

CASE STUDY

Students' Perceptions of Enhanced e-Assessment Feedback Addressing Common Student Errors in Mathematics

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Abstract

The Common Student Errors Project (CSE Project) has been running at the University of the West of England (UWE, Bristol) since 2017. The main aim of this project is to introduce a method to detect CSEs and to provide tailored feedback in Engineering Mathematics e-Assessment questions. In this case study we briefly describe the process of collecting CSEs related to Engineering Mathematics and delivering personalised enhanced feedback to students who made CSEs on Dewis e-Assessment questions. We then present how we carried out a questionnaire to gather student perceptions on the enhanced feedback they received. Finally, we present the outcomes of the questionnaire data, the conclusions on students' perceptions of the current enhanced feedback and ascertain possible future directions for further development of the enhanced feedback.

Keywords: e-assessment, Dewis e-Assessment system, Common Student Errors, enhanced feedback.

1. Introduction and Background

The main aim of the Common Student Errors Project (CSE Project) is to introduce a method to detect CSEs and to provide tailored feedback in Engineering Mathematics e-Assessment questions. We have focussed on Engineering Mathematics questions using Dewis as the demonstration platform, however, the method could be useful for other e-Assessment systems and in other contexts and disciplines (CSE Project at UWE, 2019).

Developed at UWE Bristol, Dewis is a fully algorithmic open source e-Assessment system which was primarily designed for numerate e-assessments (Gwynllyw and Henderson, 2009; Gwynllyw and Henderson, 2012). Even though Dewis has been used very successfully over the past decade, it is not being used to its full potential. Therefore, one aim of the CSE project is to develop and use additional features, in order to fully realise the benefits of Dewis.

A Common Student Error (CSE) is an understandable error leading to an incorrect answer due to a student's misconception. For example, answering $a^2 + b^2$ when asked to expand $(a + b)^2$ can be considered as a CSE. This kind of an understandable but incorrect implementation of a process is also called a mal-rule (Rees and Barr, 1984; Sleeman, 1984).

Finding students' perceptions on enhanced feedback delivered through Dewis is the fourth stage of the CSE Project. In the first stage of the research, as described by Sikurajapathi, Henderson, and Gwynllyw (2020), we gathered CSEs made in the Engineering Mathematics 2018 January e-examination, by examining students' written answer scripts along with their corresponding Dewis answers. We found 40 CSEs relating to 17 questions (Sikurajapathi, Henderson, and Gwynllyw, 2020).

Having identified CSEs related to the module, in the second stage we altered the original Dewis question code, including additional scripts using the Perl programming language. Performance Indicators (PIs), are a powerful feature of the Dewis administration reporter tool, as they enable the academic to view the performance of a student on each question attempt. This is particularly useful in order to see whether a particular student scored zero by not answering the question or by answering the question incorrectly. For each identified CSE, we introduced additional PIs to the altered Dewis question code, in order to automatically capture each CSE and provide detailed enhanced feedback when they are triggered.

For the third stage of the project, the amended questions were included in the semester 1 weekly e-Assessments used as summative assessments for the 2019-2020 cohort of the Engineering Mathematics module. Further, nine of the amended questions were presented in a revision test at the end of the first semester. The fourth stage of this study, which we are going to discuss in this paper, comprises an online questionnaire given to those students who received enhanced CSE feedback in either the weekly e-assessments or the end of semester revision test.

2. Objective and Research Questions

The primary focus of our research is to design enhanced feedback to address CSEs and underline mathematical misconceptions of engineering students at UWE Bristol. In other words, we want to develop enhanced feedback which promotes students' conceptual change and facilitates student learning. Further, we want the enhanced feedback to be user-friendly with a coherent structure (clear, organised, detailed and yet simple), and to have ergonomic features (user-friendly format, font, font-size, and appropriate labelling and highlighting).

For example, the enhanced feedback given for a question regarding finding the modulus of a given complex number is shown in Figure 1. The CSE related to this problem was to take $(-2)^2$ equal to -4 . For the enhanced feedback we used different colours, a step by step method and equation numbering to provide clear and concise feedback to address students' misconceptions.

The aim of the questionnaire study was to gather students' views on the enhanced feedback they received as a result of triggering a CSE. The main research questions were:

- How and to what extent does the current enhanced feedback help students to change their conceptual understanding and facilitate their understanding of the subject?
- What are their views on the user-friendly features of the enhanced feedback?

3. Research Method

The questionnaire was planned to gather students' views on how and to what extent the current enhanced feedback helped them to change their conceptual understanding and facilitate their understanding of the subject. In addition, we wanted to gather students' views on the user-friendly features of the enhanced feedback.

3.1. Ethical Review of the Research

The questionnaire was designed in accordance with policy, procedures and guidance of the Faculty Research Ethics Committee (FREC) at UWE, Bristol. The questionnaire distribution and collection of data for the research was commenced after receiving written approval from the FREC to undertake research involving human participants.

The Question
Find the modulus $|z|$ of the complex number $z = -2 + 5j$, correct to two decimal places.

The Solution
The modulus of $z = a + jb$ is $|z| = \sqrt{(a)^2 + (b)^2}$,
hence when $z = -2 + 5j$ we find $|z| = \sqrt{(-2)^2 + (5)^2} = \sqrt{29}$.
The value of $|z|$ is 5.38516.. which, to two decimal places, is 5.39.

