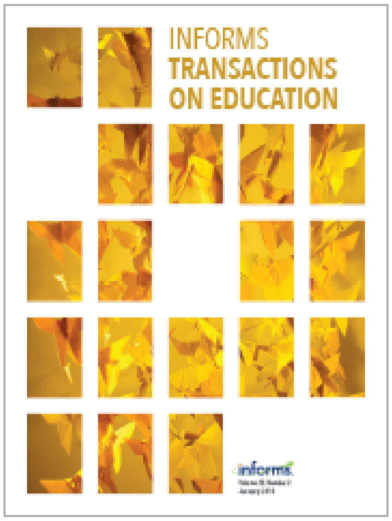

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Creating Online Quizzes with Multiple Attempts with Microsoft Excel and Word

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Abstract. Problem solving plays an important role in students' learning, especially in quantitative topics, such as mathematics, statistics, operations research, and management sciences. Learning management systems (LMS) and online homework management systems can assist students' learning by offering quizzes and tests allowing multiple attempts with immediate feedback. In this paper, using the software readily available to most institutions (Microsoft Word and Microsoft Excel), we explain how to create quizzes in an LMS, such as Desire2Learn, that allow students multiple attempts. Although most systems offer a way to create questions algorithmically, the functions available for creating those questions are limited. As a result, they are often unsuitable for complex quantitative topics. The method shown in this paper overcomes the limitation of algorithmic questions in an LMS.

Supplemental Material: The Excel dataset is available at https://doi.org/10.1287/ited.2017.0170

Keywords: learning management system • algorithmic questions • excel • word • mail-merge • question bank

1. Introduction

In mathematics, problems are traditionally used "as vehicles of instruction, as means of practice, and as yardsticks for the acquisition of mathematical skills" (Schoenfeld 1992, p. 337). That is, by using problems, an instructor demonstrates mathematical techniques that students need to learn, students are asked to practice on similar problems requiring the demonstrated techniques, and the result of the students' works are used to gauge their understanding. This is also true in many related fields, such as statistics, operations research, and management sciences.

If students are allowed to try the same questions more than once when they miss them, it can promote better understanding of the materials (Yourstone et al. 2010). That is, multiple attempts can help students master certain techniques/skills. To effectively do so, however, quizzes or tests should be designed in such a way that they allow multiple tries through algorithmic questions that use different data/numbers in each try or random selection of questions from a question bank (or question library). As an added benefit, using algorithmic questions or random selection on an assignment can discourage cheating or free-riding (Tsai and Wardell 2006).

All popular learning management systems (LMS) can create such Questions, both algorithmic and a question bank for random selection. In 2016, according to edutechnia.com,[1] popular LMS in higher education field in terms of market share included Blackboard (33.5%), Moodle (19.4%), Canvas (17.1%), and Desire2Learn (D2L) (9.8%). All of these systems can set up online quizzes. Various types of questions in the quizzes can be immediately graded, thus facilitating immediate feedback for students.

One of the authors tried to set up online quizzes using algorithmic questions in D2L to provide students with multiple tries. He quickly found out that it could not handle the topics that he wanted to test, i.e., probability distribution, such as a normal distribution, and simple linear regression based on a data set. Further research on the algorithmic question type in various LMS revealed its limitations due to the lack of many mathematical and statistical functions. For example, Blackboard and D2L have only the following basic functions and special constant, i.e., basic arithmetic operations (+, −, *, /, \), modulo, power, absolute value, cosine, sine, square root, tangent, log base 10, log base e, inverse tangent, secant, cosecant, factorial, power of natural log (e), pi, and e. With this limited set of functions, algorithmic questions that instructors can create in an LMS are also limited and often too simple. To overcome this limitation, other software, such as Microsoft Excel, can be used. For example, Tsai and Wardell (2006) explained how to create individualized data sets using Microsoft Excel and Visual Basic for regression analysis (and other data analysis questions), but they did not use the data sets for the online quizzes in an LMS. As a result, students could not get immediate feedback on their work.

Homework management systems (HMS), such as Aplia and ALEKS, by various textbook publishers also offer algorithmic questions similar to those in LMS. The limitations of an HMS include the rigidity of the questions available in the system. An HMS may not have questions that instructors wish to use. This is especially true if an instructor covers materials that are not in the textbook. In such cases, instructors can create their own (algorithmic) questions based on whatever tools and functions are available in an HMS. Yet these tools tend to be limited, similar to those available in LMS, which does not allow the creation of sophisticated questions.

In this paper, we explain how to create quizzes in an LMS that allow students multiple tries through random selection of questions from a question bank, rather than through algorithmic questions. The method explained here is most useful when algorithmic questions in an LMS cannot satisfy instructor's needs for creating quizzes that allow multiple tries. The method augments, not replaces, the algorithmic question type in an LMS, and offers great flexibility in terms of questions that instructors can create. Questions are created outside of an LMS using more sophisticated calculation software, such as Microsoft Excel, and are imported to an LMS. Instructors can more precisely tailor questions for online quizzes through this procedure than through algorithmic questions.

2. Overview

The focus of this paper is the creation of a text file (e.g., comma-separated values file) that contains questions to be imported to an LMS. Each LMS has different formatting requirements for this text file. We used the D2L format in this paper, but the procedure can be easily adapted for Blackboard, Moodle, and other LMS. This text file is later imported to an LMS as a question library (or a question bank). An instructor can make a quiz using the question library, from which questions are pulled *randomly* every time a student attempts the quiz.

Even though many types of questions for an online quiz are available, we recommend the multiple choice (MC) format for its ease of automatic grading and immediate feedback to students. An MC question has two parts, i.e., stem and choices (or options). The stem is the problem given in the question, and the choices are a list of suggested solutions. The choices consist of one correct answer and multiple incorrect distractors.

Stems for the procedure explained in this paper have two parts, i.e., static and random. The random parts are typically numbers that can change their values in each attempt. For example, a stem is "Find the probability that X is greater than A, where X follows a normal distribution with a mean of 30 and a standard deviation of 5." A is the random part with possible values between 40 and 50, and everything else is the static part of the stem.

For a given stem, we first generate values of random parts in Microsoft Excel, calculate the answer, and then generate the distractors. Then, this Excel file is combined with the static part of the stem written in Microsoft Word using mail merge. The merged Word document is then saved as a text file that is ready to be imported to an LMS. This procedure is depicted in Figure 1, and each step is explained in detail in the following sections.

3. Step 1—Generate Values for a Question

Three groups of values are generated, i.e., the random parts of the stem, the answer, and the distractors. In addition, the order between the answer and the distractors will be shuffled, and the point for each choice is assigned.

