The effectiveness of remediating mathematical Common Student Errors in e-Assessments

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Project team

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Plan of talk

Background

The Common Student Errors (CSE) Project at UWE, Bristol

- ➢ Stage One: Data (CSEs) Collection
- ➢ Stage Two: CSE code Development
- ➢ Stage Three: CSE code Trial Phase
- ➢ Stage Four: Students' Perceptions on CSE Feedback
- ➢ Stage Five: Outcomes of CSE Project

Discussions and Conclusions

Background: Common Student Errors (CSEs)

Misconceptions;   mistakes due to carelessness

$$\frac{1}{12} > \frac{1}{6}$$

$$\frac{1}{5} + \frac{5}{12} = \frac{6}{17}$$

$$\frac{a+x}{b+x} = \frac{a}{b}$$

$$(-3)^2 = -9$$

$$\sqrt{1+x^2} = 1+x$$

$$(a+b)^c = a^c + b^c$$

Background: Dewis E-Assessment System

Developed at UWE Bristol

Algorithmic

Different question input types

Lossless data collection

Student friendly features

The Common Student Errors (CSEs) Project at UWE, Bristol

? **Research questions:**

➤ What CSEs do first year Engineering mathematics students make?

➤ How to detect CSEs and improve Dewis feedback to address these CSEs?

Aim:

➤ To introduce a method to detect CSEs and to provide tailored feedback in Engineering Mathematics e-Assessment questions on Dewis.

The Common Student Errors (CSEs) Project at UWE, Bristol...

Benefits:

- Dewis emulates a human marker
  - Provides instant enhanced feedback highlighting possible CSEs made
  - Gives tailored guidance on how to improve students' topic knowledge
- Teachers can identify areas in which more help is needed in student learning.

- Students' learning experience improves.

- Beneficial to several disciplines and organisations.

CSE Project Stage One: Data (CSEs) Collection

Engineering Mathematics Module: Assessments and Practice tests

Regular weekly e-assessments (engagement & attainment)

Mid-module Revision test (practice tests)

Mid-module (January) e-examination (2 hours)

End of module (May) written examination

DEWIS @ UWE

CSE Project Stage One: Data (CSEs) Collection...

2017/18 e-examination: **19** Dewis questions

➢ Fixed parameters for the morning and afternoon sessions

➢ Collected **298** students' answer scripts (rough work)

➢ Used Dewis Reporter to find **Most Common Wrong Answers (CWAs)**

➢ Examined students' rough work to find clues for **Common Students Errors (CSEs)** which led to the CWAs.

➢ Collected **40** CSEs related to **17** Engineering Mathematics questions.
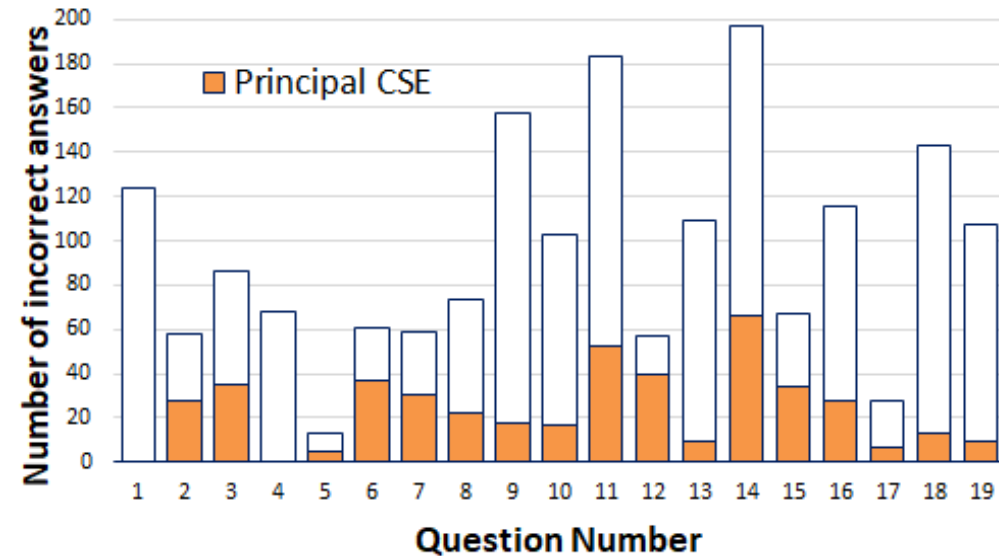
CSE Project Stage One: Data (CSEs) Collection...