The Report
Your answer for $|z|$ is 4.58.
Your answer is **not** correct.

Your incorrect answer seems to have been derived by assuming that $(-2)^2$ equals to -4 . This is incorrect.

Please note that $(-2)^2 = 4$.

The modulus of the complex number $z = a + jb$ is,

$$|z| = \sqrt{(a)^2 + (b)^2}. \rightarrow \textcircled{A}$$

To find $|z|$ when $z = -2 + 5j$, we substitute $a = -2$ and $b = 5$ in \textcircled{A}

$$|z| = \sqrt{(-2)^2 + (5)^2}, \text{ [Note that } (-2)^2 = 4 \text{]}$$

$$= \sqrt{4 + 25}$$

$$= \sqrt{29}$$

$$= 5.38516..$$

$$= 5.39 \text{ (to two decimal places)}$$

Figure1: An example of the enhanced CSE feedback

3.2. Questionnaire Design and Distribution

The questions in the questionnaire, shown in Figure 2, fell into two groups: Likert-scale and open-ended. Participants received four closed questions, using a 5-point Likert-scale ranging from "Strongly agree" to "Strongly disagree". For each of the three open-ended questions, a comment box was provided for students to input their response.

The questionnaire was administrated via Qualtrics software (Qualtrics, 2005). Qualtrics is a web-based survey software tool which can be used to conduct publicly available surveys, or to give specific users access to a survey. Using online questionnaires has numerous benefits in terms of cost, time, ease of administration, data collation and analysis (Dillman, 2007). Another advantage of using an online questionnaire was that it was easy to reach all of the students who made CSEs by emailing them with a link to the questionnaire. However, the collected responses were anonymous.

QUESTIONNAIRE

Evaluating the effectiveness of the enhanced feedback on the Dewis e-Assessment System

This questionnaire has a number of questions asking you for your feedback on the enhanced feedback you received on Engineering Mathematics weekly test (*include assessment number here*) on the Dewis e-assessment system.

Please tick (✓) in the appropriate column alongside the question number on the questionnaire.

Do not worry about projecting a good image. Your answers are **CONFIDENTIAL**. Thank you for your cooperation.

| | | Strongly disagree | disagree | Neutral | Agree | Strongly agree |
|---|---|-------------------|----------|---------|-------|----------------|
| 1 | The enhanced feedback I received on weekly test (<i>number</i>) improved my mathematical understanding. | | | | | |
| 2 | The enhanced feedback makes me feel confident/comfortable with Engineering Mathematics. | | | | | |
| 3 | The information in the enhanced feedback is relevant to the question asked. | | | | | |
| 4 | I am satisfied with the overall structure of the enhanced feedback. | | | | | |

5. What do you like about the enhanced feedback you received?

6. What do you dislike about the enhanced feedback you received?

7. Do you have any suggestions for improvement?

Figure 2: Example of the questionnaire sent out to students

The questions were designed to avoid long, double-barrelled, technical, ambiguous, leading or double negative questions or statements. In order to make the questionnaire short and clear we avoided lengthy questions and made sure that the questionnaire fitted on one page (Dillman, 2007). Great care was taken to make the questionnaire visually appealing (Frankfort-Nachmias, 1996). The UWE logo was inserted at the top of the questionnaire to make it more professional and institution-related. In the invitation email it was specifically stated how the participants' responses would be used in the future development of Dewis and hence be valued as a whole by the UWE community (Oppenheim, 1992).

As suggested by Dillman (2007), in order to maximise response and completion rates, a clear indication of how long the questionnaire would take to complete was given in the invitation email. Further, clear instructions were included, together with the purpose of the questionnaire and important information related to the research which were available in a separate 'Participant Information Sheet' (PIS). A link to the PIS, which was placed on the CSE project web page (CSE Project at UWE, 2019), was included in the 'Informed Consent' section at the beginning of the questionnaire.

For each assessment, we identified which students had received enhanced feedback on each question by analysing the additional PIs in the Dewis Reporter. At the end of each weekly test we sent a questionnaire to those identified students. There were some students who received CSE enhanced feedback, and hence the questionnaire, in more than one week. The total number of questionnaires sent by the end of the semester was 336 and these were sent to 196 distinct students, who received CSE enhanced feedback in at least one of their weekly tests.

At the end of the revision test, we identified 129 distinct students who had received enhanced feedback for this test. Since we wanted to gather more responses from the students, we decided to send the questionnaire to all of the students who had received enhanced feedback in some form. There were 78 students who received enhanced feedback for both the weekly and revision tests. Therefore, in order to avoid sending the questionnaire to those students twice, we sent the same questionnaire to the 247 distinct students who had received enhanced feedback for either the end of semester revision test or the weekly tests.

4. Data Analysis

In total, we received 33 responses to the 336 weekly questionnaires and 26 responses to the 247 end of semester questionnaires. The 2019-2020 cohort had 330 students and 247 of these students made at least one CSE in either their weekly tests or the revision test. In total, we received 59 responses to all of the questionnaires sent.

