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**Revised CTM Exam
ATMAE_Conference_Proceeding.pdf**

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Management

The Revised Certified Technology Manager Exam: The First Year's Results

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Introduction

The objective of this study was to evaluate the performance of the revised Certified Technology Manager (CTM) exam after implementation in order to determine if it is meeting expectations and if further revision is needed. In addition, this study provided a methodology framework for evaluating other similar exams both now and in the future. Three groups benefit from this research. Test-takers can have a fair evaluation of their performance. Test-designers can use the results of the study to improve their question design skills for other exams or revisions to the current CTM exam. The Association of Technology, Management, and Applied Engineering (ATMAE) and hiring industrial organizations can have confidence that the exam results actually measure the relevant competencies specified by the certificate.

Background for the Study

In the academic year 2014-2015, the ATMAE Certification Board released a revised version of the ATMAE Certified Technology Manager (CTM) exam. Reasons for the revision were that the previous exam was based on 10-year old ATMAE accredited program curricula and accreditation standards. The previous exam also created prior to the 2011 outcomes-based program accreditation standards. Thus, the exam was looking backwards rather than forward. The goal of the new exam was to be congruent with current industry needs and useful for outcomes-based program assessment. As the previous exam was often used as an output measure of program competency, the revised CTM exam also needed to focus on technology manager competencies, not just technical competencies.

In order to ensure the validity of the revised exam, the Certification Board drew upon previous research conducted by the ATMAE Management Division that defined technology management core competencies using a technology management model (Doggett, McGee, & Scott, 2014). The model provided a generic set of entry-level competencies for a technology manager within a category of knowledge (i.e., processes, projects, systems, and operations) for a specific managerial context such as managing people, quality, risk, and self. The ATMAE Management Division ratified the management competencies and technology management model in 2013. In addition, the source literature most frequently assigned to students in technology management courses within ATMAE accredited programs was utilized as the body of knowledge for the exam (Doggett, 2015). This literature and a sampling of the exam questions is listed in the CTM Certification and Assessment Study Guide available on the ATMAE website (www.atmae.org). In summary, the objectives of the revised exam were to (a) emphasize technical managerial professional skills, (b) align with the technology management body of knowledge, (c) be competency-based, and (d), be able to be incorporated into outcomes assessment, accreditation, and individual evaluation.

The Revised Exam Architecture

Before describing the revised exam, a brief description of the previous exam is relevant. The previous exam consisted of 160 questions in nine major topic categories with 42 sub-categories. It contained a heavy focus of quality and safety within a manufacturing context. The perspective of the exam was that of a technologist with questions not only on technology and management, but also chemistry, physics, and English. ATMAE has since expanded its influence to more than manufacturing programs and the technologist has evolved into the technology manager, particularly at the four-year level. The revised exam needed to reflect the current competencies required for the technical managerial professional across all industrial contexts.

The revised CTM exam has 160 questions in ten major topic categories with 38 sub-categories. It is based on the technology management body of knowledge with a balance of questions across the categories. Approximately 45% of the questions are new. The ten major categories are leadership (10 questions), self-management (18 questions), systems (18 questions), processes (19 questions), operations (19 questions), people (19 questions), projects (19 questions), quality (19 questions), risk (7 questions) and safety (12 questions). Of the topic categories, 100% of the questions from the old exam were retained for quality, risk, and safety. For the other topic categories, the following percentages of questions were retained from the old exam: people 68%, processes 52%, operations 50%, systems 50%, and leadership 30%. Alternatively, the project management and self-management questions were primarily new consisting of 85% and 100%, respectively. Ten questions were revised to correct for mechanical errors or gender bias.

First Year Findings

The 2014-2015 academic year was the first implementation year for the revised exam and it was taken by 436 examinees. Of the 436 who completed the exam, 267 (61%) passed with the minimum cut-off score of 95 or higher. The average score was 96.3 with a standard deviation of 26.6. Three of the examinees did not answer any questions. Each question on the exam is worth one point and the range of scores was 138. The average percentage of the 160 questions answered correctly ranged from 12 to 90 percent. For example, 21 questions on the exam were answered correctly 80-90% of the time. These 21 questions represented 13% of the entire exam questions. Table 1 shows the number and percentage of questions scored correctly.

