Personalising the Examination Paper by Harnessing Technology

Author:

Elizabeth M Laws, e.m.laws@talktalk.net

Abstract – A method of generating examination papers and the corresponding solutions is described by which a cohort of students can be presented with different variants of an examination paper. This variation is generated by all students being presented with the same basic questions but with those questions being based on different numerical data and with the order in which the questions appear in the paper being randomly varied. Thus students sitting adjacent to each other in an examination hall could be presented with essentially different examination papers whilst the academic content of the papers remained the same. This would greatly simplify, though not totally eliminate, the invigilation process. However, the approach advocated could make the subsequent marking of scripts more difficult. To ease the marking processes the solutions to all of the paper variants are presented in a uniform way, not that in which the question appeared in the paper, allowing the academic to easily mark all questions of the same type before moving on to the next, the usual way of marking.

The questions are generated in MS Word and the corresponding solutions using MS Excel with the numerical data for both the questions and the solutions being exported from Excel to Word using mail merge through tables generated within the Excel spreadsheet. As part of this process multiple versions of the same question are generated with the question data being produced within the spreadsheet by the use of random number generators within pre-defined limits. The examination paper variants are then assembled from a random mix of one of each of the questions with the order in which the selected question appears in the paper being automatically varied.

The method gives the potential for each student to receive an individual examination paper, though for the purposes of elimination of copying within the examination hall only a limited number of variants would be required, possibly as low as four.

With further development the same approach could be used to revolutionise the way in which students are examined with tailored examination papers being delivered to individual students on-line and a total move away from the formal examination hall arrangement. This would free up valuable resources to be used elsewhere within an Institution whilst the rigour of the examination process is retained.

Index Terms – Assessment, Learning Outcomes, Quality standards, Efficiency gains

INTRODUCTION

The preparation, organisation and management of assessment consumes considerable resources in any Higher Education Institution and involves both academic and non-academic staff input. The use of the set formal unseen examination conducted under supervised and time limited test conditions to assess student performance still dominates, though other forms of assessment increasingly have a place. In [1] a comparison between the traditional closed examination and continuous assessment is drawn with the conclusion being made that examinations are associated with negative emotions, fear, panic and anxiety. However, whilst in certain disciplines more practical, clinical assessment methods are deployed in disciplines with a numerate basis like engineering the formal examination has distinct practical advantages for the academic though the opportunity to give student feedback is very limited.

When examinations are conducted under strict time and place constraints there is little scope for the use of unfair means and thus it is possible with some certainty to know that the script submitted can be attributed to the correct student. However, the necessary invigilation required to ensure this, places an extra burden on University resources. Whilst in some Institutions invigilators are appointed externally in the majority of cases the role is given to the already pressured academic staff member. Invigilators are essential to ensure that there is no possibility of collusion between students or the possibility of students bringing in extraneous materials into the examination hall.

The setting of examination papers is an academic function and the requirement to supply papers well in advance of the end of semester examination period usually means that the academic will be required to set papers in parallel with teaching on a number of modules. Pressures on academic staff in that crucial period can lead to errors creeping in to either the examination paper or the solutions to the paper.

The author has been working on a method of automating the production of examination papers and generating the solutions aimed to address this problem and this is described in [2]. An adaptation of this method is described here in which students taking examinations would be presented with different examination papers, thus largely eliminating the opportunity for the copying of one students work by another. The differentiation has been achieved by harnessing

features of MS Office such that students are presented with the selected questions presented in a random order and with different numerical question data though all students sit the same questions. The cosmetic changes introduced by this approach ensure that no two students sit the same examination paper, this would reduce the demands on the invigilation process as it would only be necessary to ensure that students did not communicate during the examination but the prospect of copying would be eliminated.

THE METHOD ADOPTED

The method adopted harnesses features of the work described in [1] and uses a similar naming convention. Questions are stored in files in Ms Word labelled QuestionA.doc, QuestionB.doc, Question C.doc …..etc. Now each Ms Word file is linked to a corresponding Excel spreadsheet so that QuestionA.doc is linked to QuestionA.xls, QuestionB.doc to QuestionB.xls …….etc. In each Word or Excel file all the variables necessary to form either the questions or the solutions to those questions are prefixed by the appropriate question letter, so that for QuestionA.doc and QuestionA.xls all the variables would be prefixed by A and similarly for all other questions.