4.1. Analysis of the Likert-scale questions

The first four questions of the questionnaire were in Likert-scale format. Therefore, quantitative methods were used to analyse the participant responses. In the following sections we discuss each of these questions in the questionnaire separately and present figures which show the percentages of each Likert-scale response with the agreement percentage for each statement. It should be noted that percentages do not always total to 100% due to rounding. The agreement percentage (AP) is the number that selected "Agree" or "Strongly Agree" divided by the sum of those participants selecting a response on that question.

Q1: The enhanced feedback I received on weekly test [x] improved my mathematical understanding

Figure 3 presents the participants' responses to the statement '*The enhanced feedback I received on weekly test [x] improved my mathematical understanding*' in the weekly questionnaire and/or the end of semester questionnaire.

This shows that the majority of participants either strongly agreed or agreed that the enhanced feedback they received improved their mathematical understanding. The AP of the participants to the statement is 88% and this figure indicates the participants' positive appreciation towards the conceptual change afforded by the enhanced feedback.

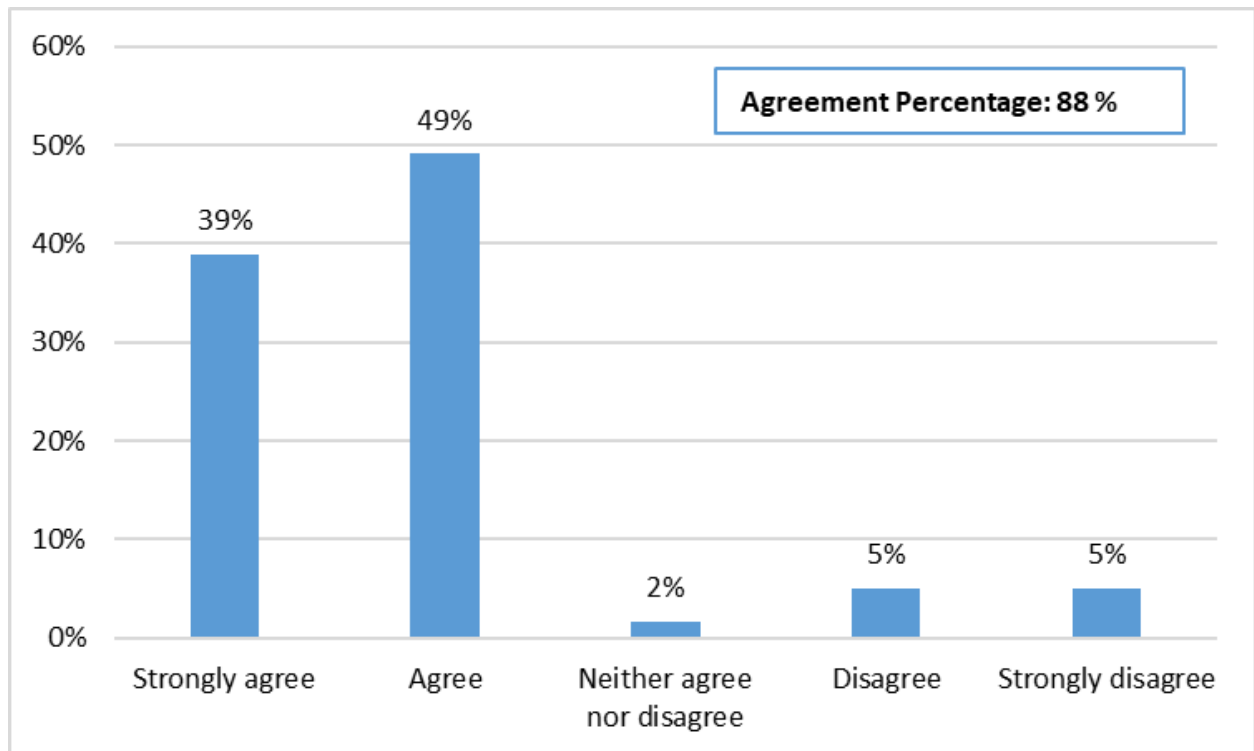


Figure 3: Questionnaire responses to the question "The enhanced feedback I received improved my mathematical understanding"

Q2. The enhanced feedback makes me feel confident/comfortable with Engineering Mathematics

Figure 4 shows the participants' responses to the statement '*The enhanced feedback makes me feel confident/comfortable with Engineering Mathematics*' for the weekly questionnaire and/or the end of semester questionnaire. The results show that the majority of the participants agreed with this statement and the AP of the participants to the statement is 73%.