Table (1) Number of Questions Correctly Answered by Stratified Percentage

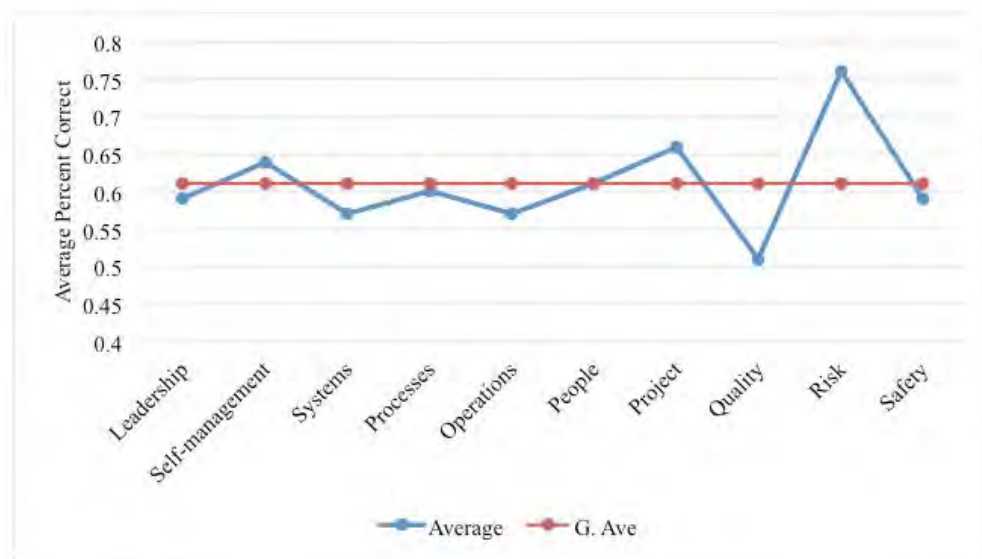
Average Percent of Correct Responses	Number of Questions	Percent of Total Questions
12%-19%	4	2%
12%-29%	6	4%
30%-39%	9	6%
40%-49%	19	12%
50%-59%	32	20%
60%-69%	37	23%
70%-79%	32	20%
80%-90%	21	13%

The grand average across all exam categories was 60% with an average standard deviation of 16%. The average range was 56%. The average chart for each question is shown in the Appendix. Table 2 shows the overall average, standard deviation, and range for each topic category. The average percent correct by topic category is shown in Figure 1. The lowest scoring category was quality (51%) and the highest scoring category was risk (76%), which also had the lowest variation (11%). The most variation was in the category of safety (21%).

Table (2) Average, Standard Deviation, and Range for Each Topic Category

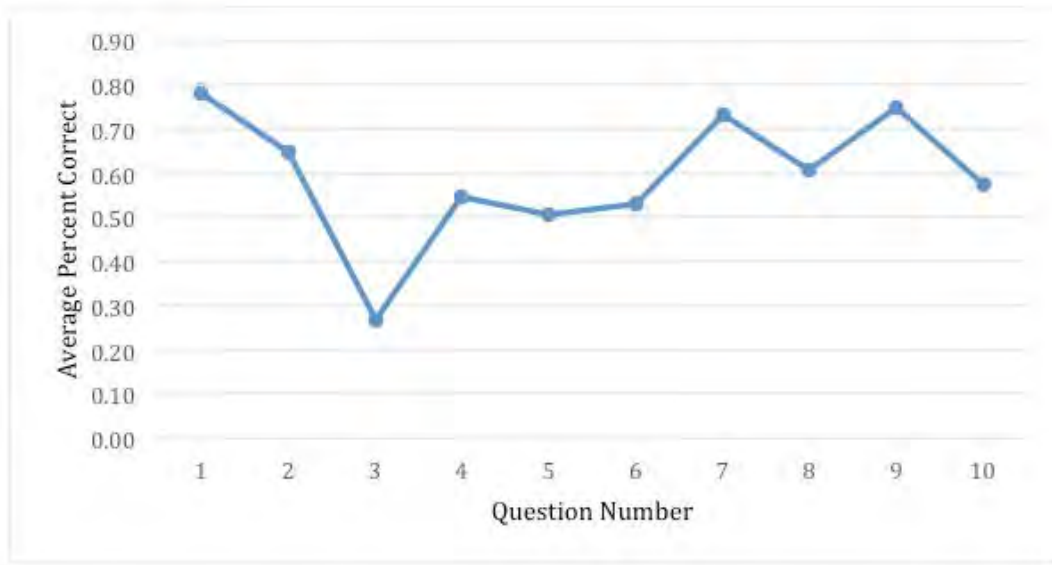
	Lead.	Self-Mgmt.	Sys.	Proc.	Ops	People	Proj.	Qual.	Risk	Safety
Avg.	0.59	0.64	0.57	0.6	0.57	0.61	0.66	0.51	0.76	0.59
SD	0.15	0.16	0.15	0.15	0.16	0.15	0.19	0.18	0.11	0.21
Range	0.51	0.52	0.58	0.57	0.62	0.53	0.78	0.61	0.28	0.61

