Investigating Student Perceptions of Some of the Key Learning Activities in T272: Core Engineering B

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Executive Summary

The purpose of this research is to engage with Stage 2 engineering students, studying T272 *Core Engineering B* module, about different modes of online activities and how effective these are in engaging, informing, and reinforcing their learning. In T272, students take part in three key *activities* that are designed to reflect practice and introduce them to content included in future modules; these include Finite Element Analysis (*FEA*), the OpenEngineering Laboratory (part of the OpenSTEM labs) and interactive online Maths simulations. This project aims to better understand student perceptions about these three sets of activities and determine appropriate next steps to better support this learning.

To effectively capture and better understand student perceptions about the three activity areas, a three-phase research process was developed. In phase 1, students were asked to complete Real Time Student Feedback (*RTSF*) questionnaires throughout their T272 module to reflect on the different activities as they happened. A small number of students also took part in semi-structured interviews that explored their understandings and interpretations of the activities more deeply. These methods produced qualitative and quantitative data that supported phase 2. The outputs from Phase 2 led to devising and implementing additional maths tutorials for the following module presentation. These changes responded to concerns raised by students and addressed proposed learning gaps around the understanding of the maths content. For phase 3, RTSF questionnaires were redeployed and semi-structured interviews with new students were conducted in the updated module presentation.

They key findings from this research project were:

- Overall the students found the Finite Element Analysis (FEA) software ANSYS difficult to use, although tutorials were easy to follow. Only a few students encountered difficulties downloading and using the software. Although completed, the majority did not understand, or could not articulate the purpose of the exercise. Most (perhaps all) students felt unable to use or navigate the software independently, although 14 of the 16 students interviewed did not attempt any of the additional exercises.
- The OpenEngineering Laboratory (OEL) Pressure Vessel Experiment was enjoyed by students. They were pleased to control the experiment remotely. This helped many bridge theory and practice as well as reflect on the nuances or factors that could influence real-world results. They did not encounter problems comparing the data, but most were unable to explain how theoretical and practical results differ, nor state which is more reliable.
- Whether students declared that they enjoyed maths or not, they found module content overwhelmingly difficult. None interviewed were able to complete the module without external support such as textbooks, private tutors, or online videos. While students who had recently completed the previous module (T194) found it easier to learn, all students found the content difficult to assimilate. It was reported to lack flow between subjects and to be written in a way that presumed a foundation in maths which they had not yet established.

The knowledge gained from this project will inform future curriculum developments and current presentation practices.

1. Aims and Scope of the Project

Undergraduate-level Engineering students develop several skills through their modules that directly support and prepare them for real-world practice. In T272, Core Engineering B, students take part in three *activities* that are designed to reflect practice and introduce them to content included in future modules:

Activity 1: Finite Element Analysis (FEA)
Students are introduced to an industry standard finite element analysis software called ANSYS, which has a wide range of applications but in the context of T272 module is used for stress analysis of simple engineering static structures. Students complete two exercises, firstly to model and analyse a beam under torsion and secondly to model and analyse a simplified aeroplane wing in bending. It provides a foundation for students to further develop their skills using this industry standard software in later modules in the qualification.

Activity 2: OpenEngineering Laboratory (OEL)
In the OEL, students remotely run a real in-lab experiment using an instrumented pressure vessel. They use the Pressure Vessel Experiment to collect real data measuring the strain in the walls of a cylindrical pressure vessel under internal pressure and compare the experimental results to those predicted by theory.

Activity 3: Maths
In the second part of the module, students are introduced to new, more complex, topics in mathematics including relating plane Cartesian and polar coordinates, and taking calculus further by introducing Integration rules, polar unit vector derivates, and second-order differential equations. This is viewed as a major mathematical step up for students compared to the maths content in earlier module, some of which may have been studied six months to a year earlier. The maths topics covered in T272 are used for engineering applications such as thermodynamics, and objects in motions; topics that will serve in later modules such as T229 Mechanical Engineering: heat and flow and T329 Mechanical Engineering: computer-aided engineering.

The purpose of this research was to hear from students about different modes of online activities and how effective they are in engaging, informing, and reinforcing their learning. This project aims to understand student perceptions about the three activities outlined above and determine appropriate next steps to better support students. Specifically, the data collected is analysed to:

- Determine if the activities help students form a *deeper* understanding about the subject.

- Determine whether students understand the activities and the *relevance* in the module (and along the engineering curriculum more broadly).
- Identify any issues in current module presentation (or curriculum design) that *hinder* students from engaging with these activities.
- Identify any *accessibility* issues when trying to complete or conduct the activities.

Findings from this research will support other short- and long-term goals. Short-term goals include (i) changes to the current module presentation format (including Associate Lecturers (AL) tutorial delivery, forum signposting, and module amendments), and (ii) supporting remote teaching in engineering through conference presentations and publications about this case study. Long-term goals include (i) insights into future module rewrites, and (ii) journal publications on the development of deeper understanding through practical activities within remote learning.

2. *Activities*

To effectively capture and better understand student perceptions about the three activities (FEA, OEL, and Maths), a three-phase research process was developed. In phase 1, students were asked to complete Real Time Student Feedback (RTSF) questionnaires (see section 2.1 for further details) throughout their T272 module to reflect on the different activities as they happened. A small number of students also took part in semi-structured interviews, held with a T272 associate lecture on the project, that explored their understandings and interpretations of the activities more deeply. These methods produced qualitative and quantitative data that supported phase 2. In phase 2, the research team, alongside the module presentation team, staff tutors and ALs, devised and implemented additional maths tutorials to the following module presentation (22D). These changes responded to concerns raised by students and addressed proposed learning gaps around maths content. For phase 3, RTSF questionnaires were redeployed and semi-structured interviews with new students were conducted in the new module presentation. An overview of the process is illustrated below:

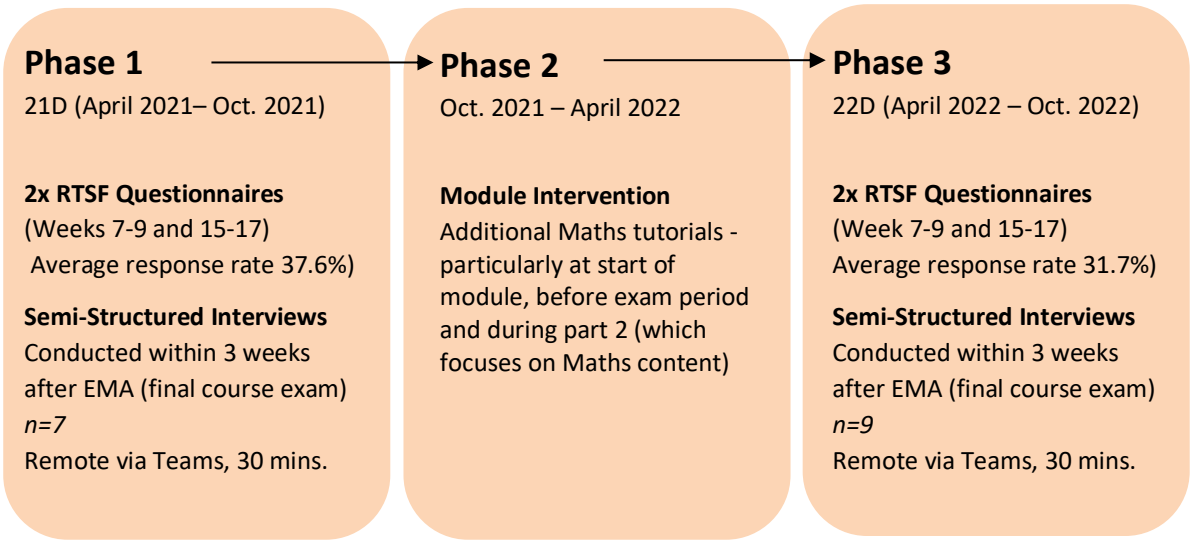

Figure 1: Overview of Research Methodology

2.1 Real Time Student Feedback (RTSF) Questionnaires

Real Time Student Feedback is a mechanism by which the module team can gather feedback from students as they are studying the module. A set of short questionnaires - focused on selective and recently studied topics - are integrated into student's online study planner (see appendix 1 for full questionnaire). Students can then reflect and comment on their experiences as they study the module.

The Real Time Student Feedback questionnaires were designed to learn about the impressions of each activity from a large representation of students. Scholarship around real time student feedback has been carried out on the module T271 *Core Engineering A* (a

feeder module into T272) and on other modules (T212 Electronics: sensing, logic and actuation for example).

Questions are answered by using a scale (i.e., from most likely to least likely, or strongly agree to strongly disagree). For example, students were asked:

Q: How easy or difficult was it to complete the OEL pressure vessel experiment?

- Very Easy
- Quite Easy
- Neither Easy nor Difficult
- Quite Difficult
- Neither Easy nor Difficult.

In total, students were asked 13 questions about the three activities. This includes questions on whether they experienced challenges during the activities, their impressions of completing each activity, and the usefulness or value of each activity to their success in completing the module (see Appendix 1 for full questions / cues).

In both phases, students were reminded via the module-wide forum to take part in the study. In week 7 and 15 (of 21), students were given a three-week window to complete the questionnaire:

- In Week 7, students are expected to submit their first tutor marked Assessment (TMA01) which assesses their understandings of Part 1.
- In Week 15 students are expected to submit TMA02 which assesses the second part of the module.

The table below presents student response rates for each RTSF questionnaire across both presentations.

Module	Part 1 Responses	Part 1 Response Rate	Part 2 Responses	Part 2 Response Rate	Number of Students Enrolled*	Average Response Rate
21D	198	39.6%	179	35.8%	500	37.7%
22D	167	31.7%	167	31.7%	527	31.7%

*Number of Students Enrolled represents total active students at 25% fee liability date.