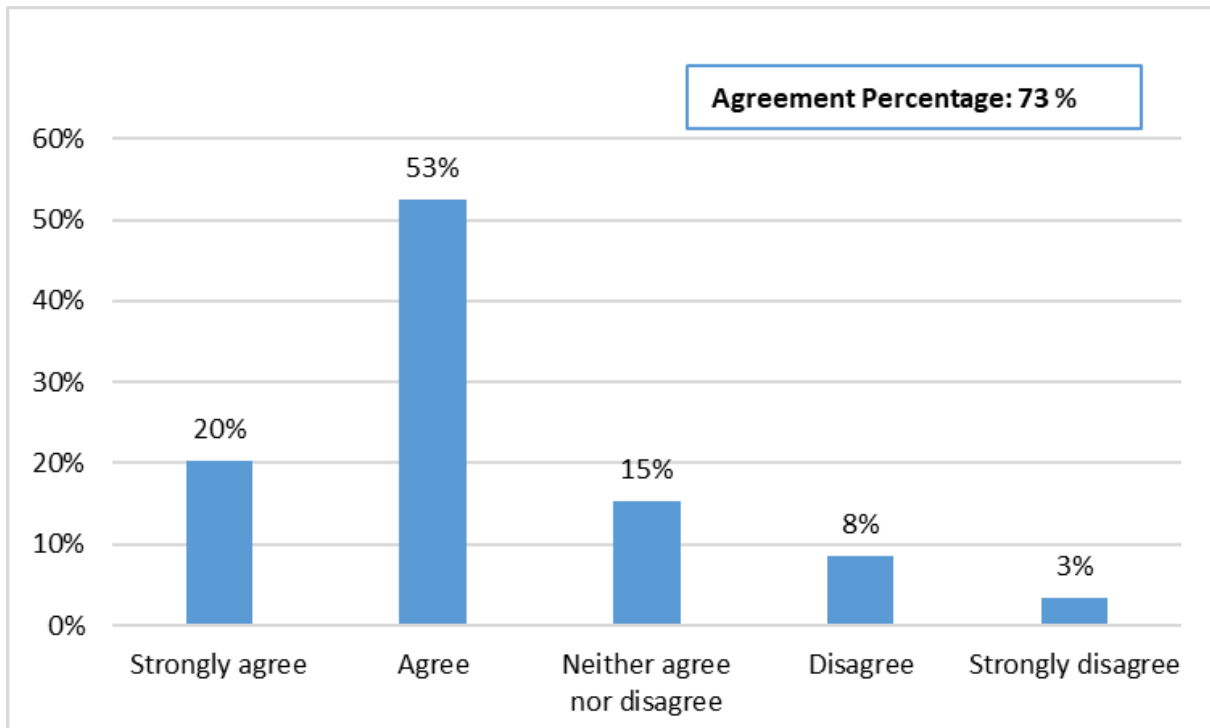


Figure 4: Questionnaire responses to the question "The enhanced feedback makes me feel confident/comfortable with Engineering Mathematics".

Q3. The information in the enhanced feedback is relevant to the question asked

The third statement of the questionnaire is where we are looking for how students feel about the relevance of the enhanced feedback. Figure 5 shows the questionnaire responses to the question “*The information in the enhanced feedback is relevant to the question asked*” for the weekly questionnaire and/or the end of semester questionnaire.

What stands out in Figure 5 is that almost all of the participants agreed or strongly agreed that the information in the enhanced feedback is relevant to the question asked (AP 95%).

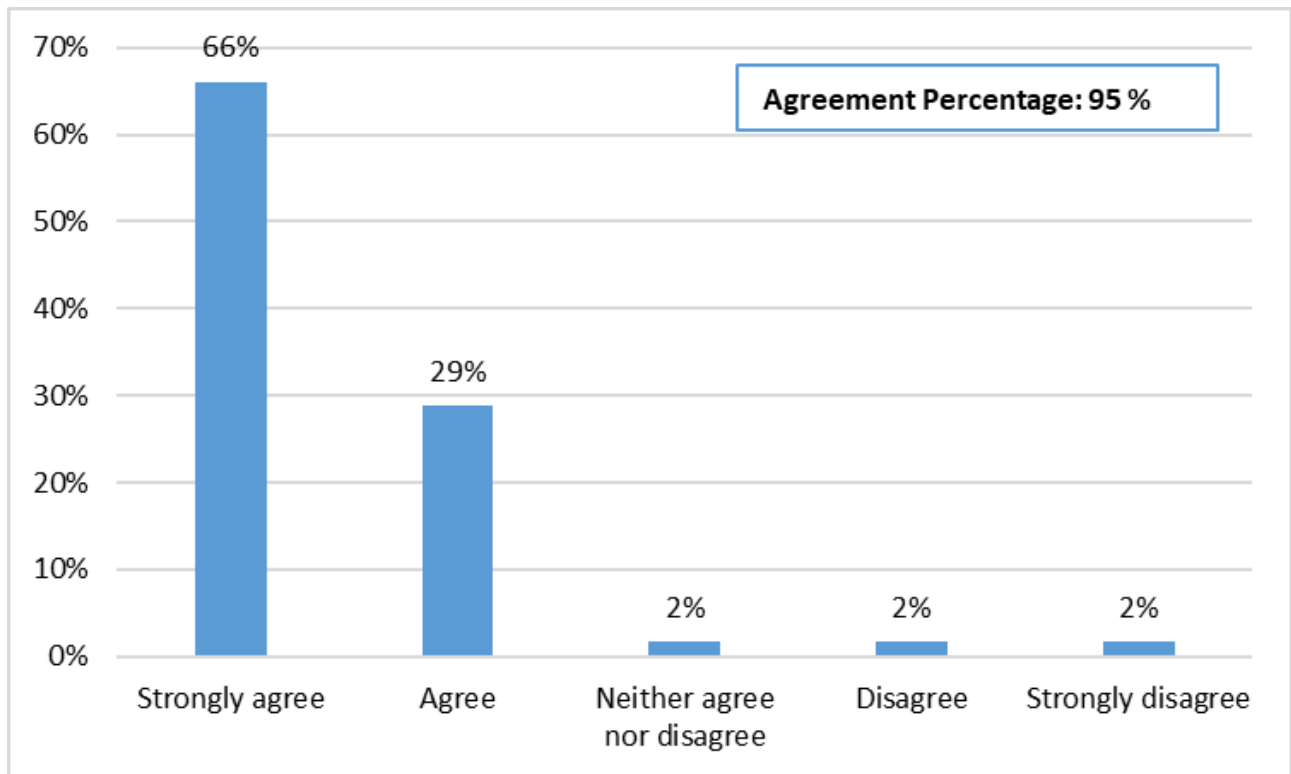


Figure 5: Questionnaire responses to the question “The information in the enhanced feedback is relevant to the question asked”

