

# Interactive Visualisation of National Student Survey Data

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**Abstract** – The National Student Survey (NSS) is an annual survey published to assist higher education institutions in evaluating teaching performance and student satisfaction. To ensure that the raw result data could be presented in a digestible format, one of the most effective ways would be through data visualisation. However, although two solutions (namely the official NSS dashboard and university NSS spreadsheet) have been developed throughout the year, less is known about their strengths and weaknesses in addressing decision-makers specific needs and how could they be further improved. A user design approach (UCD) approach accompanied by case study interviews and software engineering was applied to investigate the strength and weakness of the existing NSS visualisation solutions and capture the data and functionality desired by the users. The study revealed that although the existing NSS visualisation solutions are straightforward and has a great usage in colour coding, it still could be relatively slow and overwhelming. The study has also found that the existing NSS visualisation solutions could be improved through the implementation of user preferred NSS data visualisations, comparative analysis view and more. Based on these findings, a new NSS dashboard alongside with an Extract, Transform, Load (ETL) approach data integration system was developed to improve user's ability to analyse NSS insights. The new dashboard has evidenced the effectiveness of UCD approach in ensuring the development of an insightful and user-centred interactive dashboard considering the positive perception received from the user acceptance test and ability to capture the new dashboard's limitations concerning the overall visual presentation and inefficiency in the data integration system from a user perspective. Hence, to ensure the new NSS dashboard could remain insightful and user-centred, it was recommended that future work could not only addresses the current limitations found in the new NSS dashboard but also compare the UCD approach against alternative user-centred approach in the upcoming future.

**Index Terms** – National Student Survey (NSS), Data Visualisation, User-Centred Design (UCD), Dashboard

## 1. INTRODUCTION

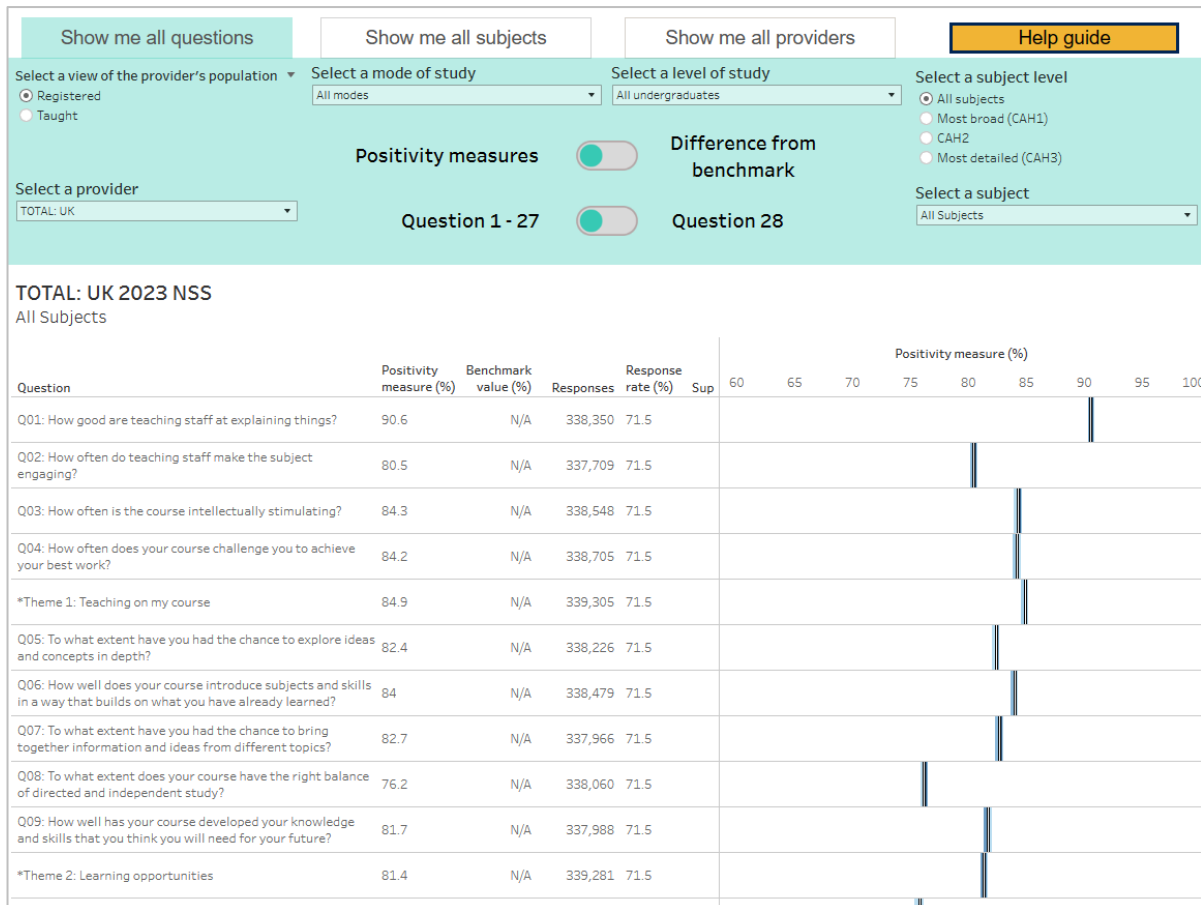
The National Student Survey (NSS) is an annual survey commissioned by the Office for Students (OfS) that has been conducted in the United Kingdom (UK) since 2005. It is a UK-specific initiative that invites students from all publicly funded

Higher Education universities or colleges located in England, Scotland, Wales, and Northern Ireland. Over the years, the NSS has seen significant growth in participation with approximately 446 academic providers (universities and colleges) who has been actively engaging with the survey. Furthermore, the NSS have also encompasses over 203 unique subject areas (which includes but not limited to medical science, physics and computer science) offered by the participating academic providers to provide students across various subject areas an opportunity to express their opinions based on the overall course satisfaction and study experience.


The NSS survey consists of 27 core questions (Appendix A) that has been categorised into 7 unique themes, including: the teaching on the course, learning opportunities, assessment and feedback, academic support, organisation and management, learning resources, and student voice, where the students were requested to rate their overall satisfaction based on a 4-point Likert scale, ranging from 1=Not at all well to 4=Very well. Annually, the NSS result was published and visualised on the OfS website to serve as a key element for wider regulatory landscape and quality assurance to benefit higher education institution in evaluating their teaching performance while also understanding student satisfaction [1].

Effective data visualisation portrays a significant role in interpreting and delivering beneficial insights from the vast amount of data collected through the NSS. By visualising raw data in a series of visual representation such as a bar chart or pie chart, decision-makers would be provided with an intuitive way to effortlessly analyse the trends and patterns [2] retains in the NSS data and make appropriate instantaneous decision to potentially enhance overall student experience and satisfaction. Over the years, two solutions have been implemented to visualise and aid decision-makers in interacting with the NSS data:

**Official NSS dashboard:** The official dashboard by OfS [3] visualises data in both numerical format and shaded bar graph (Figure 1). Their dashboard primarily focuses on visualising data, including:



**Fig 1: Official NSS Dashboard by the OfS**

NSS 2023 Subject Level Quartiles Performance Report (CAH3) - Positivity Scores and Ranks															
Teaching on my Course Group Performance															
Subjects (CAH3)	The teaching on my course			1. How good are teaching staff at explaining things?			2. How often do teaching staff make the subject engaging?			3. How often is the course intellectually stimulating?			4. How often does your course challenge you to achieve your best work?		
	% Positive	Rank	% Rank	% Positive	Rank	% Rank	% Positive	Rank	% Rank	% Positive	Rank	% Rank	% Positive	Rank	% Rank
ADSS															
American and Australasian studies	100.0	1	100%	100.0	1	56%	100.0	1	89%	100.0	1	89%	100.0	1	89%
Cinematics and photography	79.9	58	28%	87.7	57	29%	77.8	56	30%	70.4	57	29%	84.0	39	52%
Design studies	86.6	44	46%	85.1	68	16%	86.6	40	51%	88.1	17	80%	86.6	57	30%
English language	89.6	21	47%	100.0	1	68%	72.0	79	2%	100.0	1	82%	83.3	21	47%
History	91.7	45	50%	93.9	63	30%	93.9	29	68%	90.4	63	30%	88.6	39	57%
Journalism	76.0	46	12%	88.5	42	20%	69.2	46	12%	69.2	43	18%	76.9	46	10%
Literature in English	90.8	32	48%	93.1	48	20%	90.8	31	50%	85.7	37	40%	83.7	15	73%
Media studies	82.8	53	42%	89.2	17	92%	82.4	46	50%	74.3	68	26%	77.0	63	21%
Politics	89.0	26	68%	90.0	65	16%	90.0	20	75%	92.0	24	71%	84.0	26	68%
Sociology	67.9	102	1%	76.2	102	1%	65.0	99	4%	59.8	102	1%	70.4	96	7%
BL															
Accounting	93.4	14	87%	86.6	15	86%	93.1	7	94%	89.7	23	78%	86.2	39	60%
Business and management (non-specific)	76.0	42	29%	82.0	49	17%	70.6	40	33%	73.2	34	43%	78.0	38	36%
Business studies	83.6	16	84%	95.7	19	81%	87.7	15	85%	84.7	22	77%	90.2	16	84%
Finance	82.6	52	43%	93.9	32	64%	81.8	30	67%	72.7	80	11%	81.8	58	35%
Human resource management	74.1	81	2%	90.0	75	33%	69.8	32	10%	65.0	39	5%	87.5	16	82%
Law	87.9	33	71%	95.3	16	86%	79.0	51	53%	87.8	47	58%	90.0	22	81%
Management studies	60.6	77	0%	65.4	79	3%	57.7	75	3%	61.5	75	3%	57.7	77	0%
Marketing	74.4	76	17%	81.6	76	17%	69.7	71	22%	67.1	72	21%	80.6	52	43%
Tourism, transport and travel	72.7	54	9%	90.9	42	23%	81.8	33	34%	54.6	58	0%	63.6	56	5%
EE															
Architecture	91.6	23	62%	94.6	18	71%	84.8	38	36%	92.4	19	69%	94.6	17	72%
Astronomy	93.2	8	79%	90.9	20	39%	90.3	5	85%	100.0	1	67%	90.9	15	58%
Building	81.4	19	49%	89.2	18	51%	78.4	14	60%	79.4	14	63%	78.4	26	29%
Civil engineering	87.9	20	68%	92.1	7	90%	80.0	22	64%	85.7	28	54%	88.6	25	59%
Computer science	86.1	20	82%	94.1	12	90%	80.0	18	83%	83.7	45	58%	84.4	15	87%
Electrical and electronic engineering	81.5	32	54%	90.3	25	65%	77.4	18	75%	83.9	33	51%	74.2	57	10%
Environmental sciences	88.9	18	47%	98.1	15	56%	80.4	8	78%	78.9	26	72%	88.0	13	63%
Human geography	97.6	1	100%	100.0	1	76%	95.2	6	88%	95.2	4	90%	100.0	1	100%
Information systems	97.4	1	100%	100.0	1	67%	100.0	1	92%	94.7	2	92%	94.7	2	92%
Mathematics	86.4	24	64%	90.9	36	44%	81.8	13	81%	81.8	57	13%	90.9	17	73%
Mechanical engineering	64.4	68	7%	72.0	69	6%	46.3	70	0%	72.0	55	25%	68.8	71	3%
Physical geographical sciences	83.9	28	36%	92.9	31	29%	78.6	33	21%	78.6	35	19%	85.7	19	57%
Physics	84.0	34	25%	82.2	41	9%	82.2	20	57%	89.3	39	14%	82.2	37	18%
Production and manufacturing engineering	67.1	33	9%	84.2	25	31%	52.6	33	9%	62.4	34	6%	63.2	35	3%
Software engineering	82.7	18	69%	87.2	28	53%	79.5	15	76%	84.6	21	62%	79.5	41	31%
HLs															
Adult nursing	77.8	51	33%	86.1	41	47%	73.4	51	33%	71.4	64	16%	80.2	53	31%
Biology (non-specific)	69.8	46	2%	73.2	45	4%	62.5	45	4%	62.5	47	0%	75.0	41	13%
Biomedical sciences (non-specific)	85.3	36	50%	82.5	55	31%	73.9	46	40%	67.5	47	45%	92.9	13	86%
Chemistry	88.6	28	49%	90.9	37	32%	50.9	10	83%	81.8	49	9%	90.9	23	58%
Children's nursing	100.0	1	100%	100.0	1	90%	100.0	1	94%	100.0	1	96%	100.0	1	90%
Counselling, psychotherapy and occupational therapy	76.4	40	19%	78.2	53	12%	70.3	46	24%	80.0	40	34%	76.4	46	24%
Forensic and archaeological sciences	84.5	30	25%	82.8	37	12%	81.0	25	41%	83.5	28	34%	86.1	24	44%
Health sciences (non-specific)	100.0	1	99%	100.0	1	82%	100.0	1	97%	100.0	1	97%	100.0	1	94%
Learning disabilities nursing	100.0	1	100%	100.0	1	67%	100.0	1	83%	100.0	1	89%	100.0	1	78%
Mental health nursing	89.9	22	69%	93.6	20	72%	87.1	26	63%	85.5	27	62%	93.6	10	67%
Midwifery	92.5	50	9%	92.5	52	6%	77.6	38	30%	82.4	52	6%	81.6	41	26%
Nutrition and dietetics	94.6	4	93%	100.0	1	85%	85.7	16	61%	100.0	1	90%	92.9	8	83%
Physiotherapy	89.7	19	61%	91.1	25	48%	87.5	19	61%	87.5	22	54%	92.9	13	74%
Psychology (non-specific)	82.5	74	35%	91.2	67	41%	76.5	69	39%	81.8	80	29%	80.6	65	43%
Social work	89.5	37	55%	86.7	60	26%	91.8	24	71%	89.8	35	58%	89.8	25	58%
Sport and exercise sciences	86.5	57	33%	94.2	48	43%	83.8	56	34%	83.8	56	34%	85.0	57	33%
Teacher training	85.2	28	51%	93.0	28	53%	76.1	38	35%	81.7	30	49%	90.1	19	68%

**Fig 2: Example University NSS Spreadsheet by Northumbria University**

- **Positive Measures:** An aggregated value of responses with a positive answer between 3=Well to 4=Very Well.
- **Benchmark Score:** A value that were used to compares academic providers' performance against external factors such as mode of study, subject of study, level of study, sex, disability, age, and ethnicity.
- **Response Rate:** A value that indicates the rate of responds for a specific question.