The Ms Word files contain the questions with the data for the questions appearing in the form of merge fields. Two versions of the Word files are created one in a folder called Questions and the other in a folder called Solutions the distinction being that the Word files in the Questions folder contain the question text only and the Word files in the Solutions folder contain both the question and the solutions to the question presented in a step by step method with the calculations being performed within the Excel spreadsheet association with that question.

For each question provision is made within the Excel spreadsheet for a number of versions of the question and solutions to be generated, as an example 100 was used. The number of versions is specified at the outset and supplied as information to the Excel spreadsheet with each question spreadsheet consisting of four separate worksheets.

Figure 1 illustrates the method by which the calculations are performed in each question spreadsheet.
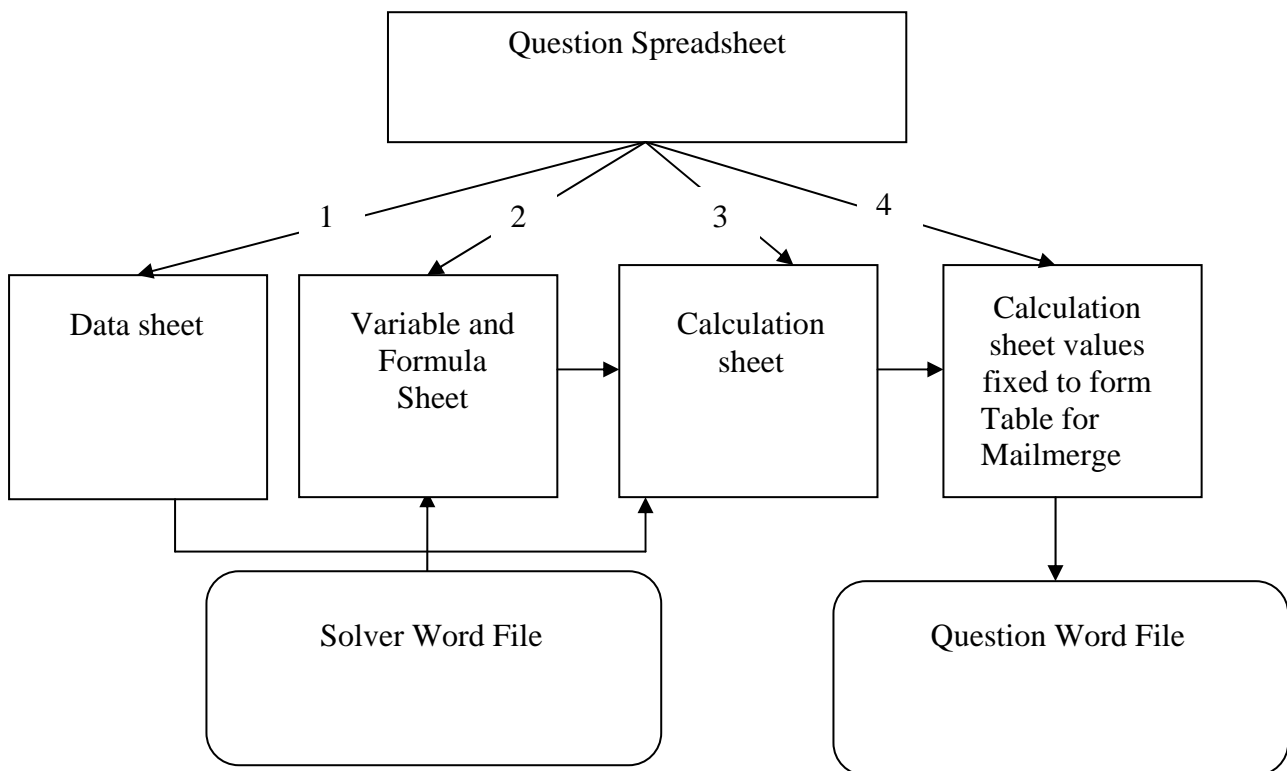

