Development and Assessment of a Multiple-Choice Quiz for a Bending Stress Quiz

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Abstract

A structured process is presented for developing or revising a multiple-choice quiz. A multiple-choice checklist form was created based on the best practices found in educational measurement books. The multiple-choice checklist form serves as a guide for an instructor to revise an old quiz or develop a new quiz. The effectiveness of the multiple-choice quiz checklist form is determined based on an assessment and evaluation process. This paper considers the development a 'new' quiz for bending stress in a sophomore level fundamentals of mechanics course. Four instructors used the multiple-choice checklist form to develop a new quiz and five instructors developed a new multiple-choice quiz without the checklist form. Independent reviewers are used to carry out a quantitative evaluation of the new quizzes developed with and without the multiple-choice checklist form. The assessment form is based on the multiple-choice checklist form. The results of the assessment process show that the proposed multiple-choice quiz checklist form is a valuable tool for instructors to develop more effective quizzes.

Introduction

Finite element (FE) learning modules have been developed for fifteen required undergraduate engineering courses.[1,2,3] Some modules have been developed for the following topics: curved beam, bolt and plate stiffness, lateral frequency of a cantilever beam, lateral vibration of a tapered cantilever beam, steady state heat transfer in a bar, transient heat transfer in a l-bar, cylindrical drag, friction flow in a pipe, probe feed patch antenna, specific absorption rate, transmission parameters of an infinitely long co-axial cable, and human head. These FE learning modules are used to introduce basic and complex engineering problems to enhance student learning of the theory and fundamentals of the finite element method (FEM).

After the implementation of a new fatigue FE learning module in the spring of 2009, the pre- and post-quiz assessment results showed no improvement in student learning.[3] This was the first time a FE learning module did not show significant improvement in student learning. After closer examination, we realized the quiz for the fatigue FE learning module used different question formats. The fatigue FE learning module quiz used half multiple-choice and half open-ended questions. Previous FE learning modules used entirely multiple-choice questions. Since open-ended questions are more challenging to assess student learning, future FE learning modules will use only multiple-choice questions. Whether a multiple-choice quiz should be used as opposed to a different format of a quiz (short answer, etc.) is a completely separate question.

We have chosen to use a multiple-choice quiz as part of the assessment strategy for our learning modules.

This paper presents a multiple-choice checklist form that was developed based on a review of educational measurement books. The checklist provides a list of best practices divided into domains for an instructor to develop a new quiz or revise an old quiz. The proposed checklist form is easy to use and requires minimal time to complete. The checklist was validated using an assessment and evaluation process.

First, the paper reviews the educational literature for multiple-choice and discusses how the multiple-choice checklist form was developed. A supplemental instructor guide for developing/revising quizzes is discussed. The quiz development/revision process used in this work is described. The paper addresses the assessment process used to evaluate the effectiveness of the checklist form. Instructor groups used to develop new quizzes are defined. Assessment results are presented for the two instructor groups that did and did not use the checklist to write their quizzes. Finally, the paper discusses the conclusions.

Multiple-Choice Quiz Checklist Form Literature Review

The literature review for the quiz development/revision process first considered engineering educational journals and conference proceedings. This review yielded widely varying results and very little guidance in developing quizzes. Most of the engineering educational literature focused on developing web based quizzes so that an instructor can easily grade and change questions for large enrollment courses.[4,5,6] A review of multiple-choice and educational measurement literature[7-29] provided insights into a process of developing new quizzes or revising old quizzes. Multiple-choice revision checklists were found in several books and contained very similar information.[7,10-12, 14, 27,28]

The checklist developed in this work is a derivative of checklists found in the educational measurement and multiple-choice exam writing books by Bloom[7], Gronlund[10], Haladyna[11], Hambleton[12], McDonald[14], Reynolds[27], and Linn[28]. Only these texts presented organized checklists. A majority of other texts contain long lists of guidelines followed by additional reading. These lengthy readings are impractical due to instructor time constraints. Checklists provide a direct means to evaluate quiz quality in a timely manner. Based on the literature review carried out by the authors, this is the first checklist that has been used in an engineering education environment.

Multiple-Choice Quiz Checklist Form

The ***Multiple-Choice Quiz Question Checklist Form*** developed in this work is shown in Figure 1. This checklist has been revised to meet the needs of our quizzes. The number of questions have been condensed and the questions rewritten to remove much of the jargon.

Multiple-Choice Quiz Question Checklist Form

Instructions: Review your new or old quiz using this checklist. The "perfect" quiz answers '**YES**' to all questions. The pages that follow will provide guidance in filling out this checklist, and references are included if an in-depth explanation is required. Any question from the checklist that is answered '**NO**' must be addressed in revising the quiz.