**University NSS spreadsheet:** In contrast with the official NSS dashboard, the current NSS spreadsheet created and used by Northumbria University primarily focuses on visualising data concerning positivity measures (Figure 2). However, the spreadsheet has also visualised additional data that were not made available in the official NSS dashboard, including:

- **Times Rank:** A ranking value (available in both absolute and percentage) used by the university to evaluate each questions' performance rank among the 131 providers included in the Times Good University Guide. The Times Rank is provided in two available formats: absolute value (the numerical position among 131 providers) and percentage value (the rank expressed as a proportion of the total providers).
- **Quartile Performance:** A colour coding technique used to categorise each questions' Times rank performance into four quartiles (Q1-4). For illustration, a specific question that had achieved a Times rank percentage between 75% to 100% will be colour coded as green, indicating they are at a top quartile (Q1). Conversely, a Times rank percentage between 0 to 23% will be colour coded as red, indicating that they are at the lowest quartile (Q4).

Nevertheless, although there has been existing NSS visualisation solutions (both official dashboard and university spreadsheet) towards visualising the NSS data, it is considered valuable to conduct an exploratory study on their strengths and weaknesses from a user-centred point of view, while also investigate whether these solutions have certainly met with specific user needs and how could they be further improved. Henceforth, by considering the identified

gaps, the following research aim and objectives have been established:

*“To develop an interactive dashboard for visualising National Student Survey data using a user-centred design approach”*

**RO1:** To explore the strength and weakness of the existing NSS visualisation solutions from a user-centred perspective.

**RO2:** To capture university staff's preferences for NSS data visualisation and desired functionality to improve the existing NSS visualisation solutions.

**RO3:** To develop an insightful and user-centred interactive dashboard for visualising NSS data.

**RO4:** To conceptualise a data integration system for integrating new annual NSS data.

However, it is crucial to note that the research objectives (RO1-4) have been refined since the initial research proposal review to better align with the user-centred approach of the research aim. The current refinement reflects a shift towards a structured approach by employing research objectives instead of research questions to ensure a clearer roadmap working towards the main research aim.

The dissertation has been structured into eight sections. The second section features the literature review section where it will discuss relevant literatures concerning existing studies on NSS, data visualisation, interactive dashboards, user-centred design, and data integration. Subsequently, the third section features the methodology section where research approach, dataset, tool, and techniques selected for the study were introduced, alongside with a brief discussion of the ethical consideration. The fourth section featured the results and analysis from the conducted interview including the introduction of the identified themes and their interpretations on the strength and weakness of the existing NSS visualisation solutions and functional requirements. The fifth section delved into the technical development where the use case documentation, new NSS dashboard and types of applied visualisations method will be introduced. The sixth section features the functionality test and user acceptance test results and analysis, which follows by discussion and conclusion.

Nevertheless, although modern technology advancement has resulted in variation of visualisation techniques, Helfman and Goldberg [12] has highlighted the potential challenge towards the appropriate choices of visualisation techniques as it can heavily varies depending on the visualising data type. For example, in the context of NSS data, a labelled bar chart could be employed to visualise and compare the responses towards the 4-point Likert scale based on the student overall satisfaction, while a line chart could be employed to compare positivity measure between two or more academic providers. However, it was revealed that data visualisation can also go beyond the variations between shape, length, and sizes as Lonsdale and David [13] discussed that appropriate colour usage in data visualisation can also enhance readability and perceptual effectiveness. For example, the employment of doughnut chart with

appropriate colour palette could be used to categorise the proportion of response rate for each NSS questions.

The findings are significantly relevant towards the proposed study considering it has aligned with the broader challenge retained in data visualisation and it has evidenced that there are certainly no one-size-fits-all solutions when it comes to visualisation technique. In the context of NSS data, the challenge is intensified by its quantitative characteristics (e.g., 4-point Likert scale responses). While the sentiment bar chart and word cloud has shown an exceptional effectiveness in visualising qualitative results (e.g., student comment), they might not be compatible in capturing numerical responses retained in the NSS data. Thus, this has highlighted the need for selecting an appropriate data visualisation technique to effectively deliver insights and digesting complex NSS datasets during the development of the new dashboard.

### 2.3 Interactive Dashboard

An interactive dashboard could be considered as one of the most applied tools for data visualisation. Many dashboards have been developed over the decade to provide an engaging way to visualise and interpret data. For example, Azevedo et al. [14] developed an interactive dashboard for visualising key performance indicators (KPI) data for Higher Education Institution (HEI). Their interactive dashboard was capable of breaking down heavy information into digestible statistical chart, including geographical map, pie chart and more to support HEI manager in accelerating decision-making process and improves overall time efficiency. However, although their developed dashboard has presented a wide ranges of data visualisations method, the usage goal of the specific dashboard remains unclear.

This was considered critical as existing literature has revealed that thorough planning on an appropriate dashboard usage goal should be prioritised before the development of a proposed dashboard to ensure that it reflects and aligns with the type of data and potential user needs [15]. According to Sarikaya et al. [16], some of the most common dashboard usage goal includes operational and strategic:

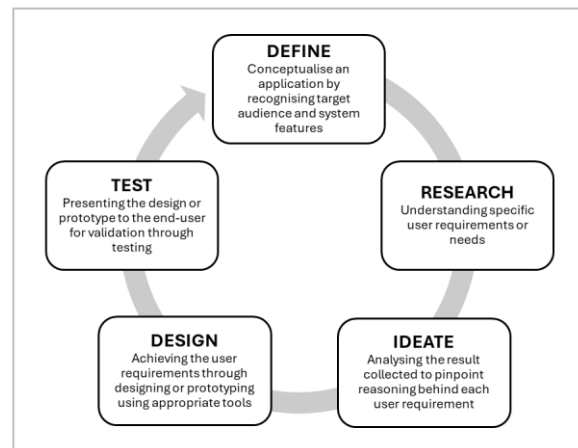
**Operational Dashboard:** The operational dashboard primarily focus on communicating and presenting real-time data which significantly allow users to monitor ever-changing phenomena or values,

such as temperature or moisture level, and make immediate decisions based on their needs [17].

**Strategic Dashboard:** The strategic dashboard primarily designed and focused on high-level data and long-term data, such as historical trends or key performance indicators (KPI), that would effectively provide insights into overall long-term performance and progression, allowing users to formulate informed decisions [18].

The finding was significantly valuable towards the progression of the proposed study considering it has significantly advised the researcher about the criticalness of considering an appropriate dashboard usage goal by taking considerations into the type of data to be visualised. In relation to visualising NSS data, it was revealed operational dashboard may not be the most optimal choice considering the NSS data's incapacibilities in providing real-time insights. Conversely, strategic dashboard design may be more suitable for appropriately visualising NSS data due to its great capability in handling long-term annual trends data. This has significantly highlighted the necessity in considering strategic dashboard usage goal in the proposed study to effectively visualises NSS insights.

### 2.4 User-Centred Design



**Fig. 5.** User-Centred Design Procedure

Before the development process could be considered, it is crucial to acknowledge that the NSS data has been designed to be majorly used or analysed by student or academic decision makers. In recognition of the user-focused orientation and research aim of the proposed study, the adaptation of a user-centred visualisation design has become apparent to ensure that an insightful and user-centred data

visualisation dashboard could be presented towards the potential users. As described by Goel et al. [19], the user-centred design (UCD) is a software design approach that were typically divided into 5 unique repetitive phases in which could be revisited over multiple iteration (Figure 5), to ensure that the developed software has accurately aligned with users requirements and satisfaction.

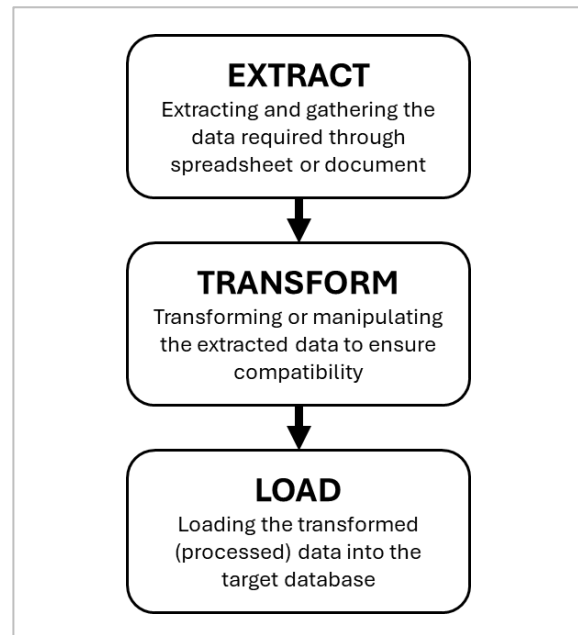
Despite UCD's nature in enhancing overall system usability and user-friendliness, recent literature has significantly highlighted the application of elicitation exercises into existing UCD process. For example, Schmidt et al. [20] emphasise the integration of ethnographic interview in gathering information regarding their targeted user and requirement using a set of open-ended questions that were not leading. Alternatively, Faisal et al. [21] gather and establish functional requirements for the proposed Learning Management System (LMS) through a series of survey questionnaire. And finally, Ahmed et al. [22] emphasised the effectiveness of integrating semi-structured focus group as a method for capturing and understanding end user's need and thoughts.

As evident in the cited study above, it has shown that elicitation exercise has certainly been applied in UCD approaches to potentially capture user needs and thoughts efficiently. However, although their specific reason behind the selection of elicitation technique is unclear, the finding has still effectively highlighted the value of incorporating elicitation exercises throughout the UCD approach to not only capture user preferences but also ensuring user participation throughout the proposed study. This finding would be beneficial towards the achieving the preliminary research aim by ensuring the proposed new NSS dashboard could be developed with a maximised user-focused orientation, which also potentially enhance user experience.

## 2.5 Data Integration

The annual exponential growth of data such as the NSS has resulted in academic institution requiring an extensive data integration mechanisms for maintaining the relevance and timeliness of the data to understand and address student volatile changes in preferences and needs [23]. However, it was revealed that data integration has certainly posed challenge concerning data inconsistency. Merieme et al. [24] revealed that existing data integration mechanisms are potentially vulnerable to data inconsistencies due to the variation of data origins. For example, an existing and new data that expressing identical data could

potentially have different data scheme, specifically in variation of data type.



**Fig. 6.** ETL Data Integration Approach

Arputhamary and Arockiam [25] addressed the highlighted challenge by investigating the Extract-Transform-Load (ETL) approach where data would undergo data transformation and manipulation to ensure compatibility before it could be loaded (Figure 6). However, Sivabalan and Minu [26] discovered that ETL retains performance and cost issue concerning its high configuration characteristic in performing data transformation, making ETL significantly challenging at handling high veracity and velocity data source. Consequently, their study has proposed an alternative approach, Extract-Load-Transform (ELT) with Analytical Massively Parallel Processing (MPP) approach where it eliminates the extensive processing resources by splitting data transformation processes into multiple cloud processors (nodes).

The finding has added significant value towards understanding the options available for data integration and their potential trade-offs. For example, although ELT might appears as a better approach over ETL, it is essential to note that its reliance on cloud service could potentially leads to availability issue [27]. Thus, it has become apparent that thorough considerations are essential when deciding between data integration approach such as ETL or ELT for integrating NSS data.

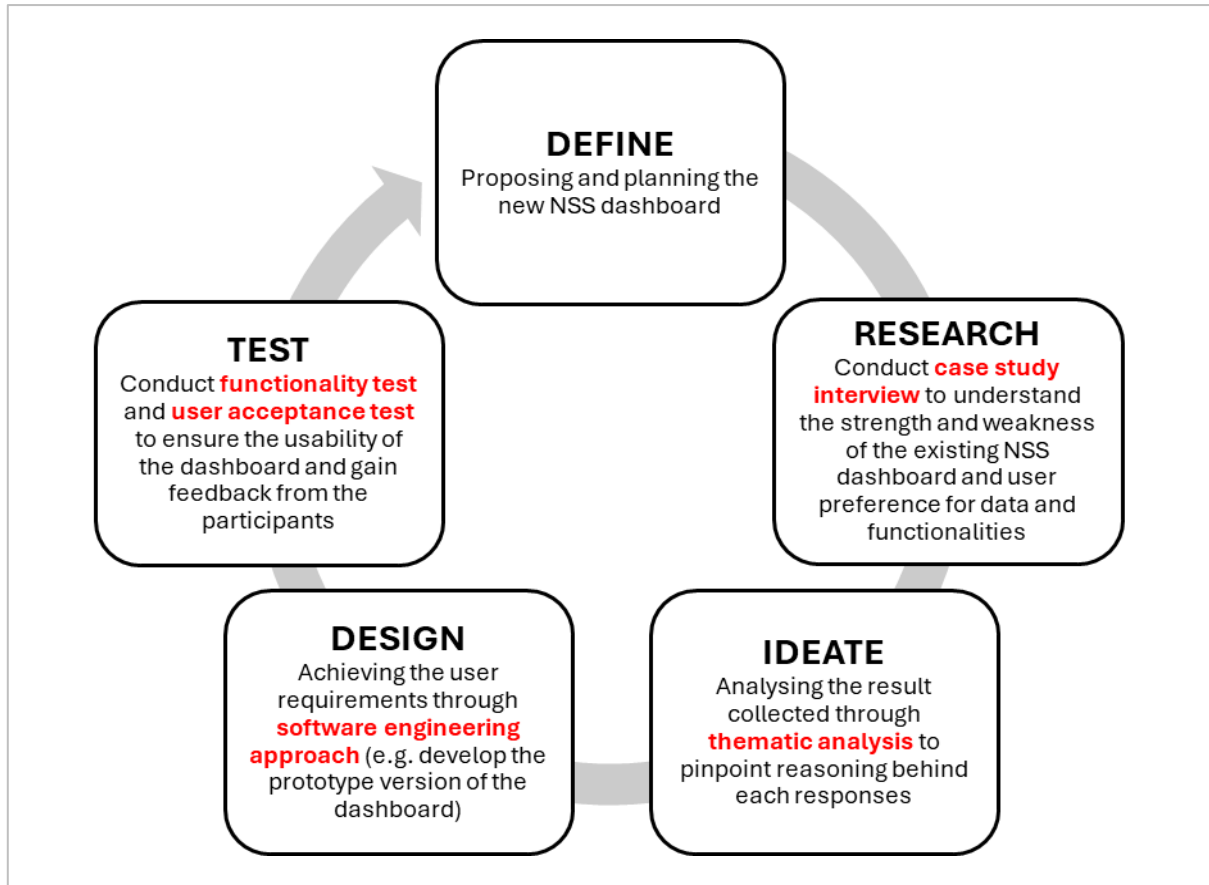


Fig. 7. The proposed study's UCD Procedure and Descriptions

### 3. METHODOLOGY

#### 3.1 Research Approach

Figure 7 above provided an overview of the study procedure constructed based on the 5-phase UCD discussed in section 2.4. To achieve the proposed study's preliminary research aim and objectives, the proposed study will be following a UCD approach accompanied by mixed-method approach that combines both case study and software engineering:

**Case Study:** In alignment of RO1 and 2, a case study approach has been selected to investigate and explore the strengths and weaknesses of the existing NSS visualisation solutions and capture university staff's preferences for NSS data visualisation and desired functionality in a modern context through the usage of appropriate elicitation exercise, such as interview [28].