FIGURE 1
SCHEMATIC LAYOUT OF SOLUTION PROCESS

The four different worksheets in each Question spreadsheet have the following functions:

The first sheet is used to generate the data to be used in the questions. The second sheet is used to import the formulae linking the solution variables to the data variables and within this sheet the Visual Basic (VB) modules needed to produce the solutions are created together with the necessary calls to those VB modules. The third worksheet is used to perform the calculations using the VB modules. Thus the calculation sheet would contain a number of rows each row corresponding to the values for one question variant and also includes a header row giving the names of the variables.

There is however a problem when mailmerging from Excel to Word, this is that unless steps are taken to fix the number of decimal points to which numerical information is to be printed the variables in Ms Word would be printed with upto 14 decimal places, thus an additional VB module (Module 1) was written to perform the task of fixing the number of places to be used. The values in the fourth worksheet take the output from the third sheet and fix the number of decimal places to which the variables should be printed, this would be the selected value for the data variables and set at 3 for calculated values. The entire fourth worksheet was then created as a Table in the Excel spreadsheet. When this table was used to mailmerge with the question word file in the Questions folder a single word file containing the selected number of variants of the question would be generated and when merged with the Word file in the Solutions folder the solutions to all of the questions would be generated.

Generating the Data for the Questions

As there was a requirement to produce a large number of variations of each question and solutions it was not practical to enter the data to be used to manually. A method was arrived at where for each variable the maximum value (max), minimum value (min), the number of decimal places (ndp) to which the variable was to be printed was specified. A formula was then used to generate the data based on the use of a random number generator. In Excel this took the form: Round(Rand()*(max-min)+min),ndp). This command generated a random number between the minimum and maximum value and printed it to the number of specified decimal places. This formula was replicated through the required number of question variants producing that number of different data sets.

The formula was subsequently adapted by the inclusion of a scale factor to allow for those situations where data selection needed to be restricted. For example, for angles values of 30°, 45° and 60° are convenient for question use this could be ensured using the formula Round(Rand()*(4-2)+2,0)*15. In this case a scale factor of 15 has been used though in many cases the scale factor would be simply set to 1.

GENERATING THE VISUAL BASIC MODULES NEEDED TO PRODUCE THE SOLUTIONS

Generating the VB modules necessary to perform the calculations could be both tedious and a potential source of error. A method of facilitating the generation of the required VB modules was developed starting with MS Word. Each question word file was associated with a second word file called the Solver file, this is shown schematically in figure 1.

The solver word file took the form of a five column table. The first column listed all the variables used in both the question and solutions with the first variable, the question letter, being used to indicate the question number, this would range from 1 to the number of variants of the question to be generated. For the variables associated with the question data the second column was left blank but for those variables required to produce the solutions the second column contained the formula linking that variable to the data variables or any previously specified solution variables. The third column following the header row contained the cell location in which the variable would appear on worksheet 3 of the Excel spreadsheet starting at position A2 and continuing through B2, C2 …etc until all the non-blank rows in the third column were completed. For the variables associated with the solutions the fourth column showed the dependent variables on which that variable was based with a comma being placed between each separate variable. Finally the fifth column converted those dependent variables into the corresponding cell references for worksheet 3 from column 3, again with a comma being placed between each cell reference.

The Solver word table (without the header row) was then cut and pasted into the first five columns of the second Excel worksheet as shown schematically in figure 1. As an example Table 1 shows the Solver file for QuestionC and an additional row has been added at the bottom of this table to show the location to which the table will be copied in the second Excel worksheet.