Table 1: RTSF Questionnaire Responses

2.2 **Semi-Structured Interviews**

Semi-structured interviews were conducted to learn more about student impressions and perceptions of the activities. They provided a deeper insight into their personal practices and understandings. This helped to determine how students engaged with the content, and whether they were achieving the skills set out by the module through these activities. Interviews were conducted remotely through MS Teams and lasted around 30 minutes (+/- 10 minutes). In both phases, two attempts were made to recruit participants. First, the

module team posted in the general module forums, and students were sent a generic email about participation in the project. This did not incite enthusiasm, and zero students responded to the call. Next, Associate Lecturers were asked to directly contact students who may show interest to volunteer and take part. In total, seven students took part in phase 1, and nine in phase 3 (n=16). Their profiles are outlined below:

Participant	Phase	Declared Profile
P1	1	Younger, first degree. Balancing work and study. New to the field and hopes to pursue engineering.
P2	1	First degree in the 1990's. Pleased to learn more and study. Shifting from information technology (IT) to energy and engineering.
P3	1	Studying on their own time, enjoys the flexibility and subject. Considers a future in teaching and tutoring. Shifting careers through this degree.
P4	1	No longer able to work in their field (lorry transportation) shifting careers after 20 years. Interested and motivated to learn about engineering.
P5	1	Already works in the field of engineering. Balancing work and studies to hold a degree and advance their career (to become a chartered engineer).
P6	1	Works full-time in the field on engineering and machinist. Studying to advance career and become a manufacturing engineer.
P7	1	Works in building and project management. Studying to advance career and work within the same field as an engineer.
P8	3	Has already worked in engineering, currently a senior manager in facilities management. Working towards becoming a chartered engineer.
P9	3	Working full time whilst completing an engineering degree. Attempted conventional university but abandoned. Enjoyed maths and was encouraged by family to study. Looking towards aerospace.
P10	3	Unsure about next steps. Studied humanities and drama. Worked full time while studying maths and fluid dynamics. Enrolled in the OU since A-levels not needed.
P11	3	Retired from technology and economics in late 2000's. Has since completed an OU degree in International Studies, now studying engineering (both for pleasure).
P12	3	Mechanic, intends to study and gain higher qualification to advance career.
P13	3	Works in instrumentation (oil industry). Studying to advance in current career.
P14	3	Initially worked as a nurse for 10 years. Completed a masters in sustainability and has decided to study towards engineering – renewable energy pathways.
P15	3	Went to work and develop skills in transportation – interested in developing career and enjoys engineering. Intends to become chartered.
P16	3	Decided to study for a degree after completing an apprenticeship in manufacturing. Intends to complete doing the "bare minimum".

Table 2: Overview of student participants and their declared profiles.

Interviews took place in October 2021 (Phase 1), and October 2022 (Phase 3). They were completed soon after students submitted their final examination – within 3 weeks. This was to ensure that students were not overwhelmed while completing and studying for their examinations whilst also ensuring that their experiences were still relatively vivid and easy to remember. During the semi-structured interviews, students first consented to take part in the study and were told that it would take approximately 30 minutes (see Appendix 2 for full questions). They were then introduced to the project and purpose of the study:

> We are talking to a small number of students to draw out information about their perceptions of the above aspects [activities]. Thank you for volunteering to be one of these students. We would like you to focus on *your* views and *your* experiences.

Next, the researcher encouraged an informal conversation with students to discuss their goals, ambitions, and aims. Students were then asked about each of the three activities. Questions include:

- Finite Element Analysis (FEA)
  - Did you encounter any problems downloading and using the software? Did you feel the module content helped you answer the questions from the tutor marked assessment (TMA) that uses FEA? Did you try any of the supplementary FEA exercises? Do you feel confident that you could use the software in future modules?
- Open Engineering Laboratory (OEL)
  - Did you encounter any problems conducting the experiment? How did you find the experience of running the experiment, rather than observing as you had done before? How easy was it to analyse the results? How do you compare your results to the theoretical values (using Lame's Equation).
- Maths
  - How was your experience starting the maths content? Can you tell me about the central subject (Ordinary Second Order Differential Equations)? How did you interact with the content – did you struggle to engage with any parts? Can you suggest any changes that would help?

The interview protocol also included follow-up questions and cues to stimulate conversations if the student was unable to engage or understand the topic. Finally, the student was offered the chance to provide closing remarks about their impressions and experience of the module overall.

2.3 Phase 2 Changes

Following the analysis and interpretation of results from Phase 1, several changes were made to module presentation. Namely, students reported challenges when completing and understanding maths content. The module team provided additional support through added tutorials (and their recordings) that were designed to help students better comprehend the content, purpose, and upcoming activities (tutor marked assessments). Students were given

a series of (i) Preparatory Sessions in the first weeks based on the material covered in the Engineering Mathematics module, T194, then subsequent sessions throughout the module about (ii) key concepts, (iii) angular motion, and (iv) vibrations. The table below illustrates the added interventions as well as the number of attendees and online viewing of the recordings.

Under the University Group Tuition policy (2016) the module uses a cluster model to support its tuition strategy. The students are divided into two clusters: North and South. The North cluster includes Scotland, the Republic of Ireland, the North of Wales, the Midlands, and North of England. It is made up of roughly two thirds of students registered on T272 and also includes students outside of UK and Ireland. The South Cluster includes the whole of the South of England and Wales.

As most of the research was carried out during the Covid-19 pandemic, all tutorials were held online. In most cases each tutorial was led by two associate lecturers and the additional maths support offered within the Learning events management system.

Subject	Week	Cluster	Attendees	Online Views
Preparation	2	South	20	35
Maths Revision Session: covering material from T194 and everything you need to know to study the module.	3	South	7	24
	3	North	19	32
	3	South	4	21
Students Submit TMA 01				
Revision	7	South	5	64
Preparation and Practice for Part 2 (Maths Content).	7	South	4	63
	8	North	14	154
Angular Motion	9	South	7	62
Preparation and Practice for Part 2 (Maths Content).	9	South	5	75
	10	North	13	105
Vibrations	10	South	3	132
Preparation and Practice for Part 2 (Maths Content).	10	North	8	145
	11	South	6	81
Students Submit TMA 02				

Table 3: Maths Tutorial Delivery for T272 22D

2.4 Analysis and Interpretation

Qualitative Data

Transcripts from student testimonials were collated and summarised into a single document which was organised into 5 sections: Information about (i) their profile, (ii) their impressions of FEA, (iii) their impressions of OEL, (iv) their impressions of Maths content, and a final space dedicated to (v) researcher thoughts and summaries. In both phases, a single researcher analysed the data and summarised it into a table which was then reviewed by the broader research group. Interviews were designed to gain a deeper understanding of student experiences and the rationale behind their actions.

Quantitative Data

Tables were used to illustrate results from the Real Time Student Feedback. Each question was presented as its own table that also compared results between Phases 1 and 3 (see appendix 3 for comparison of results from RTSF for 21D and 22D) . For example:

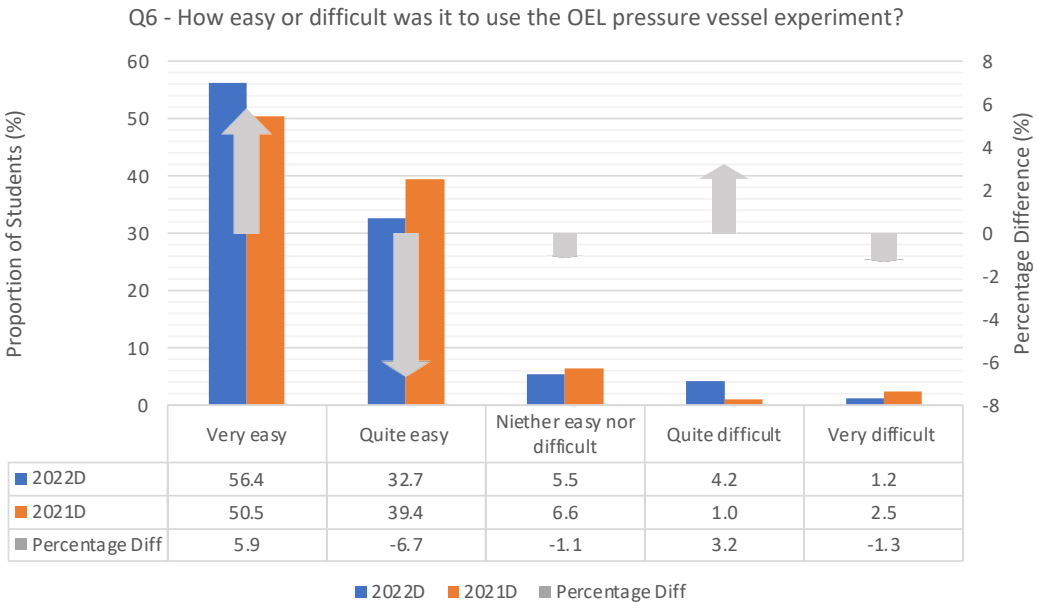

Figure 2: Results from Phase 1 and 3 of RTSF Questionnaire, Question 6

Other Supporting Data

Additional external data was collected to help compare and reflect on the impact of interventions made between module presentations (specifically 21D and 22D). This includes TMA scores, TMA submission rates, and overall module pass-fail rates. Data is mostly used to determine whether a link could be suggested between the additional maths tutorials presented in 22D and (maths related) TMA scores between 21D and 22D.

3. Findings

This section will present the results from RTSF questionnaires and semi-structured interviews for each activity. Both phases are reported together; significant differences between phases are highlighted and reflected upon. Supplementary data such as average TMA scores and TMA submission rates are also used to further understand findings.

Overall, students found the Finite Element Analysis (FEA) software difficult to use, although tutorials were easy to follow. Only a few students encountered difficulties downloading and using the software. Although completed, the majority did not understand, or could not articulate the purpose of the exercise. Most (perhaps all) students felt unable to use or navigate the software independently, yet 14 of the 16 students interviewed did not attempt any of the additional exercises.