**Software Engineering:** In alignment of RO3 and 4, a software engineering approach has been selected to build an interactive dashboard for visualising NSS

data through designing, developing, and testing a solution using appropriate tools and technique to significantly contribute towards social good in terms of resolving complex data readability and enhance time efficiency [29].

#### 3.2 Dataset

N	PROVIDER	MODE	OF	LEVEL	OF	SUBJECT	CAH	CODICAH	NAM	QUESTION	NUMBER	_NUMBER	SUPPRESS	OPTION1
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q01		67	97.7		10
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q02		67	97.7		10
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q03		66	97.7		15.33
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q04		67	97.7		13
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q05		67	97.7		12.66
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q06		67	97.7		20.99
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q07		66	97.7		17.66
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q08		67	97.7		23.66
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q09		67	97.7		18.33
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q10		67	97.7		20.33
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q11		67	97.7		15.33
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q12		66	97.7		14.33
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q13		66	97.7		23.99
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q14		67	97.7		13
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q15		67	97.7		26.66
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q16		66	97.7		13.66
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q17		67	97.7		12.33
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q18		66	97.7		13.33
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q19		66	97.7		20.66
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q20		62	97.7		27.66
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q21		66	97.7		20.99
1282	University	All	modes	All	underg	CAH3	CAH11-01	Computer	Q22		66	97.7		20.99

Fig 8. Part of NSS 2023 Result Data

The dataset that will be visualised in the new dashboard comprises of survey result collected by the



NSS in 2023. It is a CSV file that consists of 4,096,311 rows of data where each row represents the collected results from different subject areas and providers. As introduced in an earlier section, the chosen dataset covers a wide spectrum of subject areas from 446 academic providers. Additionally, the chosen dataset also contains 73 unique columns where each column represents specific variable that was used and analysed by the academic providers to assess their performance and identify areas for improvement. For a more detailed description of each column retained within the dataset, a data dictionary has been provided in Appendix B.

However, it is crucial to note that the proposed study has rejected the idea of using the entire dataset and decided to only focus on data concerning the computer science subject area. The decision made to narrow the data to computer science was primarily driven by concerns regarding the original data size and the given study time constraint. It was considered that due to the expansive nature of the dataset to incorporate diverse academic providers and courses, including the entire data set might posed significant challenges towards data load time and data storage. Subsequently, the provided timeframe towards the study has necessitated significant focused approaches to ensure that a timely completion of the study. Hence, the study has aimed to maintain a manageable data size by limiting to the usage of only NSS computer science data, thereby shifting focus to building an insightful interactive dashboard within the available timeframe.

### **3.3 Tools and Techniques**

#### **3.3.1 Data Gathering**

In alignment with the case study research approach proposed in section 3.1, a qualitative elicitation study has been considered. During the ‘Research’ phase of the study, an interview will be conducted among participants who has met the following criteria:

- Over the age of 18
- Currently a Northumbria University staff member

The proposed interview would be conducted in a semi-structured method where participants would be prompted with several open-ended questions. In alignment with RO1, the interview participants will be asked to share their experience with the NSS data and thoughts (specifically in strengths and weaknesses) on the existing NSS visualisation solutions that has been introduced in Figure 1 and 2. In alignment with RO2,

the participants will also be requested to share their preferences for NSS data and desired functionality that should be visualised and integrated in the new NSS dashboard.

#### **3.3.2 Data Analysis**

The audio data collected from the interview would be transcribed and analysed using a thematic analysis approach during the ‘Ideate’ phase. Thematic analysis, as described by Castleberry and Nolen [30], involves a systematic process in converting raw data into an usable format through a series of coding. Coding is a crucial aspect of the selected analysis method, due to its unique characteristic in data familiarisation where it allow researchers to understand the meaning behind the collected data through comparisons between each segmented code. The proposed data analysis method is valuable in the proposed study as it significantly allows the capture of deeper insight into participants’ thoughts about the existing NSS visualisation solutions and their preferences.

#### **3.3.3 Dashboard Frontend Development Tool**

In alignment with software engineering approach, the frontend interface of the new NSS dashboard would be developed using ReactJS during the ‘Design’ phase. The decision could be justified by considering factors including the framework’s component-based architecture, which it could significantly reduce development time and improve code cleanliness by allowing developers to reuse manageable and scalable UI components [31]. In addition to development time, given the limited study timeframe, ReactJS appears as an optimal option due to its efficiency in rapid development and strong community support. While there are a variety of similar frontend libraries such as NextJS, they were rejected and not considered in the research due to its significantly sharp learning curve and comparatively limited ecosystem and community support. Compared to NextJS, it was evidenced that ReactJS does offers various open-source plugins and libraries that has significantly enhance development efficiency and allow rapid integration with external application programming interfaces (API) [32].

#### **3.3.4 Dashboard Backend (API) Development Tool**

The nature of the new NSS dashboard has emerged the requirement for backend API development to perform data transaction between frontend interface and database. In alignment to the identified



requirement, the backend APIs would be developed using PHP and Python respectively. PHP was primarily selected due to significant compatibility issue with the university hosting server. As the university's server environment heavily leverage around JavaScript and PHP-based applications, the selection of building an API using PHP would not only express compatibility but also ensures that it could effectively facilitates integration with university local database server. Additionally, in alignment with RO4, particularly on integrating NSS data in the future, Python has been selected as an exceptional candidate for addressing specific data processing needs by utilising the Apache Spark library to handle large file and perform data transformation before uploading into the database.

### 3.3.5 Data Hosting

Given the default dataset structure being CSV file, it is relatively vital to consider a data hosting tool to ensure continuous data storage and transmission of the data. Two data hosting tools: MariaDB and MongoDB has been considered in the study to host and store the NSS dataset. It was decided that MariaDB would be employed in the study due to several factors including author's familiarities with the tool and its capabilities in handling complex data retrieval and management request using structured query language (SQL) [33]. Alternatively, although MongoDB has an excellent supportability and scalability in handling fast-growing unstructured data, the idea to employ MongoDB was rejected and not considered from the proposed study primarily due to cost constraints. While MongoDB does offer a freemium option that has significantly limited resources, the availability of MariaDB through the university's hosting server has significantly eliminated any additional cost associated concerning licensing fees, which makes MariaDB the most ideal choice for the proposed study.

### 3.3.6 Testing Methodology

The 'Test' phase is notably essential in the UCD approach due to its capability in ensuring the usability and reliability of a developed system [34]. The proposed study will divide the testing phase into two parts:

**Functionality Testing:** The functionality test will be carried out by the author at the end of the 'Design' phase to validate the usability of the implemented features and ensuring that each action could be executed without any potential errors [35]. In

preparation for the test, the use case testing technique will be applied by referencing to the use-case documentation that will be discussed in a subsequent section, to accelerate test case identification and formulation procedure that leverages around the basic system workflow alongside with the expected outcomes.

**User Acceptance Testing:** A follow-up interview in a form of a user acceptance test would be conducted after the functionality test to strongly emphasises user participation in testing and ensuring that the developed dashboard has been implemented to a considerable degree that achieved user satisfaction and expectation [36]. The follow-up interview would be conducted in a relatively similar approach where the participants will be invited to interact with the newly developed NSS interactive dashboard and asked to evaluate the effectiveness of the dashboard and suggesting potential future refinements.

## 3.4 Ethical Considerations

Due to the nature of the study in collecting primary data through elicitation exercises, the study would potentially experience ethical issues surrounding professional, legal, security, social and sustainability. The issue surrounding potential data misinterpretation and misrepresentation could certainly be concerning towards the participants, thus the usage of Participant Information Sheet (PIS) and Consent Form should be considered to ensures that participants have fully acknowledged the aim and objectives of the proposed study and have provided necessary consent. In addition to this, the new NSS dashboard should also ensure that all data visualised will accurately reflect the original NSS data. To address issues concerning data privacy and confidentiality, all the participants' information should be anonymised, stored within a secured cloud storage, and be treated in accordance with the university's ethical guidelines. Finally, it is crucial to note that although the proposed study heavily circulates around the usage of NSS data, no related measures would be planned considering that the data is categorised as a public data that has been made available on a public domain.

## 4. RESEARCH AND IDEATE: INTERVIEW RESULT & ANALYSIS

### 4.1 Interview Summarisation

In alignment with section 3.3.1, an interview was conducted among 3 Northumbria University faculty members (P1-P3) who have experience in analysing and using NSS data for decision-making procedure. The interview lasted approximately 30 minutes and it comprised a series of open-ended questions asked in alignment with RO1 and 2.

In accordance with the ethical considerations discussed in section 3.4, the audio data collected was anonymised, stored in the Northumbria University OneDrive, and transcribed, before they were coded and analysed through thematic analysis approach. Through this process, a total of 14 themes (T1-T14) alongside with 7 functional requirements have been identified, as shown in Appendix C and D respectively.

### 4.2 The Strength and Weaknesses of Existing NSS visualisation solutions

Before the 'Design' phase could commenced, it is essential to explore the strengths and weaknesses of the existing NSS visualisation solutions from a user perspective to understand factors that should be retained or addressed in the new dashboard. Through the result seen in Appendix C, it was revealed in theme T2 and T3 that some participants described that the existing NSS visualisation solutions, like the university spreadsheet was their favourable option due to its straightforwardness and usage of colour-coding to serve as a visual representation in recognising the assigned quartile performance:

*"Use of colours, its good in that regard, right? It allows us to easily have a quick glance of actual performance." – P1*

However, it was shown that this was not always the case, considering that P3 has hypothetically challenged these previous points by describing her confusing experience on attempting to understand the meaning behind each acronym and colour used (T5):

*"I don't really know what those mean. And likewise, when we're talking about select the subject level, the categories. I didn't understand either, that's very confusing."*  
– P3

In addition to theme T5, T4 has also shown that some participants have shared their thoughts regarding the current weaknesses of the existing NSS visualisation solutions. For some participants, they revealed that the official dashboard could occasionally be intolerably slow especially during the launch day or peak hour due to heavy server traffic load, while some participant emphasised that both the existing NSS visualisation solutions could be too textual with fairly little to no visualisation.

*"It's not entirely clear what it's made into, I think you know, generally when we're trying to visualise effectively, its poor practise to have a huge round of text." – P1*

Interestingly, all participants have revealed that the abundant amount of data presented on both existing NSS visualisation solutions has potentially made them feel overwhelmed, which it had significantly reduced their user experience. For example, P1 has stated that:

*"It's quite tricky to use, it's not very responsive. It's hard to know if you're really looking in the right place and so just usability perspective it's not good." – P1*

### 4.3 Requested Functional Requirements

After the current strength and weakness of the existing NSS visualisation solutions have been acknowledged, it is only sensible that certain changes should be considered in the new NSS dashboard to ensure that user experience could be effectively improved. Thus, in alignment with RO2, the interview has also captured 7 functional requirements (FR1-7) from the user perspective as presented in Appendix D. Through the result seen in Appendix C, it was revealed between themes T6 to T10 that the participants have shown preference towards analysing NSS data including positivity measures, quartile performance, qualitative comments, response rate, and Times rank. Some of the responses that have led towards this observation includes:

*"It will be good to see which of the themes on my course are positive or more, how they rank in comparison with." – P3*

*"Qualitative commentary that's provided within there as well that really gives you an insight into any kind of specific areas that could influence our programme." – P2*

*“We call it quartile indicators, in quartile 1,2,3,4 where Q1 is the best quartile and record for each of those... I think what’s there is quite good.” – P1*

Subsequently, themes T11 and T12 have also revealed that the participants have expressed their preference in performing certain comparative and performance analysis through the new NSS dashboard:

*“You know obviously I want to see how we stack up against competitors.” – P2*

*“At present, there’s no way of knowing that makes, so you know if you’re in Q2, how far are you from Q1?” – P1*

Through the participants’ acknowledgement in the lack of ability towards directly conducting a performance analysis using the existing NSS visualisation solutions, the participants have suggested that the proposed dashboard should implement certain features which would allow users to effortlessly compare data between two academic providers and also rapidly identify the absolute number of positive responses required to move towards next quartile.

Interestingly, theme T13 has also revealed that some participants have shown affection towards the data filtering function included in the official NSS dashboard and suggested that it should be retained and integrated in the new NSS dashboard to ensure that the extensive number of available questions and themes could be filtered effortlessly. P2 stated that:

*“I quite like the fact that you can filter it by subjects and questions.” – P2*

Finally, theme T14 has revealed that P3 have suggested an interactive tooltip that should be considered in the new NSS dashboard to act as a solution towards a previously identified weakness (T5) and potentially aid users towards understanding the meaning behind each acronym and colour code. She stated that:

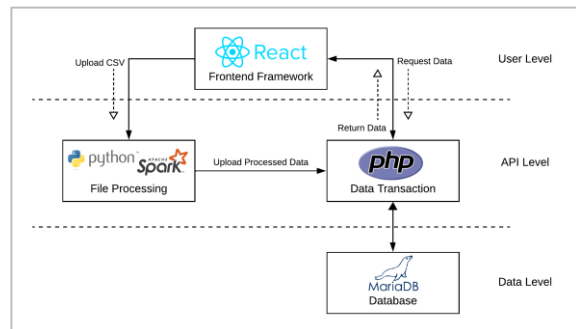
*“I think that should be some like little kind of hover over that gives you an indication.” – P3*

## 5. DESIGN: TECHNICAL DEVELOPMENT

### 5.1 Use Cases Documentation

Upon acknowledging the strength and weaknesses of existing NSS visualisation solutions and functional requirements, a use case documentation was produced to potentially outline each scenario and interactions that the users may encounter on the new NSS dashboard [37]. In the context of the use case documentation, a use case diagram that leverage around the relationship between an actor (user) and the functionalities (use cases) have been constructed alongside with a total of 11 use case descriptions to briefly describe the regular and alternative workflow towards accessing certain use cases, as shown in Appendix E(i) and E(ii) respectively.

### 5.2 New NSS Interactive Dashboard

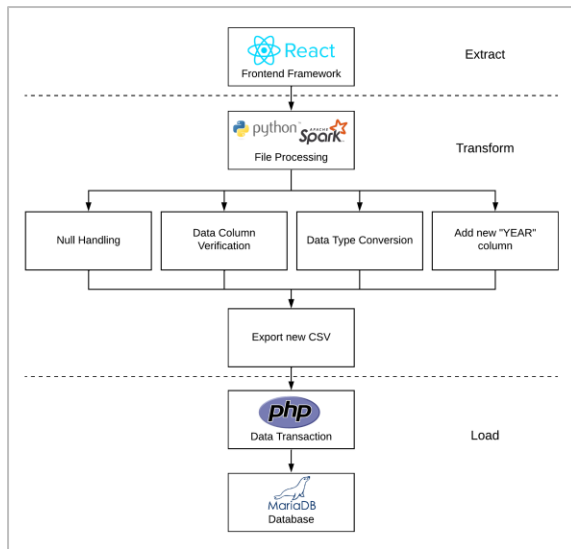


**Fig. 9.** New NSS Interactive Dashboard Architecture

By referencing to the use case documentation, a strategic interactive dashboard has been developed using the selected tools and techniques discussed in section 3.3.3 to 3.3.5. As shown in Figure 9 above, the new NSS dashboard has been designed and developed to store all the NSS data within MariaDB before it would be requested and retrieved using a backend PHP API for further visualisation at the user level.