3.1. Step 1.1—The Random Parts of the Stem

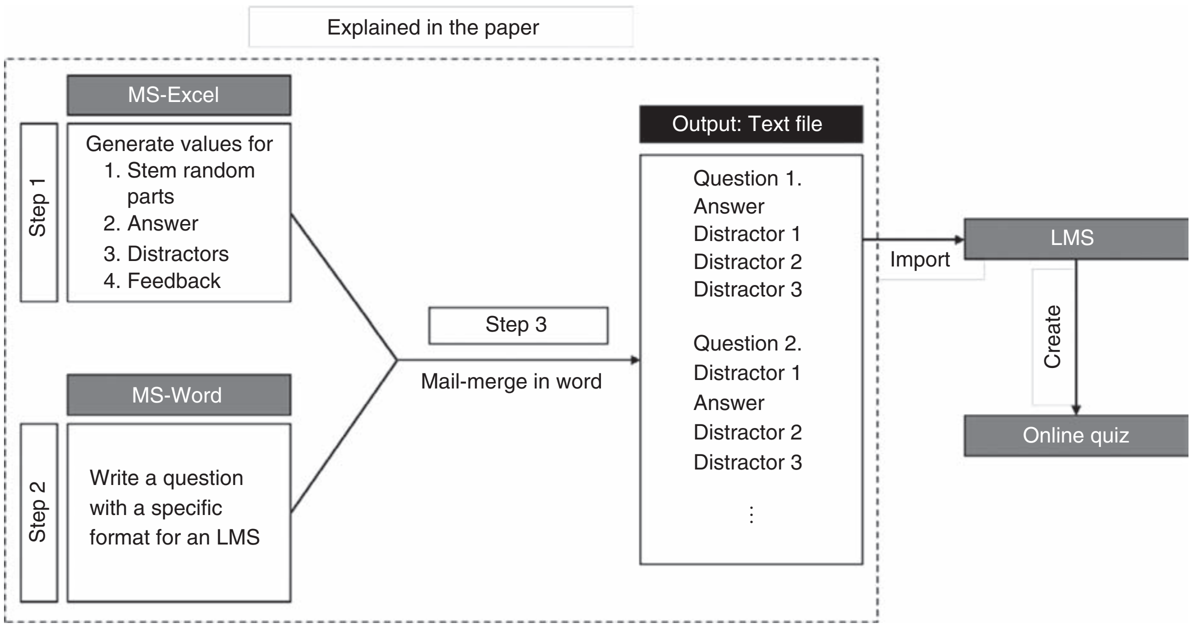
Before generating values of random parts, an instructor must determine what parts of a stem will be random. Typically, numbers are good candidates, but text can also be random parts. In the following example of a probability distribution question, a number and a text entry are selected as random parts, i.e., standard deviation (12) and direction ("will").

> "Apple Oil is sold in 940 milliliter (ml) cans. The mean volume of oil placed in a can is 920 ml with a standard deviation of 12 ml. Assuming a normal distribution of the data, what is the probability that the filling machine *will* cause an overflow in a can?"

As additional examples, the procedures for an M/M/s queuing model, an inventory model, and a simple linear regression analysis are shown in Appendices A, B, and C, respectively.[2]

Once random parts are decided, their population should be determined. That is, the possible values or the ranges from which values of the random parts are generated. The populations of two random parts in the Apple Oil example above, standard deviation (stdev) and direction, are $(12, 16)$ and {will, will not}, respectively. Each random part will be generated 10 times (rep). That is, there will be 10 questions with different values in the random parts in the end. Note that there are exactly 10 unique combinations of stdev (five different integer values) and direction (two different values). If more replications are desired, more random parts should be included or stdev can be non-integers (e.g., between 12 and 16 by an increment of 0.5). Including more random parts (e.g., the mean) will not make

Figure 1. Overview of the Process



the following procedure much more laborious or complex. If one (or two) more random parts are included, the final Excel file will have only one (or two) more columns than the final Excel file used in this paper.[3]

Figure 2 presents a spreadsheet view of step 1.1 executed in Microsoft Excel. Column A contains the replication numbers from 1 to 10. Columns B:C have the values of stdev and direction, respectively. Even though no formula was used to generate these values, one can use random number generating functions, such as `RANDBETWEEN` and `RAND`. For example, B2 can have the following formula: `=RANDBETWEEN(12, 16)` or `=RANDBETWEEN(120, 160)/10`. The former formula will produce the integer values of stdev, and the latter will produce the values with the tenth decimal place. C2 can have the following formula: `=IF(RAND()<0.5, "will", "will not")`.

Note that all repetitions are unique in Figure 2. When the repetition number is high and random functions, such as `RAND`, are used to generate values, however, the uniqueness of each row is not guaranteed. If the combinations of the random part values are not unique, the final output will contain duplicated questions. Appendix D explains how to check the uniqueness of each row using the Excel function `CONCATENATE`.

Figure 2. Generate Values of the Random Parts

	A	B	C
1	Rep	Stdev	Direction
2	1	12	Will
3	2	13	Will
4	3	14	Will
5	4	15	Will
6	5	16	Will
7	6	12	Will not
8	7	13	Will not
9	8	14	Will not
10	9	15	Will not
11	10	16	Will not

3.2. Step 1.2—Calculate the Answer

The next step is to calculate the correct answer to each combination (i.e., row) of the random part values, i.e., stdev and direction. The question is asking the probability of overflow or no-overflow for given values of the mean, the standard deviation, and the can size, that is, $P(X > 940)$ or $P(X \le 940)$, where X is the amount of oil filled.

In Figure 3, the correct answers (s1) are placed in F2:F11. F2 has the following formula, which is copied to F3:F6: `=ROUND(1-NORM.DIST(940,920,B2,1),4)`. F7 has the following formula, which is copied to F8:F11: `=ROUND(NORM.DIST(940,920,B7,1), 4)`. The answers are rounded to the fourth decimal place.[4]

3.3. Step 1.3—Generate the Distractors

The next step is to generate distractors. Research suggests that three choices are often sufficient for multiple-choice questions, which means one correct answer and two distractors (Haladyna et al. 2002). Other good practices for making choices include varying the location of

Figure 3. Calculate the Correct Answers

	F
1	s1
2	0.0478
3	0.062
4	0.0766
5	0.0912
6	0.1056
7	0.9522
8	0.938
9	0.9234
10	0.9088
11	0.8944

Figure 4. Generate Distractors

	G	H	I
1	s2	s3	s4
2	0.9522	0.5	0.0763
3	0.938	0.5	0.0152
4	0.9234	0.5	0.0764
5	0.9088	0.5	0.0345
6	0.8944	0.5	0.0162
7	0.0478	0.5	0.028
8	0.062	0.5	0.0373
9	0.0766	0.5	0.0131
10	0.0912	0.5	0.0871
11	0.1056	0.5	0.0132

the right answer, placing choices in logical or numerical order, making all distractors plausible, and using typical errors of students as distractors (Haladyna et al. 2002). Therefore, finding typical student errors is important to generate plausible distractors; an instructor's past experience with students can help to identify such errors.

When all distractors are made based on typical student errors, the location of the correct answer in the numerically ordered choices may always be the same for all questions. Therefore, it may be necessary to generate a random distractor, which still looks plausible, to break this predictable pattern; this is shown in column I in Figure 4.

In Figure 4 above, the first distractor (s2) is the complement of F1, which is a common mistake among students; the second (s3) is a constant; and the third (s4) is a random number. The range of the third distractor is between 0.0100 and 0.0900. Range G2:I2 is then copied to G3:I11. The formulas used in Figure 4 are shown below. As demonstrated in this section, instructors can generate distractors in various ways.

```
G2: =1-F2
H2: 0.5
I2: =ROUND(RANDBETWEEN(1000,9000)/100000, 4)
```

3.4. Step 1.4—Provide Feedback

One great benefit of using online quizzes is to provide instant feedback, i.e., correctness of the student's selection and general feedback (or hints) about the question. Depending on an LMS, feedback can be provided to each choice or to the question itself or both. In this example, we provide feedback to questions, which will be available to students regardless of their choice . This is shown in Figure 5.

