

# System Verification and Validation Plan for Measuring Microstructure Changes During Thermal Treatment

Team #30, ReSprint

Edwin Do

Joseph Braun

Timothy Chen

Abdul Nour Seddiki

Tyler Magarelli

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Table 1: **Revision History**

| <b>Date</b>  | <b>Developer</b>       | <b>Notes/Changes</b>   |
|--------------|------------------------|--|
| Oct 31, 2022 | Timothy Chen           | Added to 5.2, 5.3, 7.2                                       |
| Oct 31, 2022 | Edwin Do               | Added section 4 for V&V Plan                                 |
| Nov 1, 2022  | Abdul Nour Seddiki     | Added to 5.1, 5.3  |
| Nov 2, 2022  | Joseph Braun           | Added Section 3  |
| Nov 2, 2022  | Edwin Do               | Added more content to section 4                              |
| Mar 4, 2023  | Edwin Do               | Revised tests for non functional requirements                |
| Mar 4, 2023  | Timothy Chen           | Revised Usability and Performance NFR test                   |
| Mar 6, 2023  | Abdul Nour Seddiki     | Revised tests for Functional Requirements & fixed formatting |
| Mar 8, 2023  | Edwin Do, Timothy Chen | Further revision of tests for non functional requirements    |
| Mar 8, 2023  | Tyler Magarelli        | Updated user experience survey for section 6.2               |
| Mar 8, 2023  | Abdul Nour Seddiki     | Revised tests for Functional Requirements                    |

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# 1 Symbols, Abbreviations and Acronyms

| symbol               | description                          |
|----------------------|--------------------------------------|
| T                    | Test                                 |
| SRS                  | Software Requirements Specifications |
| VS                   | Visual Studio                        |
| UWP                  | Universal Windows Platform           |
| MIN_USER_ACCEPT_RATE | 90% - minimum acceptance rate        |
| TARGET_TIME          | 60 seconds                           |
| INTERACT_TIME        | 5 seconds                            |
| MAX_MISTAKE          | 2                                    |
| MAX_CAPACITY         | 8GB                                  |
| MIN_UPTIME           | 30 minutes                           |
| MIN_SAMPLE_RATE      | 60 samples per second                |
| TIME_ACCEPTED        | 1 second                             |
| ACCEPTED_SIGFIG      | 3 decimals                           |

[symbols, abbreviations or acronyms – you can simply reference the SRS (Author, 2019) tables, if appropriate —SS]

## **2 General Information**

### **2.1 Summary**

The purpose of this document is to provide a detailed plan for the testing of our system. This will include:

- Verification and Validation Plan
- System Test Description
- Unit Test Description

### **2.2 Objectives**

The objectives of testing are to ensure that all functional and non-functional requirements of the system are being met. It is important to include both unit tests as well as system tests, as issues may arise when components are connected together in the system.

### **2.3 Relevant Documentation**

Relevant documentation includes:

- SRS
- MIS
- MG

## **3 Plan**

In this section of planning, it will outline our approaches to cover the requirements outlined in various areas such as the SRS document, Hazard analysis document, our implementation and design. Tools that will be used for automated unit testing and linting will also be introduced.

The following topics will be covered:

- The verification and validation team along with their respective responsibilities
- Our approach towards the SRS Verification plan
- Our approach towards the Design Verification plan
- Implementation verification plan
- Any testing and verification tools we plan to use

### **3.1 Verification and Validation Team**

Below is a table outlining the members of the Verification and Validation team along with their respective responsibilities. Note that the listed responsibilities are only used as a guideline, responsibilities can shift between team members on a as-per-needed basis.

Table 2: Team and Responsibilities

| Team Member        | Role Name               | Responsibilities  |
|--------------------|-------------------------|---|
| Edwin Do           | Software and SRS Tester | Ensures that all requirements are valid and verified under the scope of software capabilities in this project and the SRS |
| Timothy Chen       | Software Tester         | Ensures that all requirements are met and verified under the scope of software capabilities in this project               |
| Tyler Magarelli    | Software Tester         | Ensures that all requirements are met and verified under the scope of software capabilities in this project               |
| Joseph Braun       | Hardware Tester         | Ensures that all requirements are met and verified under the scope of hardware capabilities in this project               |
| Abdul Nour Seddiki | Hardware Tester         | Ensures that all requirements are met and verified under the scope of hardware capabilities in this project               |
| Dr. Hatem Zurob    | Supervisor              | Ensures that all requirements are valid and meets the expected result   |