In addition towards the developed dashboard, a series of functionalities have also been implemented in alignment with the functional requirements captured in Appendix D. A noteworthy functionality that had significantly enriched the overall analytical capabilities of the new NSS dashboard is the quartile difference functionality, where an absolute difference between each quartile was visualised to aid decision makers in identifying the absolute number of positive responses required to achieve the next quartile. The process of implementing such functionality was considerably challenging and complex due to the absence of direct “quartile difference” data column

available in the NSS dataset. In recognition of the identified limitation, the researcher has attempted in replicating the desired data by using a series of complex database query and custom algorithm to retrieve the minimum positivity measure for each quartile and calculate the absolute positive responses difference between each subsequent quartile. A flowchart of the custom algorithm could be found in Appendix F.



**Fig. 10.** Data Integration ETL Approach

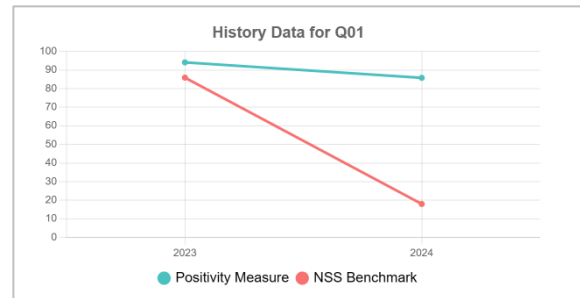
Subsequently, a data integration system has also been conceptualised in accordance with RO4 by replicating the ETL approach (Figure 10). The data integration system has been designed to allow CSV file upload through the dashboard and subsequently perform file processing through Python and Apache Spark. During transformation phase, each data column was verified and converted to ensure that they are compatible with the available data field retained in the database. Consequently, a YEAR column was added into the processed data to label the specific year of the uploaded NSS data. Finally, empty value was also appropriately handled by replacing each empty string with “NULL” before the data is loaded into the database.

### 5.3 Type of Visualisation Techniques

The new NSS dashboard has been developed to employ diverse visualisations techniques for reducing complex NSS data into a digestible format that could be easily interpreted by user in a single glance. The role of each visualisation techniques are as follows:

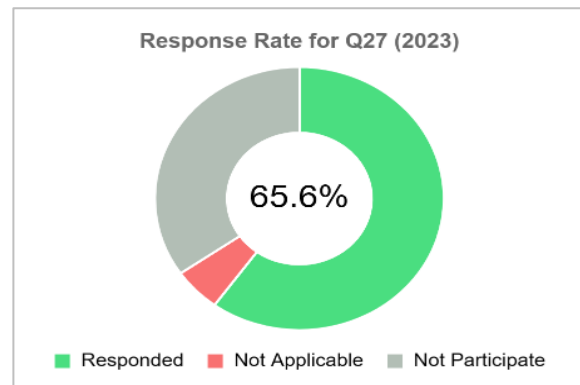


**Fig 11:** Comparative View between providers



**Fig 12.** Comparative View for Positivity Measure and NSS Benchmark between years

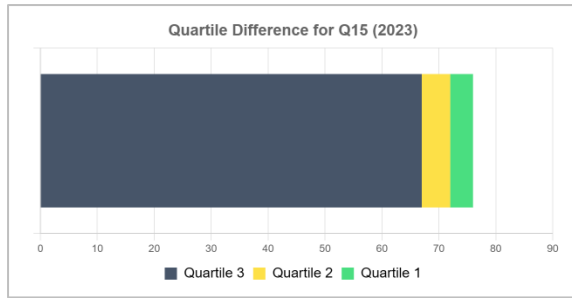
**Line Chart:** The line chart has been employed for visualising a comparative view between providers and historical data (Figure 11 and 12). In alignment with FR2 seen in Appendix D, the positivity measures and NSS benchmark data has been visualised in a series of line chart to aid decision makers in conducting comparison task or trend assessment [38].



**Fig. 13.** Response Rate for each question

**Doughnut Chart:** The doughnut chart has been employed to visualise the response rate of each question (Figure 13). The chart has been divided into three groupings, representing number of students that:

- Have responded.
- Have selected “Not Applicable”.
- Did not participate.



**Fig. 14.** Quartile Difference for each question

**Stacked Bar Chart:** The stacked bar chart has been employed for visualising the quartile differences (Figure 14) to clearly indicates the absolute number of positive responses required to achieve next quartile.



**Fig. 15.** Traffic Light Representation for Quartile Performance

TABLE I.  
TRAFFIC LIGHT COLOUR CODE

Colour Code	Times Rank (%)	Quartile
Green	75 - 100	1
Yellow	50 - 74	2
Red	24 - 49	3
Red	0 - 23	4

**Traffic Light:** The traffic light representation has been employed by referencing to the colour palette shown in Table I to colour code and indicate the quartile performance relative to Times rank (Figure 15)

## 6. TEST: TESTING RESULT & ANALYSIS

### 6.1 Functionality Test

A functionality test has been conducted to test the usability and functionality of the new NSS dashboard. As discussed in Section 3.3.6, a total of 50 test cases have been constructed and evaluated against an expected outcome. Subsequently, the actual outcome of each test cases were recorded alongside with a Pass or Fail label used to indicate if the actual outcome has certainly aligned with the expected outcome. A copy of the full functionality test result could be found in Appendix G.

TABLE II.  
FUNCTIONALITY TEST RESULT

Test Result	Iteration 1	Iteration 2
Pass	49	50
Fail	1	0
<b>TOTAL</b>	<b>50</b>	<b>50</b>

As shown in Table II above, the first iteration of the test has returned with 49 passed test cases (approximately 99%) in which it has significantly indicated the overall robustness and usability of the new NSS dashboard. However, it has also successfully identified a failed test case where the functionality related to displaying comparative view in positive measure or benchmark score was not behaving as intended. Hence, to continue ensure the usability and quality of the new NSS dashboard, the identified issue was immediately investigated and successfully resolved as evidenced in the second iteration of the test before moving into the next testing phase.

### 6.2 User Acceptance Test Summarisation

In alignment with section 3.3.6, a follow-up interview in a form of a user acceptance test was conducted among the group of participants who have previously took part in the case study interview. The

interview lasted approximately 30 minutes where the participants were prompted to interact with the new NSS dashboard and provide thoughts based on their user experience alongside with recommendations for the dashboard. Similar to section 4.1, the collected audio data were also carefully stored and transcribed, before they were analysed through thematic analysis approach. As a result, a total of 17 themes (T15-T31) have been identified as seen in Appendix H.

### 6.3 Users Acceptance and Recommendations

According to the themes identified in Appendix H, theme T15 to T21 has revealed that the developed NSS dashboard has received a positive perception, where it has been strongly appraised as user-friendly, insightful, well-oriented, and modern. Some of the responses that have led to this observation includes:

*“It’s quite intuitive, there’s nothing which in your demonstration of the functionality, I don’t think it would be difficult to figure oneself.” – P1*

*“I get a clear orientation about what I need to do and how I need to use the system” – P2*

*“I think that’s really good. It’s nice, clean, modern, easy to use.” – P3*

Interestingly, some participants have further expressed their gratitude over the data visualisations and functionalities such as the quartile difference and comparative view, stating that the developed dashboard has effectively outperformed existing NSS visualisation solutions:

*“If I had to do an AB test against the system I saw in our first meeting to this one, this one has makes it easier for me to understand.” – P2*

However, it is undeniable that although the new NSS dashboard has received a positive review, the dashboard is yet to be flawless considering that some participants have raised concerns highlighting several issues regarding the overall visual presentation. For some participant, they thought that the available tooltips could be easily overlooked (T22) presumably due to inappropriate usage of font colour and size, while some participants thought that some visualisation, particularly response rate, could be

slightly over dominant (T23) which has slightly resulted in participant having to constantly shifting their attention towards the lesser important doughnut chart:

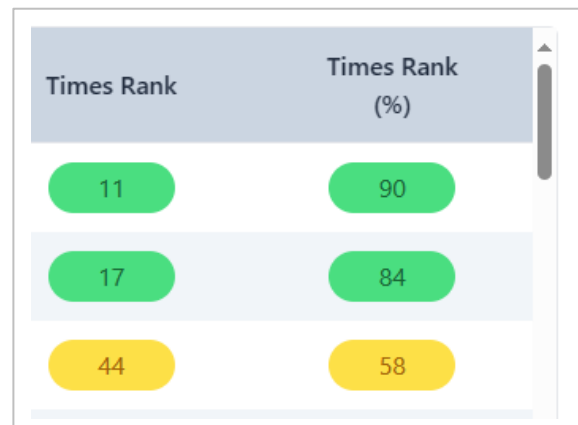
*“I think it’s not obvious that the text that says what does these colours should be?” – P3*

*“Response rate. I wonder if that is as important because you know, obviously your eyes are drawn to it.” – P1*

Moreover, theme T24 have also highlighted that some participants have discussed an issue over the lack of pre-attentive support for the colour coded representation. For example, P1 stated that:

*“That for me actually makes it quite difficult to see the overall Times rank trends.” – P1*

The participant states that the issue was specifically highlighted considering that the new NSS dashboard require users to scroll through all available question to gain insight into all colour coded Times rank, which he thinks has significantly compromised the pre-attentive capabilities as illustrated in the figure below.



Times Rank	Times Rank (%)
11	90
17	84
44	58

**Fig. 16.** Scrollable Times Rank Table

At the end of the interview, the participants were prompted to provide a few recommendations for the new NSS dashboard. As shown between theme T25 to T28, some participants have proposed several valuable suggestions ranging from the implementation of additional visualisation (T25) and comparison options like sector average (T26) to enhancing the existing user guidance by having a clearer tooltips explanation or new FAQ page (T27) and filtering system by implementing a dropdown search feature (T28):

*“I think being able to have this in comparison to like a sector average would be really helpful.” – P1*

*“This is a classic one, but having some form of FAQ to give us an understanding of what you mean by data overview, comparative view, and integrate data.” – P2*

To ensure that the potential of the dashboard could be fully realised in the future, the participants have also suggested that the dashboard should utilise a brighter colour and larger font size to ensure that information could be noticeable to the user (T29). Alternatively, some participants have also suggested that the historical visualisation should be expanded by integrating with more historical data (T30) beyond the current available data:

*“It would be good to have this going back further 20 years that the history data before we take that question moving back further so you could see general trends.” – P1*

Finally, theme T31 has also captured an interesting recommendation concerning the current data integration system, where the participant have highlighted the inefficiency of the current manual process and suggested that the new NSS dashboard should have adopted a more automated solution:

*“So the way that I would suggest to improve this because that's quite a manual administrative process to keep adding them.” – P3*

## **7. DISCUSSION**

### **7.1 The Proposed Study and Contributions**

The proposed study presented a new insightful interactive dashboard to visualise the National Student Survey data. To ensure that the potential of UCD approach could be fully realised, the research process has adopted a mixed-method approach between the combination of case study and software engineering as seen in Figure 5. Given that there is an absence of studies in literature related to NSS data visualisation, the proposed study has significantly contributed towards introducing new insights into the strengths and weaknesses of the existing NSS visualisation solutions from a user-centred point of view and how

could they be further improved to potentially enhance user satisfaction and experience.

### **7.2 Appraisal of Ethical Considerations**

Throughout the proposed study, ethical issues are considered as one of the major concerns. However, appropriate measures have been undertaken as a mitigation towards ensuring the ethical integrity of the study. As shown in an example consent form available in Appendix I(i), informed consent has been obtained from all participants prior to the study to ensure that the participants are fully aware of the purpose, aim, and objectives of the study. Furthermore, all audio recorded during the study has been appropriately anonymised, transcribed, and stored within an authorised Northumbria University OneDrive as shown in Appendix I(ii).

### **7.3 The strength and weakness of the existing NSS visualisation solutions from a user-centred perspective**

The proposed study has successfully achieved objective RO1 by exploring the strength and weakness of the existing NSS visualisation solutions during the “Research” and “Ideate” phase of the UCD approach as seen interpreted in section 4. The finding from the case study interview conducted as part of RO1 has revealed that the participants’ think that the existing NSS visualisation solutions have presented significant strength by considering their straightforwardness and usage of colour coding. The finding has significantly aligned with an existing study by Cham et al. [39] where they found that colour is certainly one of the effective aspects in conveying quantitative differences through the variation of dimensions, such as brightness or saturation. However, although the usage of colour code has been evidenced as beneficial towards efficiently conveying NSS insights, it was found that the finding could be hypothetically challenged as the proposed study has also found that some participants think that the colour code retained in the existing NSS visualisation solutions could be rather confusing with a lack of comprehensive explanation. This observation is certainly true, as existing study by Firat et al. [40] has highlighted the significance of data visualisation literacy in interpreting visual elements and underlying data, which suggested that a dashboard with a lack of clear explanations may potentially hinders user’s ability towards comprehending the context and meaning behind the visualising data.



Apart from the strength of the existing solution, the proposed study has also revealed weaknesses suggesting that the official dashboard is unreasonably slow and overwhelming, presumably due to the huge volume of redundant textual information displayed with fairly little visualisation made available on the screen. According to an existing study by Kopp et al. [41], this could potentially be the case considering that redundant information would certainly contribute towards negative impact on user experience due to extraneous cognitive load that demands additional mental effort to process and understand the data.

#### **7.4 The university staff's preferences for NSS data visualisation and desired functionality to improve the existing NSS visualisation solutions**

The proposed study has also successfully achieved objective RO2 during the “Research” and “Ideate” phase by capturing user preferences on the NSS data and desired functionality that should be considered in the new NSS dashboard for enhancing their ability to analyse and extract insights. The finding from the case study interview for RO2 revealed that the participants have shown a common preference in viewing and analysing NSS data, particularly in positivity measures, quartile performance, qualitative comments, response rate, and Times rank. However, while the requirement for visualising qualitative comments were not considered in the current study due to the commentary data not being publicly available within the NSS data and the author's lack of authorisation in accessing these confidential data, the observation is still significantly valuable as it allows the researcher to focus on presenting data that are considered as most insightful to the user, while also effectively minimising the cognitive load and working memory required for the users to identify areas of improvement [42].