3.5. Step 1.5—Assign Points to the Alternatives

The next step is to assign points to the answer and the distractors or to mark the correct answer among the choices. This step is necessary for an LMS to grade students' submissions. Four columns F:I (Figures 3 and 4) contain the choices. The first column is the answer, and the other three columns are distractors. In D2L, the point for each choice is expressed by percentage. Therefore, the answer will get 100% (pt1) of the total points assigned to the question, and the distractors will get 0% (pt2, pt3, pt4), as shown in Figure 6. It is possible to give a partial credit to certain distractors by assigning a positive percentage rather than zero.

If an LMS can create a quiz in which choices are presented in a random order, the question set generated above does not pose any problem. However, if random ordering of the choices is not done in an LMS, the order between the answer and the distractors should be shuffled in Excel. Otherwise, every question in this question library will have the first choice as the answer. One way to shuffle the choices is explained in Appendix E.

3.6. Save the File

Steps 1.1 to 1.5 generate all necessary parts for mail merge in Microsoft Word. This work is saved as a CSV format with name, Normal question I.csv, which is used for mail merge in Microsoft Word. The file can be saved as a native Excel file format (i.e., xlsx), but often number formatting can be a problem in step 3.

Even though Microsoft Excel is adequate for various questions, other calculation software or programming languages can also be used, which provide more

Figure 5. Feedback for the Question

	J
1	Feedback
2	Overflow will occur if the filling amount (X) is greater than the size of the can. That is, P(X > size). Is it normdist() or 1-normdist()?
3	Overflow will occur if the filling amount (X) is greater than the size of the can. That is, P(X > size). Is it normdist() or 1-normdist()?
4	Overflow will occur if the filling amount (X) is greater than the size of the can. That is, P(X > size). Is it normdist() or 1-normdist()?
5	Overflow will occur if the filling amount (X) is greater than the size of the can. That is, P(X > size). Is it normdist() or 1-normdist()?
6	Overflow will occur if the filling amount (X) is greater than the size of the can. That is, P(X > size). Is it normdist() or 1-normdist()?
7	Overflow will NOT occur if the filling amount (X) is less than the size of the can. That is, P(X < size). Is it normdist() or 1-normdist()?
8	Overflow will NOT occur if the filling amount (X) is less than the size of the can. That is, P(X < size). Is it normdist() or 1-normdist()?
9	Overflow will NOT occur if the filling amount (X) is less than the size of the can. That is, P(X < size). Is it normdist() or 1-normdist()?
10	Overflow will NOT occur if the filling amount (X) is less than the size of the can. That is, P(X < size). Is it normdist() or 1-normdist()?
11	Overflow will NOT occur if the filling amount (X) is less than the size of the can. That is, P(X < size). Is it normdist() or 1-normdist()?

Figure 6. Points Assigned to Alternatives

	K	L	M	N
1	pt1	pt2	pt3	pt4
2	100	0	0	0
3	100	0	0	0
4	100	0	0	0
5	100	0	0	0
6	100	0	0	0
7	100	0	0	0
8	100	0	0	0
9	100	0	0	0
10	100	0	0	0
11	100	0	0	0

flexibility. Appendix F shows how step 1 can be done using R.

4. Step 2—Write a Question in Microsoft Word

An instructor writes a question according to the specific format to an LMS. The example shown below in Figure 7 is based on the CSV formatting requirement of D2L. The parts enclosed by the square brackets are random parts, and they will be replaced by appropriate merge fields in the next step. The square brackets are used for illustration and may not be used when questions are typed. Complete versions of the text file format for D2L, Blackboard, and Moodle are included in Appendix G.

Figure 7. Question Typed in Microsoft Word

NewQuestion, MC
QuestionText, "Apple Oil is sold in 940 milliliter (ml) cans.
The mean volume of oil placed in a can is 920 ml with a standard deviation of [stdev] ml. Assuming a normal distribution of the data, what is the probability that the filling machine [direction] cause an overflow in a can?"
Points, 1,
Option, [pt1], [s1]
Option, [pt2], [s2]
Option, [pt3], [s3]
Option, [pt4], [s4]
Feedback, "[feedback]"

The first line specifies that the question is a MC. The following line is the question text. Note that double quotations are used. If the question text includes a comma, the double quotations are needed for a CSV file. Otherwise, the question will be separated by the comma(s) when imported to an LMS. The next line specifies the point of the question (1 point). The next four lines are the choices, with the percentage of the point of each choice, and wording for the choices. The last line is the feedback to students.

5. Step 3—Mail Merge

In Microsoft Word, execute mail merge as explained below:

1. Click **MAILINGS** menu in the ribbon.
2. Click **Start Mail Merge** and select **Letters**.
3. Click **Select Recipients** and select **Use Existing List**. In the popup window, select the CSV file (Normal question I.csv) saved in Step 1 (Section 3.6).
4. Highlight the first random part (e.g., [stdev]) in the question.
5. Click **Insert Merge Field** in the ribbon, and select an appropriate field (in this example, stdev) as shown in Figure 8.
6. Repeat steps 4 and 5 until all random parts are replaced with appropriate merge fields.
7. Click **Preview Results** to check the final outcome.
8. Click left or right arrow to see other repetitions. The preview of merged document (with repetition #7) is shown in Figure 9. If you are satisfied with the merged result, move to step 9.
9. Click **Finish and Merge** and select **Edit Individual Documents**. Select All and click OK.
10. A new document with a name, "Letters1," is now created. Save this document as the plain text format (*.txt). In the File Conversion pop-up window, click OK. Even though the file extension of CSV is not used,