The Open Engineering Laboratory (OEL) was enjoyed by students. They were pleased to control the experiment. This helped many bridge theory and practice as well as reflect on the nuances or factors that could influence real-world results. They did not encounter problems comparing the data, but most were unable to explain how theoretical and practical results differ, nor which is more reliable.

Whether students enjoyed maths or not, they found module content overwhelmingly difficult. Of those interviewed, none were able to complete the module without external support such as textbooks, private tutors, or online videos. While students who had recently completed the previous module (T194) found it easier to learn, all students found the content difficult to assimilate. It was reported to lack flow between subjects and to be written in a way that presumed a foundation in maths which they had not yet established.

Before presenting the results, a few preliminary limitations are suggested. First, as an exploratory inquiry, the RTSF and interview questions did not always capture the breadth of responses. For instance, students were limited to a set number of potential issues in RTSF when downloading or completing an activity. Testimonials revealed issues outside those presented in RTSF. Students also reported on the usefulness of certain activities in the RTSF but could not justify their response (revealing which parts of the activities were particularly useful or not). Otherwise, results could be influenced by COVID-19 measures also in place at the time. It is well accepted that student responsibilities, lifestyles, and schedules may have significantly shifted when emerging from public health restrictions. Third, as a general engineering course, the number of students taking different pathways (such as Mechanical Engineering, Electronics or Broad Engineering) can significantly differ from one cohort to the next. Their interests and priorities can shift – dedicating more time to one subject or another.

3.1. Finite Element Analysis (FEA)

In the RTSF questionnaire, students were asked to share their experiences downloading and using the ANSYS software, its usefulness in answering part of the Tutor Marked Assessment (TMA01), and their impression of the added value from experimenting with the software.

During semi-structured interviews, students provided deeper insight into these questions, discussed their experience navigating the supporting FEA module content, and reflected on the underlying principles that these tutorials intend to instil.

3.1.1. Downloading the Software

First, 68% of students found **downloading the software** easy/very easy, and 11% reported neither easy nor difficult. Most notably, 18% of students in Phase 3 declared they were unable to download the software. Although, these students still answered subsequent questions about using and navigating the software. This can suggest that they were unable to download the software at first, but eventually succeeded. It was already known that some Mac users faced issues downloading ANSYS, but they represented 7% of respondents. Indeed, several students from the semi-structured interviews encountered issues downloading the software. One reported that they re-installed the software six times before it functioned properly, while another explained that they opened the software code themselves and deleted a section to overcome download issues:

> The install was a bit of a nightmare […] because of the way you have to do it. There were a lot of students that I know who were struggling. At one point I started looking at the license files and to find out that there was actually a line within the license text file that was wrong, and it duplicated a phrase. It wasn't until I was on the phone with computer services and identified this line. I thought "Hang on a minute if I just take that out, I wonder whether it would work" ...

They suggest that the challenge was shared with other students in the module. Otherwise, most were able to download the software or did not report on any issues during the process.

3.1.2. Using ANSYS

Second, students answered **how easy or difficult they found it to use ANSYS.** 28% of students (in each of the following categories) found it either quite difficult, neither easy nor difficult, or quite easy. This represents approximately 87% of all students, while 4% found it very difficult, and 8% very easy. This suggests that students can have rather mixed experiences when using the software. Semi-structured interviews concurred that while some students found the software enjoyable, others were intimidated. It was noted that they didn't comprehend the breadth of the software. They found to be given "just enough guidance to complete the assignment" but unable to go much further. They did not find the software user-friendly or easy to navigate – although many accepted it as an industry standard. This suggests that they are willing to accept the software and overcome their unfamiliarity and reluctance.

3.1.3. Particular Challenges

Third, about 67% of student did not find **any particular challenges when completing the proposed exercises** using the software. Otherwise, students selected within the following challenges:

- Insufficient support materials: 12%
- Accessibility issues: 9%

- Unable to verify: 7%
- Lack of support in tutorials: 5%

During semi-structured interviews, students reported that the screen cast provided in the module material was able to guide them through the exercise but did not provide enough support to navigate the software independently. One student reported that their computer lacked the internal memory to run the software and they instead watched the tutorial rather than complete it alongside the instructions. Both RTSF data and student testimonials highlight a lack of support material. Yet only 2 of the 16 students attempted additional exercises – and only one reported that they completed all additional tasks. They noted either a lack of time, interest, or priority since the additional work did not contribute directly to their overall grade.

3.1.4. Usefulness of activities for TMA01

Fourth, students were asked about **the usefulness of completing the tasks in week 6 to help them answer part of their TMA1**. Overall, only 10% of students reported that it was not useful or slightly useful. Otherwise, 18% of students found it extremely useful, 41% very useful, and 29% moderately useful.

Students articulated that they were able to follow instructions and complete the task without any significant issues. Instructions felt clear, and some reported that the task was enjoyable. Yet, few were able to clearly articulate the value of completing these tasks. Of those few, the testimonials show that the interviewer nudged students towards the answers. This suggests that while students were able to create a link between week 6 and TMA1, they were unable to articulate or comprehend the deeper purpose of the task. Students were able to compare the reliability between software calculations and hand calculations but did not explain how the principles were managed differently and the potential of the software to calculate different possible variations.

2021 and 2022 RTSF results report a slightly upward trend; about 5% of student responses shifted from slightly and not useful into extremely useful (4%) or very useful/moderately useful (1%). No interventions from phase 2 were made that could explain this change.

3.1.5. Value of software for T272

Fifth, students were asked about the perceived **value of their experience using the software as part of T272.** Students were positive in reporting around 17% extremely valuable, 31% very valuable, and 35% moderately valuable. Otherwise about 8% of students reported slightly valuable, or 7% not valuable at all. During the semi-structured interviews, students reported that the software was a useful glimpse into industry standard software. Only a few students connected the exercises to their relevance as an introduction to upcoming modules. Each also mentioned that they would be unable to work on the software independently as it appeared too robust and intricate. They did not intend to practice in the software further, and only two students reported that they attempted to complete the proposed additional exercises.

Just as question four, this question saw an increase in 22D students finding their experience very valuable (+5%) and moderately valuable (+10%) between phases 1 and 3. Fewer students answered extremely valuable (-4%) or slightly (-7%) and not valuable at all (-4%). There were no significant interventions within Phase 2 that could explain these changes.

3.2. Open Engineering Laboratory (OEL)

The OEL experiments were devised similarly to those from FEA. The module introduces the experiment, its purpose, and its usefulness in answering part of their TMA1. In the RTSF questionnaire, students were asked roughly the same questions as those about FEA: Ease of use, usefulness, and added value. During semi-structured interviews, students discussed their experience booking a time slot to complete the experiment, controlling the experiment remotely, analysing and comparing theoretical to practical results, and their understandings of strains, hoops, and radial stresses.

3.2.1. Using OEL

First, about 90% of students found it either very or quite easy to **use the OEL pressure vessel experiment.** During the Semi-structured interviews, nearly all students did not report any difficulties controlling or booking the experiment. Two students reported issues accessing through Google Chrome, but the issue was resolved once they used another browser. One student reported that they were impressed by the experiment; they expected a latency between their inputs and actions but actually found the experience very smooth.

3.2.2. Particular Challenges

Second, 75% of students did not encounter any **challenges when conducting the experiments**. Otherwise, students reported within the following challenges:

- Unable to connect to the OEL 11%
- Accessibility issues: 9%
- Unable to book 3%
- Insufficient support materials: 2%

Testimonials did not reveal any significant challenges. In one case, the student reported that their screen was sometimes 'fuzzy' or unclear. They propose that this was caused by unreliable WIFI at home. In another case, the student found the process quite 'clunky' but did not explain further or state any further issues. Due to the nature of the experiment, students needed to quickly collect data and report on observations. Some conducted the experiment several times to read out findings, while others recorded their computer screen and were able to pause the video at different key moments. Overall, students were very positive about their experiences. They were pleased to conduct a real experiment and were easily able to complete the work.

3.2.3. Issues Comparing Theory and Practical Observations

Third, during the experiment, students are asked to **calculate the theoretical stresses, and compare them against those observed when using the OEL**. 88% of students did not encounter any issues, while the remaining responses were evenly distributed across the following prescribed challenges:

- Insufficient instructions to analyse data: 3%
- Insufficient instructions to calculate theoretical stresses: 3%
- Unable to compare data: 3%
- Accessibility issues: 3%

During interviews, students recognised that there was a difference between theoretical and practical data, but about two-thirds were unable to explain the reasons behind it. Many did not understand which was more reliable or accurate than the other. Other students speculated experimental errors such as hardware malfunctions or inaccurate readings that could explain the nuances. They otherwise reported that experimental readings were more reliable as they were representative of

real-world conditions. Students who only completed the RTSF questionnaire would have been unable to report on these issues as the option was not available. It is unclear how these comments relate to RTSF questionnaire results – whether this relates to an inability to compare data, accessibility issues, or another unidentified option.

3.2.4. Usefulness of Activities for TMA01

Fourth, students were asked about **the usefulness of completing the tasks in week 6 to help them answer part of their TMA1**. Around 2% of students found it either slightly useful, or not useful at all. Otherwise, 47% of students found it very useful while 28% found it extremely useful or 20% moderately useful. Most notably, in Phase 3 student responses of extremely useful fell 8%, although they were redistributed across moderately useful (7%) and very useful (1%). Based on the semi-structured interviews, the experiment was considered enjoyable, and clear. In TMA01, students were asked to report on the difference and reliability between practice (OEL experiment) and theory (Lame's Equation). Beyond findings reported in *section 3.2.3.* (above), most students were unable to recall the exercises from TMA01. Through several prompts provided by the interviewer, students were somewhat able to articulate a justification. However, given the significant support provided by the interviewer, it isn't sensed that their results could accurately represent their views.

3.2.5. Value of OEL experiment

Fifth, students were asked about the perceived **value of their experience using the OEL as part of T272.** Most notably, students' responses of not valuable at all fell 18%, from 20% in phase 1, to 2% in phase 3. No interventions in Phase 2 were made that could justify a significant shift. Answers were mainly redistributed from not valuable at all into very valuable (+9% increase compared to Phase 1, to an average of Phase 1 and Phase 3 responses amounting to 42%), moderately valuable (+5% to an average of 21%), extremely valuable (+2% to an average of 21%), and slightly valuable (+1% to an average 4%).