Moreover, the proposed study has also found that apart from the functionality that the participants think should be retained from the official NSS dashboard, such as data filtering, the participants have expressed interest in performing comparative and performance analysis, particularly in functionalities which would allow users to effortlessly compare data between two academic providers and also identify the absolute number of positive responses required to move towards next quartile. The observations are significantly valuable and it could contribute towards the improvement of existing NSS visualisation solutions, considering it has aligned with an existing study where they found that comparative task is one of

the most effective methodologies in understanding the differences between multiple objects [43]. Thus, by considering these features will not only allow users to understand the annual trends and patterns, but also aiding users in accelerating the decision-making process.

Finally, the proposed study has also suggested that the existing NSS visualisation solutions could be further improved by considering an interactive tooltip functionality to potentially aid users in understanding the meaning behind each complex acronym and visualisations retained in the existing dashboard. The finding has been evidenced as valuable considering its alignment with a weakness discussed previously on section 7.3 and also a study by Isaksen et al. [44] where they found that tooltip is certainly an effective method for assisting users in learning a new or existing system.

#### **7.5 Developing an insightful and user-centred interactive dashboard for visualising NSS data**

The proposed study has successfully achieved the preliminary research aim and objective RO3 by developing a new insightful interactive dashboard for visualising NSS data. Through the proposed study, the user acceptance test conducted as part of the “Test” phase has significantly evidenced the effectiveness of the new NSS dashboard in providing insightful NSS information for the participants and it has certainly outperformed the existing NSS visualisation solutions.

Interestingly, the proposed study has also justified the capability of UCD approach towards building a dashboard that is primarily user-centred oriented. The justification could be further evidenced by the extensive amount of positive feedback received during the user acceptance test, where participants have complimented on the new dashboard's insightfulness and user-friendliness. This observation is considered as valuable as it has significantly reinforced a finding in an existing study by Alao et al. [45] where they have also found that UCD approach has certainly contributed to the ease of use, effectiveness, and learnability of their system.

Finally, the proposed study has also demonstrated that the UCD approach could be used to ensuring the new NSS dashboard will retain continuous user-centredness in the upcoming iteration of the development, justifiable by the participants' recommendation received during the user acceptance

test. For example, the recommendation concerning the lack of pre-attentive support as discussed in section 6.3 is significantly valuable towards retaining long term user-friendliness considering its alignment with an existing study where they discussed that pre-attentive support is essential in a dashboard as it significantly aid users in absorbing information in a glance without requiring additional mental or physical actions [46].

### **7.6 Conceptualising a data integration function for integrating new annual NSS data**

While the research aim has been targeted to build an interactive NSS dashboard, the proposed study has successfully achieved objective RO4 by conceptualise a functionality for integrating newer data in the future. The integrated ETL approach as discussed in section 5.2 has significantly contributed to the development of a robust proof-of-concept data integration system that was able to effectively integrate data that would be released in the subsequent years. This finding has effectively contributed to aligning and strengthening an existing study by Rodzi et al. [47] where they found that the ETL approach holds significant capability in ensuring data reliability and enhance decision making.

However, it was revealed that this finding remains challengeable considering an opposing finding identified from the user acceptance test where it has revealed a limitation concerning the inefficiency of the current data integration system, such as the manual administrative process required for extracting and uploading data through a designated dashboard page.

### **7.7 Limitations and Future Recommendations**

Like many other existing studies, the proposed study have limitations in the adopted methodologies. The first limitation arises from the chosen sample size for the proposed study's elicitation exercise. While it has significantly demonstrated as an effective method in answering each research question, the difficulty in recruiting appropriate participants have significantly limited the amount of sample size, which it could potentially influence the credibility and reliability of the study result [48]. Thus, future research should consider a larger sampling size to ensure that more diverse data could be collected to further enhance current and new finding's generalisability.

The second limitation arises from the chosen UCD approach for the development of a user-friendly NSS

dashboard. As discussed in Section 2.4, a UCD approach should be a repetitive process that are designed to be revisited by researcher over multiple iterations. However, the proposed study was merely able to complete one iteration due to the proposed study's strict timeframe, which it may resulted in the restriction of the ability to fully capture and address every usability issue, leading to a potentially less user-friendly dashboard as seen in issues captured in Section 6.3 and 7.5. Thus, future research could potentially attempt multiple UCD iteration or exploring and incorporating alternative user-centred approaches such as contextual inquiry [49] or card sorting [50].

Finally, the proposed study has found that the current ETL approach is not considerably efficient as discussed in section 7.6. Thus, further study could be exploring an automation solution to ensure that the data integration system could be significantly contribute towards reducing workload and human-error while retaining a significant level of efficiency [51]. However, while exploring automation solutions may appears as a favourable option, it is essential to also acknowledge its potential drawbacks such as extensive development cost and time to ensures improvement towards user experience while retaining the dashboard's integrity and reliability.

## **8. CONCLUSION**

As the proposed study aims to develop an insightful interactive dashboard for visualising NSS data using a user-centred design approach. The study has added significant valuable research value and insights into the NSS data visualisation sector, while also addressing real-world stakeholders needs by enabling significant NSS data readability and availability to users who are interested in improving student experience. As seen discussed in the section above, all research aim and objectives have been successfully achieved through the employment of UCD approach accompanied by case study and software engineering research approach. Nevertheless, despite that the positive feedback received for the new NSS dashboard, it was undeniable that the proposed study still remains expandable. As a conclusion, the proposed study would conclude by highlighting the absolute necessity for revisitation with a consideration on resolving the identified issues or adopting an alternative approach to ensure a greater opportunity to make the future of data visualisation brighter within the National Student Survey sector.

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**APPENDIX A.**  
**NATIONAL STUDENT SURVEY (NSS) CORE QUESTIONS AND THEMES**

<b>Question Number (Q#)</b>	<b>Question</b>
<b>Theme 1: Teaching on my course</b>	
Q01	How good are teaching staff at explaining things?
Q02	How often do teaching staff make the subject engaging?
Q03	How often is the course intellectually stimulating?
Q04	How often does your course challenge you to achieve your best work?
<b>Theme 2: Learning opportunities</b>	
Q05	To what extent have you had the chance to explore ideas and concepts in depth?
Q06	How well does your course introduce subjects and skills in a way that builds on what you have already learned?
Q07	To what extent have you had the chance to bring together information and ideas from different topics?
Q08	To what extent does your course have the right balance of directed and independent study?
Q09	How well has your course developed your knowledge and skills that you think you will need for your future?
<b>Theme 3: Assessment and feedback</b>	
Q10	How clear were the marking criteria used to assess your work?
Q11	How fair has the marking and assessment been on your course?
Q12	How well have assessments allowed you to demonstrate what you have learned?
Q13	How often have you received assessment feedback on time?
Q14	How often does feedback help you to improve your work?
<b>Theme 4: Academic support</b>	
Q15	How easy was it to contact teaching staff when you needed to?

Q16	How well have teaching staff supported your learning?
<b>Theme 5: Organisation and management</b>	
Q17	How well organised is your course?
Q18	How well were any changes to teaching on your course communicated?
<b>Theme 6: Learning resources</b>	
Q19	How well have the IT resources and facilities supported your learning?
Q20	How well have the library resources (e.g., books, online service, and learning spaces) supported your learning?
Q21	How easy is it to access subject specific resources (e.g., equipment, facilities, software) when you need them?
<b>Theme 7: Student voice</b>	
Q22	To what extent do you get the right opportunities to give feedback on your course?
Q23	To what extent are students' opinions about the course valued by staff?
Q24	How clear is it that students' feedback on the course is acted on?
Q25	How well does the students' union (association or guild) represent students' academic interests?
<b>*New questions that has yet been allocated a theme</b>	
Q26	How well communicated was information about your university/college's mental wellbeing support services?
Q27	During your studies, how free did you feel to express your ideas, opinions, and beliefs?

\*Two new questions (Q26 and Q27) were added into NSS 2023, and they have not been allocated or associated with any old or new theme. As stated by the Office for Students (OfS), the 2023 version of NSS consists of multiple new or revised questions. Hence it is inadvisable to perform a direct comparison with NSS result collected before 2023. For more information about the changes, please visit [About the NSS data - Office for Students](#).

**APPENDIX B.**  
**NSS DATASET DATA DICTIONARY**

<b>Data Column Name</b>	<b>Data Type</b>	<b>Description</b>
NUM	Integer	The column records a number used for labelling purposes only, it does not reflect majorly to the information or result of the data.
POPULATION	String	The column records the population of the study (e.g., Registered, Taught)
UKPRN	String	The column consist of an ID number used to indicate different academic providers.
PROVIDER_NAME	String	The column records the academic provider's registered name.
MODE_OF_STUDY	String	The column refers to the way in which the education is delivered or undertaken (e.g., Full-time, Part-time)
LEVEL_OF_STUDY	String	The column refers to the academic stage or level of the study a student are currently undertaking (e.g., All undergraduates, First Degree)
SUBJECT_LEVEL	String	The column records the Common Aggregation Hierarchy (CAH) level for categorising a group of available subjects or field of study (e.g., CAH1, CAH2, CAH3)
CAH_CODE	String	The column records the CAH code for a specific subject (e.g., the CAH code for Computer Science would be CAH11-01-01)
CAH_NAME	String	The column records the name of the subject (e.g., Computer science)
QUESTION_NUMBER	String	The column records the question number and theme number for each available questions (e.g., Q01, Q02) and themes (e.g., T01, T02)
NUMBER_RESPONSES	Double	The column records the full person equivalence number of responses towards each question (excluding student who responded 'Not Applicable')
NUMBER_POPULATION	Double	The column records the full person equivalence number of eligible students who are currently registered with the academic providers.



SUPPRESION_REASON	String	The column records the level or reason of suppression that has been applied to the specific data (e.g., DPL represents low level of data protection and BK represents a suppression in benchmark score due to various unknowns retained in the benchmarking factor)
OPTION[1-5]	Double	The column represents the number of respondents who have selected each available option. There were 4 available option data columns where OPTION1 indicates the most positive option whilst OPTION4 indicates the most negative option for the four-point Likert scale. (Please note that as of 2023, the amount of Likert scale has been changed from five-point to four-point, which indicates that OPTION5 would not be used from 2023 onwards.)
NOT_APPLICABLE	Double	The column represents the number of respondents who have selected “Not Applicable” for a specific question.
POSITIVITY_MEASURE	Double	The column represents an aggregated value of responses indicating significant level of satisfaction (e.g., students who have responded with “Very Good” and “Good”)
STANDARD_DEVIATION	Double	The column represents the standard deviation of the difference between positivity measure and benchmark score.
BENCHMARK	Double	The column represents the benchmark score that reflect the sector average positivity measure but adjusted to reflect the mix of students and subjects at the academic provider. The adjustment takes account of the following factors: Subject of study, level of study, age, sex, ethnicity, disability, and mode of study)
DIFFERENCE	Double	The column represents the absolute difference between positivity measure and benchmark score.
CONTR_BENCHMARK	Double	The column represents the overall percentage that academic provider contributes towards their own benchmark. A high contribution to benchmark makes it more likely that results will be close to the benchmark score, hence resulting in a less meaningful data.
MATERIALLY_BELOW_BENCH	Double	The column represents the overall proportion of the difference from benchmark score statistical uncertainty distribution which is below -2.5.
INLINE_WITH_BENCH	Double	The column represents the overall proportion of the difference from benchmark score statistical

		uncertainty distribution which is between -2.5 to 2.5.
MATERIALLY_ABOVE_BENCH	Double	The column represents the overall proportion of the difference from benchmark score statistical uncertainty distribution which is above 2.5.
DIFFERENCE_LOWERCI[99, 97, 95, 92, 90, 87, 85, 82, 80, 77, 75]	Double	The column represents the lower confidence interval for the difference from benchmark score.
DIFFERENCE_UPPERCI[99, 97, 95, 92, 90, 87, 85, 82, 80, 77, 75]	Double	The column represents the upper confidence interval for the difference from benchmark score.
INDICATOR_LOWERCI[99, 97, 95, 92, 90, 87, 85, 82, 80, 77, 75]	Double	The column represents the lower confidence interval for the indicator.
INDICATOR_UPPERCI[99, 97, 95, 92, 90, 87, 85, 82, 80, 77, 75]	Double	The column represents the upper confidence interval for the indicator.
PUB_RESPONSE_HEADCOUNT	Integer	The column records the full person equivalence number of publication responses towards each question (including student who responded 'Not Applicable')
PUB_RESPRATE	Double	The column records the full person equivalence percentage of publication response rate towards each question (including student who responded 'Not Applicable')

## APPENDIX C.

### CASE STUDY INTERVIEW THEMATIC ANALYSIS RESULT

The appendix shows a tabular formatted themes and their respective descriptions identified from the thematic analysis performed on the case study interview. For full evidence and more information on the data collected including the original audio files and textual transcription, please visit the following folder, [Case Study Interview](#).