Figure 8. Inserting Merge Fields to the Question

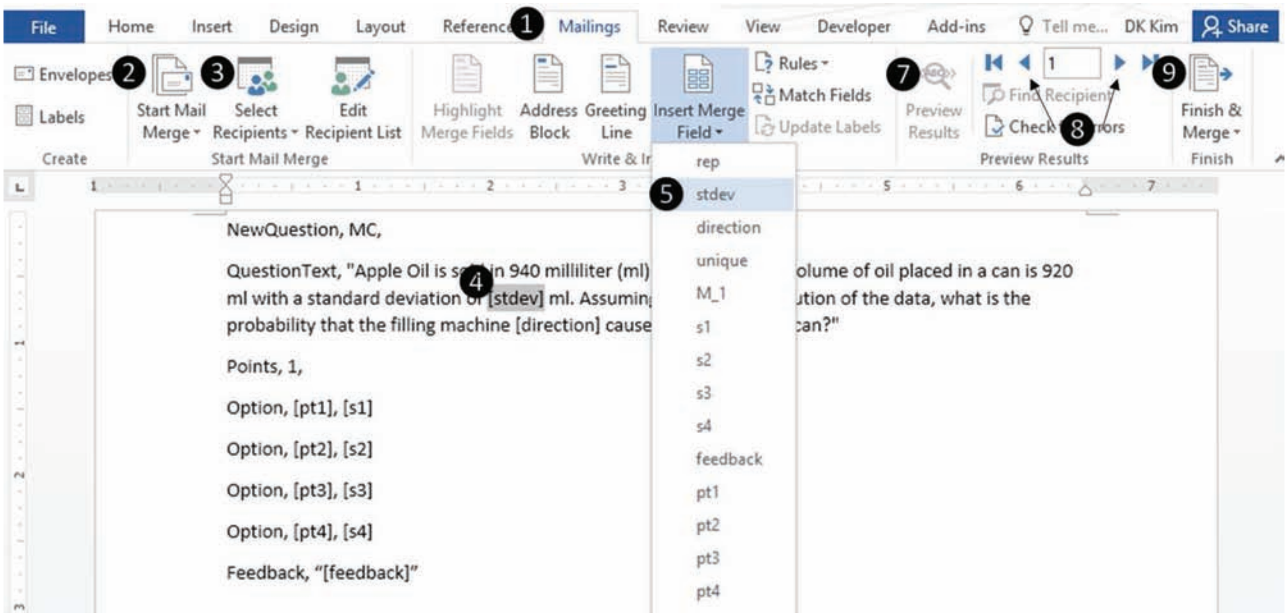
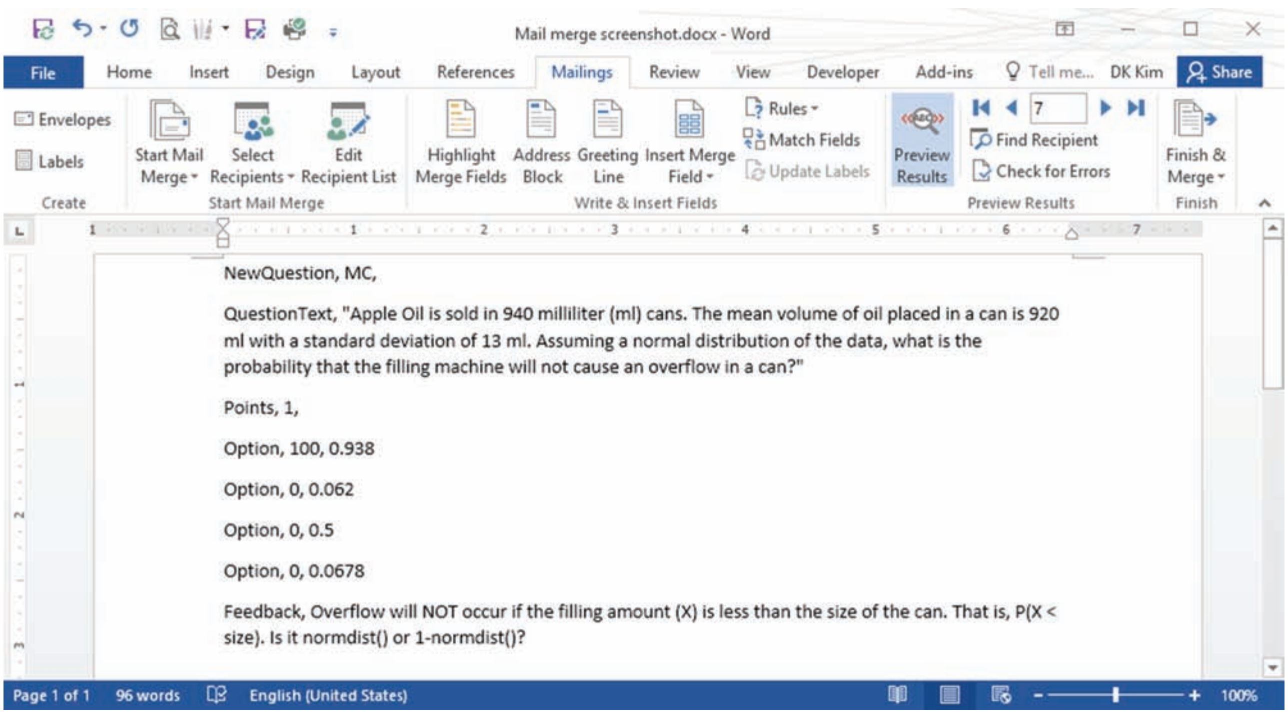


Figure 9. Merged Document



this text file is a CSV file. If you open this text file using text editing software, such as Notepad, it will look similar to Figure 10.

6. Import the txt File Created in Step 3 to LMS

The process of importing this txt file varies from one LMS to another. In D2L, the text file created in step 3 will first be imported to D2L as a question library, not as a quiz. Next, a new quiz is created in D2L, in which random sections will be created. Then, the imported questions, which are now available in the question library, will be included in the random sections of the newly created quiz. An instructor can decide how many questions will be pulled from the question library for each try. Note that the steps 1–3 are for making a question library for one question. Therefore, if an instructor wishes to create a quiz with, for example, three different questions, he/she needs

Figure 10. Merged CSV File

```
NewQuestio1.txt - Notepad
File  Edit  Format  View  Help
NewQuestion, MC,
QuestionText, "Apple Oil is sold in 940 milliliter (ml) cans. The mean volume of oil
placed in a can is 920 ml with a standard deviation of 12 ml. Assuming a normal
distribution of the data, what is the probability that the filling machine will cause an
overflow in a can?"
Points, 1,
Option, 100, 0.0478
Option, 0, 0.9522
Option, 0, 0.5
Option, 0, 0.0301
Feedback, Overflow will occur if the filling amount (X) is greater than the size of the
can. That is, P(X > size). Is it normdist() or 1-normdist()?
NewQuestion, MC,
QuestionText, "Apple Oil is sold in 940 milliliter (ml) cans. The mean volume of oil
placed in a can is 920 ml with a standard deviation of 13 ml. Assuming a normal
distribution of the data, what is the probability that the filling machine will cause an
overflow in a can?"
Points, 1,
Option, 100, 0.062
Option, 0, 0.938
Option, 0, 0.5
Option, 0, 0.0258
Feedback, Overflow will occur if the filling amount (X) is greater than the size of the
can. That is, P(X > size). Is it normdist() or 1-normdist()?
NewQuestion, MC,
```

to create three question libraries as text files, each of which will be imported to an LMS. The detailed steps of importing the text file in D2L is shown in Appendix G, which also includes brief steps for Blackboard and Moodle.

7. Conclusion

This paper shows how to create a quiz that allows students multiple attempts in an LMS. Such quizzes provide students chances to learn from their mistakes. If their answer to a question is incorrect, they can rework and find out where they made a mistake. Then, unlike quizzes allowing only one attempt, they can apply newly learned understanding to the same question but with different numbers, which can bolster their understanding and improve their confidence (Yourstone et al. 2010).

Even though the method presented in the paper is similar to quizzes with algorithmic questions in an LMS, it is more flexible than the latter questions as to what questions can be asked. Most functions available for algorithmic questions in an LMS are too basic and may not have the power to generate questions for complex topics. For those topics, instructors often use off-line quizzes and homework assignments, which are manually graded later by instructors. This means that students will must wait a day or more before they can receive feedback on their work. Furthermore, these assignments typically do not allow multiple tries. Using the method described in this paper, instructors can make on-line quizzes for those topics, which can provide instant feedback. Therefore, the method presented here is an additional tool, along with algorithmic questions, that instructors can use to build online quizzes for various complex topics.

One obvious drawback of the method presented here is the time commitment required to make quizzes. Instructors need to think about what questions to ask in what ways. Then they will have to determine how to calculate correct answers before starting Step 1. According to our experiences, Step 1 requires the most amount of time, i.e., figuring out what to randomize and how to calculate an answer and distractors. Steps 2 and 3 should not take much time once instructors familiarize themselves with those steps. We believe that this time investment is well worthwhile if students can learn better. Furthermore, once the quizzes are made, they can be continuously reused in the future with minimal changes.