Quiz Name:_____

Instructor:_____ Date:_____

Content	**YES**	**NO**
1. Is each question designed to measure a *single learning objective*?	_____	_____
• If no, what *learning objectives* are not addressed (check appropriately)? #1_____ #2_____ #3_____ #4_____		
• How many questions are on the quiz? _____		
• State the number of quiz questions that address each *learning objective*. #1_____ #2_____ #3_____ #4_____		
Note: Sum total above must equal total number of quiz questions.		
2. Has new material, not introduced to students, been avoided in formulating problems measuring understanding and applications?	_____	_____
3. Has an appropriate number of questions been selected?	_____	_____
Format Suggestions		
1. Have numbers and letters been used to denote questions and options, respectively?	_____	_____
2. Are all options grammatically consistent with the question and parallel in form?	_____	_____
3. Are options listed vertically on separate lines?	_____	_____
Writing the Question		
1. Is the problem defined clearly in the question?	_____	_____
2. Is as much information in the question as possible?	_____	_____
3. Has no irrelevant information been included in the question ?	_____	_____
4. Have grammatical cues or clues been avoided in the question ?	_____	_____
5. Has a minimum number of negatively stated questions been used?	_____	_____
6. If a negative statement is used, has it been clearly emphasized?	_____	_____
Writing the Multiple-Choice Options		
1. Do all distractors represent plausible alternatives to examinees that do not possess the skill measured by the test question?	_____	_____
2. Are all the options as homogeneous as possible?	_____	_____
3. Are all options of the same length and complexity?	_____	_____
4. Have two options that mean the same been avoided, such that both can be rejected?	_____	_____

Figure 1. ***Multiple-Choice Quiz Question Checklist Form.***[7,10-12,14,27,28]

***Multiple-Choice Quiz Question Checklist Form* 'Continued'**

Instructions: Review your new or old quiz using this checklist. The "perfect" quiz answers '**YES**' to all questions. The pages that follow will provide guidance in filling out this checklist, and references are included if an in-depth explanation is required. Any question from the checklist that is answered '**NO**' must be addressed in revising the quiz.

Quiz Name:_____

Instructor:_____ Date:_____

***Writing the Multiple-Choice Options* 'Continued'**	**YES**	**NO**
5. Have modifiers like "usually" and "sometimes" been avoided in the options?	_____	_____
6. Are there important, detailed, or technical sounding words in the distractors?	_____	_____
7. Has the correct answer not been described in more detail than other options?	_____	_____
8. Has the length of the correct answer been varied, thereby eliminating a potential clue?	_____	_____
9. Is there one correct or clearly best answer?	_____	_____
10. Have the use of options such as "All-of-the-above" or "None-of-the-above" been avoided or minimized?	_____	_____

Figure 1. ***Multiple-Choice Quiz Question Checklist Form***.[7,10-12,14,27,28] 'Continued'

The ***Multiple-Choice Quiz Question Checklist Form*** was divided into four domains based on the guidelines described in Haladyna.[11] Almost all other books were not categorized into domains. The four checklist domains used in this paper are as follows:

- *Content.* This domain is used to evaluate the content of the entire quiz.
- *Format Suggestions.* This domain provides guidelines to format a quiz question and options.
- *Writing the Question.* This domain provides guidelines on writing the stem for a question.
- *Writing the Multiple-Choice Options.* This domain presents guidelines to develop the responses for correct and incorrect options for a given question.

Dividing the checklist into four domains could be very beneficial in future work. After the checklist has been used many times to develop or revise quizzes, the assessment results may show that there are common trends in certain domains. This may be beneficial in identifying problems and improving the quality of future quizzes.

Completion of the ***Multiple-Choice Quiz Question Checklist Form*** by the instructor verifies that items within the specified domains are addressed. Any checklist item that is answered 'NO' by the instructor suggests that the quiz questions be reevaluated. For example, consider the first

checklist item 'Is each question designed to measure a single learning objective?'. This checklist item requires the instructor to examine each quiz question to determine if each learning objectives is addressed by the quiz. The instructor is also required to determine the number of quiz questions that address each learning objective. The subcategories were added by the authors of this paper for an in-depth analysis of the overall content of the quiz.

Supplemental Guidelines for Writing or Revising Multiple-Choice Quizzes

The ***Multiple-Choice Quiz Question Checklist Form*** was designed to be concise. Therefore, the authors developed ***Supplemental Guidelines for Writing or Revising a Multiple-Choice Quizzes*** as shown in Appendix A. This supplement provides vocabulary and formatting guidelines for an instructor in the quiz development/revision process. Furthermore, this supplement could be a valuable resource for faculty members and graduate students who are new or inexperienced in developing multiple-choice quizzes. The supplement contains additional guidelines and best practices based on the knowledge-base in multiple-choice educational literature.[7-29] Textbook references are also included in the supplement for instructors who desire additional in-depth knowledge about multiple-choice quiz development/revision. The supplement is divided into the following four sections:

- *Definitions for Multiple-Choice Questions.* The definitions of the stem and options that form a multiple-choice question are discussed.
- *Multiple-Choice Question Formats.* This section defines the two types of multiple-choice question formats that should be used and they include direct questions and completion or incomplete statements.
- *Items from the Multiple-Choice Quiz Question Checklist Form.* This section provides additional guidelines for each domain, i.e., content, format suggestions, writing the question, and writing the multiple-choice options.
- *Proofreading the Quiz.* This section provides guidelines in proofreading the quiz.