Theme No. (T#)	Theme(s)	Description
T1	Importance of NSS	The participants have highlighted the importance of NSS in their job position and confirmed that the NSS has been referred as an indicator for decision-making to address identified area of concern
T2	Straightforward spreadsheet	The participant highlights that the NSS spreadsheet is straightforward and well-presented, where information was able to be captured and extracted effortlessly
T3	Colour Code	The participant praised the colour code used in the NSS spreadsheet to potentially serve as a visualisation representation to easily recognise the assigned quartile of the current question
T4	Current Issue of NSS Visualisation	The participants highlighted that the current existing dashboard was quite cumbersome, overwhelming and slow. Some participants have also highlighted that the existing dashboard could be too textual with various inappropriate use of colours or text size.
T5	Lack of data or acronyms explanation	The participant discusses the issue with some of the visualised data or acronyms used in the NSS dashboard or spreadsheet being confusing
T6	Positivity Measure	The participant highlights interest in looking at positivity measure data collected within the NSS result
T7	Quartile Performance	The participant highlights interest in looking at quartile ranking that retains within the NSS spreadsheet used by the university
T8	Qualitative Comments	The participant highlights interest in looking at qualitative comment data that retains within the NSS spreadsheet used by the university
T9	Response Rate	The participant highlights interest in looking at response rate data collected within the NSS result
T10	Times Ranking	The participant highlights interest in looking at Times ranking data that retains within the NSS spreadsheet used by the university

T11	Comparative Data Analysis	The participant suggested a comparative function to potentially compare data between years or providers
T12	Quartile Differences	The participant suggested a function to view the absolute difference between quartiles that allows them to identify the absolute number of positive responses required to achieve the next quartile
T13	Data Filtering	The participant suggested a function to filter data and view a specific question that are directly related to their programme
T14	Tooltips	The participant suggested a function to have tooltips that allows them to hover over certain acronyms to find out more information on the meaning of each data or acronyms

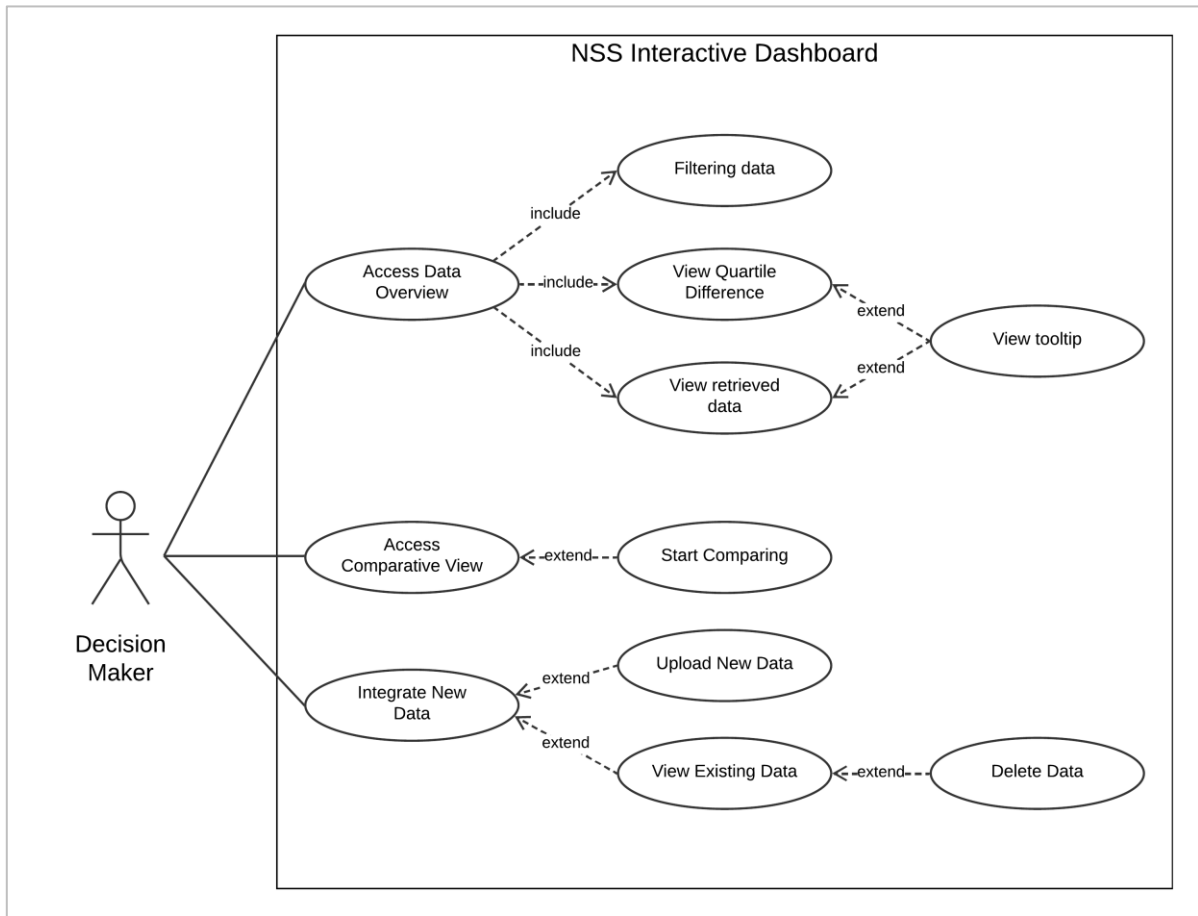
## APPENDIX D. INTERACTIVE NSS DASHBOARD FUNCTIONAL REQUIREMENTS

The functional requirements captured in the following table were extracted from the thematic analysis result seen in Appendix C. Each functional requirement (FR) was recorded with a brief description accompanied by their respective theme ID (T#) to represent alignment with the identified themes. For example, FR1 represents the requirement in visualising the data that is interested by the users, and the requirement was constructed in alignment with themes T6 to T10.

Functional Requirement (FR#)	Requirement(s)	Theme Alignment (T#)	Description
FR1	Interested Data Visualisation	T6 – T10	The interactive dashboard <b>SHOULD</b> only visualise data that are interested by the user, such as the Positivity Measure, Quartile Performance, Response Rate, and Times Rank
FR2	Comparative Data Analysis	T11	The interactive dashboard <b>SHOULD</b> include a comparative data view that allow users to compare data between years or providers
FR3	Quartile Difference	T12	The interactive dashboard <b>SHOULD</b> include a quartile difference visualisation that aid users in understanding the absolute difference or distance between each quartile
FR4	Data Filtering	T13	The interactive dashboard <b>SHOULD</b> include a data filtering function that allow users to filter down the data into specific question(s) or theme(s) that are relevant to their programme
FR5	Colour-Coded Data	T3	The interactive dashboard <b>COULD</b> retain and integrate the colour-code visualisation method used in the NSS spreadsheet to represent quartile performance
FR6	Informative Tooltip	T5	The interactive dashboard <b>SHOULD</b> include informative tooltip function that would potentially aid users in understanding certain technical acronyms or visualisation.
FR7	Data Integration	-	The interactive dashboard <b>SHOULD</b> include a data integration function that allows user to effortlessly integrate new data concerning other subjects into the existing ones.

**APPENDIX E.**  
**USE CASE DOCUMENTATION**

**i. Use Case Diagram**



## ii. Use Case Descriptions

Use Case	Access Data Overview (Homepage)
Use Case Description	User may access the data overview dashboard to view all the collected NSS data including positivity measures, benchmark, Times ranking, and response rate.
Actor	Decision Maker
Precondition	-
Basic Flow	<ul style="list-style-type: none"><li>• The decision maker accesses the webpage.</li><li>• The decision maker is directed into the data overview dashboard.</li></ul>
Alternative Path	<ul style="list-style-type: none"><li>• <b>The decision maker was on a different page and select “Data Overview” from the navigation pane.</b> The decision maker is directed into the data overview dashboard.</li><li>• <b>The system fails to retrieve the NSS data stored in the database.</b> The decision maker is presented with an error 404 message.</li></ul>

Use Case	Access Comparative View
Use Case Description	User may access the comparative view page to compare positivity measures or benchmark between two providers.
Actor	Decision Maker
Precondition	-
Basic Flow	<ul style="list-style-type: none"><li>• The decision maker accesses the webpage.</li><li>• The decision maker selects “Comparative View” from the navigation pane.</li><li>• The decision maker is directed into the comparative view page.</li></ul>
Alternative Path	<ul style="list-style-type: none"><li>• <b>The system fails to access the comparative view page.</b> The decision maker is presented with an error 404 message.</li></ul>



Use Case	Access Integrate New Data
Use Case Description	User may access the Integrate New Data page to integrate new subject data into new or existing NSS year data or manage existing data.
Actor	Decision Maker
Precondition	-
Basic Flow	<ul style="list-style-type: none"> <li>• The decision maker accesses the webpage.</li> <li>• The decision maker selects “Integrate New Data” from the navigation pane.</li> <li>• The decision maker is directed into the data overview dashboard.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li>• <b>The system fails to retrieve the NSS data stored in the database.</b> The decision maker is presented with an error 404 message.</li> </ul>

Use Case	View retrieved data
Use Case Description	User may view the retrieved NSS data including positivity measures, benchmark, Times ranking, response rate, and quartile rank.
Actor	Decision Maker
Precondition	The decision maker has accessed the data overview page.
Basic Flow	<ul style="list-style-type: none"> <li>• The decision maker is on the data overview dashboard.</li> <li>• The decision maker views the collected data displayed on the dashboard.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li>• <b>The decision maker selected a new question.</b> The dashboard updates the visualisation with new data.</li> <li>• <b>The system fails to retrieve the NSS data stored in the database.</b> The decision maker is presented with an error 404 message.</li> </ul>

Use Case	View Quartile Difference
Use Case Description	User may view the retrieved quartile difference to study the absolute difference or distance between each quartile. For example, decision maker can learn and study how much positive response until reaching the next quartile.
Actor	Decision Maker
Precondition	The decision maker has accessed the data overview page.
Basic Flow	<ul style="list-style-type: none"> <li>The decision maker is on the data overview dashboard.</li> <li>The decision maker views the quartile difference.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li><b>The decision maker selected a new question.</b> The dashboard updates the quartile difference with new data.</li> <li><b>The system fails to retrieve the NSS data stored in the database.</b> The decision maker is presented with an error 404 message.</li> </ul>

Use Case	Filtering data
Use Case Description	User may filter the retrieved data by selecting various options including Year, Population, Mode, Level, Subject, and Questions
Actor	Decision Maker
Precondition	The decision maker has accessed the data overview page.
Basic Flow	<ul style="list-style-type: none"> <li>The decision maker is on the data overview dashboard.</li> <li>The decision maker views the quartile difference.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li><b>The system fails to retrieve the NSS data stored in the database.</b> The decision maker is presented with an error 404 message.</li> </ul>

Use Case	View Tooltip
Use Case Description	User may hover pointer to highlighted item to learn more about specific colour code or acronym.
Actor	Decision Maker
Precondition	The decision maker has accessed the data overview page.
Basic Flow	<ul style="list-style-type: none"> <li>• The decision maker is on the data overview dashboard.</li> <li>• The decision maker hover pointer over highlighted item.</li> <li>• The tooltip was displayed.</li> </ul>
Alternative Path	-

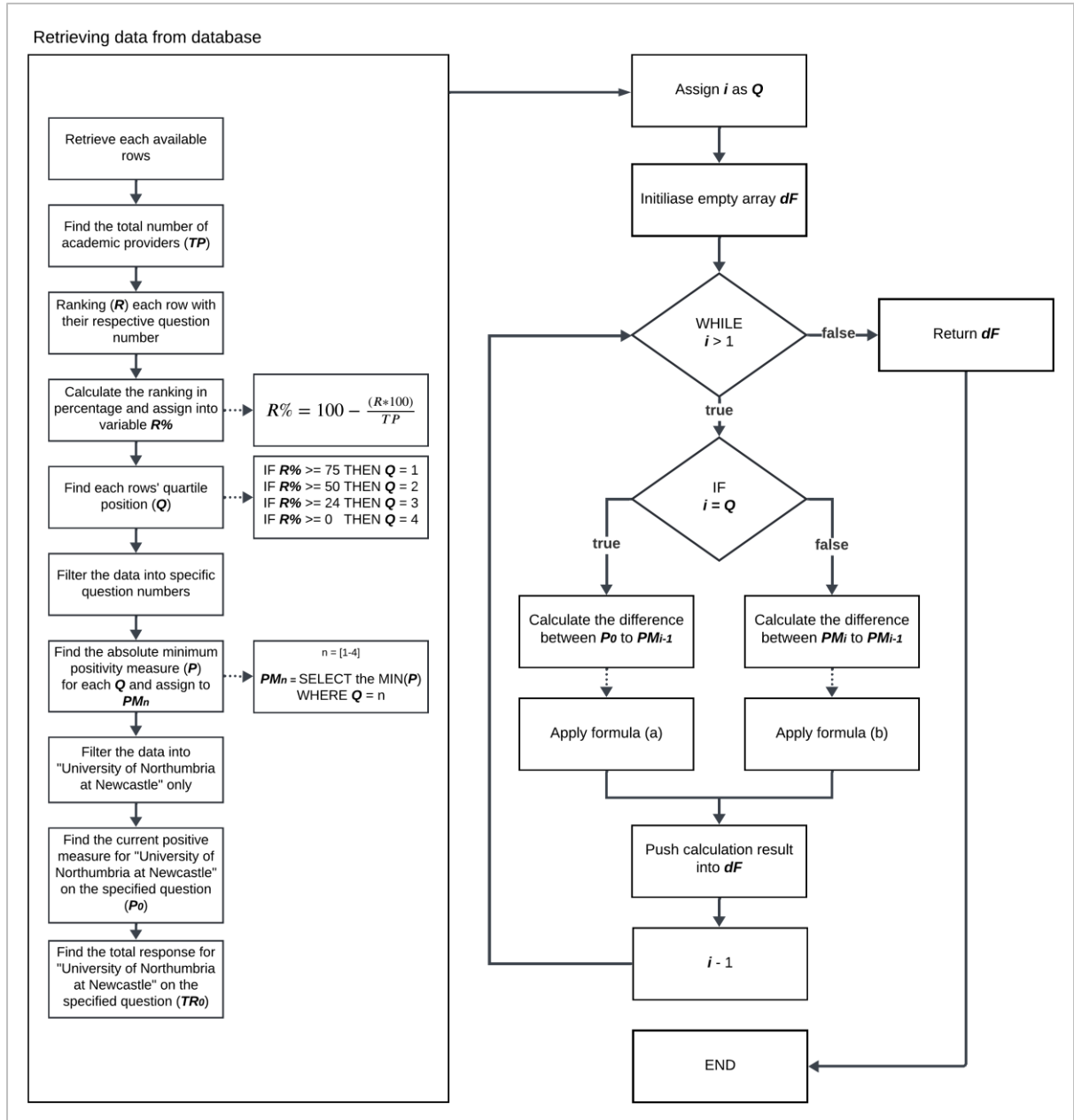
Use Case	Start Comparing
Use Case Description	User may compare the positivity measures or benchmark between two providers.
Actor	Decision Maker
Precondition	The decision maker has accessed the comparative view page.
Basic Flow	<ul style="list-style-type: none"> <li>• The decision maker is on the comparative view page.</li> <li>• The decision maker selects both providers options.</li> <li>• The decision maker clicks on “Start Comparing”.</li> <li>• The decision maker analyses the visualised data.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li>• <b>The decision maker has started the comparison and tried to select a new provider.</b> The dashboard updates the line graph with new data.</li> <li>• <b>The decision maker wanted to compare benchmark data instead of positivity measure.</b> The dashboard updates the line graph with benchmark data.</li> <li>• <b>The system fails to retrieve the NSS data stored in the database.</b> The decision maker is presented with an error 404 message.</li> </ul>

Use Case	Upload New Data
Use Case Description	User may integrate new data concerning different subject area in the future.
Actor	Decision Maker
Precondition	The decision maker has accessed the Integrate New Data page.
Basic Flow	<ul style="list-style-type: none"> <li>• The decision maker is on the Integrate New Data page.</li> <li>• The decision maker selects a year they like to add the data into.</li> <li>• The decision maker selects a CSV file.</li> <li>• The decision maker selects "Upload" button.</li> <li>• The decision maker was prompted with a successful message.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li>• <b>An existing subject has existed in the database.</b> The dashboard prompt users with a "Looks like there is already an existing subject" error message.</li> <li>• <b>If the uploaded file is not in CSV format.</b> The dashboard prompt users with a "The uploading file must be in CSV format" error message.</li> <li>• <b>If the uploaded file did not have the correct data column.</b> The dashboard prompt users with a "Looks like the CSV file does not contain the correct data column" error message.</li> <li>• <b>If the upload file section was left blank.</b> The dashboard prompt users with a "File upload cannot be blank" error message.</li> <li>• <b>If the uploaded file contains data that could not be converted into the correct data type.</b> The dashboard prompt users with a "Looks like there is some data that is incompatible or inconvertible!"</li> </ul>