Appendix A. M/M/s Queuing Model

"On average, *30* customers arrive per hour at a branch of Neighbor Bank. It takes an average of *2* minutes to serve each customer. There are *5* tellers. Assuming both

Figure A.1. Random Parts and the Answer of M/M/s Queuing Model

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Num	l	sm	m	s	r	0	1	2	3	4	5	6		p0a	p0b	p0	p
2	1	20	2	30	7	0.095238	1	0.666667	0.222222	0.049383	0.00823	0.001097	0.000122		1.947721	1.28E-05	0.513417072	6.59E-06
3	2	20	4	15	7	0.190476	1	1.333333	0.888889	0.395062	0.131687	0.035117	0.007804		3.791891	0.001836	0.263592987	0.000484
4	3	20	3	20	4	0.25	1	1	0.5	0.166667	0.041667	0.008333	0.001389		2.718056	0.055556	0.360540811	0.02003

interarrival and service times follow exponential distributions, what the probability that all servers are busy?"

The first random part is the arrival rate (λ); the second is the average service time in minutes, which can be converted to the service rate per server (μ); the third is the number of servers (s). Then, the probability that all servers are busy (p) is

$$p = \frac{(s\rho)^2 p_0}{s!(1-\rho)},$$

where ρ = the traffic intensity ($\lambda/(\mu * s)$) and

$$p_0 = \frac{1}{\sum_{n=0}^{s-1}((s\rho)^n/n!) + (s\rho)^2/(s!(1-\rho))}.$$

B2 in Figure A.1 is the random arrival rate (λ) between 20 and 50 by an increment of 10. C2 is the average service time between 2 and 4. D2 is the service rate per server (μ) per hour. E2 is the random number of servers (s) between 3 and 8. F2 is traffic intensity (ρ). G1:N1 are the values of n in p_0, starting from 0 and ending at $s-1$. G2:N2 is calculating the first part of the denominator in p_0 for each value of n, which are then combined in O2. P2 is the second part of the denominator in p_0. Q2 is the value of p_0 calculated from O2 and P2. R2 is the value of p, which is the answer to the question. The formulas used in Figure A.1 are shown below.

```
B2: =RANDBETWEEN(2,5)*10
C2: =RANDBETWEEN(2,4)
D2: =60/C2
E2: =RANDBETWEEN(3,8)
F2: =B2/(D2*E2)
G1: 0
H1: =IF($E$2>1,1,"")
I1: =IF($E$2>2,2,"")
 ⋮
N1: =IF($E$2>7,7,"")
G2: =IF(G$1="","",($E2*$F2)^G$1/FACT(G$1))
(H2:N2): Copy of G2
O2: =SUM(G2:N2)
P2: =(E2*F2)^E2/(FACT(E2)*(1-F2))
Q2: =1/(O2+P2)
R2: =($E2*$F2)^$E2*Q2/(FACT($E2)*(1-F2))
```

Appendix B. Inventory Model

"Walton Bookstore buys calendars for *$7.50*, sells them at the regular price of *$10*, and receives a refund of *$2.50* for all calendars that cannot be sold. Walton estimates that demand for the calendar has a normal distribution with mean of *175* and standard deviation of *40*. How many calendars should Walton order to maximize expected profit?"

The optimal order quantity Q satisfies the following:

$$\text{P(Demand} < Q) = \textit{Critical Fractile}(CF),$$

$$\text{where } CF = \frac{C_{\text{under}}}{C_{\text{under}} + C_{\text{over}}}$$

C_{over} and C_{under} are the unit costs of overstocking and understocking, respectively.

B2 in Figure B.1 is the random cost between 6 and 10.5 by an increment of 0.5. C2 is the random profit margin, which is also the unit cost of understocking (C_{under}), between 1 and 3.5 by an increment of 0.5. D2 is the price, which is the sum of B2 and C2. Even though the price is a random part, its values are not directly randomly generated, but indirectly through the random cost and profit margin. E2 is the random refund amount between 2 and 4.5 by an increment of 0.5. F2 and G2 are the mean and the standard deviation of the demand distribution, respectively. The range of the mean is from 16 to 18.5, and that of the standard deviation is from 3 and 4.5. H2 is the value of CF, where C_{over} = cost (B2) − refund(E2). I2 is one possible wrong way of calculating CF, where C_{over} = price (B2) − refund(E2); it will be used to generate distractors. J2 is the answer. K2, L2, and M2 are distractors. M2 randomly generates numbers either less than the answer (J2) or greater than the biggest distractor (K2). This will make the answer not always the second biggest among the alternatives. The formulas used in Figure B.1 are shown below.

```
B2: =RANDBETWEEN(6,10)+IF(RAND()<0.5, 0, 0.5)
C2: =RANDBETWEEN(1,3)+IF(RAND()<0.5, 0, 0.5)
D2: =B2+C2
E2: =RANDBETWEEN(2,4)+IF(RAND()<0.5, 0, 0.5)
F2: =10*(RANDBETWEEN(16,18)+IF(RAND()<0.5, 0,
0.5))
G2: =10*(RANDBETWEEN(3,4)+IF(RAND()<0.5, 0, 0.5))
H2: =C2/(C2+B2-E2)
I2: =C2/(C2+D2-E2)
J2: =ROUNDUP(NORM.INV(H2,F2,G2),0)            K2:
=ROUNDUP(NORM.INV(1-H2,F2,G2),0)
L2: =ROUNDUP(NORM.INV(I2,F2,G2),0)
M2: =IF(RAND()<0.5, RANDBETWEEN(J2-11,J2-1),
RANDBETWEEN(K2+1,K2+11))
```

Figure B.1. Random Parts, the Answer, and the Distractors of an Inventory Model

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Num	Cost	pm	Price	Refund	Mean	Stdev	cf	cf_w	s1	s2	s3	s4
2	1	7.5	2.5	10	2.5	175	40	0.333333	0.25	158	193	149	202
3	2	9.5	1	10.5	4	175	45	0.153846	0.133333	130	221	126	231
4	3	6	2	8	3	175	30	0.4	0.285714	168	183	159	161

Figure C.1. Random Parts, the Answer, and the Distractor of a Simple Linear Regression Problem

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Num	1	2	3	4	5	6	7	8	9	10	b0	b1	s1	s2
2	1	1345000	1352000	1463000	1511000	1610000	1649000	1713000	1850000	2051000	2203000	1168200	92090.91	2181200	12942291
3	2	1332000	1397000	1448000	1458000	1470000	1552000	1593000	1679000	1778000	1831000	1260467	53333.33	1847133	13918467
4	3	1350000	1440000	1476000	1531000	1550000	1598000	1603000	1676000	1737000	1824000	1324867	46115.15	1832133	14619648

Appendix C. Simple Linear Regression

"The Best Chips Company produces and sells potato chips throughout the country. Its sales have been growing steadily over the past 10 years; the data is shown below. What will be the predicted sales in year 11 using a simple linear regression?"