The usage of the supplement by the instructor was optional in this work.

Quiz Development/Revision Process by Instructors

The multiple-choice quiz development/revision and assessment process used in the work is shown in Figure 2. This process was developed based on examples described in multiple-choice educational literature.[11] This section will only discuss the instructor's role in the quiz development/revision process. The multiple-choice quiz development/revision process begins with an instructor developing the quiz based on the learning objectives. Two groups of instructors defined as the control group and experimental group are used to assess the effectiveness of the multiple-choice quiz development/revision process. These groups are defined as follows:

- *Control Group.* The control group is shown on the left-hand side of Figure 2. The control group consists of instructors who each write the quiz based on their professional experience. The control group does not use the ***Multiple-Choice Quiz Question Checklist Form***.

- *Experimental Group.* The experimental group is shown on the right-hand side of Figure 2. The experimental group consists of instructors who each write independently a new quiz using the ***Multiple-Choice Quiz Question Checklist Form*** in Figure 1. All instructors in the experimental group are required to use the checklist form. The form will provide guidance for an instructor to identify any deficiencies in the quiz. An instructor can obtain additional guidance in writing a new quiz using the ***Supplemental Guidelines for Writing or Revising a Multiple-Choice Quiz*** in Appendix A. This guide is not required (optional) to be used by the instructor. After the quiz is written the instructor is required to fill out the checklist form.

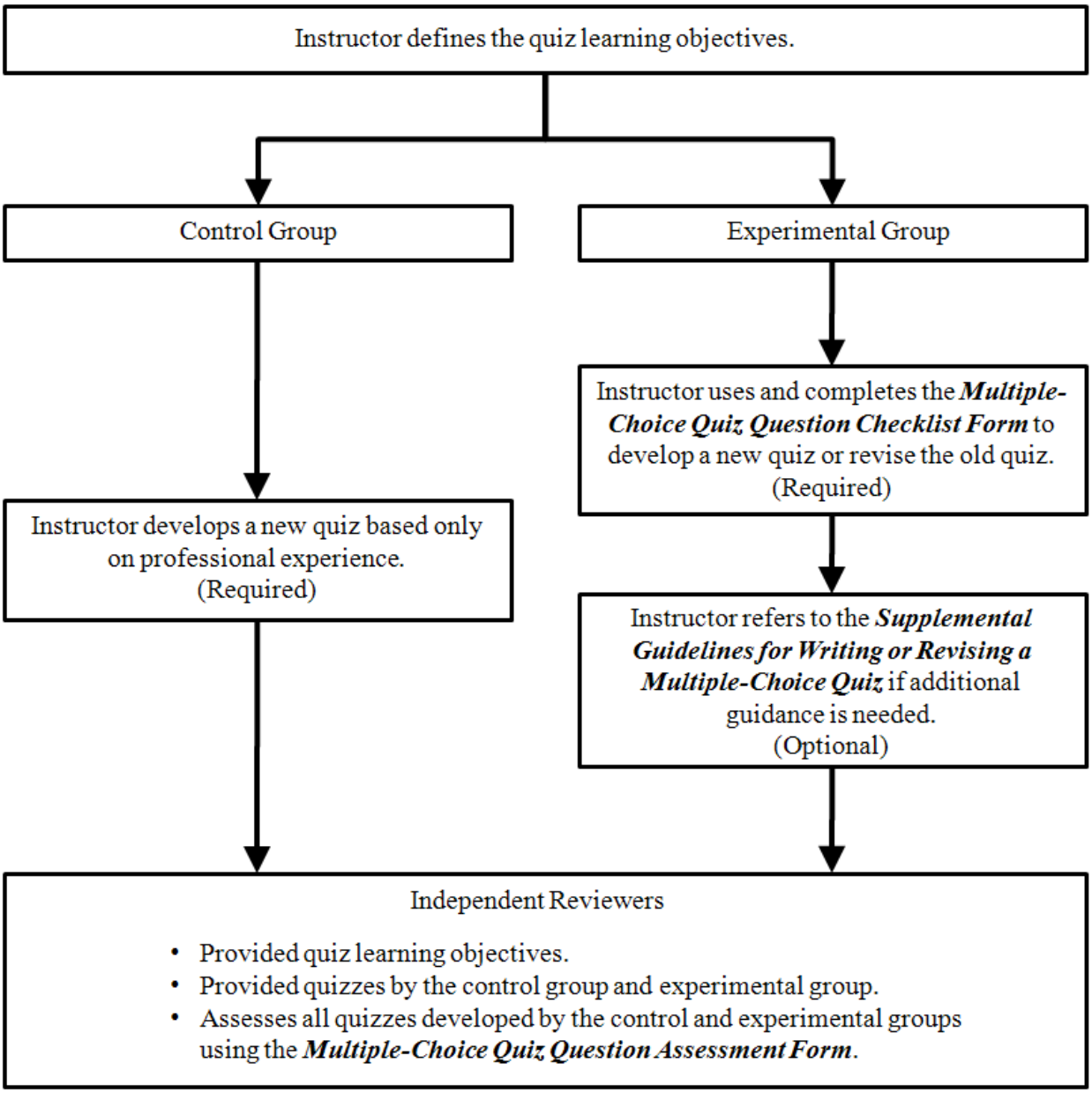

Figure 2. Multiple-choice quiz development/revision and assessment process.