40 CSEs found in the following mathematics topics:

- Algebra

- Unit-step function

- Wave forms

- Trigonometric functions

- Differentiation

- Implicit differentiation

- Partial differentiation

- Mean Value Theorem

- Complex numbers

- Geometric series

- Maclaurin Expansion

- Centre of Mass

- Integration by parts

- Volume of revolution

For more details on outcomes of **the first stage of the CSE Project** can be found at:

Sikurajapathi, I., Henderson, K., and Gwynllyw, R., 2020. Using E-Assessment to Address Mathematical Misconceptions in Engineering Students. *International Journal of Information and Education Technology*. 10(5), pp.356–361.

CSE Project Stage One: Data (CSEs) Collection ...

CSE Example 1

Correct Answer	CSE Answer (70%)
$z = -3 + 7j$	$z = -3 + 7j$
$|z| = \sqrt{(-3)^2 + (7)^2}$	$|z| = \sqrt{(-3)^2 + (7)^2}$
$= \sqrt{9 + 49}$	$= \sqrt{-9 + 49}$
$= \sqrt{58}$	$= \sqrt{40}$
$= 7.62$	$= 6.32$

CSE Project Stage One: Data (CSEs) Collection …

- **CSE Example 2**

Question 7.

Obtain the derivative of the function

$$f(x) = 3\ln(5x)$$

Enter the answer as a function of x:

Correct Answer	CSE Answer (51%)
$f'(x) = 3\dfrac{d}{dx}(ln(5x))$ $= 3 \times \dfrac{1}{x}$ $= \dfrac{3}{x}$	$f'(x) = 3\dfrac{d}{dx}(ln(5x))$ $= 3 \times \dfrac{1}{5x}$ $= \dfrac{3}{5x}$

CSE Project Stage Two: CSE code Development

- ➤ Introduced additional **Performance Indicators** (PIs) into each original question code to **capture CSEs** when they are triggered.

- ➤ Created **detailed feedback** based on students' answers:

  - ✓ Highlighted what could have gone wrong (possible CSE) in the Report section

  - ✓ Used different colours and boxes to emphasis the important facts

  - ✓ Created clear detailed step by step FEEDBACK

  - ✓ Provided Additional Notes where necessary

Feedback Report

Your answer for $|z|$ is 6.32.
Your answer is **not** correct.

Your incorrect answer seems to have been derived by assuming that $(-3)^2$ equals to -9.

Please note that $(-3)^2 = 9$.

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

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

To find $|z|$ when $z = -3 + 7j$, we substitute $a = -3$ and $b = 7$ in $\textcircled{A}$

$|z| = \sqrt{(-3)^2 + (7)^2}$, [Note that $(-3)^2 = 9$]

$= \sqrt{9 + 49}$

$= \sqrt{58}$

$= 7.61577..$

$= 7.62$ (to two decimal places)

Highlighting what could have gone wrong

Providing the correct worked solution in detail

CSE Project Stage Three: CSE code Trial Phase

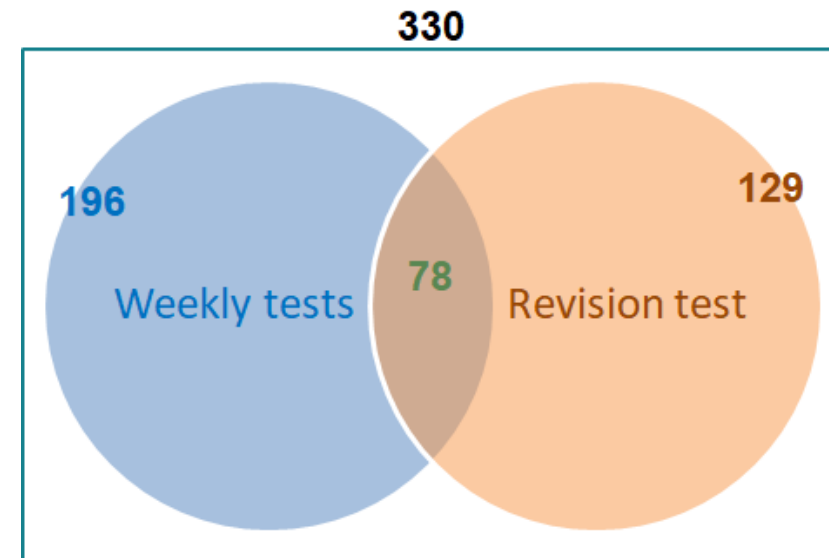**Improved questions used in 2019/20 (total no. of students: 330)**

Weekly tests:

➤ 15 questions which capture 29 CSEs altogether

➤ **196** distinct students received enhanced feedback

Revision test:

➤ 9 questions which capture 21 CSEs altogether

➤ **129** distinct students received enhanced feedback

78 distinct students received enhanced feedback for questions in <u>both</u> **weekly** or **revision** tests

247 distinct students received enhanced feedback for questions <u>either</u> in **weekly** or **revision** tests

CSE Project Stage Four- Students' Perceptions on CSE Feedback

An online questionnaire

Aim: To gather students' views on the enhanced feedback they received

? 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?