Year	Sales
1	*1345000*
2	*1352000*
3	*1463000*
4	*1511000*
5	*1610000*
6	*1649000*
7	*1713000*
8	*1850000*
9	*2051000*
10	*2203000*

B2:K2 in Figure C.1 are the 10 random observations for the simple linear regression. B2 is the randomly generated sales of the first year between 1,330,000 and 1,350,000 by an increment of 1,000. C2 is the randomly generated sales of the second year by adding the firstyear sales (B2) and a random number between 5,000 and 100,000 by an increment of 1,000. Then, C2 is copied and pasted to D2:K2. L2 and M2 are an intercept and a slope of the simple linear regression. N2 is the answer, and O2 is a possible distractor. The formulas used in Figure C.1 are shown below.

```
B2: =RANDBETWEEN(1330, 1350)*1000
C2: =B2+RANDBETWEEN(5,100)*1000
L2: =INTERCEPT(B2:K2,$B$1:$K$1)
M2: =SLOPE(B2:K2,$B$1:$K$1)
N2: =L2+M2*11
O2: =M2+L2*11
```

If students are allowed to use Excel to solve this problem, they can copy the observations from the online quiz page and paste them to Excel. Using **Text to Columns** command in **Data** tab in Excel ribbon, students can convert the copied data set to one that is ready for further analysis.

Appendix D. Check the Uniqueness of the Combinations

There are two places where the uniqueness of the combinations can be checked, i.e., Excel and Word. In Excel, an instructor can use the CANCATENATE function to combine all random parts in one cell as shown in column D in Figure D.1. Then, each combination (i.e., the result of CANCATENATE) is counted out of all the combinations; this is shown in column E. If it is unique (that is, no duplication), the frequency will be one. Then, all counts are multiplied together and placed in E1. This product will be one if and only if all combinations are unique. If random parts are generated by using some random functions, an instructor can regenerate all the random parts by pressing function key F9 until E1 becomes one. The formulas used in Figure D.1 are shown below.

```
D2: =CONCATENATE(B2,C2)
E2: =COUNTIF($D$2:$D$11,D2)
E1: =PRODUCT(E2:E11)
```

Microsoft Word can also detect duplicate combinations, but not as robustly as Excel. While mail-merging, click **Edit Recipient List**. Then, click **Find duplicates**. (See Figure D.2.) Word will find all duplicate entries, and these duplicates can be excluded from the final outcome. However, duplicates are based on all merge fields used in the documents. That is, not only the random parts, but also all the choices. Therefore, if random functions are used for distractors, some questions can be classified as unique even if their random parts values are the same.

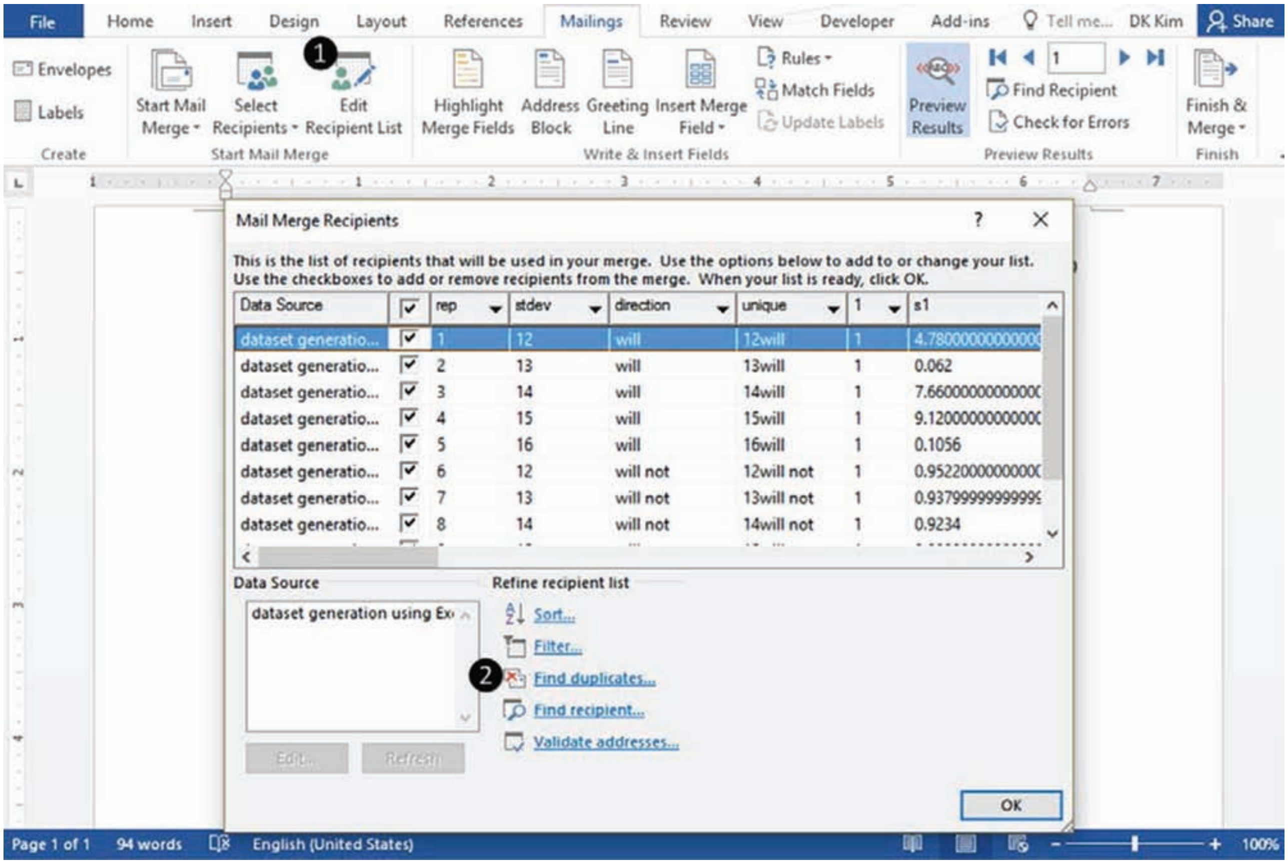
Appendix E. Shuffle the Alternatives

In the Apple oil example, the answers are in column F (Figure 3), and the distractors are in columns G:I (Figure 4). That is, the correct answer is always in the first column, which makes the first choice always the correct answer in the finalized quiz. Some LMS, such as Moodle, can shuffle the choices when the questions are imported. Other LMS may be unable to shuffle the choices during the import, and each question must be individually set to randomize the order of the choices after the import. Because this would be very tedious and time consuming, this appendix explains how to shuffle the order in Excel.

Figure D.1. Check the Uniqueness of the Combination of the Parameters

	B	C	D	E
1	Stdev	Direction	Unique	1
2	12	will	12will	1
3	13	will	13will	1
4	14	will	14will	1
5	15	will	15will	1
6	16	will	16will	1
7	12	will not	12will not	1
8	13	will not	13will not	1
9	14	will not	14will not	1
10	15	will not	15will not	1
11	16	will not	16will not	1

Figure D.2. Finding Duplicate in Mail Merge



First, create a pattern in which each place of the four alternatives will be the correct answer about 25% of the time. In Figure E.1, the number one (1) in columns O:R dictates the location of the correct answer in the shuffled order. For example, the first choice in the shuffled order is the correct answer in the first question (row 2); the second choice is the correct answer in the second question (row 3); etc. The patterns in the four rows (O2:R5) are then copied to O6:R11.