### 3.2 SRS Verification Plan

To verify our SRS, our team intends on revisiting the SRS document on a bi-weekly basis to verify that the requirements are up to date and in sync with the project goal. This will also allow us to cover any newly discover risks or hazards which will also be reflected in the Hazard Analysis document. Any new changes within the two week window will be noted and discussed at the end to see if additional changes to the SRS document would be necessary. At each bi-weekly review, the team also plans on using the SRS checklist as a guideline throughout the meeting.

In addition, the team will use ad hoc feedback from reviewers such as classmates from our 4GA6 Capstone class as well as instructor, supervisor and



teaching assistants. This will act as a supplementary addition if any element of the SRS is out of date or missing.

### **3.3 Design Verification Plan**

Our plans to verify our design document includes using the MIS checklist and reviews from our classmates. The MIS checklist will help our team ensure that the design logic helps us meet the requirements specified in the SRS document and cover any hazards or risks outlined in the Hazard analysis. The team will conduct an internal design review, by going over all the outlined requirements, risks and hazards and verifying that the design does not contain any logical flaws to the best of our abilities.

In addition, the team will use the feedback from reviewers such as classmates from our 4G06 Capstone class as well as instructor, supervisor and teaching assistants. This will help further assist our team to ensure that the design is free from any logical flaws and is able to help meet the outlined requirements.

### **3.4 Implementation Verification Plan**

Throughout the development phase of this project, the team will use GitHub Issues and pull requests to implement various features. Each pull request will require at least two other team members to inspect and review the code ensuring that it meets the requirement and design discussed. A pipeline can also be implemented in GitHub to ensure that the build in the main branch is always stable. Unit tests will also be used to ensure that the implementation of the product is verified.

### **3.5 Automated Testing and Verification Tools**

The final product will be an Universal Windows Platform (UWP) application built using Microsoft Visual Studio (VS) in C# and XAML.

Majority of the project's testing will be conducted within VS. For unit testing, the team will use the built-in features of Unit Test Applications in VS to create unit tests projects and units tests.

Code coverage tests is also covered within the suite of tools available within VS. The team will be able to create testing suites and unit tests for the VS project. The team also plans on using the results of the code coverage tests to identify which portion of the project's code not covered by our tests. Uncovered blocks of code can be colour-coded to signify to the developer that no current test covers that block of code. Other metrics such as number of lines covered, % of a block covered will be summarized per code coverage project to help indicate where more testing efforts are needed.

Using Visual Studio's IDE extensions, the team plans on using SonarLint and CSharpier as its linter and formatting tool for C# respectively.

### **3.6 Software Validation Plan**

To verify that the software will work as intended and designed, the team will use the sample data provided by Dr. Zurob and see if the results are within a reasonable margin of error. This sample data is obtained from a collection of existing materials with known results. If the actual results are outside a reasonable range, then the team shall conclude that the results are not valid.

## **4 System Test Description**

### **4.1 Tests for Functional Requirements**

FR-T1. Control: Dynamic & Manual

Initial State: Entire system is set up and the application is running.

Input: Developers will initialize the current source with supply parameters, initialize the nanovoltmeter and capture measurements, and set up a sample and demonstrate the main function of the application.

Output: The current source shall be reset and the application shall input the parameters of the current supply and set them to the current source appropriately, then enabling and disabling the current. The current level shall be displayed appropriately. The nanovoltmeter shall be reset and the application shall display the voltage levels appropriately when capture is started. When stopping capture, the application shall pause the measurements and keep the last batch of data displayed. The application shall calculate and display the resistivity of the metallic

sample based on values obtained from the measurement devices.

Test Case Derivation: Since the measurement devices are connected via a high-speed communication bus (GPIB) to the control computer, calculations are expected to be synchronized to the measurements and displayed in real-time.

How test will be performed: Test will be performed by developers. By checking the “Current Source” radio button and specifying other parameters then clicking “Current ON” button and “Current OFF” button. Checking the “Nanovoltmeter” radio button and clicking “Start Capture” button and “Stop Capture” button. Then verify the resistivity calculations by taking samples from the logs and doing a manual calculation. Simultaneously monitoring both the values displayed on the current source and the ones displayed in the application while observing for latency.

