

NUMBAS for engineers - Unique assessments with automated marking

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1. What is NUMBAS?

NUMBAS is a highly versatile, free and open-source web-based tool to create online assessments. It is mainly targeted at maths based assessments but can be adapted to fit a wide range of applications and has been used in subjects such as business, psychology, chemistry and engineering [www.numbas.org.uk]. NUMBAS assessments can be completed through learning platforms such as Canvas and Blackboard or downloaded and accessed offline through a USB stick.

3. Creating the E-Assessment

The questions in the assessment were a combination of number entries into a matrix style grid, single numerical answers and multiple choice questions (MCQ). An example of the matrix style question is shown below in Figure 1. NUMBAS allowed the quasi-randomisation of the values given to the students in the table and therefore makes each assessment unique with a unique set of answers.

Staff Pos	BS	IS	FS	Rise	Fall	Reduced Level	Remarks
Stn 1	0.560						Station 1
CP5	0.433		2.482				Change Point 5
Stn 2	2.621		2.568				Station 2
CP6	2.088		0.116				Change Point 6
Stn 1			0.529				Station 1
Sum							
Misclosure							
Allowed misclosure (mm)							

Figure 1 – Example assessment question.

5. Adaptive Marking

A further key advantage of automatic marking is its ability to undertake adaptive marking, also known as follow through marking. In many assessments the answer to a question is reliant on an answer to a previous question. Adaptive marking allows the students' previous answers to be used to assess if the correct methods have been used even if the correct answer is not achieved. Using adaptive marking in NUMBAS it is possible to award any % (in this case 50%) of the available marks for a question if the answer is correct using previous incorrect answers.

2. Why use NUMBAS?

Within the School of Engineering class sizes can often be large making formal assessment challenging for a number of reasons:

- Manual marking is time intensive
- Difficult to maintain marking consistency
- Opportunity for plagiarism amongst students
- Difficult to give individual student feedback

These challenges are only going to become greater with the introduction of a common first year in engineering with class sizes of ≈ 500 .

To evaluate if NUMBAS was an appropriate tool for online assessments a piece of coursework given to ≈ 200 1st year students was selected. This assessment involved three mainly maths based questions around the computations involved in levelling for surveying. Previously, the assessment was completed by hand and marked manually. Where possible the style of the assessment was not altered to enable comparisons of results to previous years to be made.

4. Automatic marking

One of the key advantages of an e-assessment is its ability to instantly and accurately mark the assessment without user input. To achieve this each empty box in the grid was assigned an expected answer with minimum and maximum values and a number of corresponding marks to award. Additionally, answer precision is also important in surveying and therefore a user defined % (in this case 50%) of marks could be removed if answers were not given to correct precision. MCQs were also used to replace short free text answers in the paper based assessment. Each answer within the MCQ is assigned a number of marks and it is possible to set incorrect options as negative marks to discourage guessing.

Figure 2 below shows an example of a marked question including one cell where the answer was given to the wrong precision. Once results have been released the students can also see the expected answer for each cell which was incorrect to improve individual feedback.

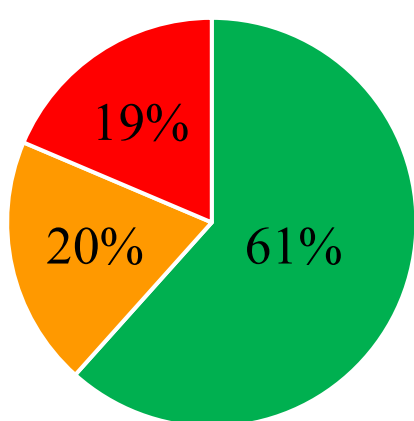
Staff Pos	BS	IS	FS	Rise	Fall	Reduced Level	Remarks	
Stn 1	0.796					68.107	Station 1	Correct answers
CP5	0.355		2.221		1.425	66.682	Change Point 5	
Stn 2	2.892		2.827		2.472	64.21	Station 2	Incorrect precision
CP6	2.173		0.415	2.477		66.687	Change Point 6	
Stn 1			0.746	1.427		68.112	Station 1	Incorrect answers
Sum	6.216		6.209	3.904	3.897			
Misclosure	0.007			0.007		0.005		
Allowed misclosure (mm)	3.2							

Figure 2 – Marked assessment question.

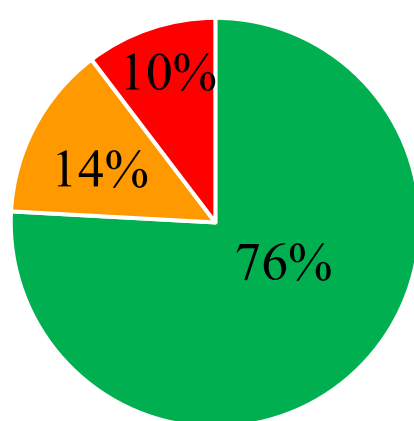
7. Student Feedback

Once the assessment was completed the students were asked feedback questions to evaluate the success of the e-assessment. The feedback results shown in Figure 4 were positive with students finding the NUMBAS assessment straightforward and generally preferring it to previous paper based assessment. These student feedback results alongside the time saving in marking and benefits in reducing opportunity for plagiarism mean the NUMBAS tool has great potential for use in assessment within engineering.

I prefer E-assessment to paper assessment?



Using NUMBAS is straightforward?



- Agree
- Neutral
- Disagree

Figure 4 – Student feedback results

6. E-Assessment vs Paper Assessment

The marks awarded to ≈ 200 students using NUMBAS were compared to the previous year who completed it on paper. The overall mean mark for the assessment decreased by 1.3% as shown in Figure 3. This decrease is caused by a combination of an increase in the marks for Q1 and a decrease in marks for Q2 and Q3. The increase in the mean mark of Q1 where the mean increased by 8.4% is likely to be due to a practice question (with answers provided) similar to Q1 being supplied ahead of the assessment. Conversely, Q2 and the significantly harder Q3 were answered worse in NUMBAS than on paper. This could be due to either reduced plagiarism due to each student having a unique question and therefore unique answers, or the loss in ability for the marker to award method marks for incorrect answers.

	Overall		Q1		Q2		Q3	
	18/19	19/20	18/19	19/20	18/19	19/20	18/19	19/20
Mean	-1.3%		+8.4%		-6.7%		-5.7%	
STD	19.3	21.2	21.9	19.8	20.9	28.5	30.5	28.6

Figure 3 – Statistical comparison of student marks