Outcomes of the Likert-scale questions

Statement	Agreement Percentage
The enhanced feedback improved my mathematical understanding	**88%**
The enhanced feedback makes me feel confident/comfortable with Engineering Mathematics	**73%**
The information in the enhanced feedback is relevant to the question asked	**95%**
I am satisfied with the overall structure of the enhanced feedback	**87%**

For more details on outcomes of **open-ended questions** and the **whole questionnaire** can be found at:
Sikurajapathi, I., Henderson, K., and Gwynllyw, R., (under review). Students' Perceptions of Enhanced e-Assessment Feedback Addressing Common Student Errors in Mathematics. *MSOR Connections*

CSE Project Stage Four- Students' Perceptions on CSE Feedback...

A few responses to Open-ended questions:

☺ **What do you <u>like</u> about the enhanced feedback you received?**

"Very useful and well structured."

"The enhanced feedback got right to the reason the answer was wrong."

"The fact that it tells you what you've done based on your final input is clever."

"I think it is a great model of reinforcing problems of understanding."

"It was certainly useful to receive enhanced feedback alongside the standard feedback."

CSE Project Stage Four- Students' Perceptions on CSE Feedback...

☹ **What do you <u>dislike</u> about the enhanced feedback you received?**

*"**Nothing**."*

*"Some answers can be quite brief so **more in depth answers would be great**."*

*"I wish the enhanced feedback was **more detailed**."*

💡 **Do you have any <u>suggestions</u> for improvement?**

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

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

*"**Not all questions has enhanced feedback**."*

*"**Videos** of a maths teacher doing each question and talking through each step."*
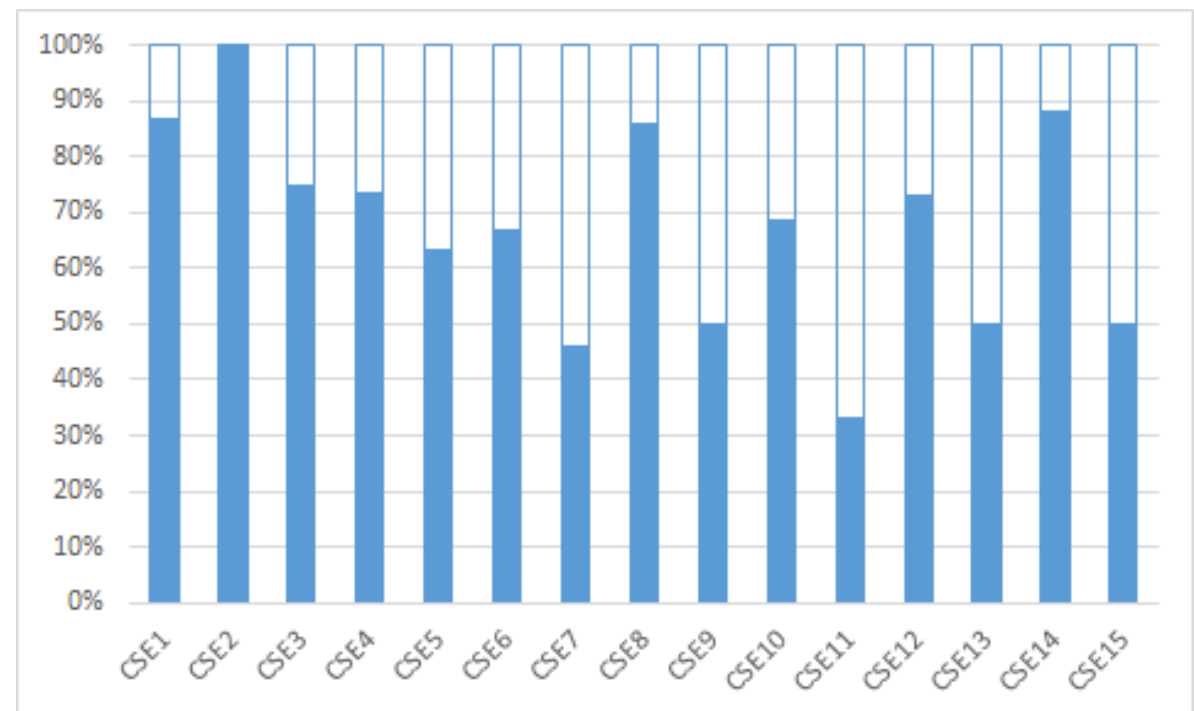
CSE Project Stage Five : Outcomes of CSE Project

