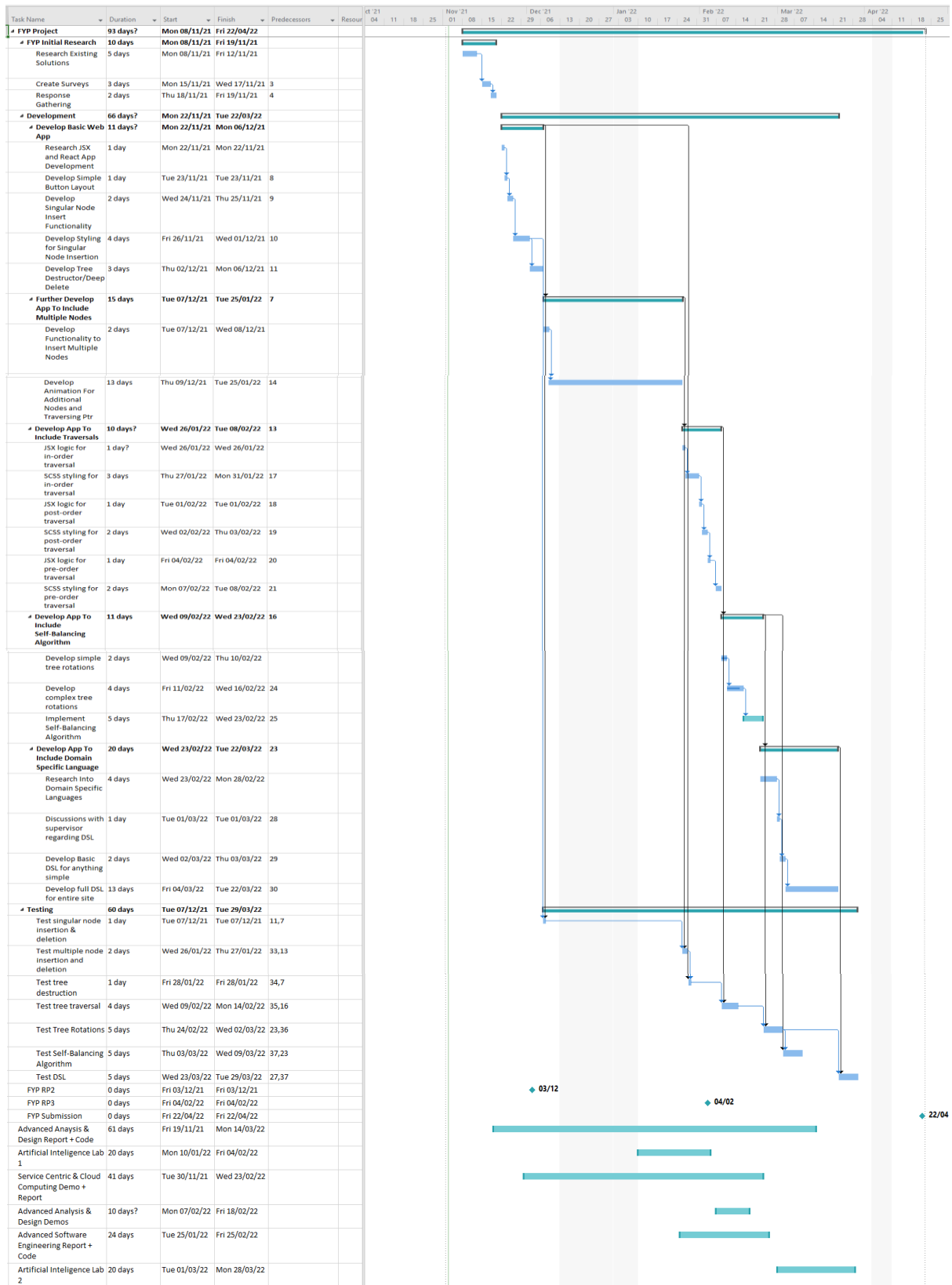


Figure 1. Gantt Chart