FR-T2. Control: Dynamic & Manual

Initial State: Entire system is set up and the application is running.

Input: Developers will set up a sample and perform thermal treatment on it.

Output: The application shall monitor and take note of critical changes in resistivity.

Test Case Derivation: While the application is constantly monitoring the state of resistivity of samples in real-time, any major change in the resistivity indicates a transition in the phase of the material.

How test will be performed: Test will be performed by developers. Performing thermal treatment and observing changes in resistivity as calculated by the application.

FR-T3. Control: Dynamic & Manual

Initial State: Entire system is set up and the application is running.

Input: Developers will control the sampling rate of the voltage measurement.

Output: The nanovoltmeter shall display measurements at a rate faster or slower than the default rate, and the application shall follow suit when displaying measurements and calculations.

Test Case Derivation: The application is expected to be able to sample the data at variable rates, by changing the ‘integration rate’ of the nanovoltmeter through Powerline Cycles per calculation (PLC) and

since the nanovoltmeter is connected via a high-speed communication bus (GPIB) to the control computer, calculations are expected to be synchronized to the measurements and displayed in real-time.

How test will be performed: Test will be performed by developers. By choosing an integration rate from the drop-down menu and starting capture. Simultaneously monitoring both the values displayed on the measurement devices and the ones displayed in the application while observing for latency in the display and calculation.

FR-T4. Control: Dynamic & Manual

Initial State: Entire system is set up and the application is running.

Input: Developers will set up a sample and perform thermal treatment on it.

Output: The application shall automatically calculate the slopes of resistivity-temperature in the phase change diagram, identify changes in these slopes and attributing slope changes to phase transitions. This information is highlighted with appropriate phase transition labels.

Test Case Derivation: While the application is constantly monitoring the resistivity of samples in real-time, major changes in the resistivity to temperature ratios correlate to phase changes of the material.

How test will be performed: Test will be performed by developers. Performing thermal treatment, capturing measurements, and observing notifications and labels on graphs or logs made by the application.

FR-T5. Control: Dynamic & Manual

Initial State: Entire system is set up and the application is running.

Input: Developers will prompt a wireless connection to control computer and stop an experiment.

Output: The application is able to be controlled using a proxy/web application.

Test Case Derivation: The control computer is expected to be connected to the network so that when the system is set up the application is operable remotely.

How test will be performed: Test will be performed by developers communicating remotely with the control computer through a web app. The main application is already capturing measurements and making calculations. Remotely, the testing developer will click “Stop Experiment” button on the web app and that will prompt the main app to

stop capturing data and turn the current supply off.

**FR-T6. Control: Dynamic & Manual**

Initial State: Entire system is set up, connected to a sample, and the application is running.

Input: Developers will start an experiment.

Output: The application displays a graph that shows real-time values and calculations.

Test Case Derivation: Since the application is constantly monitoring and displaying resistivity of samples and other measurements in real-time, a graph will be able to follow these values and display them in a visual representation.

How test will be performed: Test will be performed by developers. By initializing the current source and voltmeter, then turning current supply on and starting capture. Then observing the graph in the application window.

**FR-T7. Control: Dynamic & Manual**

Initial State: Entire system is set up, connected to a sample, and the application is running.

Input: Developers will start an experiment then stop it.

Output: The application shall save a file on the control computer containing the measurements and calculations of the experiment.

Test Case Derivation: Since the application is constantly monitoring and displaying resistivity of samples and other measurements in real-time, a file system will be able to follow these values and write them to a data file outside of the application.

How test will be performed: Test will be performed by developers. By inputting information about the experiment and the personnel involved, then initializing the current source and voltmeter, and turning current supply on and starting capture. When enough data has been captured, they shall stop the experiment and check the generated file.

## **4.2 Tests for Nonfunctional Requirements**

### **4.2.1 Appearance Test**

**NF-AT1. Type: Static & Manual**

Initial State: Application is opened and ready for use.

Input/Condition: User will follow a simple set of instructions to explore application, followed by a survey  
Output/Result: Survey result will indicate *MIN\_USER\_ACCEPT\_RATE* of users agree or strongly agree application is uncomplicated.  
How test will be performed: Test will be performed by the user. They will receive a survey with a question. If *MIN\_USER\_ACCEPT\_RATE* of users indicate agree or strongly agree, then it will be considered successful. (Refer to Appendix for Sample Survey)

NF-AT2. Type: Static & Manual

Initial State: Application is opened and ready for use.