No significant differences between testimonials from 21D and 22D can explain this shift in RTSF results. Overall, students were very positive about their experiences with the OEL pressure vessel experiment. They appreciated that the experiment can help bridge theory and 'reality'. They sensed that the experiment could help calculate results more accurately. They were able to understand the influence of properly calibrating the experiment and troubleshooting any issues that could affect results: such as equipment errors, margins, and potentially expired hardware certifications. Some went beyond the concept of a physical lab and were able to conduct the experiment several times due to its design as an off-site and pre-set experiment. Some students also performed the experiment, calculated data, and conducted the experiment again (sometimes during out-of-office hours) to validate their findings or review their results. Finally, students appreciated that the experiment provided them with a sense of ownership or liability of their results. They felt in control of their findings which – according to them – enhanced the learning experience beyond its theory.

3.3. Maths Content

Part 2 of the RTSF questionnaire asked student to reflect on the value of maths content. Content was distilled into four simulation tool activities that were designed to support students understanding and skills in the mathematical content for Part 2 and answer questions in TMA02. In the RTSF questionnaire students answered the following: whether the simulation tools were valuable or not and whether the activities helped them to understand module content or to

complete TMA02. Overall, an average of 88% student reported that the tools were either helpful to some or to a greater extent.

Yet, although they were helpful, students reported during interviews that the content was quite challenging and a "massive step-up" in difficulty. Often, students felt unprepared for the challenge and found the content insufficient. They sought out help from textbooks, Youtube videos, private tutors, or friends to understand the content. They found that the content assumed a foundation (preliminary understanding) that they had not acquired – or forgotten. Students who had recently completed the previous module (T194) found content assimilation easier than their counterparts (within the last 6 months).

In response to RTSF findings, the tuition team provided additional tutorials throughout the module to support students. Details about frequency and attendance rates are outlined in *section 2.3.* In sum, a 22D student would have been able to attend four additional tutorials (13 additional tutorials were provided, spread across the different student clusters). Despite the interventions, RTSF questionnaire results show a downward trend in the reported usefulness and value of the content.

	21D	**22D**
How useful were the simulation tools? (Useful or very useful)	92%	87%
Were the tools helpful to understand module content? *(Yes, to some or to a greater extent)*	91%	83%
Did the tools help answer TMA02? *(Yes, to some or to a greater extent)*	89%	86%

Table 4: Students answering 'positively' to questions in RTSF questionnaire Part 2

During 22D interviews, some students attended the additional maths support tutorials, but most continued to report on the significant challenges in the core module content. They stated that this content often felt disconnected and presumed that students were much more experienced than they felt. Overall, issues raised in 21D interviews were echoed and the additional maths tutorials, although appreciated by the group who both attended and participated in interviews, did not seem to improve broader RTSF questionnaire results. Furthermore, TMA02 results show that fewer 22D students submitted the assessment (from 89% to 85.5%) and received lower overall results (from 74% to 71%) than those in 21D; although this may have been due to other socio-economic factors at play.

4. Impact

This section briefly highlights the outcomes and impact from this research project.

4.1. Student Experience

A series of additional tutorials were implemented to support students with some of the maths content. They were offered at the outset of the module as well as one to two weeks before students submitted the relevant TMA. Although there is not an increase in the average TMA score, the recordings reached several hundred views. The biggest impact may be a better understanding of the issues and added value that these activities can provide to students, issues are raised, and the positive impact of some activities is made clear.

4.2. Teaching

The research project will help redress some of the underlying concerns raised by students. Students should be able to better articulate the purpose of these activities and their tutors, through inputs from the module team, will now focus on fostering this kind of critical reflection and rationale. This is particularly relevant to OEL experiments and FEA tutorials.

4.3. Module Production

It's been determined that maths content will require a significant review. Students do not comprehend the content as they should, and additional tutorials do not overcome their challenges. Otherwise, content about ANSYS and FEA should clearly frame its purpose in the module as an introduction. It is simply a software commonly used in industry through which students will develop their skillsets in later modules.

4.4. Dissemination

Dissemination is ongoing. Results will be shared with module chairs to highlight some of the notable concerns and qualities of the activities. Results have and continue to contribute to student experience with maths content, industry standard software packages and OpenEngineering Laboratory experiments. Improved signposting (from tutors, and the student forums) are planned to amplify tutorial attendance. Otherwise, academic publications and events are scheduled to further expose findings within and beyond the OU. The outcomes of this project will also inform the re-write of the Engineering qualifications already planned for the near future.

5. Deliverables

- A poster and presentation is scheduled for the 12th eSTEeM Annual Conference
- An abstract has been submitted and accepted to present at the UK Horizons 2023 Conference to explore *praxis* and fostering Higher Order Thinking Skills within students.
- Submission of the T272 Esteem final report to the Board of Studies.

6. Acknowledgements

We are grateful to eSTEeM for their financial support of this project and for the help and encouragement we received from the team. Last, but not least, we would like to thank all the engineering students who dedicated their time to participate in the survey interviews.

7. Appendices

7.1. Appendix 1

Real Time Student Feedback

T272-Part 1 Have your say

Welcome to the T272 Have your say survey!

The module team would like to hear about your experience with ANSYS and the OEL pressure vessel experiment. We are particularly interested in understanding whether you could make the connection with the taught theory when doing the activities. Towards the end of the module, after the exam, we would like to invite a small number of students who engaged with this questionnaire for a more detailed conversation.

We are keen to gather your views, through this questionnaire and interviews, and to apply lessons learnt to the improvement and future design of such activities for T272 and wider engineering modules.

We encourage you to help the module team by responding to this questionnaire, but you are not obliged to participate.

We will comply with the OU's General Protection Data Regulation (GPDR) policy and in the event of publishing the outcomes of the data will be anonymised.

On behalf of the T272 module team

Foroogh Hosseinzadeh (T272 Module Chair)

Q1: How easy or difficult was it to download and install the ANSYS software?

A: MAC user –unable to download/install
B: PC user – unable to download/install
C: Not easy due to insufficient support materials and instructions
D: Not easy due to accessibility issue
E: Neither easy nor difficult
F: Quite easy
G: Very easy

Q2: How easy or difficult did you find it to use the ANSYS software?

A: Very easy to use
B: Quite easy to use
C: Neither easy nor difficult to use
D: Quite difficult to use
E: Very difficult to use

Q3:Did you encounter any of these particular challenges when completing the ANSYS FEA exercises?

A: Insufficient support materials and instructions
B: Unable to verify results

C: Accessibility issue
D: Lack of support in tutorials
E: No issues

Q4: How useful did you find the tasks, which you completed in Week 6, when answering TMA 01 Question 5?

A: Extremely useful
B: Very useful
C: Moderately useful
D: Slightly useful
E: Not at all useful

Question #5

Q5: Overall, how valuable did you find your experience of using ANSYS in T272?

A: Extremely valuable
B: Very valuable
C: Moderately valuable
D: Slightly valuable
E: Not at all valuable

Q6: How easy or difficult was it to use the OEL pressure vessel experiment?

A: Very easy to use
B: Quite easy to use
C: Neither easy nor difficult to use
D: Quite difficult to use
E: Very difficult to use

Q7: Did you encounter any of these particular challenges when using the OEL pressure vessel experiment?

A: Insufficient support materials and instructions
B: Unable to book a slot to use the OEL
C: Unable to connect to the OEL
D: Accessibility issue
E: No issues

Q8: Did you encounter any of these particular challenges when comparing the derived and theoretical stresses in the OEL pressure vessel experiment?

A: Insufficient instructions to analyse data
B: Insufficient instructions to calculate theoretical stresses
C: Unable to compare data
D: Accessibility issue
E: No issues

Q9: Overall, how valuable did you find you experience of using the OEL in T272?

A: Extremely valuable
B: Very valuable
C: Moderately valuable
D: Sightly valuable
E: Not at all valuable

Q10: How useful did you find the OEL-related tasks, which you completed in Week 5, in answering TMA 01 Question 4?

A: Extremely useful
B: Very useful
C: Moderately useful
D: Slightly useful
E: Not at all useful

T272-Part 2 Have your say

Welcome to the T272 Have your say survey!

The module team would like to hear about your experience with Part 2 simulation tools. We are particularly interested in understanding whether you could make the connection with the taught theory when doing the activities. Towards the end of the module, after the exam, we would like to invite a small number of students who engaged with this questionnaire for a more detailed conversation.

We are keen to gather your views, through this questionnaire and interviews, and to apply lessons learnt to the improvement and future design of such activities for T272 and wider engineering modules.

We encourage you to help the module team by responding to this questionnaire, but you are not obliged to participate.

We will comply with the OU's General Protection Data Regulation (GPDR) policy and in the event of publishing the outcomes of the data will be anonymised.

On behalf of the T272 module team

Foroogh Hosseinzadeh (T272 Module Chair)

Q1: How useful did you find using the simulation tools in Week 8 (Motion in 2D simulation tool), Week 9 (Collision simulation tool), Week 10 (Vector simulation tools) and Week 11 (Vibration simulation tool)?

A: Very useful
B: Useful
C: Not useful
D: Did not use them

Q2: Did using the simulation tools help you better understand the topics covered in each study week?

A: Yes, to a greater extent
B: Yes, to some extent
C: No, not really
D: No, I could not make the link between the topics taught and the simulation tools.

Q3: Did the simulation tool on a rotating flywheel help you to answer TMA 02 Question 2?

A: Yes, to a greater extent
B: Yes, to some extent
C: No, not really
D: I did not answer TMA 02 Question 2

7.2. Appendix 2

Semi-Structured interview for T272

Purpose of interview

To investigate the student's perceptions of: -

a. The introduction to ANSYS FEA software in T272
b. Operating the OEL experiment on T272 (Thick cylinder experiment)
c. The step-up in mathematical content from previous studies in T272

The usefulness/helpfulness of ANSYS FEA and OEL to their learning journey and ability to answer questions in the TMA and beyond.