The second Excel worksheet has formulae already prepared in columns 7-11. These formulae harness the MS Excel command Concatenate () which can be used to combine cell contents and text within a single Excel cell. To illustrate this the first solution variable Carea would appear in the 8th row of the second worksheet in cell A8 with the formula appearing in cell B8. However, when the calculations are performed within the third worksheet the variable names would appear as a header row and the values for the variables associated with each question variant would appear in the rows below so that the first set of question values would be in row 2 and for 100 question variants the last row data would be in row 101. Thus column E of the second worksheet shows the cell location of the variable on worksheet3. Replicating the formulae in column 2 of table 2 down the second Excel worksheet would generate all the VB modules, Module 3, Module 4…etc, necessary to produce the solutions and also the required call to the module needed within worksheet 3 to generate the solutions.

All that is necessary is to create the VB modules within the Excel spreadsheet by either cutting and pasting the modules from MS Word or manually re-typing the VB modules and then to copy and transpose the contents of column J from cell 8 onwards into the second row of the third worksheet starting from column G. The values for the first 7 columns are supplied from the data worksheet. This automatically generates the solutions to all the questions with the variables associated with each question appearing on individual rows and with the first row, which will form the header row, containing the variable names.

As previously explained the third worksheet is then copied to the fourth worksheet with the number of decimal places to be used for output fixed to set values and the entire fourth worksheet is then used to form a table which can then be used to mailmerge with the solutions word file to generate 100 versions (in this case) of the same question, complete with the solutions.

Variable	Formula	Excel Cell	Dependent Variables	Cell Reference
C		A2		
CQ		B2		
cdensity		C2		
Cdynv		D2		
cdiameter		E2		
Cpipelength		F2		
Carea	CArea= ATAN(1) * cdiameter ^ 2 * 10 ^ -6	G2	cdiameter	e2
cvelocity	cvelocity = cq * 10 ^ (-3) / carea	H2	cq,carea	b2,g2
CRe	CRe=cdensity * cdiameter / 1000 * cvelocity / cdynv	I2	cdensity,cdiameter,cvelocity,cdynv	c2,e2,h2,d2
Ctest	Ctest=If cre < 2500 Then ctest = "laminar" Else ctest = "turbulent"	J2	Cre	i2
Cdynamicp	Cdynamicp= 0.5 * cdensity * cvelocity ^ 2	K2	cdensity,cvelocity	c2,h2
cdynamicpkpa	Cdynamicpkpa=cydynamicp/1000	L2	cydynamicp	k2
Cf	CF=If ctest = "laminar" Then cf = 16 / cre else cf = 0.3125 / cre ^ 0.25	M2	Ctest	j2
CK	CK= cf * cpipelength / cdiameter * cdynamicp	N2	cf,cpipelength,cdiameter,cdynv	m2,f2,e2,k2
Column A	Column B	Column C	Column D	Column E

Table 1
The Solver File for Question C

Excel Column	Command	Result
Cell F8	=CONCATENATE("Function "&A8&"("&D8&")")	Function Carea(Cdiameter)
Cell G8	="End Function"	End Function
Cell H8	="Module"&ROW(A2)	Module 2
Cell I8	=CONCATENATE(F8&CHAR(10), B8&CHAR(10),G8&CHAR(10))	Function Carea(Cdiameter) Carea=Atan(1)*Cdiameter^2*10^-6 End Function
Cell J8	=CONCATENATE(A8&"("&E8&")")	Carea(F2)

TABLE 2
AN EXAMPLE OF THE FORMULAE IN COLUMNS F TO J OF THE SECOND WORKSHEET

PERSONALIZING THE EXAMINATION PAPER

In order to enable a number of different examination papers to be produced all based on the same questions but with different numerical data and question order a second spreadsheet was developed. Within this new spreadsheet the questions on which the examination paper was to be based were specified manually by their question letters. Based on producing an examination paper with 5 questions in it there would then be 25 different possible combinations of those questions and within the new spreadsheet a random number generator was used to select a number between 1 and 25 with the number selected giving one possible unique combination of the five questions. A second random number generator was used to select a number between 1 and 100 so that for each question one of the 100 versions of each question which were generated using the method described previously would be selected. The selected questions were then collated into a number of different examination papers. This combined with the use of the random number generated question data ensured that no duplication of examination papers could occur.