Q4. I am satisfied with the overall structure of the enhanced feedback

Figure 6 shows the questionnaire responses to the question “I am satisfied with the overall structure of the enhanced feedback”. The majority of those who responded to this statement indicated that they were satisfied with the overall structure of the enhanced feedback. The figure shows that the AP for this statement is 87%.

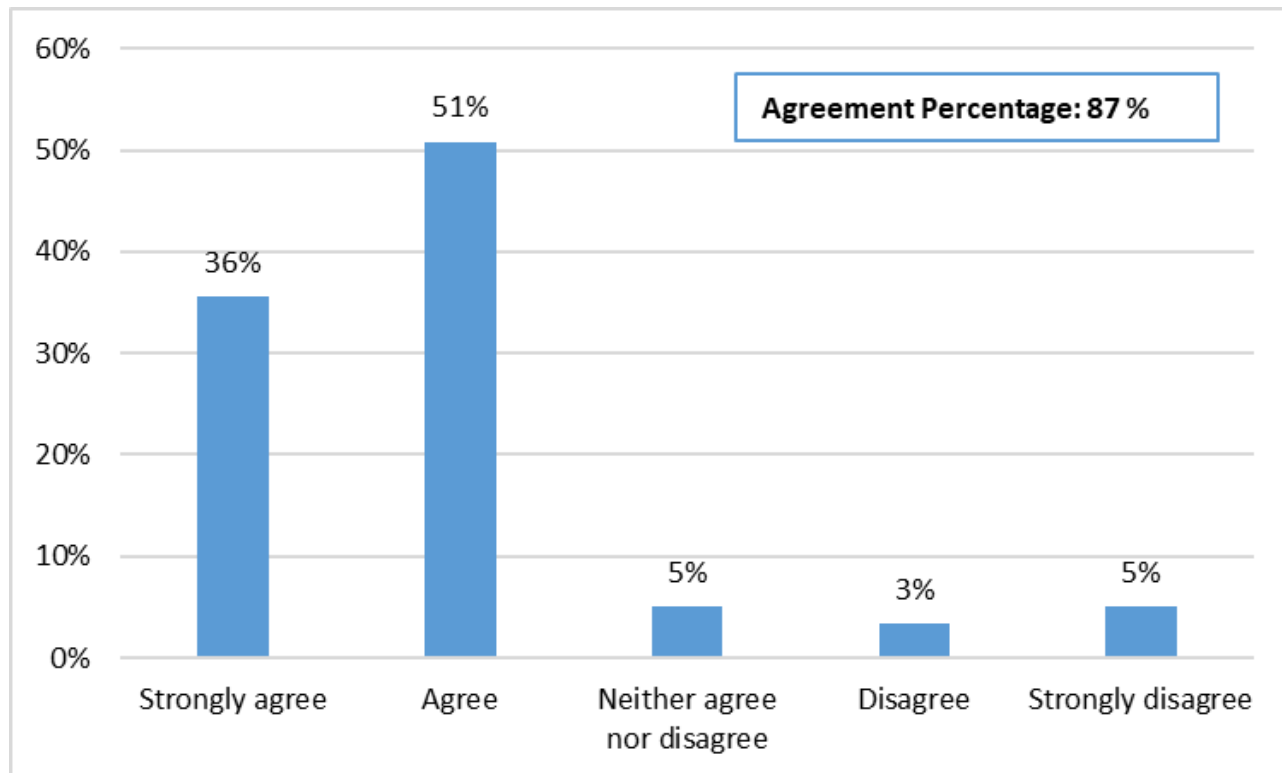


Figure 6: Questionnaire responses to the question “I am satisfied with the overall structure of the enhanced feedback”

4.2. Analysis of the open-ended questions

We used thematic analysis to analyse the three open-ended questions. Thematic analysis is a widely used qualitative method. It is used to analyse qualitative data gathered in the form of open-ended responses to questionnaires (Castleberry and Nolen, 2018).

Thematic analysis is used for identifying, analysing and reporting patterns or themes within data. In their paper, Braun and Clarke (2006) describe how to conduct thematic analysis in six phases (Familiarizing yourself with your data, Generating initial codes, Searching for themes, Reviewing themes, Defining and naming themes, Producing the report). Following the six phases as described by Braun and Clarke (2006), we conducted thematic analyses on the responses to the open-ended questions on the questionnaire for both the weekly and the end of semester questionnaires combined.

Q5. What do you like about the enhanced feedback you received?

From this question, we want to capture what students like about the enhanced feedback so that we can keep those features unchanged when new enhanced feedback is constructed in the future.