To find the barriers that students encounter when using ANSYS FEA and OEL, and when learning the maths content.

To learn from students about their use of ANSYS FEA and OEL and how they may overcome accessibility barriers on their own.

Student Consent

Interviewer to state that the conversation will be recorded, and that the first thing we will do is to identify who you are and record whether you give your consent to taking part in this research.

[START RECORDING]

Can I ask you to confirm your name and student PI number please?

I am now going to read the statement about the way your data will be used, kept and ultimately destroyed. At the end of the statement, I will ask you to clearly state whether you agree or do not agree to your data being used in this way.

At any time during the research, you are free to withdraw and to request the destruction of any data that have been gathered from you, up to the point at which data are aggregated for analysis.

Your participation or non-participation will not affect your module results in any way.

The results of any research project involving Open University students constitute personal data under the Data Protection Act and the General Data Protection Regulation (from 25th May 2018) as set out in our Student Privacy Notice. They will be kept secure and not released to any third party.

The data collected will be used in an anonymous form in written reports, presentations and published papers. Your written consent would be sought separately before any identifiable data are used in such dissemination.

All personal data will be destroyed when the final paper describing this work has been accepted for publication.

Are you willing to take part in this research, and do you give your permission for the data collected to be used as just described?

Pre-amble and Introduction to study

We are conducting a project to better understand what students think about three aspects of T272 - your introduction to FEA (finite element analysis) using ANSYS, the Open Engineering Laboratory together with your perceptions about the mathematics introduced in part 2 of the module.

We are doing this by conducting an online survey, which you participated in (thank you for that), but we are also talking to a small number of students in order to draw out information about their perceptions of the above aspects. Thank you for volunteering to be one of these students.
We would like you to focus on your views and your experience.

We expect that the interview will take about 30 minutes of your time.

Structured conversation

So, could you start by telling me a little about why you are studying with the OU and what your goals are?

Find out what and why they are studying, their background and aims.

I would like to split this interview into three sections~~, as indicated earlier~~.

Finite Element Analysis software – ANSYS

T272 is the second core module that all Engineering students' study and it is the first that introduces ANSYS, a commercially available Finite Element Analysis package, that is used on future modules

Did you have any problems downloading and installing the software? Did you have any problems running the software?

{May need to develop this about if they had a MAC, if they had to download the student version from ANSYS, installation problems etc.}

Also trying to establish if they found any problems when running the software and who they used to help them out.

In TMA1 there was a whole question devoted to your experience of using ANSYS – did you feel that the material provided allowed you to engage and answer the question?

{May have to follow up with questions relating to the TMA questions, such as assumptions made, changes that could have been made etc.

Could follow up with questions about what they thought about the instructions given}

Did you try any of the extension activities using ANSYS from week 4?

{Trying to see if the student was simply following the menu steps or attempting to understand the necessary steps behind the module?}

Do you feel confident that you could carry on using the package in future modules?

Follow on questions could include: -

- Could you replicate another study based on the introduction provided?
- Do you feel confident that you could carry onto future modules with confidence in FEA?
- What do you feel was "missing" from the introduction?

One thing to note is that T276 used ANSYS Workbench rather than Mechanical APDL as the "front end" and some students may comment of the differences.

Page Break

OEL – Open Engineering Laboratory – Thick cylinder experiment

I'd now like to bring in the Open Engineering Laboratory experiment that you performed.

Did you encounter any problems before, during and after performing the online experiment?

Possible follow-on questions: -

- Were you able to book slots that were convenient?
- Did you manage to perform the experiment at one sitting? Was a 60-minute slot (as advised in the instructions) sufficient?
- How easy was it to read the instruments?
- What challenges did you have to overcome during the experiment?

In previous modules all you needed to do was observe an experiment, so how did you find the experience of "controlling" the experiment and taking the results?

How did the students perceive the "doing" and being in control of the experiment rather than the passive watching of previous OEL experiments?

You then needed to analyse the results and transform the strains in hoop and radial stresses. How easy was it to do this?

The instructions were given, but were they clear?
Did you try the examples shown or did you simply reveal the answers?
Did you use a spreadsheet for the analysis or hand calculations?
If spreadsheet, did you verify a sample of results by hand?

Question 5 on TMA 012 was all about the analysis of the results and comparison to the predicted Lame's equation stresses. Experiments such as this are performed to compare your experimental results with those obtained from Lame's equations.

Would you think that your results verified Lame's equations?

Possible follow-on questions: -

Were your experimental and theoretical results within "experimental" error as defined by the measures of experimental error you calculated?

Do you see the experiment as "something that has to be done" for the TMA or is there a purpose in doing experiments?

Did you see the relevance of some of the calculations (range, uncertainty etc.)?

Mathematics on T272

Now I'd like to explore your thoughts about the mathematics introduced in T272. You have met some calculus in T194 and T272 is an advance on those earlier studies.

Can you tell me about your experience of starting the T272 mathematical content?

Possible follow-on questions: -

Was there too much emphasis on your knowledge from T19X modules?
Did you look back at that material before/during T272?
Were there steps "missing" from the explanations?

The main mathematics introduced was integration by substitution and solving Ordinary Second Order Differential Equations. Can you tell me about your experiences with the content?

How did you feel it went? Were there any parts that you felt you couldn't engage with?

Can you tell me how you coped? Did you use any additional resources beyond the content in the book? Or did you find the book was self-explanatory?

Do you have any suggestions on a different approach that would have made their experience better?

We're just about coming to the end now, but let me ask if there is anything about T272 that you think is important but which we haven't discussed in detail?