8 Improved questions included in the end of semester (controlled conditioned) exam 2019/20

➢ Tested for 17 CSEs, only 15 CSEs triggered

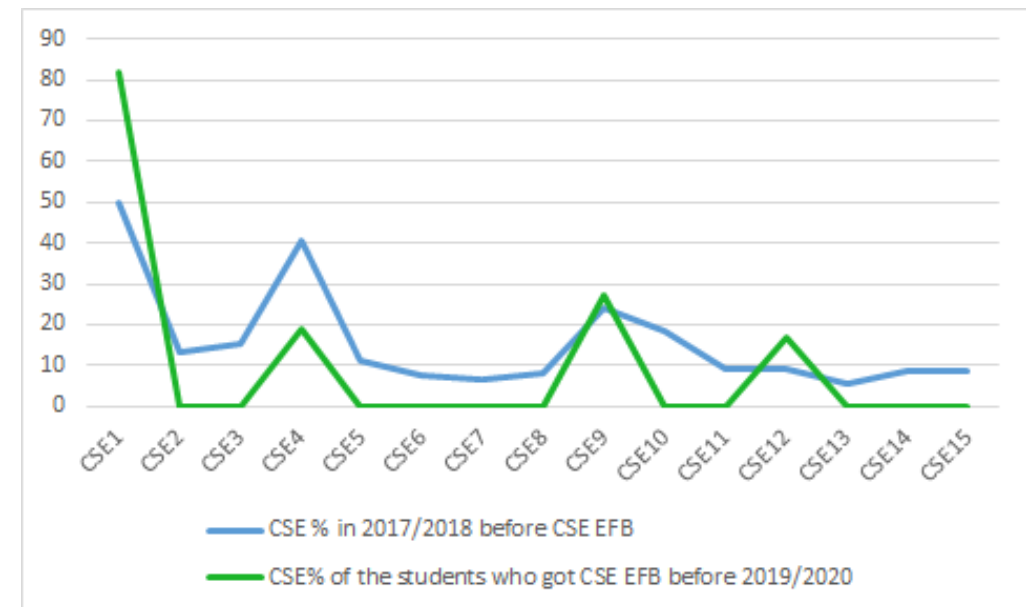| CSE ID	No. of students who received CSE EFB before the exam & answered correctly in the exam (A)	No. of students who received CSE EFB before the exam (B)	Success rate (A/B%)
CSE1	86	99	87%
CSE2	11	11	100%
CSE3	3	4	75%
CSE4	44	60	73%
CSE5	12	19	63%
CSE6	4	6	67%
CSE7	6	13	46%
CSE8	6	7	86%
CSE9	14	28	50%
CSE10	11	16	69%
CSE11	1	3	33%
CSE12	19	26	73%
CSE13	2	4	50%
CSE14	15	17	88%
CSE15	6	12	50%

Success rate %

CSE Project Stage Five: Outcomes of CSE Project...