In order to make the selected question spreadsheets available so that the correct row of the output table could be selected it was necessary that the Question spreadsheets were open. Whilst it would be possible to open all the files in either the Question or Solutions folder this would be inefficient since only 5 files are needed to produce a particular paper. To open only the necessary files, within the new worksheet the names of the Question spreadsheet files were

International Conference on Engineering Education ICEE-2010 July 18–22, 2010, Gliwice, Poland. 2

specified in fixed cells, again employing the command Conatenate(), and a Macro was recorded which then opened those five files and with the files open it was possible to select the correctly numbered row from the fourth Excel worksheet of those files together with the corresponding header row giving the variable names. Thus as the question letters were manually changed different Excel files were opened allowing examination papers based on different questions to be produced and data sets.

Because of the use of the random number generator to specify the order of the questions in the examination paper and the particular set of values to be used for the question and solutions generation care was necessary to ensure that values did not change before the complete data set could be captured. To ensure this the Macro used to open the files was extended to include selection of the two random numbers, thus ensuring that a particular layout of questions had been selected and also particular sets of data, this information was then cut and pasted as values into a different rows of the worksheet. Duplicating this operation within the Macro a number of times gave different combinations of questions, data and solution variables. Each combination of values was used to form a table which could then be used for mailmerge.

GENERATING THE SOLUTIONS

When marking scripts from large student cohorts of students it is usually convenient to mark one individual question at a time before moving on to the next question. However, in the method arrived at here, the questions on each examination paper would be in a different position and the numerical data would be different as well. To ease the problems associated with marking scripts the solutions to all the examination paper variants were produced in a standard way, the order in which the questions had been originally selected, not that which corresponded to the way that the paper would have been printed and a unique code would appear on both the examination paper and the solutions indicating the questions selected and the particular data set selected for each of those questions.

Paper1														
Code	Filep1	Filep2	Filep3	Filep4	Filep5	Files1	Files2	Files3	Files4	Files5	S1	S2	S3	S4	S5
dscgf/ 67.36.31.79.90	Paper\ Question D.doc	Paper\ Question S.doc	Paper\ Question C.doc	Paper\ Question G.doc	Paper\ Question F.doc	Solutions\ Question C.doc	Solutions\ Question. S.doc	Solutions\ Question D.doc	Solutions\ Question F.doc	Solutions\ Question G.doc	3	2	1	5	4
Paper2														
Code	Filep1	Filep2	Filep3	Filep4	Filep5	Files1	Files2	Files3	Files4	Files5	S1	S2	S3	S4	S5
cdfsg/ 58.73.53.87.43	Paper\ Question C. doc	Paper\ Question D.doc	Paper\ Question F.doc	Paper\ Question S.doc	Paper\ Question G.doc	Solutions\ Question C.doc	Solutions\ Question. S.doc	Solutions\ Question D.doc	Solutions\ Question F.doc	Solutions\ Question G.doc	1	3	4	2	5
Paper3														
Code	Filep1	Filep2	Filep3	Filep4	Filep5	Files1	Files2	Files3	Files4	Files5	S1	S2	S3	S4	S5
csdfg/ 50.17.27.32.48	Paper\ Question C.doc	Paper\ Question S.doc	Paper\ Question D.doc	Paper\ Question F.doc	Paper\ Question G.doc	Solutions\ Question C.doc	Solutions\ Question. S.doc	Solutions\ Question D.doc	Solutions\ Question F.doc	Solutions\ Question G.doc	1	2	3	4	5

TABLE 3
PART OF THE SECOND EXCEL SPREADSHEET

Table 3 shows an example of part of the tables exported from the second Excel spreadsheet, to reduce space in the Table 3 the drive location for the particular word files has been omitted though they would appear in the Excel spreadsheet. For this case the questions selected were QuestionC, QuestionS, QuestionD, QuestionF and QuestionG. In the first possible examination paper 1, these questions would appear in the order D, S, C, F and G. but the solutions would be consistently printed in the order C, S ,D, F and G however for Paper 1 it would be flagged up that the examination paper is to be marked in the order question 3, 2, 1, 5 and 4. For Paper 1 the examination paper has been composed from the 67th data set for QuestionD, the 36th data set for QuestionS, the 31st data set for QuestionC , the 79th data set for QuestionF and the 90th data set for QuestionG. This information would appear as a code on both the examination paper and the solutions.