Once all instructors from the control and experimental groups write their quiz, the assessment process is carried out by independent reviewers. The section to follow will discuss the assessment process used in this work.

Assessment Process by Independent Reviewers

The reader should note that this paper only assesses the usage of the ***Multiple-Choice Quiz Question Checklist Form*** (Figure 1) to improve quiz quality. This paper does not consider the impact of the checklist on student performance based on a quiz developed by the proposed multiple-choice development/revision process. This will be done in future work.

Figure 2 shows that after the quizzes are completed by instructors in the control and experimental groups an assessment is performed by independent reviewers. The following provides addresses the types of individuals that should be used as independent reviewers:

> "The persons asked for comment might be content-area experts, editorial specialists, or even examinees. Judgmental reviews have two guiding principles: each reviewer must be qualified for the task, and the task itself must be a systematic process. Both numerical analysis and judgmental review are important ways for writers to learn about the items they have written."[7]

Based on this information, the authors 'ideally' would like the following types of independent reviewers:

- *Engineering Faculty Members.* Engineering faculty members have the background to prove the validity of the quiz content related to the quiz learning objectives.
- *Non-engineering Faculty Members.* The non-engineering faculty members would have scientific and educational backgrounds. Their knowledge and experience of test construction and student learning will be a factor in identifying weaknesses within quizzes.
- *Cognitive Psychologists.* Cognitive psychologists provide further validation that the desired cognitive processes to be measured are addressed.
- *Educational/Testing Experts.* Individuals well versed in educational measurement, more specifically associated with multiple-choice testing formats.

The distribution of reviewers described above was difficult to achieve due time commitment (typically 2-3 hours) required to assess the quizzes. Also, no funding was available to compensate reviewers; therefore, all independent reviewers were volunteers. Due to the technical content of the quizzes, efforts to include an educational specialist were unsuccessful. However, the authors feel that the independent reviewers selected met the criteria as stated in the quote above.

The independent review is similar to content reviews suggested by educational measurement text; however, it has been extended to cover the other domains from the checklist form.[11,16] The requirements of an independent reviewer are shown in Figure 2. Each independent reviewer was first given the quiz learning objectives. The reviewers were also provided the quizzes from the control and experimental groups. The group associated with each quiz was not identified to the

independent reviewers. Each reviewer independently evaluated each quiz. Independent reviewers were provided the ***Independent Reviewer Multiple-Choice Quiz Question Assessment Form***, in Appendix B, to record their evaluation. This assessment form is almost identical to the ***Multiple-Choice Quiz Question Checklist Form*** in Figure 1. One difference between the two forms is that the checklist form items are written as questions and the assessment form items are written as statements. A second difference is that each item in the checklist form is evaluated on a 1 to 5 Likert Scale. The independent reviewer uses the Likert Scale to evaluate how well the quiz satisfies each assessment form statement. The scale used was as follows: (1) not at all, (2) needs improvement, (3) marginal, (4) satisfactory, and (5) exceptional. This assessment process is used to determine if the checklist is a valuable tool to develop/revise more effective quizzes.

Control and Experimental Groups for Developing New Quizzes

A sophomore level fundamentals of mechanics course is required for all students at The United States Air-Force Academy (USAFA). The course is three semester hours (no lab) and topics included statics and mechanics of materials. This course was offered in the fall of 2009 and has 24 sections, 1 lead instructor, 10 instructors, and 650 students. The factors of a single university, single course, same quiz topic, same quiz learning objectives, and short timeline allowed for a controlled setting for the development of a new quiz and assessment of the multiple-choice quiz development process proposed in this work.

The authors Josh Coffman and Dan Jensen first held a meeting at USAFA with the lead instructor to discuss the process and the requirements of the participating instructors. The lead course instructor suggested that a new quiz be developed for the bending stress lessons. This lesson was selected by the course instructors since the lesson learning objectives could be evaluated by a multiple-choice quiz. The lead instructor provided demographic data for each instructor that included age, teaching experience, number of times the instructor taught the course, and the instructor's engineering discipline. The control and experimental groups were established based on the demographic being approximately equal to one another. The control group consisted of five instructors and each instructor developed a new quiz based on their professional experience. The experimental group consisted of four instructors (actually five, but one instructor declined to participate later) and each instructor developed a new quiz using the multiple-choice quiz development/revision process as shown in Figure 1. The lead instructor was a member of the experimental group.