Closing

Thank the student, turn off the recorder and terminate the interview

7.3. Appendix 3

Comparison of 21D and 22D Part 1 Real Time Student Feedback Results

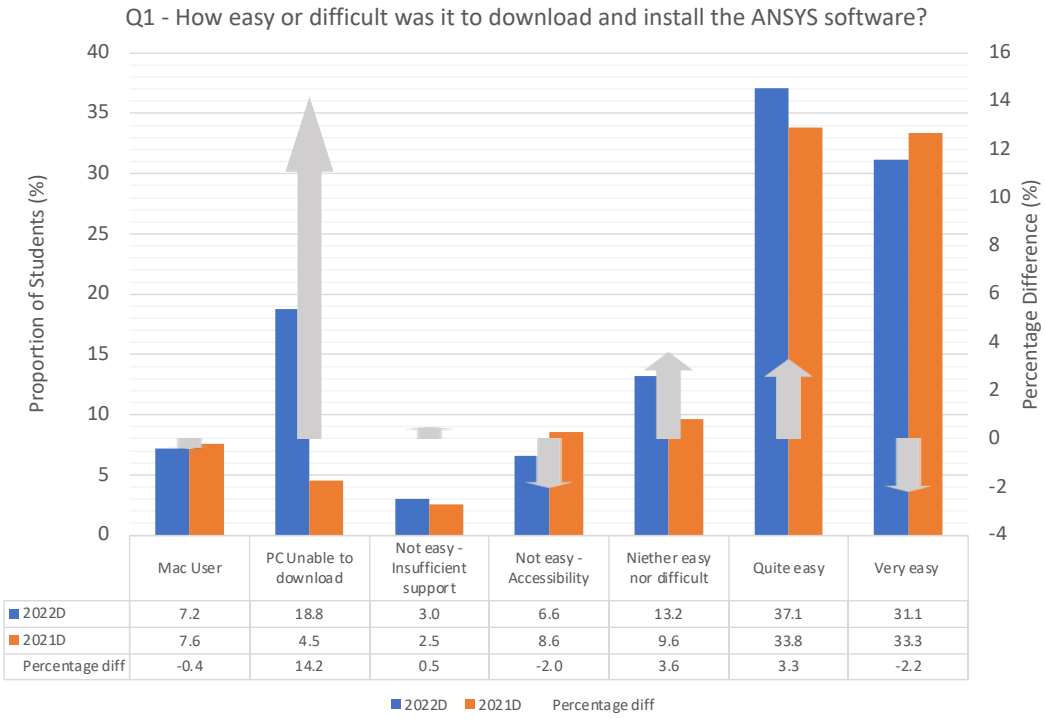

Figure A3.1: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 1

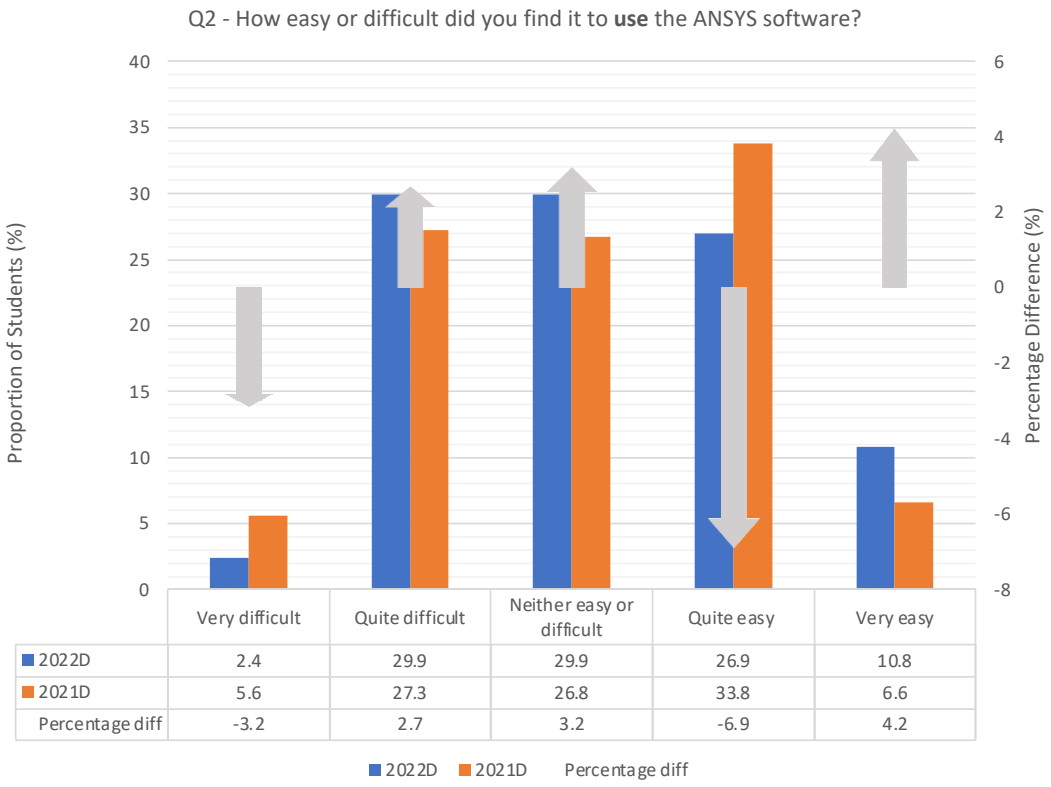

Figure A3.2: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 2

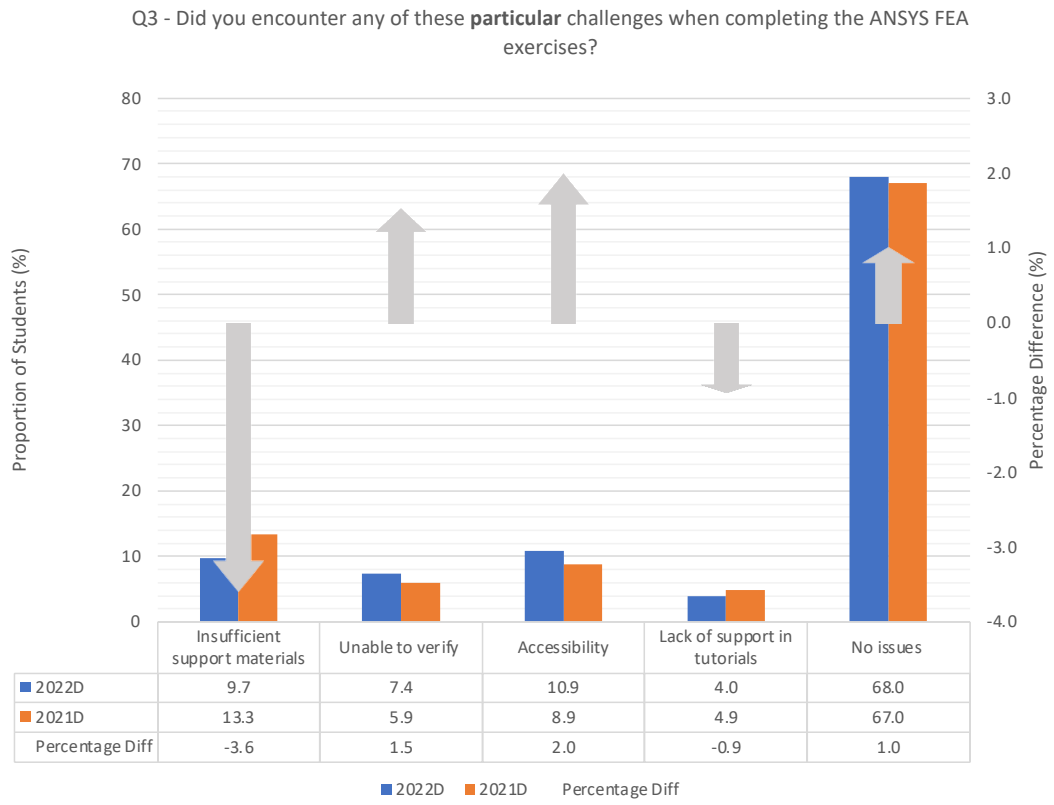

Figure A3.3: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 3

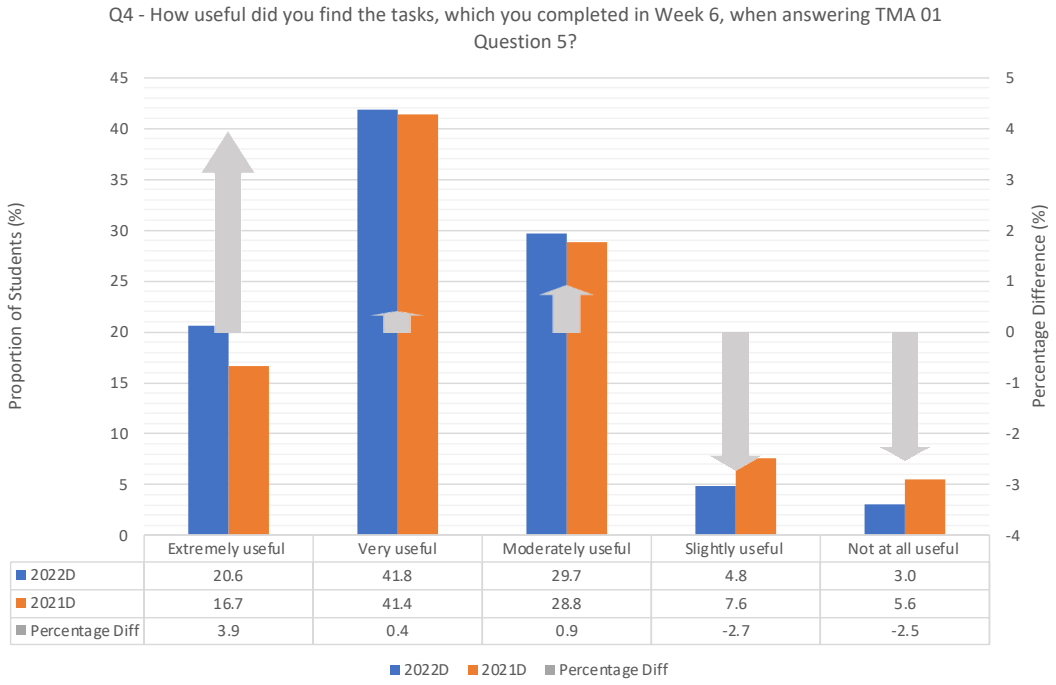

Figure A3.4: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 4