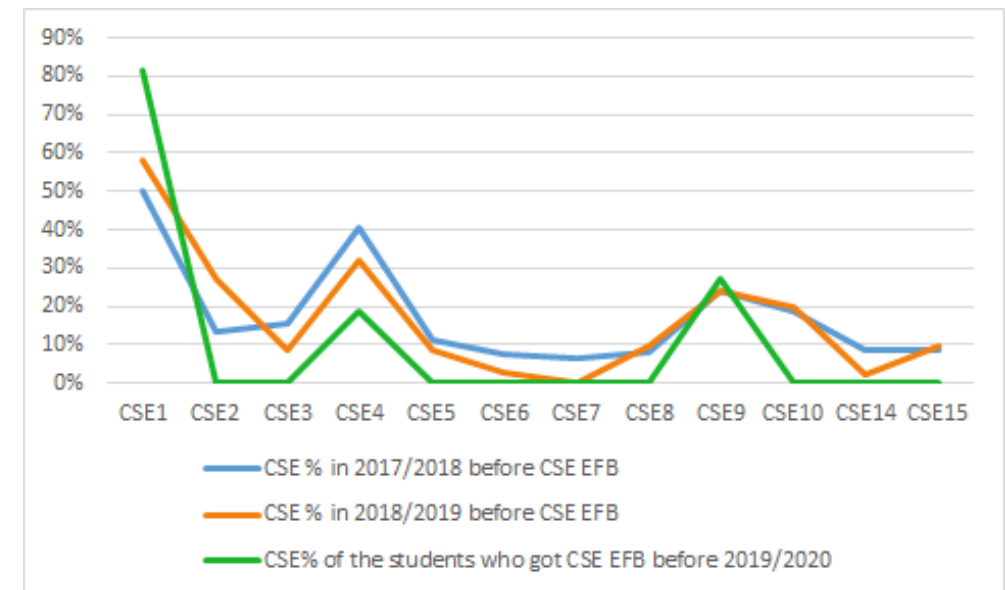- **Comparing CSE occurrence before and after Dewis has the CSE enhanced feedback feature**

	2017/2018 before CSE EFB			2019/2020 after CSE EFB		
	No. of times CSE triggered (C)	No. of incorrect answers (D)	CSE % (C/D %)	No. of times CSE triggered by students who had previously received EFB (E)	No. of incorrect answers submitted by students who had previously received EFB (F)	CSE % (E/F %)
CSE1	28	56	50%	9	11	82%
CSE2	6	45	13%	0	0	0%
CSE3	4	26	15%	0	1	0%
CSE4	35	86	41%	3	16	19%
CSE5	18	158	11%	0	7	0%
CSE6	12	158	8%	0	2	0%
CSE7	10	158	6%	0	7	0%
CSE8	9	109	8%	0	1	0%
CSE9	28	116	24%	3	11	27%
CSE10	11	59	19%	0	2	0%
CSE11	13	143	9%	0	2	0%
CSE12	13	143	9%	1	6	17%
CSE13	8	143	6%	0	1	0%
CSE14	9	107	8%	0	2	0%
CSE15	9	107	8%	0	6	0%

CSE % in 2017/2018 before CSE EFB

CSE% of the students who got CSE EFB before 2019/2020

CSE Project Stage Five: Outcomes of CSE Project

- **Re-marked 2018/2019 exam with new Enhanced Feedback code**
- **Comparing 6 questions (12 CSEs) given in 2017/2018, 2018/2019, 2019/2020**

	2017/2018 before CSE EFB			2018/2019 before CSE EFB			2019/2020 after CSE EFB		
	No. of times CSE Triggered (C)	No. of incorrect Answers (D)	CSE % (C/D %)	No. of times CSE Triggered (G)	No. of incorrect Answers (H)	CSE % (G/H %)	No. of times CSE triggered by students Who had previously received EFB (E)	No. Of incorrect answers submitted by students who had previously received EFB (F)	CSE % (E/F%)
CSE1	28	56	50%	33	57	58%	9	11	82%
CSE2	6	45	13%	14	51	27%	0	0	0%
CSE3	4	26	15%	2	24	8%	0	1	0%
CSE4	35	86	41%	32	100	32%	3	16	19%
CSE5	18	158	11%	15	180	8%	0	7	0%
CSE6	12	158	8%	5	180	3%	0	2	0%
CSE7	10	158	6%	0	180	0%	0	7	0%
CSE8	9	109	8%	9	95	9%	0	1	0%
CSE9	28	116	24%	29	122	24%	3	11	27%
CSE10	11	59	19%	16	80	20%	0	2	0%
CSE14	9	107	8%	3	135	2%	0	2	0%
CSE15	9	107	8%	13	135	10%	0	6	0%

Discussions and conclusions

➢ Dewis has a new feature in detecting CSEs and emulates a human marker:

  ➢ Provides instant enhanced feedback highlighting possible CSEs made

  ➢ Gives tailored guidance on how to improve their knowledge related to the topic

➢ We can now easily address CSEs in a large cohort

➢ Long-term benefit of this feature outweigh the time to identify CSEs and write enhanced feedback

➢ Can be utilised in other cohorts

➢ Teachers can identify areas in which more help is needed in student learning.

➢ Students' learning experience improves.

➢ Further development of Dewis will be beneficial to several disciplines and organisations.

➢ Similar methods can be used to develop other e-Assessment Systems.

Thank you !

☺