The lead instructor, Josh Coffman, and Dan Jensen met with the ten instructors from the control and experimental groups to discuss the project. In this meeting the instructors were asked to develop a new quiz with five to ten multiple-choice questions that were based on the learning objectives for bending stress lessons. The quiz learning objectives are as follows:

1. Explain how to find the distance, y, in the elastic flexure formula.
2. Calculate moments of inertia for symmetric cross-sections.
3. Analyze a beam using the flexural (normal stress due to bending) stress formula to calculate the stress at any point in the beam's cross-section.
4. Explain how the magnitudes of M, y, and I influence the magnitude of the flexure stress and where flexural stress will be a maximum.

5. Draw the flexural stress distribution on the cross-section of a beam.
6. Look around you—identify construction techniques (in bridges, flooring, bookcases, aircraft, etc.) that use concepts discussed in lessons 24.

Each instructor was required to develop the quiz independently. The usage of the quiz in the course was not mandatory. The instructors were told that their names would not be associated with the quizzes in any publication or saved in any manner. This was done to ensure that the instructors were not being evaluated on their quiz writing skills. The meeting provided enough information about the development of a new quiz without discussing the ***Multiple-Choice Quiz Question Checklist Form*** and ***Supplemental Guidelines for Writing or Revising a Multiple-Choice Quiz***. The instructors were allowed to only ask questions that did not reveal the goals of this work. At the end of this meeting the control group instructors were asked to leave.

A five minute meeting was held with the experimental group instructors. The ***Multiple-Choice Quiz Question Checklist Form*** (Figure 1), and ***Supplemental Guidelines for Writing or Revising a Multiple-Choice Quiz*** **(**Appendix B) were distributed and discussed. The instructors were told how to use these documents to develop a new quiz. The instructors were also allowed to ask any type of question.

The quizzes were returned to Dan Jensen within one week by the instructors in the control and experimental groups. The quizzes were then distributed to the independent assessment reviewers. The independent review process was discussed in the previous section entitled 'Assessment Process by Independent Reviewers.' The assessment results of the independent reviewers are presented in the next section.

Independent Reviewer Assessment Results

Six independent reviewers carried out assessment of quizzes from the control and experimental groups. The independent reviewers consisted of three engineering faculty members, one engineering Ph.D. candidate, one engineering M.S. student with an educational background, and one humanitarian engineering education Ph.D. candidate with a background in education. Recall, each reviewer evaluated all the quizzes using the ***Independent Reviewer Multiple-Choice Quiz Question Assessment Form*** in Appendix B. Tables 1 and 2 show the assessment results of the independent reviewers.

Table 1 shows the five control group quizzes and the four experimental group quizzes (in the second column). Averages and standard deviations are shown for each assessment form domain (columns four to seven), each overall quiz (last column), and for the control and experimental groups (rows seven and twelve). Analyzing these rows (seven and twelve) containing the group averages, the experimental group shows significantly higher averages in the Content, Format, and Writing the Question assessment form domains. This is also shown to a lesser extent for the Writing the Options domain (column six). The last column shows the experimental group overall quiz averages tend to be higher than control group. A further analysis of Table 1 shows, in general, the high to low average ranking of each domain is the same in the control and experimental groups as follows: Format domain, Writing the Question domain, Content domain, and Writing the Options domain. Overall, Table 1shows that for an instructor that uses the quiz

development guidelines (***Multiple-Choice Quiz Question Checklist Form*** in Figure 1 and ***Supplemental Guidelines for Writing or Revising a Multiple-Choice Quizzes*** in Appendix B) may effectively improve the overall quiz quality.

The first two columns of Table 2 show the assessment form domains and the associated assessment form statement numbers from the ***Independent Reviewer Multiple-Choice Quiz Question Assessment Form*** (Appendix B). The average independent reviewer scores for the control group and experimental group are shown for each assessment form statement number in the third and fourth columns, respectively. The fifth column shows for each assessment form statement number a difference between the average experimental and control groups based on the independent reviewers' scores. The second to last column shows the confidence interval for each assessment form statement number of the control and experimental groups. Negative difference values imply that the control group received higher average assessment form statement scores compared to the experimental group. Four negative difference values occur in the Writing the Options domain and are associated with assessment statement numbers four, five, seven, and ten (shown as shaded rows). The four assessment form statements (Appendix B) are as follows: 4. No two options that mean the same are used such that both can be rejected. 5. The use of modifiers like 'usually' and 'sometimes' has been avoided in the options.; 7. The correct answer has not been described in more detail. 10. The use of options such as 'All-of-the-above' or 'None-of-the-above' have been avoided or minimized.