Use Case	View Existing Data
Use Case Description	User may view existing data that is currently available in the database.
Actor	Decision Maker
Precondition	The decision maker has accessed the Integrate New Data page.
Basic Flow	<ul style="list-style-type: none"> <li>• The decision maker is on the Integrate New Data page.</li> <li>• The decision maker views existing data.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li>• <b>The decision maker would like to view each subject retain in the existing data and click on the “Manage” button.</b> The decision maker with a more detailed information.</li> <li>• <b>The system fails to retrieve existing data from the database.</b> The decision maker is presented with an error 404 message.</li> </ul>

Use Case	Delete Data
Use Case Description	User may delete subject retain in the existing data.
Actor	Decision Maker
Precondition	The decision maker has clicked on “Manage” button.
Basic Flow	<ul style="list-style-type: none"> <li>• The decision maker clicks on “Manage”.</li> <li>• The decision maker is presented with a modal displaying all the subject available for that specific year.</li> <li>• The decision maker clicks on “Delete”.</li> <li>• The decision maker is prompted with a confirmation dialog box.</li> <li>• The decision maker clicks on “Yes”.</li> <li>• The subject is deleted.</li> </ul>
Alternative Path	<ul style="list-style-type: none"> <li>• <b>The decision maker selected “No” on the confirmation dialog box.</b> The confirmation dialog box is closed.</li> </ul>

## APPENDIX F. QUARTILE DIFFERENCE FLOWCHART



$$(a) \ x = \left| \text{round} \left( TR_0 \times \left( \frac{PM_{i-1} - P_0}{100} \right) \right) \right|$$

$$(b) \ x = \left| \text{round} \left( TR_0 \times \left( \frac{PM_{i-1} - PM_i}{100} \right) \right) \right|$$

## APPENDIX G. FUNCTIONALITY TEST CASES DOCUMENTATION

### i. Functionality Test Cases Iteration 1 Result

Test Case ID	Use Case Description (UCD#)	Description	Test Input	Expected Outcome	Actual Outcome	Pass / Fail?
1	1	Accessing the data overview	Click on "Data Overview" button	Redirect to Data Overview page	Page redirected successfully	Pass
2	2	Accessing the comparative view	Click on "Comparative View" button	Redirect to Comparative View page	Page redirected successfully	Pass
3	3	Accessing the integrate new data page	Click on "Integrate New Data" button	Redirect to Integrate New Data page	Page redirected successfully	Pass
4	4	Display the retrieved Positivity Measure	-	Positivity Measure is displayed	Positivity Measure was displayed correctly	Pass
5	4	Display the retrieved NSS Benchmark	-	NSS Benchmark is displayed	NSS Benchmark was displayed correctly	Pass
6	4	Visualise the response rate	-	Response rate is visualised	Response rate was visualised correctly	Pass
7	4	Visualise the quartile rank	-	Quartile rank is visualised	Quartile rank was visualised correctly	Pass
8	4	Display all questions in a table	-	All questions along with data is displayed in a table	All questions along with data was displayed in a table correctly	Pass
9	4	Select new question	Click on question "Q02"	Visualised data is updated	Visualised data updated successfully	Pass
10	5	Display the quartile difference	-	Quartile difference for Q01 is visualised	Quartile difference for Q01 was visualised correctly	Pass
11	5	Select new question	Click on question "Q02"	Quartile difference is updated to Q02 and visualised	Quartile difference for Q02 was updated and visualised correctly	Pass
12	5	Display quartile difference tooltip	Hover over to quartile difference visualised data	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
13	6	Loading all available options	-	All options are loaded	All options were loaded correctly	Pass
14	6	Filter data by Year	Select "2024" on Year filter dropdown option	Data is filtered to 2024	Data was filtered to 2024 successfully	Pass
15	6	Filter data by Population	Select "Taught" on Population filter dropdown option	Data is filtered to Taught population	Data was filtered to Taught population successfully	Pass



16	6	Filter data by Mode	Select "Full time" on Mode filter dropdown option	Data is filtered to Full time mode	Data was filtered to Full time mode successfully	Pass
17	6	Filter data by Level	Select "First Degree" on Level filter dropdown option	Data is filtered to First Degree level	Data was filtered to First Degree level successfully	Pass
18	6	Filter data by Subject	Select "Computer science" on Subject filter dropdown option	Data is filtered to Computer science subject	Data was filtered to Computer science subject successfully	Pass
19	6	Filter data by Question	Select "Q02" on Question filter dropdown option	Data is filtered to only Q02	Data was filtered to Q02 successfully	Pass
20	6	Filter data by Theme	Select "T01" on Question filter dropdown option	Data is filtered to T01 with its questions respectively	Data was filtered to T01 with its questions successfully	Pass
21	7	Display NSS Benchmark tooltip	Hover over to highlighted NSS Benchmark table header	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
22	7	Display Positive Measure tooltip	Hover over to highlighted Positive Measure table header	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass

23	7	Display Times Rank tooltip	Hover over to highlighted Times Rank table header	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
24	7	Display Quartile tooltip	Hover over to highlighted quartile text	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
25	8	Loading all available options	-	All options are loaded	All options were loaded correctly	Pass
26	8	Start comparing two providers	Click on the "Start Comparing" button	Visualisation section is updated with information of both providers	Visualisation section was updated with correct information of both providers	Pass
27	8	Changing to another providers or subjects	Select "University of Northumbria at Newcastle" on left side of University/College dropdown option and click on the "Start Comparing" button	Line chart is updated with information of new selected provider.	Line chart was updated with correct information of new selected provider.	Pass
28	8	Changing to another providers or subjects	Select "University of Newcastle upon Tyne" on right side of University/College dropdown option and click on the "Start Comparing" button	Line chart is updated with information of new selected provider.	Line chart was updated with correct information of new selected provider.	Pass

29	8	Changing to another comparing data	Select "NSS Benchmark" on Comparing Data dropdown option and click on the "Start Comparing" button	Line chart is updated with NSS benchmark data value	Line chart did not update to NSS benchmark	Fail
30	8	Display comparing tooltip	Hover over to line chart point	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
31	9	Loading all available options	-	All options are loaded	All options were loaded correctly	Pass
32	9	Uploading new NSS data regarding new subject	Select "2024" on Year dropdown option and upload a correct CSV file and click on "Upload"	Display a successful status message	A successful status message was displayed correctly	Pass
33	9	Uploading new NSS data that existed in the database	Select "2024" on Year dropdown option and upload the same correct CSV file and click on "Upload"	Display an error message	An error message was displayed correctly	Pass
34	9	Uploading a non-CSV format file	Upload a DOCX file and click on "Upload"	Display an error message	An error message was displayed correctly	Pass
35	9	Uploading new NSS data that does not have	Upload an example Address CSV and click on "Upload"	Display an error message	An error message was displayed correctly	Pass

		the correct data column				
36	9	Leaving the upload section blank	-	Display an error message	An error message was displayed correctly	Pass
37	9	Uploading new NSS data that contains some incorrect data type value	Upload a NSS data with incorrect data type value	Display an error message	An error message was displayed correctly	Pass
38	10	Loading all existing data in the database	-	All existing data are loaded	All existing data were loaded correctly	Pass
39	10	Displaying every Year available in the existing data	-	Every Year available in the existing data are displayed	Every Year available in the existing data were displayed correctly	Pass
40	10	Displaying every "Number of Available Data (Rows)" in the existing data	-	Every "Number of Available Data (Rows)" in the existing data are displayed	Every "Number of Available Data (Rows)" in the existing data were displayed correctly	Pass
41	10	Displaying every "Number of Subjects Available" in the existing data	-	Every "Number of Subjects Available" in the existing data are displayed	Every "Number of Subjects Available" in the existing data were displayed correctly	Pass

42	10	Displaying a Manage button for each table row	-	Every row contains their own Manage button	Every row <u>have</u> successfully displayed their own Manage button	Pass
43	11	Launching a modal menu	Click on the first Manage button	A modal is open	A modal has opened successfully	Pass
44	11	Displaying correct information	-	The modal is displaying the correct information	The modal has displayed the correct information successfully	Pass
45	11	Displaying every "Subject Name (CAH Name)" available in the existing data	-	Every "Subject Name (CAH Name)" in the existing data are displayed	Every "Subject Name (CAH Name)" in the existing data were displayed correctly	Pass
46	11	Displaying every "Number of Available Data (Rows)" in the existing data	-	Every "Number of Available Data (Rows)" in the existing data are displayed	Every "Number of Available Data (Rows)" in the existing data were displayed correctly	Pass
47	11	Displaying a Delete button for each table row	-	Every row contains their own Delete button	Every row <u>have</u> successfully displayed their own Delete button	Pass
48	11	Displaying confirmation dialog box	Click on the Delete button	A confirmation dialog box is displayed	The confirmation dialog box was displayed correctly	Pass
49	11	Deleting an existing subject	Click on the OK button	The row is deleted	The row was deleted successfully	Pass
50	11	Cancelling a row deletion	Click on the Cancel button	The row is not deleted, and the dialog box is closed	The row was not deleted, and the dialog box was closed successfully	Pass

## ii. Functionality Test Cases Iteration 2 Result

Test Case ID	Use Case Description (UCD#)	Description	Test Input	Expected Outcome	Actual Outcome	Pass / Fail?
1	1	Accessing the data overview	Click on "Data Overview" button	Redirect to Data Overview page	Page redirected successfully	Pass
2	2	Accessing the comparative view	Click on "Comparative View" button	Redirect to Comparative View page	Page redirected successfully	Pass
3	3	Accessing the integrate new data page	Click on "Integrate New Data" button	Redirect to Integrate New Data page	Page redirected successfully	Pass
4	4	Display the retrieved Positivity Measure	-	Positivity Measure is displayed	Positivity Measure was displayed correctly	Pass
5	4	Display the retrieved NSS Benchmark	-	NSS Benchmark is displayed	NSS Benchmark was displayed correctly	Pass
6	4	Visualise the response rate	-	Response rate is visualised	Response rate was visualised correctly	Pass
7	4	Visualise the quartile rank	-	Quartile rank is visualised	Quartile rank was visualised correctly	Pass
8	4	Display all questions in a table	-	All questions along with data is displayed in a table	All questions along with data was displayed in a table correctly	Pass
9	4	Select new question	Click on question "Q02"	Visualised data is updated	Visualised data updated successfully	Pass
10	5	Display the quartile difference	-	Quartile difference for Q01 is visualised	Quartile difference for Q01 was visualised correctly	Pass
11	5	Select new question	Click on question "Q02"	Quartile difference is updated to Q02 and visualised	Quartile difference for Q02 was updated and visualised correctly	Pass
12	5	Display quartile difference tooltip	Hover over to quartile difference visualised data	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
13	6	Loading all available options	-	All options are loaded	All options were loaded correctly	Pass
14	6	Filter data by Year	Select "2024" on Year filter dropdown option	Data is filtered to 2024	Data was filtered to 2024 successfully	Pass
15	6	Filter data by Population	Select "Taught" on Population filter dropdown option	Data is filtered to Taught population	Data was filtered to Taught population successfully	Pass
16	6	Filter data by Mode	Select "Full time" on Mode filter dropdown option	Data is filtered to Full time mode	Data was filtered to Full time mode successfully	Pass

17	6	Filter data by Level	Select "First Degree" on Level filter dropdown option	Data is filtered to First Degree level	Data was filtered to First Degree level successfully	Pass
18	6	Filter data by Subject	Select "Computer science" on Subject filter dropdown option	Data is filtered to Computer science subject	Data was filtered to Computer science subject successfully	Pass
19	6	Filter data by Question	Select "Q02" on Question filter dropdown option	Data is filtered to only Q02	Data was filtered to Q02 successfully	Pass
20	6	Filter data by Theme	Select "T01" on Question filter dropdown option	Data is filtered to T01 with its questions respectively	Data was filtered to T01 with its questions successfully	Pass
21	7	Display NSS Benchmark tooltip	Hover over to highlighted NSS Benchmark table header	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
22	7	Display Positive Measure tooltip	Hover over to highlighted Positive Measure table header	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
23	7	Display Times Rank tooltip	Hover over to highlighted Times Rank table header	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
24	7	Display Quartile tooltip	Hover over to highlighted quartile text	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass

25	8	Loading all available options	-	All options are loaded	All options were loaded correctly	Pass
26	8	Start comparing two providers	Click on the "Start Comparing" button	Visualisation section is updated with information of both providers	Visualisation section was updated with correct information of both providers	Pass
27	8	Changing to another providers or subjects	Select "University of Northumbria at Newcastle" on left side of University/College dropdown option and click on the "Start Comparing" button	Line chart is updated with information of new selected provider.	Line chart was updated with correct information of new selected provider.	Pass
28	8	Changing to another providers or subjects	Select "University of Newcastle upon Tyne" on right side of University/College dropdown option and click on the "Start Comparing" button	Line chart is updated with information of new selected provider.	Line chart was updated with correct information of new selected provider.	Pass
29	8	Changing to another comparing data	Select "NSS Benchmark" on Comparing Data dropdown option and click on the "Start Comparing" button	Line chart is updated with NSS benchmark data value	Line chart did not update to NSS benchmark	Pass

30	8	Display comparing tooltip	Hover over to line chart point	Tooltip is displayed with correct information	Tooltip was displayed correctly	Pass
31	9	Loading all available options	-	All options are loaded	All options were loaded correctly	Pass
32	9	Uploading new NSS data regarding new subject	Select "2024" on Year dropdown option and upload a correct CSV file and click on "Upload"	Display a successful status message	A successful status message was displayed correctly	Pass
33	9	Uploading new NSS data that existed in the database	Select "2024" on Year dropdown option and upload the same correct CSV file and click on "Upload"	Display an error message	An error message was displayed correctly	Pass
34	9	Uploading a non-CSV format file	Upload a DOCX file and click on "Upload"	Display an error message	An error message was displayed correctly	Pass
35	9	Uploading new NSS data that does not have the correct data column	Upload an example Address CSV and click on "Upload"	Display an error message	An error message was displayed correctly	Pass
36	9	Leaving the upload section blank	-	Display an error message	An error message was displayed correctly	Pass

37	9	Uploading new NSS data that contains some incorrect data type value	Upload a NSS data with incorrect data type value	Display an error message	An error message was displayed correctly	Pass
38	10	Loading all existing data in the database	-	All existing data are loaded	All existing data were loaded correctly	Pass
39	10	Displaying every Year available in the existing data	-	Every Year available in the existing data are displayed	Every Year available in the existing data were displayed correctly	Pass
40	10	Displaying every "Number of Available Data (Rows)" in the existing data	-	Every "Number of Available Data (Rows)" in the existing data are displayed	Every "Number of Available Data (Rows)" in the existing data were displayed correctly	Pass
41	10	Displaying every "Number of Subjects Available" in the existing data	-	Every "Number of Subjects Available" in the existing data are displayed	Every "Number of Subjects Available" in the existing data were displayed correctly	Pass
42	10	Displaying a Manage button for each table row	-	Every row contains their own Manage button	Every row have successfully displayed their own Manage button	Pass
43	11	Launching a modal menu	Click on the first Manage button	A modal is open	A modal has opened successfully	Pass