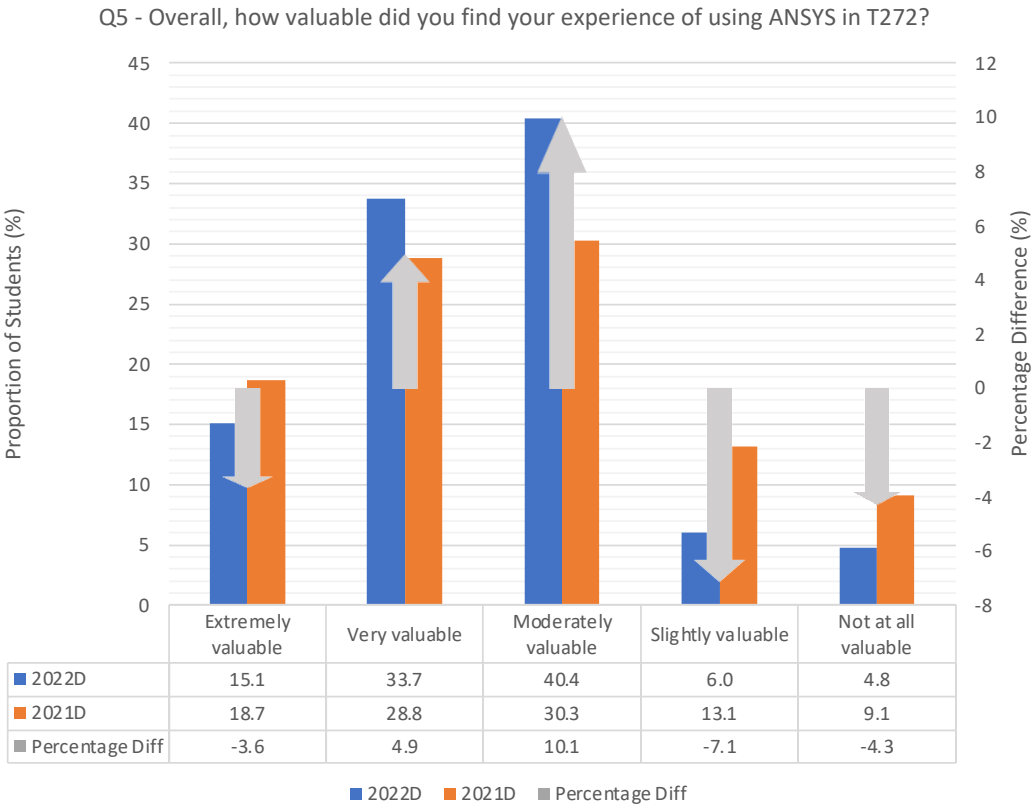

Figure A3.5: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 5

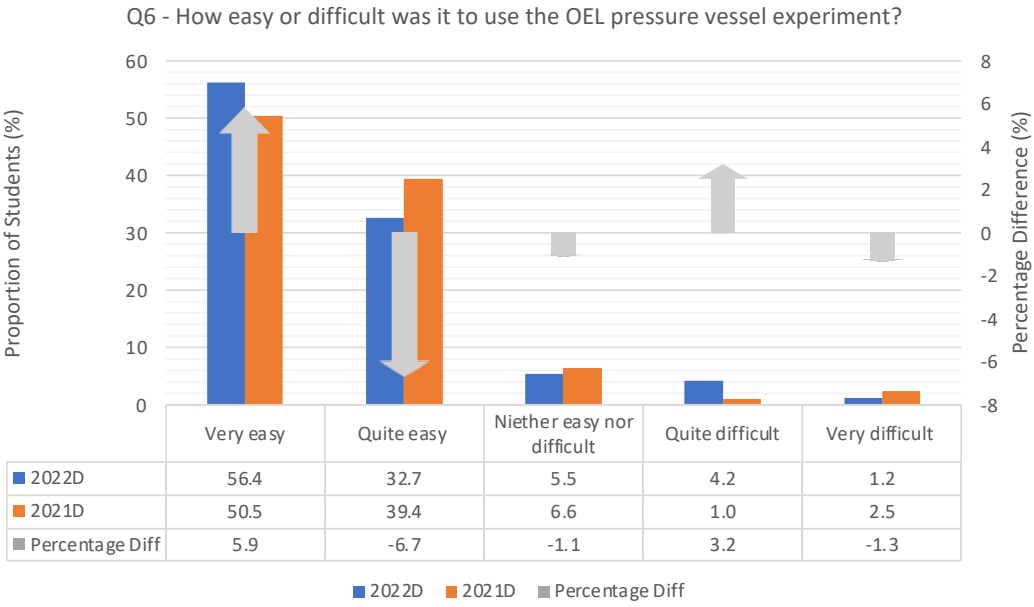

Figure A3.6: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 6

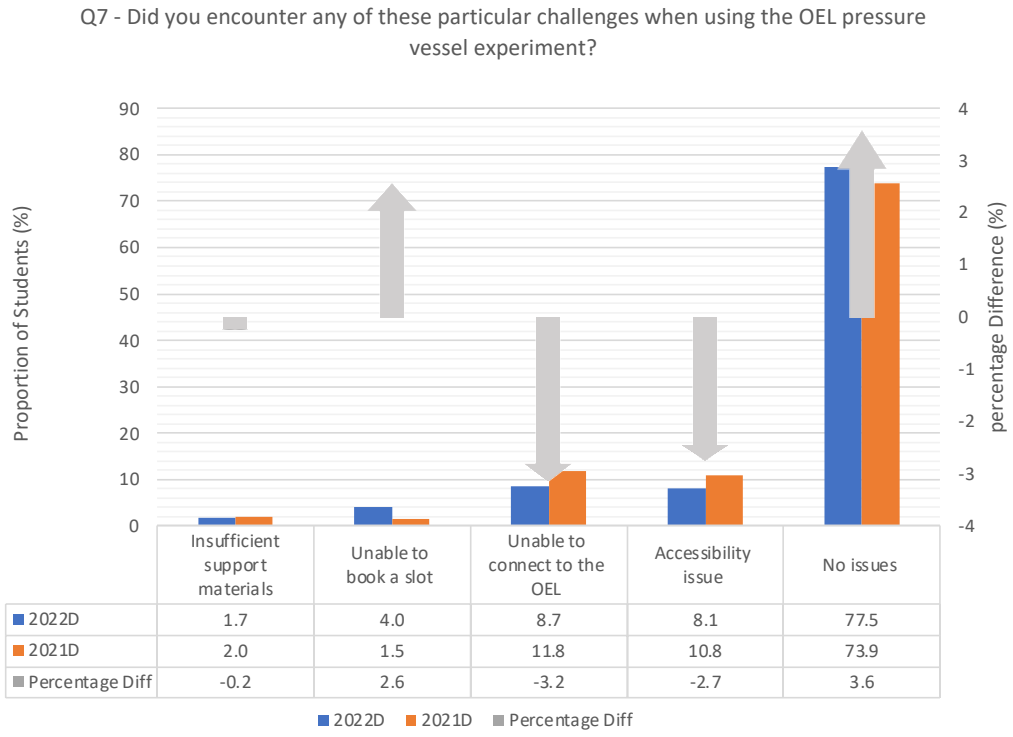

Figure A3.7: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 7

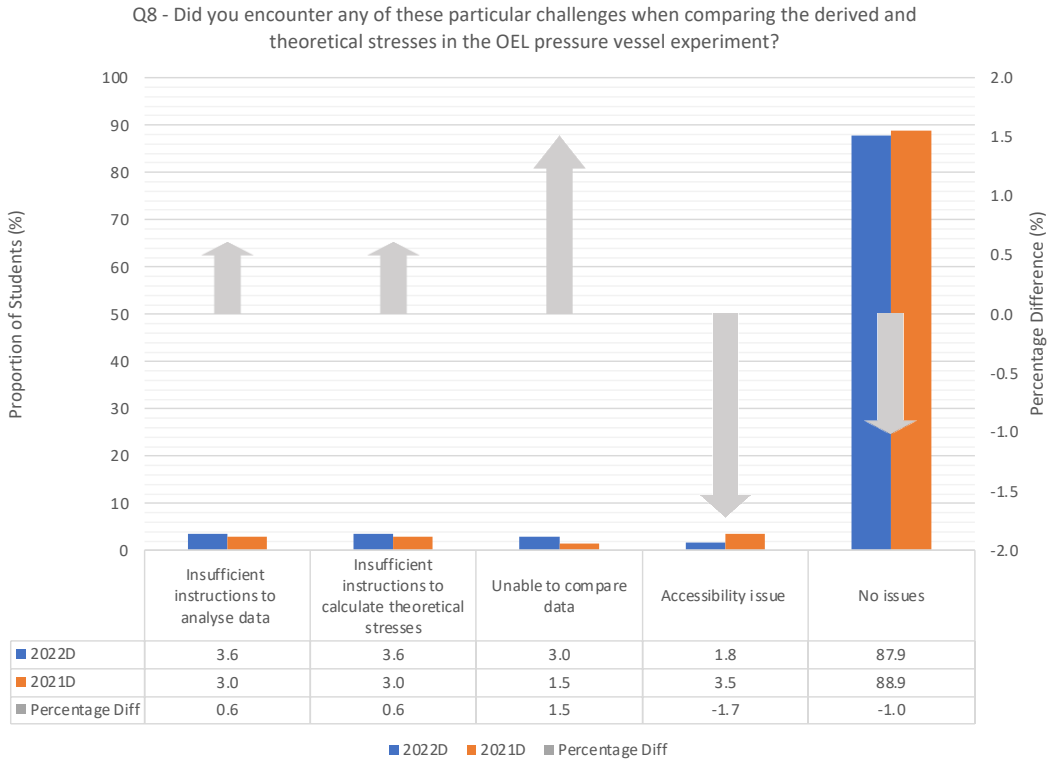

Figure A3.8: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 8

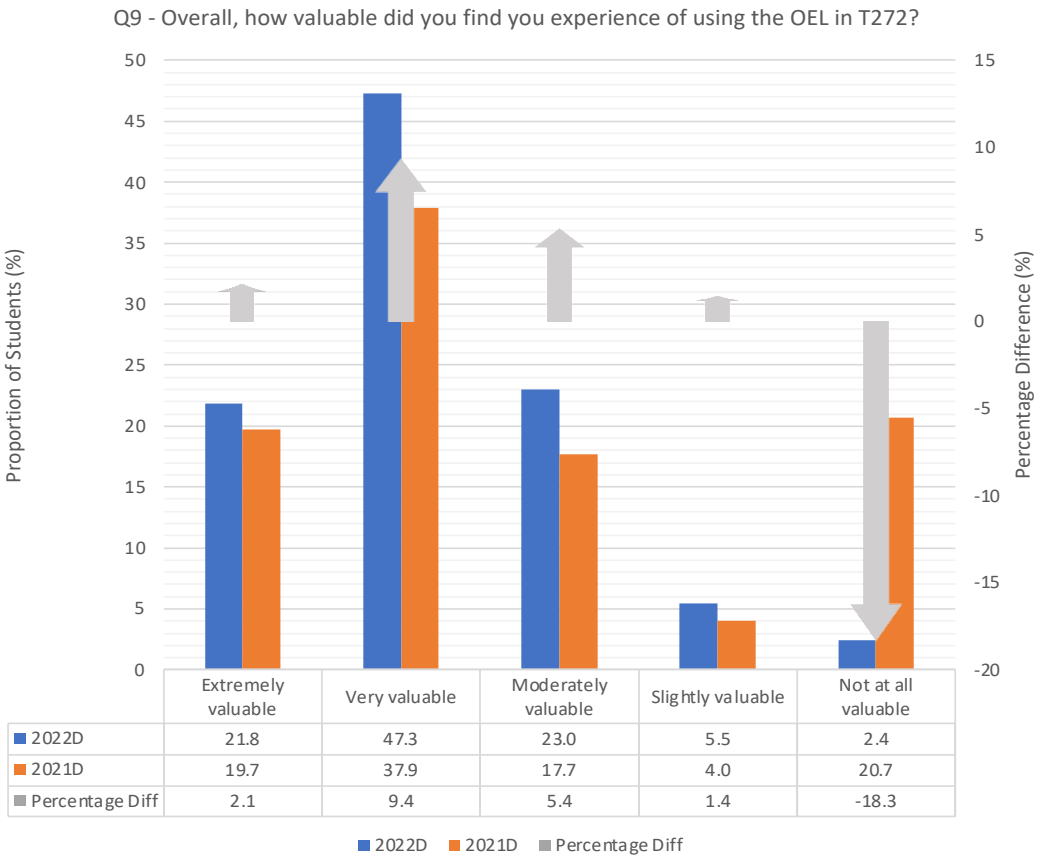

Figure A3.9: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 9