A review of the checklist forms from the experimental group instructors revealed that one or more instructors did not follow the checklist form guidelines explicitly, i.e., they answered NO to these questions (in Figure 1). The challenge for the experimental group instructors in addressing statement four could be due to the difficulty of creating suitable discriminating options that are also homogenous in nature. Reviewing the quizzes for the experimental group we found that statement five was not addressed by the instructors. The usage of 'usually' and 'sometimes' make certain quiz options vaguely described. Statement seven prevents students from recognizing familiar terms as seen in a lecture and/or textbooks. Usage of 'All-of-the-above' and 'None-of-the-above' in statement ten is understandable, since it has been done by the authors and our own college instructors in quizzes and tests. Haladyna[29] has found that for the 'All-of-the-above' option type that 70% of educational measurement textbook authors feel that it can be used if done properly. Furthermore, Haladyna[29] comments that the 'None-of-the-above' option is more controversial based on a study of educational measurement textbooks. His research suggests that 48% of educational measurement textbook authors do not support the use of 'None-of-the-above' while only 40% support the use. After careful review of the checklist and assessment forms, assessment form statement ten should be separated into two statements to reflect the common opinions of educational measurement textbook authors.

A closer look at the confidence intervals shows a very low value for the following assessment form statement: 9. One correct or clearly best answer has been keyed. This may arise in statement nine since the correct and incorrect options may be too closely related. This difficultly in writing the options to satisfy both statements four and nine may be due to the focused topic (bending stress) addressed by the quiz learning objectives. The fact that these two similar statements are shown to be problematic identifies a positive characteristic of consistency and quality of the assessment process.

Educational measurement literature states that the "most critical part of writing multiple choice items is the selection of the response alternatives - the correct answer and incorrect choices".[20] One way for an instructor to improve quiz quality in the Writing the Options domain is to initiate the development or use established multiple-choice question item banks.[7-10,14,16,28] Item banks have been created for many courses including statics.[30] These item banks contain multiple-choice questions that have be validated in practice. This allows the quiz developers to pick and choose from existing quiz questions. This will completely eliminate problems developing options or aid in the creation of new options based on existing examples.

Analyzing the last column of Table 2 shows confidence intervals for the first three assessment form domains are approximately 99%. This means that the instructors who developed new quizzes using the ***Multiple-Choice Quiz Question Checklist Form*** (Figure 1) showed statistically significant improvement in creating better quality quiz questions for these three domains. The Writing the Options domain confidence interval is approximately 91%. However, the bottom right-hand corner of Table 2 reveals that the confidence interval based on the overall average of the quizzes for the experimental group versus the control group 77%. Even though a 77% confidence interval value is not considered statistically significant, however, there is a 77% chance that the experimental group developed a more effective quiz than the control group. Since the overall number of independent reviews was small, a t-test was used. The t-test assumes a normal distribution and provides the probability of the null hypothesis that the means of data points are statistically equivalent. The two-sided t-test p-value in Table 2 suggests there is greater than an 80% chance that the data measured could be significant.

Table 1. Independent reviewers' assessment results for assessment form domain and each quiz in the control and experimental groups.

Group	Quiz Number		Assessment Form Domains				Overall Quiz
			Content	Format	Writing the Question	Writing the Options	
Control	1	Average	3.58	3.72	4.08	4.20	3.90
		Standard Deviation	1.44	1.36	0.84	1.01	1.16
	2	Average	4.67	4.94	4.40	4.36	4.59
		Standard Deviation	0.65	0.24	0.88	0.77	0.63
	3	Average	4.58	4.89	4.37	4.34	4.54
		Standard Deviation	0.67	0.32	0.84	0.95	0.70
	4	Average	4.08	4.06	4.37	3.80	4.08
		Standard Deviation.	1.16	1.00	0.77	1.20	1.03
	5	Average	2.42	3.28	3.27	3.00	2.99
		Standard Deviation	1.24	1.27	1.21	1.25	1.24
	1-5	*Group Average*	3.87	4.18	4.10	3.94	4.02
		Group Standard Deviation	1.03	0.84	0.91	1.03	0.95
Experimental	6	Average	4.58	4.94	4.47	4.20	4.55
		Standard Deviation	0.51	0.24	0.77	1.24	0.69
	7	Average	4.08	4.61	4.30	4.28	4.32
		Standard Deviation	1.08	0.85	1.08	0.92	0.98
	8	Average	4.20	4.80	4.46	3.94	4.35
		Standard Deviation	1.03	0.41	0.97	1.13	0.89
	9	Average	4.80	4.73	4.83	4.30	4.67
		Standard Deviation	0.42	0.46	0.35	0.99	0.55
	6-9	*Group Average*	4.42	4.77	4.51	4.18	4.47
		Group Standard Deviation	0.76	0.49	0.79	1.07	0.78

Table 2. Average assessment scores for assessment form statements and domains.