44	11	Displaying correct information	-	The modal is displaying the correct information	The modal has displayed the correct information successfully	Pass
45	11	Displaying every "Subject Name (CAH Name)" available in the existing data	-	Every "Subject Name (CAH Name)" in the existing data are displayed	Every "Subject Name (CAH Name)" in the existing data were displayed correctly	Pass
46	11	Displaying every "Number of Available Data (Rows)" in the existing data	-	Every "Number of Available Data (Rows)" in the existing data are displayed	Every "Number of Available Data (Rows)" in the existing data were displayed correctly	Pass
47	11	Displaying a Delete button for each table row	-	Every row contains their own Delete button	Every row have successfully displayed their own Delete button	Pass

48	11	Displaying confirmation dialog box	Click on the Delete button	A confirmation dialog box is displayed	The confirmation dialog box was displayed correctly	Pass
49	11	Deleting an existing subject	Click on the OK button	The row is deleted	The row was deleted successfully	Pass
50	11	Cancelling a row deletion	Click on the Cancel button	The row is not deleted, and the dialog box is closed	The row was not deleted, and the dialog box was closed successfully	Pass

**APPENDIX H.**  
**USER ACCEPTANCE TEST (FOLLOW-UP) INTERVIEW THEMATIC ANALYSIS RESULT**

<b>Theme No. (T#)</b>	<b>Theme(s)</b>	<b>Description</b>
T15	Positive perception on the developed dashboard	The participant has praised that the developed NSS dashboard is easy to use, easy to navigate, well presented, and fast compared to the traditional existing NSS visualisation solutions.
T16	Positive perception on the Quartile Difference visualisation	The participant has praised that the quartile difference visualisation is significantly helpful and effective in acting as a motivating factor to understanding the absolute difference between the current and next quartile.
T17	Positive perception on comparative visualisation	Some participants have praised that the comparative visualisation has effectively allowing them to capture the trends and pattern over time and easy to perform comparative analysis between universities.
T18	Positive perception on the Data Integration functionality	Some participants have praised that the current data integration functionality is sensible and intuitive with appropriate error handling.
T19	Positive perception on the colour code representation	A participant has praised that the usage of colour code representation has effectively and clearly highlighted the problem areas with regards to each available questions and themes.
T20	Positive perception on the data filtering function	A participant has praised that the data filtering function has significantly allowed them to quickly narrow down the available questions or themes.
T21	Positive perception on the tooltip functionality	Some participants have praised that the available tooltips have effectively provided extra information which allowed them to understand each acronym and visualising data.
T22	Easily overlooked tooltips	Some participants have raised concerns regarding some available tooltips that could be easily overlooked/missed.
T23	Over dominant visualisation	A participant has raised concerns regarding specific visualisation being over dominant on the screen.
T24	Lack of pre-attentive support	Some participants have raised concerns on the lack of pre-attentive support on the colour code representation where the users are required to scroll to view all the available data.



T25	Additional comparison option	A participant have suggested to also include an additional comparison option where users will be able to compare providers with sector average.
T26	Alternative visualisation	A participant have suggested to also include alternative visualisation to ensure user could have a wider range of selection depending on their preference and familiarity, while also ensuring a more robust comparative analysis could be performed.
T27	Enhancing user guidance	Some participants have suggested to enhance user guidance, ranging from having a clearer indication on the “Add into new year” option to adding a FAQ section for explaining each available page.
T28	Dropdown search	A participant have suggested to also include a dropdown search to ensures that data retain within a dropdown selection could be easily searched.
T29	Choice of font colour and size	A participant have suggested to have a brighter and larger font colour and size to ensures that information could be more standout.
T30	Expanded historical data	Some participants suggested to integrate more historical data in the dashboard to understand the full potential of some of the implemented visualisation, such as historical view.
T31	Manual data integration system	A participant have raised concerns regarding the current data integration system being a manual mechanism and have suggested that it could be improved by integrating an alternative automation solution.

**APPENDIX I.**  
**OTHER RESOURCES AND ARTEFACTS ACCESS**

**i. Participant Information Sheet and Consent Form**



**Faculty of Engineering and Environment**

**Participant Information Sheet**

**Study Title:** Interactive Visualisations of National Student Survey data

**Investigator:** Teck Xun Tan

You are being invited to take part in this research study. Before you decide it is important for you to read this leaflet so you understand why the study is being carried out and what it will involve.

Reading this leaflet, discussing it with others or asking any questions you might have will help you decide whether or not you would like to take part.

What is the purpose of the study?

The purpose of the study is to conduct comprehensive research on designing and developing an interaction visualisation of National Student Survey (NSS) data, concerning the Computer Science subject area. The study would be primarily focused on our participant's experience with the NSS data, features that they would like to see implemented in a customised NSS interactive visualisation dashboard, and thoughts on the existing NSS spreadsheet used by Northumbria University and the existing built-in visualisation feature in the NSS official website. Additionally, our participants may once again be invited before the end of the study process to participate in a user acceptance test based on the developed web dashboard in a form of a follow-up interview and provide thoughts and recommendation based on their user experience.

Why have I been invited to take part?

You have been invited to take part as you meet the following criteria:

- You are an adult aged 18+ years.
- You are currently a Northumbria University staff member.

### Do I have to take part?

You are under no obligation to take part and you will not experience any loss of benefit or penalty if you choose not to participate.

### What will I have to do?

Our team has prepared a series of open-ended question regarding your experience and opinion towards interactive visualisations web dashboards. In between each question, you would be asked to verbally provide us with your opinion and responses based on your expertise, experience, and thoughts. As for the user acceptance follow-up interview, you would be asked to interact with the developed web dashboard and verbally provide us with your experience and recommendations based on your expertise and thoughts.

Throughout the interview, your voice would be recorded through prepared mobile device or Microsoft Team built-in recording function to serve as part of the data collection process required for subsequent analysis. Before the study could be conducted, our participants would be provided with the following choice depending on their availability and personal preference:

- **Face-to-face interview:** The interview would be conducted face-to-face in a potentially sound isolated (or quiet) room within the Northumbria University premises. Alternatively, our participants may also choose to select their preferred location (if applicable) for the interview.

-OR-

- **Microsoft Team interview:** The interview would be conducted online via Microsoft Team. Our participants would be able to opt-in for the online interview and schedule a preferred time based on their availability.

Furthermore, you would also be asked to review and provide e-signature to a prepared **Participant Information Sheet (PIS)** and **Consent Form** to ensure that we have obtained the necessary consent to start the interview process.

Upon completion of the interview, the audio file will be immediately anonymised and stored in an authorised storage (Northumbria University's OneDrive) to ensure your data privacy and safety. However, you may still choose to withdraw your data if you wish (Please review the *"How can I withdraw from the project"* section below to learn more about data withdrawal). It was estimated that the total time to complete this interview will be 30 minutes and you will have the sufficient rights to halt the interview at any time.

What are the exclusion criteria (i.e. are there any reasons why I should not take part)?

You should **NOT** take part in this study if:

- You are **NOT** over the age of 18.
- You are currently **NOT** a Northumbria University staff member.

What are the possible disadvantages/risks in taking part?

It was considered that the interview would be conducted via face-to-face or online depending on our participants preference and availability. During the interview, you may encounter a level of exhaustion during the course of the session. In events of experiencing any fatigue, please feel free to request for a break to take some rest before proceeding. Do keep in mind that although the interview was expected to be completed within the maximum duration of 30 minutes, we still encourage and respect your decision in taking the time needed to ensure and maintain a healthy well-being and optimal participation.

What are the possible benefits of taking part?

Your responds towards the interview would be used and served as references to contribute to our study. Your contribution towards this interview would greatly assist us in understanding your thoughts on the existing NSS visualisation and identifying essential NSS data and features to be implemented on the web dashboard which will significantly provide us a wider perspective and insights on enhancing user experience. Additionally, you would also contribute towards providing feedback to the web dashboard which would greatly provide us with recommendation and potentially expanding our future directions.

Will my taking part be kept confidential and anonymous?

Yes. You will be allocated a unique participant code that will be used to identify any data that you provide. Your name and other personal details will not be associated with your data, for example any signed informed consent forms will be stored separately.

Only the research team will have access to any identifiable information; paper records will be stored in a locked filing cabinet and electronic information will be stored on the secure University network. This will be kept separate from any data and will be treated in accordance with the Data Protection Act

How will my data be stored?

All data will be stored on the University's OneDrive network and where appropriate additionally protected with a password. Any paper data collected will be locked away in a secure folder.

What will happen to the results of the study?

The results will be used for a postgraduate project that will be examined as part of a MSc Advanced Computer Science degree. Occasionally some results might be presented at a conference or published in a journal, but they will always remain anonymous. All information and data gathered during this research will be stored in line with the Data Protection Act and will be destroyed after a maximum of 3 years following the conclusion of the study. During that time the data may be used by members of the research team, only for purposes appropriate to the research question, but at no point will your personal information or data be revealed.

Who is organizing and funding the study?

The present research project has received no funding.

Who has reviewed the study?

The study and its protocol and its protocol has received full ethical approval from the Department of Computer and Information Sciences ethics committee. If you require confirmation of this, please contact the Departmental Ethics Lead using the details below and stating the full title and principal investigator of the study:

Name of relevant Department Ethics Lead: ~~Dr.~~ James Nicholson

Department: Computer and Information Sciences

Address: Ellison B113

Phone: 0191 227 4959

Email: james.nicholson@northumbria.ac.uk

#### How can I withdraw from the project?

The research you take part in will be most valuable if few people withdraw from it, so please discuss any concerns you might have with the investigators. During the study itself, if you do decide that you do not wish to take any further part then please inform one of the research team as soon as possible, and they will facilitate your withdrawal and discuss with you how you would like your data to be treated in the future. After you have completed the research, you can still withdraw your data by contacting one of the research team (their contact details are provided in the last section of the leaflet), give them your participant number, or if you have lost this, give them your name.

If for any reason, you wish to withdraw your data please contact the investigator within a month of your participation. After this date, it might not be possible to withdraw your individual data as the results might already have been published. As all data are anonymous, your individual data will not be identifiable in any way.

#### What happens if there is a problem?

If you are unhappy about anything during or after your participation, you should contact the principal investigator in the first instance. If you feel this is not appropriate, you should contact the Computer and Information Sciences Departmental Ethics Lead via the contact details given above.

#### **Contact for further information:**

**Researcher email:**      teck.x.x.tan@northumbria.ac.uk

**Supervisor email:**      john.rooksby@northumbria.ac.uk



**Northumbria  
University**  
NEWCASTLE

**Faculty of Engineering and Environment**

**INFORMED CONSENT FORM**

Project Title: Interactive Visualisations of National Student Survey

Principal Investigator: Teck Tan

*please tick or initial  
where applicable*

I have carefully read and understood the Participant Information Sheet.	<input type="checkbox"/>
I have had an opportunity to ask questions and discuss this study and I have received satisfactory answers.	<input type="checkbox"/>
I understand I am free to withdraw from the study at any time, without having to give a reason for withdrawing, and without prejudice.	<input type="checkbox"/>
I agree that the session can be voice recorded to facilitate further analysis	<input type="checkbox"/>
I agree to take part in this study	<input type="checkbox"/>

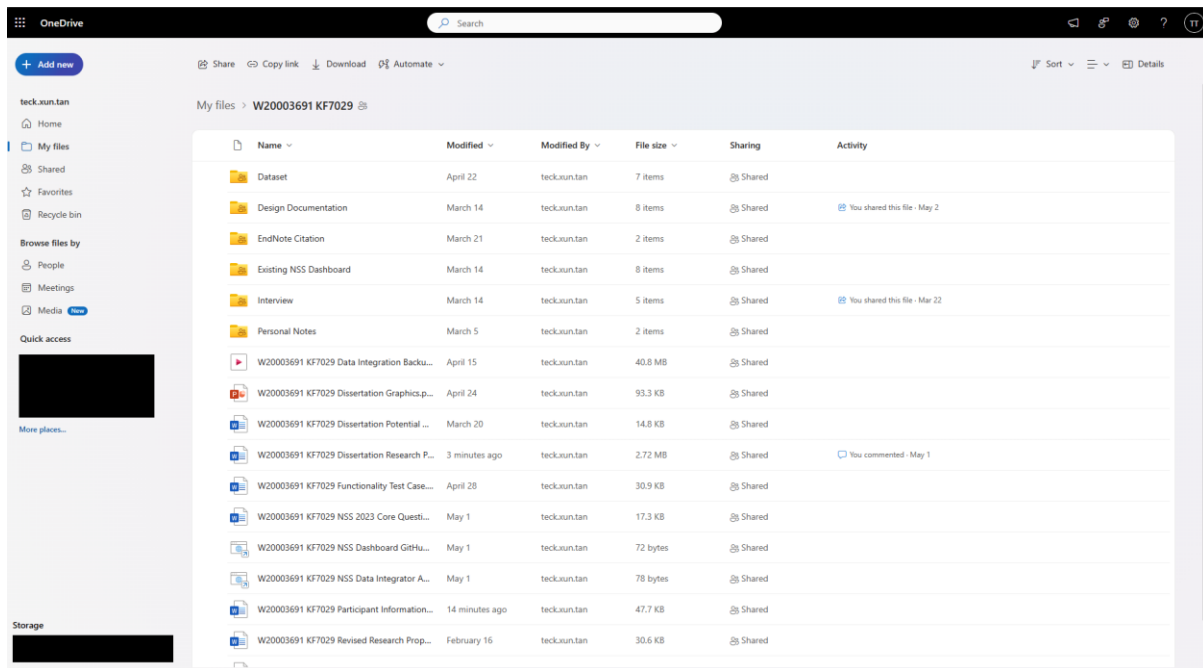
Signature of participant..... Date .....

(NAME IN BLOCK LETTERS) .....

Signature of researcher ..... Date .....

(NAME IN BLOCK LETTERS) .....

## ii. Northumbria University OneDrive



## iii. Artefact Links (Web URL)

- New NSS Dashboard GitHub Repository
  - [steven-appdev/nss-dashboard \(github.com\)](https://github.com/steven-appdev/nss-dashboard)
- New NSS Dashboard Data Processing API GitHub Repository
  - [steven-appdev/nss-integration-api \(github.com\)](https://github.com/steven-appdev/nss-integration-api)
- Ethical Approval Form
  - [W20003691 KF7029 Student Ethics Approval Form.docx](#)
- New NSS Dashboard Webpage
  - [Northumbria NSS \(nuwebspace.co.uk\)](https://nuwebspace.co.uk)