Input/Condition: Developers will navigate the application by exploring every screen and state.

Output/Result: If all sections of the applications is in English, then this test is considered a pass. Otherwise, it is considered a fail.

How test will be performed: Different sets of instructions are used to cover a subset of the application screens and states, each set of instruction is to be carried out by a developer to verify the result.

#### 4.2.2 Usability Test

NF-UT1. Type: Dynamic & Manual

Initial State: The application is open to home screen and ready to use.

Input/Condition: The users with no prior experience with the product.

Output/Result: At least *MIN\_USER\_ACCEPT\_RATE* of users with no prior experience can successfully complete each task without additional assistance

How test will be performed: The users will be observed while completing the task. The test will pass if users complete the task without additional assistance.

NF-UT2. Type: Dynamic & Manual

Initial State: The application is open to home screen and ready to use.

Input/Condition: User will be asked to modify the voltage and current parameters of the application to match a sample experi-

ment we provide.

Output/Result: The user takes no more than *INTERACT\_TIME* to interact with the application and make the modifications to the voltage and current parameters matching the sample experiment provided.

How test will be performed: The users will be observed while completing the task. The test will pass if the user takes no more than *INTERACT\_TIME*.

NF-UT3. Type: Dynamic & Manual

Initial State: The application is open to home screen and ready to use.

Input/Condition: User will use the application by following a pre-defined set of tasks.

Output/Result: The total number of mistakes made by the user when completing the tasks by interacting with application should be no more than *MAX\_MISTAKE*.

How test will be performed: The observer will record the number of mistakes that they observe as the user completes the set of tasks.

NF-UT4. Type: Dynamic & Manual

Initial State: Application will be closed.

Input/Condition: Users will open the application and perform a set of tasks listed for a sample experiment. User then will be asked to return the next day to perform the same set of tasks.

Output/Result: The time that the user takes to complete the set of tasks for the second time will be less than the time taken for the first time.

How test will be performed: The users will be observed and timed while completing the set of tasks both times. The test will pass if the user completes the set of tasks in the same or less amount of time in the next day.

NF-UT5. Type: Static & Manual

Initial State: The application is open to home screen and ready to use.

Input/Condition: User will input sample parameters and application will perform calculations.

Output/Result: The application will display the result of the application and the user will not know how the calculations are per-

formed

How test will be performed: User will be observed while performing the task and asked to fill out an usability survey question. If the user is unaware of how the calculations were performed, the test will pass.

NF-UT6. Type: Static & Manual

Initial State: The application will be installed on the research device

Input/Condition: The size of the application will be checked manually

Output/Result: Application capacity on the device will be no more than *MAX\_CAPACITY*.

How test will be performed: We will open the file properties of the application and verify that the size of the application is less than or equal to *MAX\_CAPACITY*.

#### 4.2.3 Performance Test

NF-PT1. Type: Dynamic & Automated

Initial State: Application is installed and running with measurement devices connected to a sample.

Input/Condition: Set *MIN\_SAMPLE\_RATE* and start thermal treatment of sample.

Output/Result: Calculate and output the application's sample rate and check to see if it is greater or equal to *MIN\_SAMPLE\_RATE*.

How test will be performed: Using the parameters of the devices, we will calculate the observed sample rate and compare it with the inputted sample rate by the user. The test will pass if the observed sample rate is *MIN\_SAMPLE\_RATE* or greater.

NF-PT2. Type: Dynamic & Manual

Initial State: Application is installed and running.

Input/Condition: User will be given parameters to change.

Output/Result: Application will reflect changes by within *TIME\_ACCEPTED*.

How test will be performed: User will make modifications, we will observe how long the application takes to reflect changes.

NF-PT3. Type: Dynamic & Automated

Initial State: Application is installed and running with measure-



ment devices connected to a sample.

Input/Condition: Thermal treatment sample data will be read into the device.

Output/Result: The sample reading from the thermal treatment will be accurate to *ACCEPTED\_SIGFIG* number of significant digits.