Assessment Form Domain	Assessment Form Statement Number	Average Independent Reviewer Score		Group Difference (Experimental – Control)	Experimental Group vs. Control Group	
		Control Group	Experimental Group		Confidence Intervals for Assessment Form Statement	Confidence Intervals for Assessment Form Domain
Content	1	3.93	4.36	0.43	82.3%	99.4%
	2	3.80	4.32	0.52	89.4%	
Format	1	4.40	4.91	0.51	98.5%	99.9%
	2	4.17	4.50	0.33	80.7%	
	3	3.97	4.95	0.98	99.9%	
Writing the Question	1	3.77	4.36	0.59	97.0%	99.9%
	2	4.07	4.27	0.20	55.5%	
	3	4.10	4.36	0.26	64.0%	
	4	4.27	4.82	0.55	99.6%	
	5	4.43	4.86	0.43	98.6%	
	6	3.97	4.32	0.35	63.1%	
Writing the Options	1	3.70	4.21	0.51	90.5%	90.6%
	2	3.67	4.25	0.58	95.7%	
	3	3.93	4.17	0.24	63.3%	
	4	4.27	4.21	-0.06	0%	
	5	4.67	4.46	-0.21	0%	
	6	3.77	4.08	0.31	59.8%	
	7	4.17	4.04	-0.13	0%	
	8	4.27	4.42	0.15	48.4%	
	9	3.53	3.71	0.18	32.3%	
	10	4.10	4.00	-0.10	0%	
				Confidence Interval for Experimental Group vs. Control Group Quizzes		77.4%
				Two Sided t-test p-value		0.196

Conclusion

This paper presented a checklist form for instructors to develop/revise a multiple-choice quiz using guidelines found in educational measurement literature. The checklist form is easy to use and requires minimal time to complete. The checklist form was used by a group of instructors and assessment results showed that there was a seventy-seven percent chance that the quiz is more effective than quizzes developed without the checklist form. The checklist form is a valuable resource for new and inexperienced instructors and can be used by engineers and non-engineers.

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Appendix A. Supplemental Guidelines for Writing or Revising a Multiple-Choice Quiz

Supplemental Guidelines for Writing or Revising a Multiple-Choice Quiz

Instructions

This optional supplement is included for the instructor if you desire more guidance in developing a new multiple-choice quiz or revising an old multiple-choice quiz. The supplement is a collection of best practices from educational literature for writing a new or revising a multiple-choice quiz. The first two sections list multiple-choice definitions and quiz formats which are described in detail. Following this are guidelines for writing different portions of a multiple-choice questions for a quiz. The guidelines are broken down into sections based on ***Content***, ***Format Suggestions***, ***Writing the Question***, and ***Writing the Multiple-Choice Options*** found in the **Multiple-Choice Quiz Question Checklist Form** on the previous two pages. These guidelines will help address problems found in the development or revision of quiz questions using the **Multiple-Choice Quiz Question Checklist Form**. References with page numbers are provided for more in-depth discussion at the end of this document.

Definitions for Multiple-Choice Questions

In a multiple-choice quiz question there are two parts:

1. *Stem*. Poses a problem/question through clear, simple language.
2. *Options*. Includes the correct answer (one, except for all-of-the-above) and distractors. Distractors present plausible options that can mislead a student who has not mastered the quiz content.[2,4,5,8-15]

Multiple-Choice Question Formats

The following two formats are strongly recommended in literature for effective multiple-choice quiz items:

1. *Direct Question*: A simple question is stated within the stem of the item.[1,3,9,10,16,21]
2. *Completion/Incomplete Statement*. Essentially fill-in-the-blank style, however, with multiple options. The stem provides an incomplete statement with possible options to complete the statement provided in the stem.[1,3,9,10,16,21]

It should be noted that there are other formats available; however, they are not as strongly recommended in literature as the formats above. The other formats, if desired, can be found in the references at the end of this document.

Items from the Multiple-Choice Quiz Question Checklist Form

Content

1. Each question measures a single educational objective or outcome.[4,5,7-20]
2. The reading level is appropriate for the examinees and not an excessive amount.[1,2,5-9,11,12,14-16,19,21]

3. Avoid trick questions[5,7-9], opinion based questions[5,9,12], and having correct answers fall into a pattern.[1,4,5,10,11,14,16,18,21,22]
4. Give careful consideration to the number of questions on the quiz.[21]
5. As a rule of thumb, most multiple-choice items take approximately one minute to complete, unless complex calculations or reading are required.[8]
6. Break any rule or guideline if it improves the effectiveness of a question.[4,21]

Format Suggestions

1. Directions are made as clear as possible.[5,7,21]
2. The question and options should appear entirely on one page.[21]
3. The stem and options should be grammatically consistent.[2-5,7-22]
4. Format options vertically instead of horizontally for each question.[5,21]
5. Use an efficient or recommended question format.[3,4,13]
6. Never use a "best-answer" solution when a correct answer is available.[3]
7. Questions should be carefully proofread.[5]
8. Each question should be numbered as to be easily identified with indented options identified with capital letters.[21]
9. All questions and options should all be framed in third person.[7]
10. Avoid indefinite and absolute terms, "usually" or "generally", in the stem or options.[2,3,21]