Two overarching themes, *Conceptual change* and *User-friendly features*, emerged from a detailed thematic analysis of the texts of students' responses to this question. The sub-themes which emerged from the two aforementioned main themes are summarised in Table 1.

Table 1: Themes resulting from thematic analysis on student responses to the question "What do you like about the enhanced feedback you received?"

| Main Themes | Sub-themes |
|------------------------|--|
| Conceptual change | Correct CSE capture (Correct capture) Facilitate learning (Beneficial) Relevance of the content on CSEs enhanced feedback (Relevance). |
| User-friendly features | Coherent structure Accessibility |

The *Conceptual change* theme highlighted three sub-themes which examined perception on Correct CSE capture (Correct capture), facilitating learning (Beneficial), and Relevance of the content on CSEs enhanced feedback (Relevant).

Under the sub-theme Correct capture, many participants felt that the enhanced feedback they received cleared up their doubts. Further, they claimed that the feedback made them understand why and where they went wrong. The majority of the participants' appreciated the way in which the enhanced feedback helped them to change their misunderstandings/misconceptions of the mathematical concepts and to improve their learning. In the Beneficial sub-theme, a significant number of participants mentioned the benefit they received from the enhanced feedback in improving their understanding. Further, they noted the usefulness and helpfulness of the feedback to their learning and understanding of the subject. In the Relevance sub-theme, a couple of participants mentioned how relevant the received feedback was in their learning. Table 3 in the Appendix contains several examples of such quotes which emerged from the *Conceptual change* theme and three examples of such quotes are given below:

"It makes you feel conscious of errors you made. The fact that it tells you what you've done based on your final input is clever."

"The enhanced feedback got right to the reason the answer was wrong rather than lingering on things already explained above in the solution."

"The Feedback which I received helped me to understand where I was most likely to make errors and showed the correct way of working out solutions."

The *User-friendly features* theme contained two sub-themes: Coherent Structure and Accessibility. Under the sub-theme Coherent Structure, it emerged that many participants liked the structure of the enhanced feedback and particularly highlighted its step-by-step, clear and concise explanations. Several participants appreciated the accessibility features of the enhanced feedback. In particular they commented on its instant availability, quick accessibility, and visibility in different colours. Table 4 in the Appendix shows multiple examples of those quotes which arose from the User-friendly Features Theme. One example from Table 4 is reproduced here:

“The total feedback was overall concise and accessible.”

Q6. What do you dislike about the enhanced feedback you received?

From this question we wanted to capture what students disliked about the enhanced feedback so that we can amend and improve the features of future enhanced feedback. Thematic analysis on the responses for this question highlighted four main themes: *Everything is alright*, *Short explanations*, *Less accessibility features* and *Not helpful*.

It was encouraging to see that the majority of the participants said that they were satisfied with the current CSE enhanced feedback and did not indicate any aversion to it. Some comments from the *Everything is alright* theme can be found in Table 5 in the Appendix.

A few participants indicated that the enhanced feedback is very short for some questions and suggested that they would prefer to have more detailed feedback, which would improve it in the future. Two such examples of participants' comments are shown below:

“Some answers can be quite brief so more in depth answers would be great.”

“Needs more steps for the student to fully understand what is happening throughout the equation.”

The participant who made the above comment also disagreed to all of the Likert-scale statements on the questionnaire except for statement Q3.

Further comments on the *Short explanations* theme can be found in Table 6 in the Appendix.

A few comments related to the *Less accessibility features* theme. Some participants mentioned the issue of visibility of the current enhanced feedback and gave some useful suggestions for increasing its visibility. One participant suggested that moving the enhanced feedback to the general Solution section rather than including it in a separate section (Report section) to avoid scrolling past the enhanced feedback. These inputs were very valuable to us and we will aim to incorporate them and address the issues raised in the future development of the CSE project.

Table 7 in the Appendix shows multiple examples of quotes which arose from this theme. One example of which is given here:

“The incorrect answer could be written right after the correct one rather than right at the very bottom so that it would be easier to understand.”

However, only one participant found the enhanced feedback not to be useful and stated that *“It doesn't help me to learn anything.”* The same participant strongly disagreed to statements Q1 and Q2 and disagreed to statement Q4. However, the participant agreed with statement Q3.

Q7 Do you have any suggestions for improvement?

The last item of the questionnaire was 'Do you have any suggestions for improvement?' Here we were looking for participants' views on what is lacking in the feedback and for ideas on how to further develop the enhanced feedback in the future. Thematic analysis on the responses for this question revealed three main themes: *Everything is alright*, *Suggestions to improve current features* and *Suggestions for future directions*. Table 2 summarises these themes and all of the sub-themes which emerged from this question.

Table 2: Themes resulting from thematic analysis of student responses to the question "Do you have any suggestions for improvement?"

| Main Themes | Sub-themes |
|---|--|
| Everything is alright | Everything is alright |
| Suggestions to improve current features | Detailed Explanations More Accessibility features |
| Suggestions for future directions | Enhanced feedback for all the other questions New ideas for further improvement |

Most of the participants were satisfied with the enhanced feedback they received and did not give any suggestions for further improvements. A few responses received under the *Everything is alright* theme can be found in Table 8 in the Appendix, and one of these is presented here.

"I think it is as good as it can be. Thank you!"