Figure (1) Average Percent Correct by Topic Category



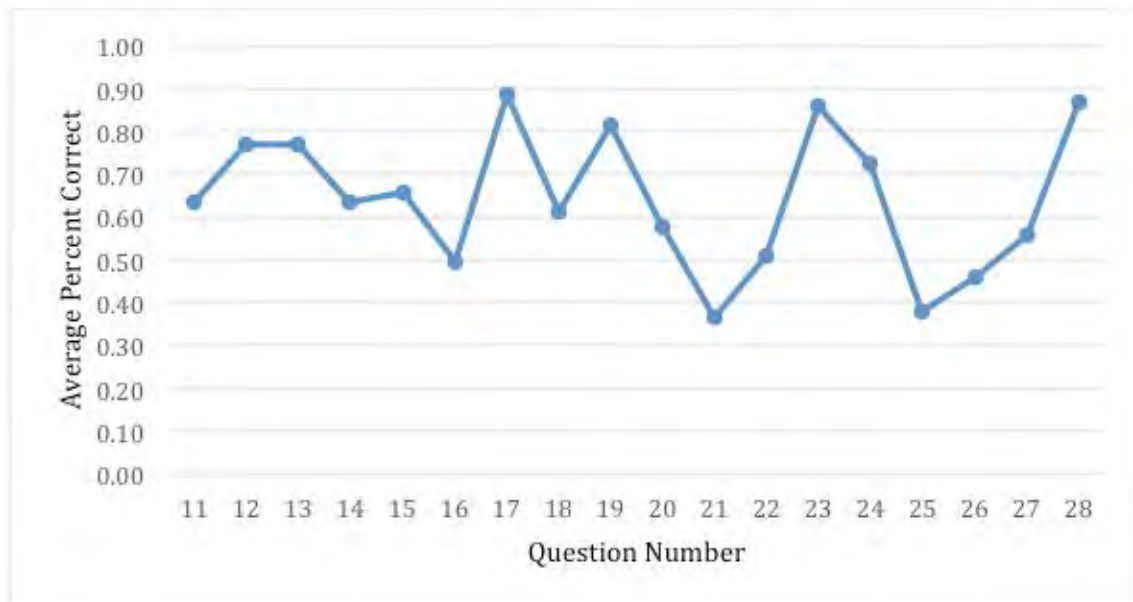
The following paragraphs discuss the exam results by topic category. Each topic category was broken down by question and the average percent correct plotted. The questions in each category were also analyzed for correlation to each other. Some of the questions within the categories appeared to be correlated. A notable category for correlation was projects, which will be discussed later. In the leadership category, question 1 had the highest correct response (78%) with question 3 having the lowest correct response (27%). None of the questions were correlated. See Figure 2.