How test will be performed: An automated test will be used to compare the expected values to the measured values. The test will pass if the result is correct up to the number of *ACCEPTED\_SIGFIG* significant digits.

NF-PT4. Type: Dynamic & Manual

Initial State: Application is installed and running with measurement devices connected to a sample.

Input/Condition: Application will be opened and user will interact with it.

Output/Result: The application will be up and running for at least *MIN\_UPTIME* and for the entire duration of the task given to the user to perform.

How test will be performed: User will complete a set of tasks using the application and the application will be left running for at least *MIN\_UPTIME* afterwards.

#### 4.2.4 Operational Test

NF-OT1. Type: Static & Manual

Initial State: Application is opened and ready with keyboard and mouse connected to the device.

Input/Condition: User will interact with the application with mouse and keyboard.

Output/Result: Application will accurately and correctly reflect the inputs from the mouse and keyboard provided by the user.

How test will be performed: User will be asked to perform a simple set of instructions using the mouse and keyboard such as clicking and typing.

NF-OT2. Type: Static & Manual

Initial State: A machine/computer that does not have the application installed.

Input/Condition: Users will be asked to install the application on the machine/computer.

Output/Result: Survey results should indicate that the installation was easy to follow for MIN\_USER\_ACCEPT\_RATE of the users.

How test will be performed: Test will be performed by the user. User will be given a survey including a question where 5 indicates easy to use, straightforward, and 1 indicating confusing, and/or difficult. If MIN\_USER\_ACCEPT\_RATE of users respond with 5, the test will be considered a pass.

#### **4.2.5 Maintainability/Support Test**

NF-MT1. Type: Static & Manual

Initial State: A machine/computer that does not have the application installed.

Input/Condition: Application will be installed on the device and connected to the required measurement devices.

Output/Result: The application is able to operate smoothly without error with the connected measuring devices.

How test will be performed: Test will be performed by a developer installing the application onto a lab computer running Windows 10.

#### **4.2.6 Security Test**

NF-ST1. Type: Static & Manual

Initial State: Application is opened and ready to use.

Input/Condition: User will attempt to enter or modify data/parameters that they currently do not have permission for.

Output/Result: Application will display a message informing the user that they do not have permission.

How test will be performed: Test will be performed by users with missing permissions, or a test account by a developer.

NF-ST2. Type: Static & Manual

Initial State: Application is opened and ready to use.

Input/Condition: User will be asked to change protected/hidden settings given the appropriate permissions.

Output/Result: The changes are accepted and saved by the application. Settings are also accurately reflected on the application's interface.

How test will be performed: Test will be performed by users who have been granted permission to access these settings, or test account by a developer.

#### **4.2.7 Cultural Test**

NF-CT1. Type: Static & Manual

Initial State: Application is opened and ready to use.

Input/Condition: Users will explore the application through a demo/test account.

Output/Result: Survey result will indicate MIN\_USER\_ACCEPT\_RATE of users agree or strongly agree application is appropriate.

How test will be performed: Test will be performed by the user.

They will receive a survey with a question. If MIN\_USER\_ACCEPT\_RATE of users indicate agree or strongly agree that application is appropriate, then it will be considered successful. (Refer to Appendix for Sample Survey)

#### **4.2.8 Health and Safety Test**

NF-HT1. Type: Static & Manual

Initial State: Application is opened and ready to use.

Input/Condition: Users will explore the application through a demo/test account.

Output/Result: Survey result will indicate MIN\_USER\_ACCEPT\_RATE of users agree or strongly agree application does not cause/pose any noticeable health concerns.

How test will be performed: Test will be performed by the user.

They will receive a survey with a question. If MIN\_USER\_ACCEPT\_RATE of users indicate agree or strongly agree that application is free from health and safety concerns, then it will be considered successful. (Refer to Appendix for Sample Survey).