A few participants echoed the same suggestions that we received for question 6 of the questionnaire. Namely, they suggested providing detailed feedback and making the feedback more accessible, readable and efficient. A few responses received in the *Suggestions to improve current features* theme are detailed in Table 9 in the Appendix and two of these are presented here.

"Include all steps, even if they seem unimportant."

"Provide enhanced feedback not just on hard questions but on easy ones too."

One participant who disagreed to the Likert-scale statements Q1, Q2 and Q4 but agreed to Likert-scale statement Q3 suggested 'To make it more readable and a more efficient design'.

Some participants provided useful suggestions for future directions, which emerged as a main theme. Within this theme, the comments were categorised into two sub-themes, namely 'Enhanced feedback for all the other questions' and 'New ideas for further improvement'. A few of the comments given in this theme are recorded in Table 10 in the Appendix, and one of these comments is as follows:

"I would also like to know the subject of each question so that I could Google anything that I didn't understand. Another option would be to have a link to the lectures that covered each question, so that if I got a question wrong I could know what lecture covered that topic."

5. Discussion, conclusion and future work

This case study investigated how and to what extent the current enhanced feedback helps students to change their conceptual understanding and facilitate their understanding of the subject, together with their views on the user-friendly features and structure of the enhanced feedback. We were looking for students' views on the effectiveness of the enhanced feedback in correcting their misconceptions and improving their Engineering Mathematics learning. Further, we looked for their satisfaction of the user-friendly features in the enhanced feedback.

The results and the agreement percentages of the Likert-scale questions indicates that the majority of the participants agreed that the enhanced feedback improved their mathematical understanding and made them feel confident/comfortable with Engineering Mathematics. They also indicated that the information in the enhanced feedback is relevant to the question asked and that they are satisfied with the overall structure of the enhanced feedback.

The responses to the Likert-scale questions and the open-ended questions showed that the majority of the participants had positive feelings toward the enhanced feedback. Participants appreciated that the enhanced feedback helped them to address their misunderstanding and to improve their engineering mathematics learning.

The study also gave insight into how students find the user-friendly features of the enhanced feedback. Most of them had positive comments about its coherent structure and ergonomic features. One specific concern that emerged related to improving the visibility of the enhanced feedback. There were some very valuable suggestions of how to improve these features, such as moving it to a more noticeable place on the feedback report, and redesigning the enhanced feedback to have a more efficient and readable structure.

Some other notable suggestions were to include videos within the enhanced feedback and web links to extra materials. The majority of the participants highly valued the effectiveness of the enhanced feedback and suggested/wished to have enhanced feedback for the rest of the questions in the Engineering Mathematics e-assessments.

These suggestions and the highly positive perception of the enhanced feedback suggest that students find the enhanced feedback valuable for their learning. The positive responses on the CSE enhanced feedback have given us the encouragement to continue with the CSE project. We plan to continue our work by searching for further CSEs, providing enhanced feedback on questions delivered through the Dewis e-Assessment system and improving the layout of the enhanced feedback by taking some of the student suggestions on board.

6. Appendix

Table 3: Students' responses of Conceptual Change Theme for the question "What do you like about the enhanced feedback you received?"

| Sub-Themes in Conceptual Change | Students' responses |
|--|--|
| Correct CSE capture (Correct capture) | <p><i>"Told me exactly where I went wrong."</i></p> <p><i>"It give me a good understanding of what I did."</i></p> <p><i>"It also explained in detail why I was incorrect."</i></p> <p><i>"The fact that the feedback tells me where I actually went wrong and if I repeat the test, then I would not make the same mistake."</i></p> <p><i>"The enhanced feedback got right to the reason the answer was wrong."</i></p> <p><i>"The Feedback which I received helped me to understand where I was most likely to make errors and showed the correct way of working out solutions."</i></p> <p><i>"I can clearly see where I went wrong and it gives me a chance to improve."</i></p> <p><i>"It helps me to make me realize the mistake where I went wrong on some type of questions."</i></p> <p><i>"It makes you feel conscious of errors you made. The fact that it tells you what you've done based on your final input is clever."</i></p> <p><i>"I think it is a great model of reinforcing problems of understanding."</i></p> <p><i>"It made me understand more in depth."</i></p> |
| Facilitate learning (Beneficial) | <p><i>"Very useful and well structured. Helps to answer any similar questions."</i></p> <p><i>"It was certainly useful to receive enhanced feedback alongside the standard feedback."</i></p> <p><i>"Very useful and helps to further understanding."</i></p> <p><i>"It helped my understanding."</i></p> <p><i>"I reckon that the enhanced feedback must be very helpful to those, who struggle with some questions."</i></p> <p><i>"I have read the feedback and it seemed very helpful and clear to me."</i></p> |
| Relevance of the content on CSEs enhanced feedback (Relevant). | <p><i>"Immediate and specific question related instead of a general explanation."</i></p> <p><i>"Its overall applicability to my work."</i></p> <p><i>"It's related to the problem."</i></p> |

Table 4: Students' responses of User-friendly Features Theme for the question "What do you like about the enhanced feedback you received?"