Figure (2) Leadership: Average Percent Correct Responses by Question



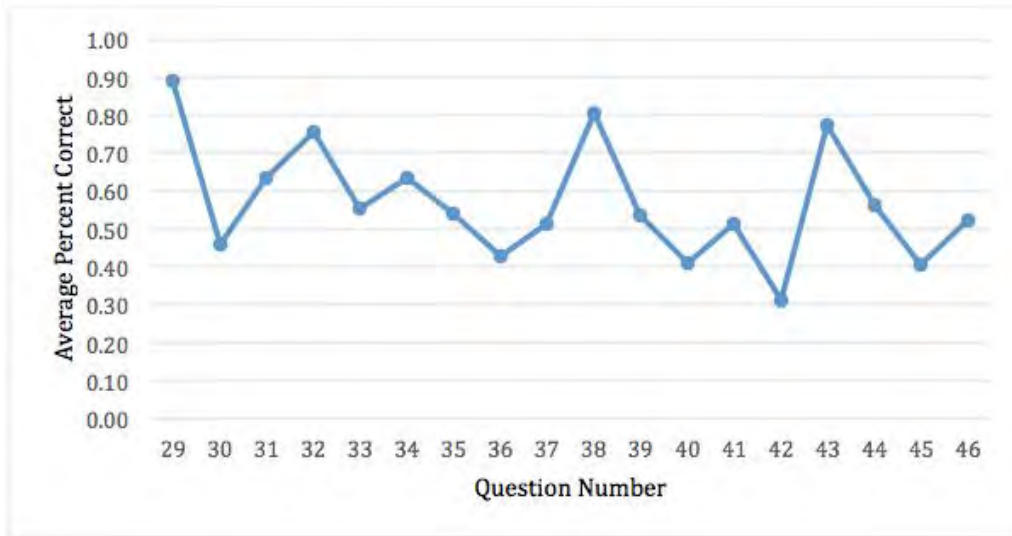
For the self-management category, question 17 had the highest correct response (89%) with question 21 having the lowest correct response (36%). See Figure 3. Question 17 may also have a relationship to question 23 with a correlation coefficient of .43.

Figure (3) Self-Management: Average Percent Correct Responses by Question



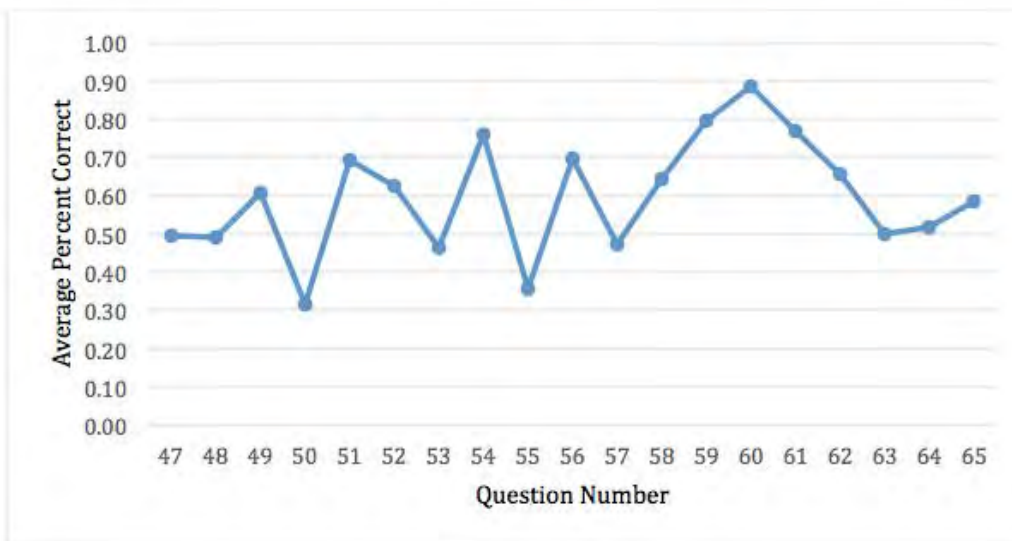
In the systems category, question 29 had the highest correct response (89%) and the lowest correct response was on question 42 (31%). Refer to Figure 4.