The answer and distractors in columns F:I are then placed in columns S:V according to the patterns in columns O:R as shown in Figure E.1. To do this, the following formulas using the INDEX function are used:

```
S2: =INDEX($F2:$I2,1,O2)
T2: =INDEX($F2:$I2,1,P2)
U2: =INDEX($F2:$I2,1,Q2)
V2: =INDEX($F2:$I2,1,R2)
```

The INDEX function returns the value of an element in an array, selected by the row and column number indexes. In the formula in S2, for example, the array is F2:I2, which contains the answer in column F and three distractors in columns G:I, and the row and column indexes are 1 (the second argument) and O2 (the third argument), respectively. Since the value of O2 is 1, the function returns the value in the first column of the first row in F2:I2.

The next step is to assign the points to each solution: 100 to the answer and 0 for distractors. That is, students will earn 100% of the point assigned to the question if they select the correct answer; otherwise, 0%. Recall that each row in columns O:R (Figure E.1) contains the pattern that specifies which choice is the correct answer. Using the IF statement, points are calculated for all choices as follows:

```
W2: =IF(O2=1,100,0)
X2: =IF(P2=1,100,0)
Y2: =IF(Q2=1,100,0)
Z2: =IF(R2=1,100,0)
```

Later, when the mail merge is performed, these shuffled solutions (ss1~ss4) and their points (spt1~spt4) are used instead of the original solutions (s1~s4) and points (pt1~pt4).

Appendix F. Step 1 by R

In this section, R code for Step 1 for the probability question is provided for interested readers. Three random parts are used:

> "Apple Oil is sold in *940* [s] milliliter (ml) cans. The mean volume of oil placed in a can is *920* [mu] ml with a standard deviation of *12* [stdev] ml. Assuming a normal distribution of the data, what is the probability that the filling machine will cause an overflow in a can?"

In the first row, the size of the can is 950 ml. The mean and the standard deviation of the filled amount are 920 ml and 13 ml, respectively. The next four columns are the choices for the question. The last four columns are the points assigned to each choice in s1~s4. In this case, the third choice (i.e., 0.01051) is the correct answer.

Figure E.1. Shuffled Choices and Points

	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	Order1	Order2	Order3	Order4	ss1	ss2	ss3	ss4	spt1	spt2	spt3	spt4
2	1	2	3	4	0.0478	0.9522	0.5	0.0763	100	0	0	0
3	2	1	3	4	0.938	0.062	0.5	0.0152	0	100	0	0
4	3	2	1	4	0.5	0.9234	0.0766	0.0764	0	0	100	0
5	4	3	2	1	0.0345	0.5	0.9088	0.0912	0	0	0	100
6	1	2	3	4	0.1056	0.8944	0.5	0.0162	100	0	0	0
7	2	1	3	4	0.0478	0.9522	0.5	0.028	0	100	0	0
8	3	2	1	4	0.5	0.062	0.938	0.0373	0	0	100	0
9	4	3	2	1	0.0131	0.5	0.0766	0.9234	0	0	0	100
10	1	2	3	4	0.9088	0.0912	0.5	0.0871	100	0	0	0
11	2	1	3	4	0.1056	0.8944	0.5	0.0132	0	100	0	0

Appendix G. Text File Formats of the Three Major LMS and Import Steps of the Questions

Desire2Learn

```
 1 //MULTIPLE CHOICE QUESTION TYPE
 2 NewQuestion,MC
 3 Title,This is a multiple choice question
 4 QuestionText,This is the question text for MC1
 5 Points,1
 6 Difficulty,1
 7 Image,images/MC1.jpg
 8 Option,100, This is feedback for option 1
 9 Option,0, This is feedback for option 2
10 Option,0, This is feedback for option 3
11 Option,25, This is feedback for option 4
12 Hint, This is the hint text
13 Feedback, This is the feedback text
```

Not all lines are required. For illustration, lines 2, 4, 5, 8, 9, 10, 11, and 13 are used in Figure 7 in Section 4. The instruction of importing the text file created in step 3 is shown below.

1. Go to Question Library in D2L. Create a new Section with a proper name, such as "Normal Type I," in which the text file created in step 3 will be imported. Click the newly created section to go inside of it.
2. Click **Import**.
3. Select **From a Desire2Learn Text Format File** in Import Source.
4. Click **Choose File**.
5. Select the txt file saved in Step 3.
6. Click **Save**.

Importing the text file is done. The following step is for making a quiz using the imported questions.

1. When creating a quiz, give a proper name (for example, "Normal probability problems")
2. Click **Add/Edit Questions**.
3. Click **New**
4. Select **Random Section**. Provide a section name (for example, "Type A")
5. Click **Save**. (The section name is by default hidden from students.)
6. Click the newly created random section.
7. Click **Import**.
8. On the next screen, choose the question library created earlier. Then, select all questions
9. Click **Save**.

Now the questions that have been created can be imported into the random section of the newly created quiz. The first step is to determine how many questions should be pulled from the library in each try. By default, this value is zero. Therefore, an instructor must specify a positive integer. In Figure G.1, the number of questions per attempt is set to one (1). Therefore, this random section will pull one question from the library in each attempt. Once this is specified, click Save and then click Done Editing questions.

If one wishes to include more than one random section (that is, more than one question) in the same quiz, the steps described in this appendix can be repeated using the same quiz.

Blackboard

Unlike D2L, Blackboard requires that each question (a stem and choices) be on one line with the following format[5]:

`MC ⇥ stem ⇥ choice 1 ⇥ correct/incorrect ⇥ choice 2 ⇥ correct/incorrect`

The ⇥ symbol represents a tab key. "MC" stands for multiple choice , which is a question type. The example used in this paper should be typed in Microsoft Word as follows (Step 2).

> MC ⇥ Apple Oil is sold in 940 milliliter (ml) cans. The mean volume of oil placed in a can is 920 ml with a standard deviation of [stdev] ml. Assuming a normal distribution of the data, what is the probability that the filling machine [direction] cause an overflow in a can? ⇥ [s1] ⇥ correct ⇥ [s2] ⇥ incorrect ⇥ [s3] ⇥ incorrect [s4] ⇥ incorrect

Then, an instructor follows Step 3 to complete mail merge. Once the text file for import is created, follow the steps below[6]:

1. Log in to Blackboard and go to your course
2. Go to **Course Tools**
3. Click **Tests, Surveys, and Pools**
4. Click **Pools**
5. Click on the name of the test to access the drop-down menu
6. Click **Edit pool**
7. Click **Upload Questions**

```
# A. Generate parameters for questions and check uniqueness

      r <- 50                          # The number of replication.
      x <- 0                           # Index variable for While loop
      while(uv < r) {
        mu <- sample(915:925, r, r=T)  # Mean between 915 and 925.
        stdev <- sample(12:16, r, r=T) # Standard deviation b/w 12 and 16.
        s <- sample(c(950, 955, 960),  # The size of the can
           r, r = T)                   #   is 950, 955 or 960.
        u <- mu*100000 + std*1000 + s  # Calculate the uniqueness IDs.
        uv <- length(unique(u))        # Count unique combinations
      }

# B. Calculate answers to the combinations of parameters
      prob <- vector(length = r)   # vector to store the correct answer

      for (i in 1:r){              # calculate P(X > a) and store it in prob.
        prob[i] <- round(pnorm(s[i], mu[i], std[i], lower = F), 5)
      }

# C. Generate distractors

      uv <- 0
      while(uv < r){                      # Run until all choices are
                                          #  unique in each row
        ws <- matrix(round(runif(r*3,     # Generate 150 random numbers
          0.00001, 0.02),5),              #  b/w 0.00001 and 0.02 and
          nrow=r, ncol=3)                 #  store them in the 50x3 matrix.
        p.ws <- cbind(prob, ws)           # Combine the correct answer with
                                          #  wrong answers.
        for (i in 1:r){
          unq <- length(unique(p.ws[i,])) # Check whether all values of each
          if (unq == 4) {                 #  row of p.ws are different.
            uv <- uv + 1                  # If they are, uv increases by 1.
          }                               # The while loop will run until
        }                                 #  each row of p.ws contains
      }                                   #  no duplicate values.

# D. Shuffle the correct answer and distractors

      vr <- matrix(nrow=r, ncol=4)     # Create a 50x4 matrix.
      for(i in 1:r){                     # In each row of the matrix,
        vr[i,] <- sample(1:4, 4)         # store 1 through 4 in random order.
      }

      ch <- matrix(, nrow=r, ncol=4)     # Create another 50x4 matrix to store
                                           the shuffled choices
      for(i in 1:r){                     # Within each row (i), the value of
        for (j in 1:4){                  #  each column (j) will be pulled from
          ch[i,j] <- p.ws[i,vr[i,j]]     #  the i-th row and j-th column of
        }                                #  p.ws.
      }

# E. Assign points to the choices

      point <- matrix(0, nrow=r, ncol=4)
      for(i in 1:r){
        for (j in 1:4){
          point[i,j] <- ifelse(vr[i,j] == 1, 100, 0)
        }
      }
```

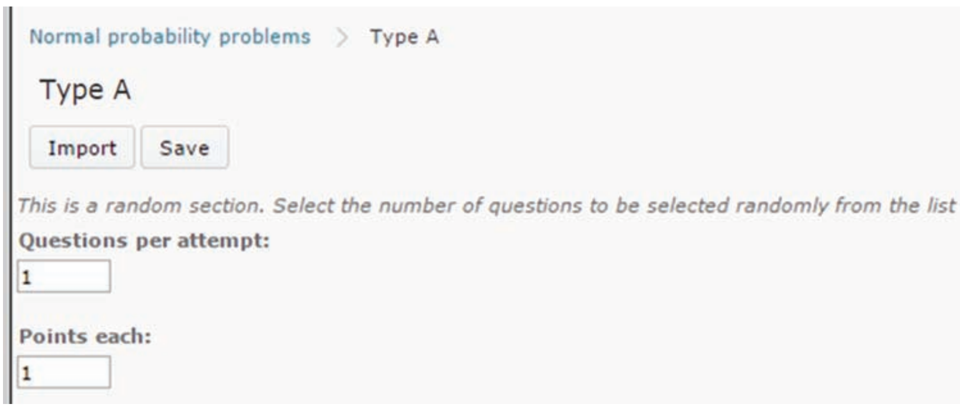
```
# Create the data set for mail merge and save it as the csv format.

      final <- cbind(s, mu, std, ch, point)        # Combine all inputs
      colnames(final) = c("size", "mean", "stdev", # Assign a name for each
        "s1", "s2", "s3", "s4",                    #  column.
        "point1", "point2", "point3", "point4")
      write.csv(final, file="Normal.csv")          # Save the data ''final''
                                                   # as ''Normal.csv''
```

The first three rows of the final data set are shown below:

```
     size mean stdev      s1      s2      s3      s4 point1 point2 point3 point4
[1,]  950  920    13 0.01422 0.01915 0.01051 0.00758      0      0    100      0
[2,]  960  925    12 0.00177 0.01517 0.01553 0.00396    100      0      0      0
[3,]  950  924    14 0.01916 0.00624 0.01608 0.03165      0      0      0    100
```

Figure G.1. Select the Number of Questions



8. Click **Browse** and select the text file of questions
9. Enter an appropriate value to Points per question
10. Click **Submit**

Moodle

For MC questions, the following simple format (i.e., the Aiken format) can be used.

```
Stem
A. option 1
B. option 2
C. option 3
D. option 4
ANSWER: A
```

The stem must be all on one line without line breaks. Each choice must start with a single-letter character, followed by a period "." or a bracket ")," then a space. The answer line must immediately follow, starting with "ANSWER: " (note the space after the colon) and then giving the appropriate letter.[7] The example used in this paper should be typed as follows in Microsoft Word:

> Apple Oil is sold in 940 milliliter (ml) cans. The mean volume of oil placed in a can is 920 ml with a standard deviation of [stdev] ml. Assuming a normal distribution of the data, what is the probability that the filling machine [direction] cause an overflow in a can?
> A. [s1]
> B. [s2]
> C. [s3]
> D. [s4]
> ANSWER: A

Then, an instructor follows Step 3 to complete mail merge. Once the text file for import is created, follow the steps below[8]:

1. Log in to Moodle and go to your course
2. In the *Administration* block, under *Course Administration*, click **Question Bank**, then click **Import**. The *Import questions from file* page will open.
3. For File format, select Aiken Format.
4. Click the **General** heading to select a **Category** (or use Default for course) for *Import category*.
5. Under *Import questions from file*, click **Choose a file...**. The *File picker* pop-up window opens.
6. Click **Upload File** (at left), then **Browse**. Find the text file for import on your computer and click **Open**. You will be returned to the *File picker* pop-up.
7. Click **Upload this File**. Below the *Choose a file* button, you will see the file name for the file you just uploaded.
8. Click **Import**. You will see a page with the message "importing (# of) question(s) from file," with a list of the questions.
9. Click **Continue**. Your Question Bank will open. You can now further edit the questions or include the questions in a quiz.

Endnotes

[1] *Edutechnica*, "4th Annual LMS Data Update," http://edutechnica.com/2016/10/03/4th-annual-lms-data-update/.

[2] All questions shown here are from Winston and Albright (2012) with a few modifications by the authors.

[3] See also endnote 4.

[4] If both the mean and the size of the can were the random parts, then the first and second arguments of the NORM.DIST function in the formula (that is, 940 and 920) would be replaced with cell addresses referring to those two random parts.

[5] An MC question can have up to 20 choices.

[6] Adapted from: http://at.blogs.wm.edu/quick-and-easy-blackboard-test-uploading/.

[7] Adapted from: https://docs.moodle.org/23/en/Aiken_format.

[8] Adapted from: https://www.umass.edu/it/support/moodle/import-quiz-questions-moodle-using-aiken-format.

References

Haladyna TM, Downing SM, Rodriguez MC (2002) A review of multiple-choice item-writing guidelines for classroom assessment. *Appl. Measurement Ed.* 15(3):309–334.

Schoenfeld AH (1992) Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. Grouws D, ed. *Handbook for Research on Mathematics Teaching and Learnin* (Macmillan, New York), 334–370.

Tsai W, Wardell DG (2006) Creating individualized data sets for student exercises using Microsoft Excel and Visual Basic. *INFORMS Trans. Ed.* 7(1):136–148.

Winston WL, Albright SC (2012) *Practical Management Science*, 4th ed. (South-Western, Mason, OH).

Yourstone S, Kraye H, Albaum G (2010) Online quantitative-based assignments—Are more attempts better for learning? *Decision Sci. J. Innovative Ed.* 8(2):347–351.