### 4.3 Traceability Between Test Cases and Requirements

Table 3: Requirements Traceability

| Requirements | Tests               |
|--------------|---------------------|
| FR1          | FR-T1, FR-T2, FR-T3 |
| FR2          | FR-T4               |
| FR3          | FR-T5               |
| FR4          | FR-T6               |
| FR5          | FR-T7               |
| NFR-L1       | NF-AT1              |
| NFR-L2       | NF-AT2              |
| NFR-U1       | NF-UT1              |
| NFR-U2       | NF-UT2              |
| NFR-U3       | NF-UT3              |
| NFR-U4       | NF-UT4              |
| NFR-U5       | NF-UT5              |
| NFR-U6       | NF-UT6              |
| NFR-P1       | NF-PT1              |
| NFR-P2       | NF-PT2              |
| NFR-P3       | NF-PT3              |
| NFR-P4       | NF-PT4              |
| NFR-O1       | NF-OT1              |
| NFR-O2       | NF-OT2              |
| NFR-O3       | N/A                 |
| NFR-M1       | N/A                 |
| NFR-M2       | NF-MT1              |
| NFR-M3       | NF-MT1              |
| NFR-S1       | NF-ST1              |

| <b>Requirements</b> | <b>Tests</b> |
|---------------------|--------------|
| NFR-S2              | NF-ST2       |
| NFR-C1              | NF-CT1       |
| NFR-H1              | NF-HT1       |
| NFR-H2              | NF-HT1       |
| NFR-I1              | NF-MT1       |

## 5 Unit Test Description

[Reference your MIS and explain your overall philosophy for test case selection. —SS] [This section should not be filled in until after the MIS has been completed. —SS]

### 5.1 Unit Testing Scope

[What modules are outside of the scope. If there are modules that are developed by someone else, then you would say here if you aren't planning on verifying them. There may also be modules that are part of your software, but have a lower priority for verification than others. If this is the case, explain your rationale for the ranking of module importance. —SS]

### 5.2 Tests for Functional Requirements

[Most of the verification will be through automated unit testing. If appropriate specific modules can be verified by a non-testing based technique. That can also be documented in this section. —SS]

#### 5.2.1 Module 1

[Include a blurb here to explain why the subsections below cover the module. References to the MIS would be good. You will want tests from a black box perspective and from a white box perspective. Explain to the reader how the tests were selected. —SS]

1. test-id1

Type: [Functional, Dynamic, Manual, Automatic, Static etc. Most will be automatic —SS]

Initial State:

Input:

Output: [The expected result for the given inputs —SS]

Test Case Derivation: [Justify the expected value given in the Output field —SS]

How test will be performed:

2. test-id2

Type: [Functional, Dynamic, Manual, Automatic, Static etc. Most will be automatic —SS]

Initial State:

Input:

Output: [The expected result for the given inputs —SS]

Test Case Derivation: [Justify the expected value given in the Output field —SS]

How test will be performed:

3. ...

## 5.2.2 Module 2

...

## 5.3 Tests for Nonfunctional Requirements

[If there is a module that needs to be independently assessed for performance, those test cases can go here. In some projects, planning for nonfunctional tests of units will not be that relevant. —SS]

[These tests may involve collecting performance data from previously mentioned functional tests. —SS]

### 5.3.1 Module ?

1. test-id1

Type: [Functional, Dynamic, Manual, Automatic, Static etc. Most will be automatic —SS]

Initial State:

Input/Condition:

Output/Result:

How test will be performed:

2. test-id2

Type: Functional, Dynamic, Manual, Static etc.

Initial State:

Input:

Output:

How test will be performed:

### 5.3.2 Module ?

...

## 5.4 Traceability Between Test Cases and Modules

[Provide evidence that all of the modules have been considered. —SS]

## References

Author Author. System requirements specification. <https://github.com/...>, 2019.



## **6 Appendix**

This is where you can place additional information.

### **6.1 Symbolic Parameters**

The definition of the test cases will call for `SYMBOLIC_CONSTANTS`. Their values are defined in this section for easy maintenance.

## 6.2 Survey Questions

UserExperienceSurvey

How easy was the system to use with no additional instruction?



How would you rate the installation of the application in terms of simplicity?



The graphics and wording are culturally and visually appropriate.

☐ Strongly agree

☐ Agree

☐ Neither agree nor disagree

☐ Disagree

☐ Strongly disagree

In your opinion the application cause/pose any health concerns or risks?

☐ Strongly agree

☐ Agree

☐ Neither agree nor disagree

☐ Disagree

☐ Strongly disagree

How would you rate the graphical interface in terms of organization, usage of space and visual appeal?



Were you aware of how the calculations were being done when the data was being displayed?

☐ Yes

☐ No

## Appendix — Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Lifelong Learning. Please answer the following questions:

- 1.
- 2.