The two rows of information below the Paper number in each case were used to form tables in MS Excel, Table1, Table2, Table3…..etc. Using these tables as the basis for mailmerge allows different combinations of questions to be generated. The remainder of the Excel spreadsheet would have more paper combinations and in addition to the information shown in Table 3 the tables would include all of the variables needed to form both the question and the solutions.

EXECUTING THE MAILMERGE

To collate the different examination papers MS Word facility Includetext was used. Two Ms Word files were created one called Paper and the other Solutions and the layout for these files is shown in Table4 The Includetext command is activated in MS Word simply by combining the keystrokes Control and F9, this automatically throws up a pair of

chevrons and within the chevrons it is necessary to type Includetext "filename.doc" . This instruction inserts the file filename.doc within the Word document. Taking the merge filenames from the different Excel tables it was then possible to combine all the question files in a single document which formed in the case of Paper.doc the examination paper and for Solutions.doc the paper the examination paper and the solutions to the actual question files. Allowance was made to add a header file at the start of the document which contained the paper details, subject, time and instructions for example and also allowance was made for the inclusion of an Appendix file which would contain any supplementary information needed to be supplied with the examination paper, for example a formula sheet.

{includetext "Headerp.doc"}	{includetext "<Headers.doc>"}
{includetext "<Filep1>"}	{includetext "<Files1>"}
{includetext "<Filep2>"}	{includetext "<Files2>"}
{includetext "<Filep3>"}	{includetext "<Files3>"}
{includetext "<Filep4>"}	{includetext "<Files4>"}
{includetext "<Filep5>"}	{includetext "<Files5>"}
{includetext "Appendixp.doc"}	{includetext "Appensixs.doc"}
Layout for Paper.Doc	**Layout for Solutions.doc**

TABLE 4
STRUCTURE OF MASTERPAPER AND MASTERSOLUTIONS FILES

A number of different versions on the Paper.Doc file and Solutions.doc file were generated each one linking to a different Excel table. Executing the mailmerge then generated the different examination papers and the corresponding solutions.

EXTENDING THE QUESTION POOL AND CHANGING SYLLABUS TOPICS

Any number of different questions can form part of the method described here. As long as the Question Word and Excel files have been created and given a unique alphabetical name the questions can form part of the selection process. Equally the questions can be easily adapted to a different subject. All that would be necessary would be to change the Solver Word file to be pasted into the second worksheet as described previously, to change the specifications (max, min, ndp and scf) for the new data variables and also to change the VB modules for the new ones formed on the second worksheet for the new solutions to replace the old. This effectively means that anyone with the ability to create the Solver file table in MS Word can adapt the Excel spreadsheets to their own questions and the second Excel spreadsheet would now produce examination papers on entirely different subject matter. This demonstrates the power of the method outlined which is both easily extendable, adaptable and also has the potential of easing the examination and invigilation burden.

CONCLUSIONS

A versatile method of generating examination papers complete with the corresponding solutions has been described which would allow a number of distinct versions of particular questions to be combined. Thus a cohort of students to can be presented with different variants of an examination paper reducing considerably the effort needed to invigilate the examination process. Students can also be easily presented with sample examination papers reducing the fear and anxiety of the unseen paper. The method can be adapted easily to address different module content. The method integrates MS Word and Ms Excel through the mailmerge feature drawing in the numerical data for and solutions to questions from Excel to Word. The method could revolutionise the way in which students are presented with examination papers since with some further development students could obtain examination papers on-line with each student receiving different papers.

REFERENCES

[1]   Race, P, "What has assessment done for us- and to us" in Knight, P, Assessment for Learning, London, Kogan 1995, pp 61-75.
[2]   Laws,E,M, "A Method of Setting Examination Papers and Generating the Solutions." ICEE 2010, Gliwice, Poland, 2010.