| Sub-Themes in User-friendly Features | Students' responses |
|---|---|
| Coherent structure | <p><i>"Very useful and well structured."</i></p> <p><i>"The total feedback was overall concise"</i></p> <p><i>"Step by step method."</i></p> <p><i>"It also explained in detail why I was incorrect."</i></p> <p><i>"Short and simple."</i></p> <p><i>"Clear and concise information."</i></p> <p><i>"Well detailed with every step explained thoroughly."</i></p> <p><i>"It shows the correct answer and detailed workings."</i></p> <p><i>"Clear and concise."</i></p> <p><i>"It's very well structured so that it is easy to understand."</i></p> <p><i>"Clear and concise method, made it easier to understand the question."</i></p> <p><i>"Write all steps of solution."</i></p> <p><i>"It's well explained."</i></p> |
| Accessibility | <p><i>"The total feedback was overall concise and accessible."</i></p> <p><i>"Its simplicity."</i></p> <p><i>"That it is instant."</i></p> <p><i>"It was in a different colour so more visible."</i></p> <p><i>"Immediate."</i></p> <p><i>"Accessible feature and introduced to the user."</i></p> |

Table 5: Students' responses of 'Everything is alright' Theme for the question "What do you dislike about the enhanced feedback you received?"

| Main Themes | Students' responses |
|--|---|
| Everything is alright/nothing to dislike | <p><i>"Nothing."</i></p> <p><i>"There is not really much there to dislike, it's just maths feedback."</i></p> <p><i>"Nothing to dislike."</i></p> <p><i>"I haven't found any cons regarding the feedback."</i></p> <p><i>"I find it good enough."</i></p> <p><i>"No."</i></p> |

Table 6: Students' responses of 'Short Explanations Theme' for the question "What do you dislike about the enhanced feedback you received?"

| Main Theme | Students' responses |
|--------------------|--|
| Short Explanations | <p><i>"Some answers can be quite brief so more in depth answers would be great."</i></p> <p><i>"Some feedback solutions explain steps without showing the working needed for those steps."</i></p> <p><i>"Sometimes the workings are not easy to understand."</i></p> <p><i>"Needs more steps for the student to fully understand what is happening throughout the equation."</i></p> <p><i>"Sometimes it's unclear on how it gets from one step to another."</i></p> <p><i>"For some questions it is really helpful. For other questions I don't think it goes far enough to explain the workings."</i></p> <p><i>"I wish the enhanced feedback was more detailed."</i></p> |

Table 7: Students' responses for 'Less Accessibility Features Theme' for the question "What do you dislike about the enhanced feedback you received?"

| Main Theme | Students' responses |
|-----------------------------|---|
| Less Accessibility features | <p><i>"It was below the general feedback and correct answer, so it's easy to just scroll past."</i></p> <p><i>"It's structure"</i></p> <p><i>"Needs to be more organised and easier to identify where you made the mistake."</i></p> <p><i>"The incorrect answer could be written right after the correct one rather than right at the very bottom so that it would be easier to understand."</i></p> |

Table 8: Students' responses of 'Everything is alright' Theme for the question "Do you have any suggestions for improvement?"

| Main Themes | Students' responses |
|--|---|
| Everything is alright/nothing to dislike | <p><i>"I think it is as good as it can be. Thank you!"</i></p> <p><i>"Nothing."</i></p> <p><i>"It's good enough."</i></p> <p><i>"No"</i></p> <p><i>"I think it is as good as it can be. Thank you!"</i></p> |

Table 9: Students' responses of 'Suggestions to improve current features' Theme for the question "Do you have any suggestions for improvement?"

| Sub-Themes | Students' responses |
|-----------------------------|--|
| Detailed Explanations | <p><i>"Include all steps, even if they seem unimportant."</i></p> <p><i>"Make it a bit clearer to understand."</i></p> <p><i>"More detailed feedback, especially for integration and differentiation questions."</i></p> <p><i>"Highlight your mistake, but show other possible common mistakes optionally. That way you can roughly know what to look out for."</i></p> <p><i>"Include an extra example? Time consuming so understandable if not"</i></p> |
| More Accessibility features | <p><i>"To make it more readable and a more efficient design."</i></p> <p><i>"I would suggest using two columns when designing the layout for the feedback. One should just show my answer. The other shows the right answer with the detailed working."</i></p> <p><i>"Moving the incorrect answer closer to the correction or right next to it and maybe making it easier to find the questions you got wrong rather than scrolling all the way and having to search for it."</i></p> |

Table 10: Students' responses of 'Suggestions for future directions' Theme for the question "Do you have any suggestions for improvement?"

| Sub-Themes | Students' responses |
|---|--|
| Enhanced feedback for all the other questions | <p><i>"I would like more feedback for all question I get wrong, and with a more detailed step by step approach."</i></p> <p><i>"It doesn't give alternate answers with different questions as an option for more complex questions."</i></p> <p><i>"Not all questions has enhanced feedback."</i></p> <p><i>"I would prefer more feedback from Dewis, in particular more steps in how problems are solved."</i></p> <p><i>"Provide enhanced feedback not just on hard questions but on easy ones too."</i></p> |
| New ideas for further improvement | <p><i>"I would also like to know the subject of each question so that I could Google anything that I didn't understand."</i></p> <p><i>"Another option would be to have a link to the lectures that covered each question, so that if I got a question wrong I could know what lecture covered that topic."</i></p> <p><i>"Videos of a maths teacher doing each question and talking through each step."</i></p> |

7. References

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