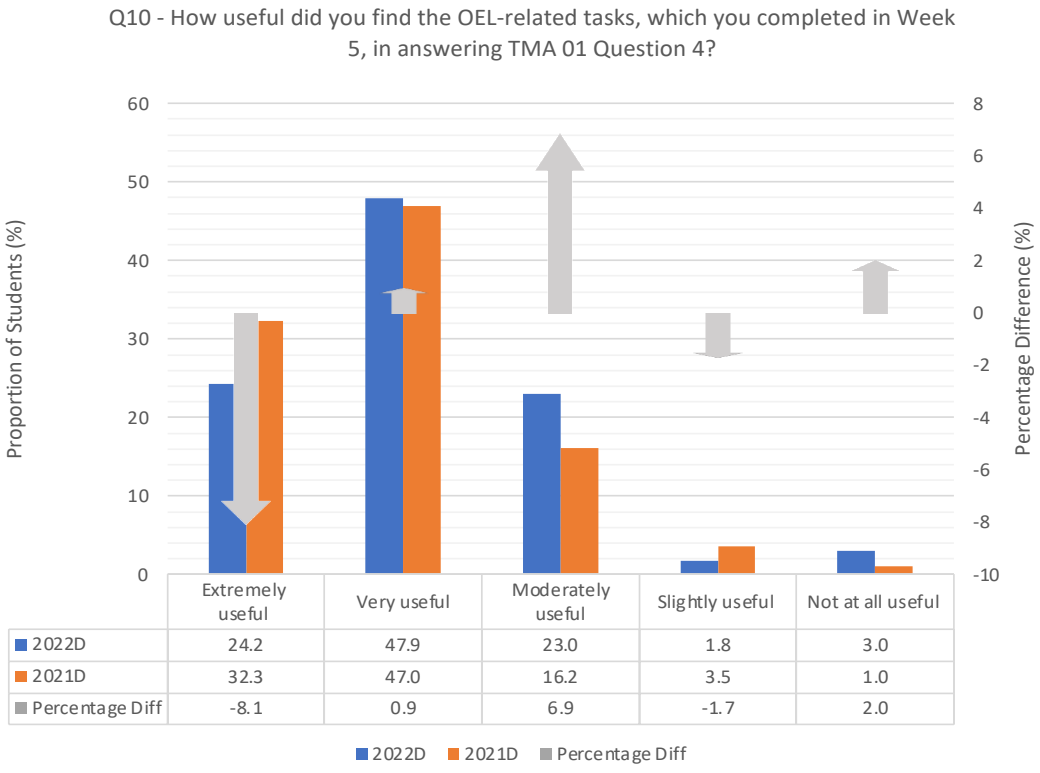

Figure A3.10: Results from Phase 1 and 3 of Part 1 RTSF Questionnaire, Question 10

Comparison of 21D and 22D Part 2 Real Time Student Feedback Results

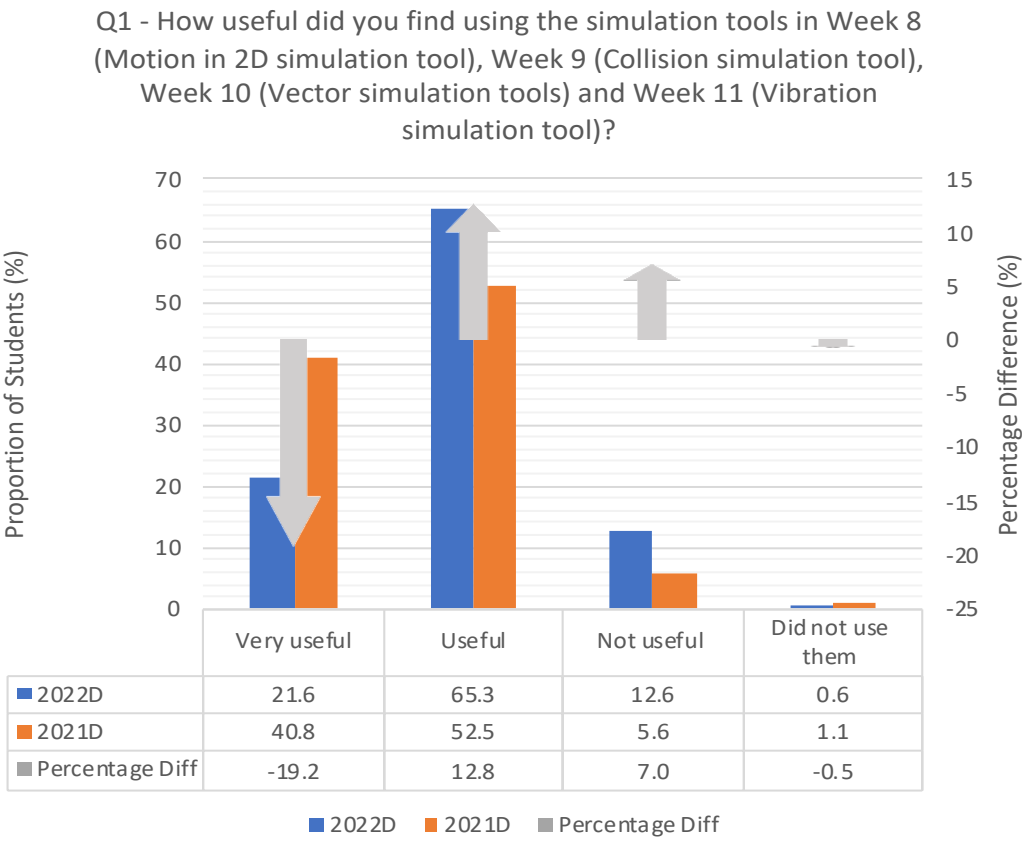

Figure A3.11: Results from Phase 1 and 3 of Part 2 RTSF Questionnaire, Question 1

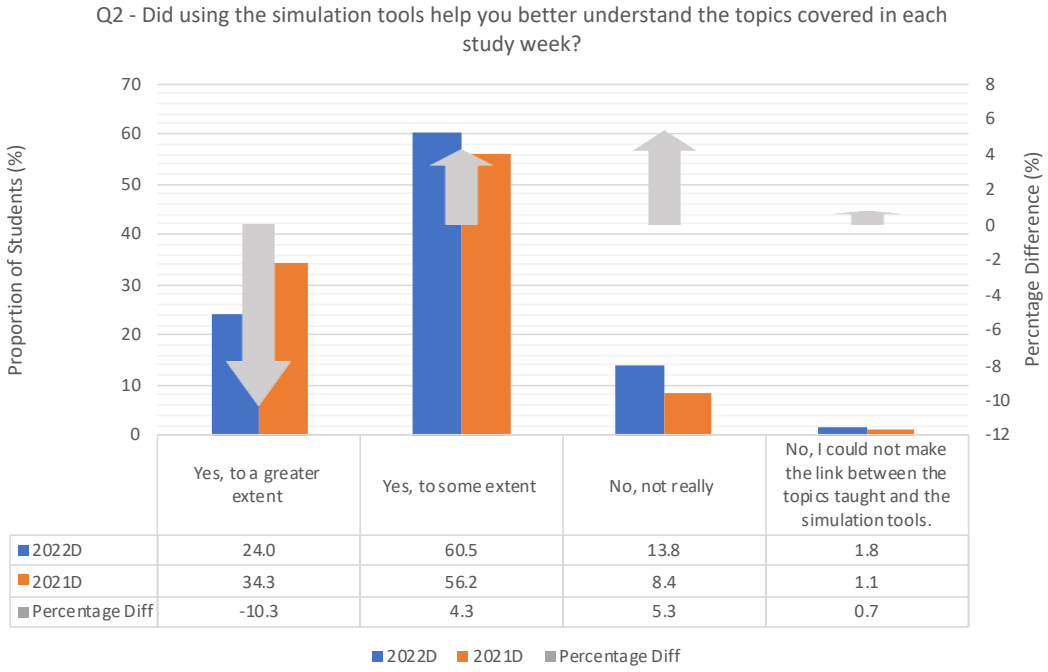

Figure A3.12: Results from Phase 1 and 3 of Part 2 RTSF Questionnaire, Question 2

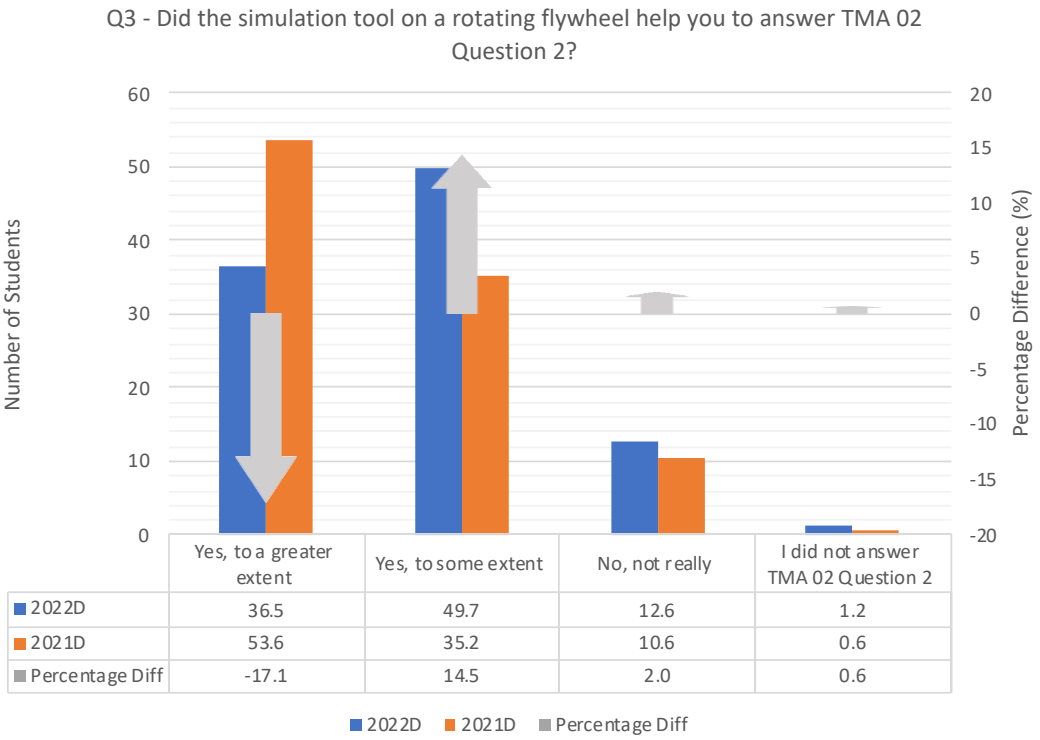

Figure A3.13: Results from Phase 1 and 3 of Part 2 RTSF Questionnaire, Question 3