Writing the Question

1. Simply, briefly, and clearly identify a single question or problem.[1,3-5,7-22]
2. Any words to be repeated in the options should be placed in the stem.[1,3-5,7-11,13,16-19.22]
3. Avoid negatively stated questions when possible.[1-5,7-13,15,16-22]
4. Questions should be independent of other questions.[2,4,5,8-15,18,19,21]
5. Use a direct question or incomplete statement.[9,10]
6. Narrow focused stems help measure understanding.[11]
7. Use the terms "why" and how" over "who", "when", and "where".[10]
8. Do not use the definition of a term as a stem.[11]

Writing the Multiple-Choice Options

1. Be sure to key the correct or clearly best answer within the options.[1-4,7-9,12,13,15,17,22]
2. Each distractor in the options should be plausible and attractive to students who have not mastered the material being examined.[1-5,7-13,15-22]
3. Difficulty can be controlled through homogeneity of distractors.[2 ,3,4,8,10-15,20,22]
4. Avoid giving clues to the correct answer.[1-5,7-15,21]
5. Complete opposites of the correct answer should be avoided because it allows the elimination of the remaining distractors.[8,16]
6. If the question is to define a term, then the distractor options should consist of alternate definitions of that term.[1]
7. Four- or five-option formats are more desirable than those with fewer options.[1,10,11,21]
8. Do not use textbook language or exact words from instructional material in the answer, but it is permissible to include in distractors.[11,12,17,21,22]

9. When possible arrange options in a logical order.[1,5,7-10,15,20,21]
10. Use the option of "None-of-the-Above" or "All-of-the-Above" sparingly.[1,2,4,5,8,9,11,13-22]
11. Options should be independent of one another.[1,8,10-12,15,18]
12. Options should be of the same length/word count.[2 ,3,5,8-22]
13. Options should all be of the same specificity and technicality.[8,10,11,15,16-22]
14. Use common misinformation and feasible erroneous conclusions for options.[11,12,14,16,22]

Proofread Quiz Questions

Review the quiz questions for clarity, grammar, spelling, punctuation, capitalization errors, and most importantly, for the accuracy of correct answers. In this review it should be ensured that there is only one right or most correct answer. Also, it is important to check for stereotyping of persons, insensitive uses of language, or any other biases towards groups of people.[5]

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Appendix B. Independent Reviewer Multiple-Choice Quiz Question Assessment Form

QUIZ # 1

Multiple-Choice Quiz Question Assessment Form

INDEPENDENT REVIEWER

Quiz Name:_____

Evaluator:_____ Date:_____

Instructions: Analyze each question in the multiple-choice quiz and record how well the quiz questions fit the statements on the scale below. Please circle the appropriate number following each statement.

1 = Not at All; 2 = Needs Improvement; 3 = Marginal; 4 = Satisfactory; 5 = Exceptional

Content					
1. Each question designed to measure a single educational objective.	1	2	3	4	5
2. New material, not described in the learning objectives, has been avoided in formulating problems to measure understanding and applications.	1	2	3	4	5
Format Suggestions					
1. Letters have been used in front of the options.	1	2	3	4	5
2. All options are grammatically consistent with the question stem and parallel in form.	1	2	3	4	5
3. Listed options are on separate lines beneath each other.	1	2	3	4	5
Writing the Question					
1. The question clearly defines the problem.	1	2	3	4	5
2. As much of the information is in the question as possible.	1	2	3	4	5
3. No irrelevant information is in the question.	1	2	3	4	5
4. No grammatical cues are in the question.	1	2	3	4	5
5. A minimum number of negatively stated questions have been used.	1	2	3	4	5
6. Negative statements, used in the question, have been clearly emphasized.	1	2	3	4	5

QUIZ #1

Multiple-Choice Quiz Question Assessment Form 'Continued'

INDEPENDENT REVIEWER

Quiz Name:_____

Evaluator:_____ Date:_____

Instructions: Analyze each question in the multiple-choice quiz and record how well the quiz questions fit the statements on the scale below. Please circle the appropriate number following each statement.

1 = Not at All; 2 = Needs Improvement; 3 = Marginal; 4 = Satisfactory; 5 = Exceptional

Writing the Multiple-Choice Options					
1. All distractors represent plausible alternatives to examinees that do not possess the skill measured by the test question.	1	2	3	4	5
2. All the options are as homogeneous as possible.	1	2	3	4	5
3. All options are of the same length and complexity.	1	2	3	4	5
4. No two options that mean the same are used such that both can be rejected.	1	2	3	4	5
5. The use of modifiers like "usually" and "sometimes" has been avoided in the options.	1	2	3	4	5
6. There are important, detailed, or technical sounding words in the distractors.	1	2	3	4	5
7. The correct answer has not been described in more detail.	1	2	3	4	5
8. The length of the correct answer has been varied, thereby eliminating a potential clue.	1	2	3	4	5
9. One correct or clearly best answer has been keyed.	1	2	3	4	5
10. The use of options such as "All-of-the-above" or "None-of-the-above" have been avoided or minimized.	1	2	3	4	5