Figure (4) Systems Management: Average Percent Correct Responses by Question



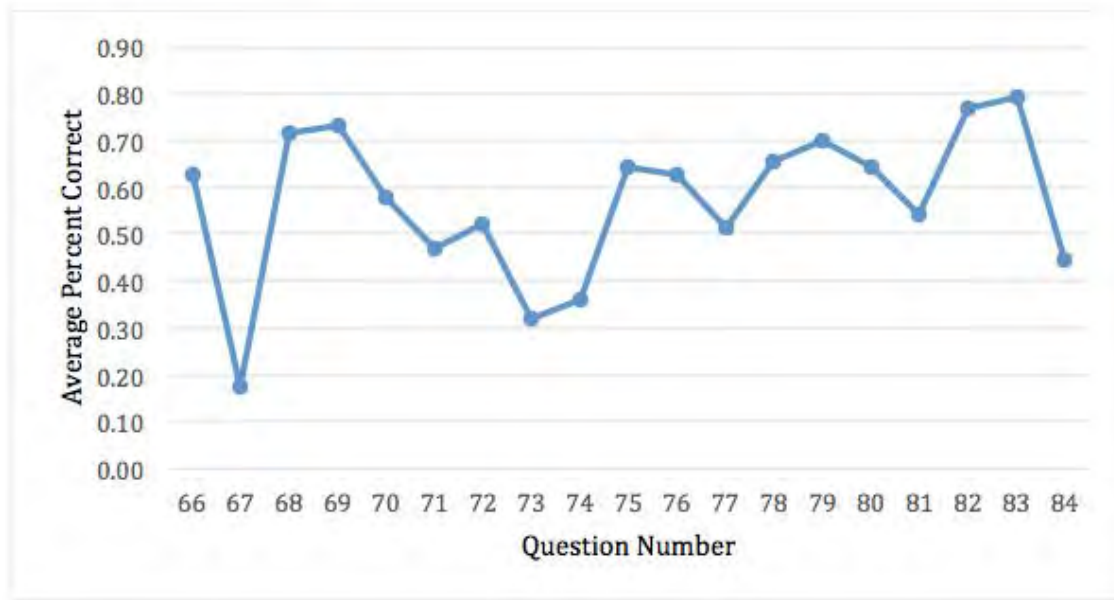
For the process category, question 60 had the highest correct response (89%) and the lowest correct response was for question 50 (31%). Refer to Figure 5.

Figure (5) Process Management: Average Percent Correct Responses by Question



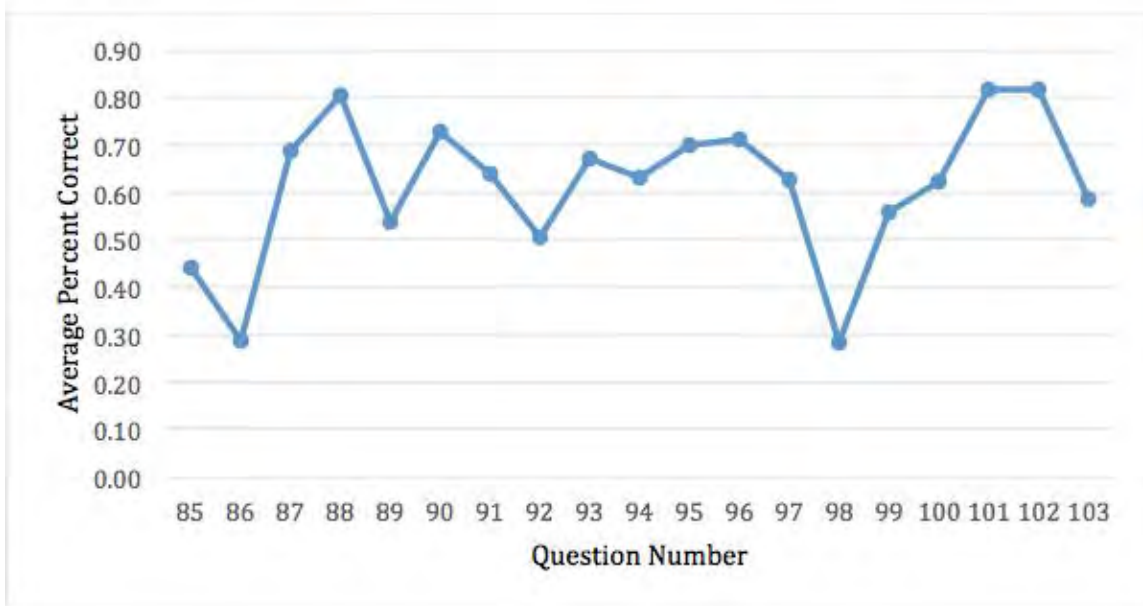
In the operations category, question 83 had the highest correct response (79%) and the lowest correct response was for question 67 (17%). Refer to Figure 6.

Figure (6) Operations Management: Average Percent Correct Responses by Question



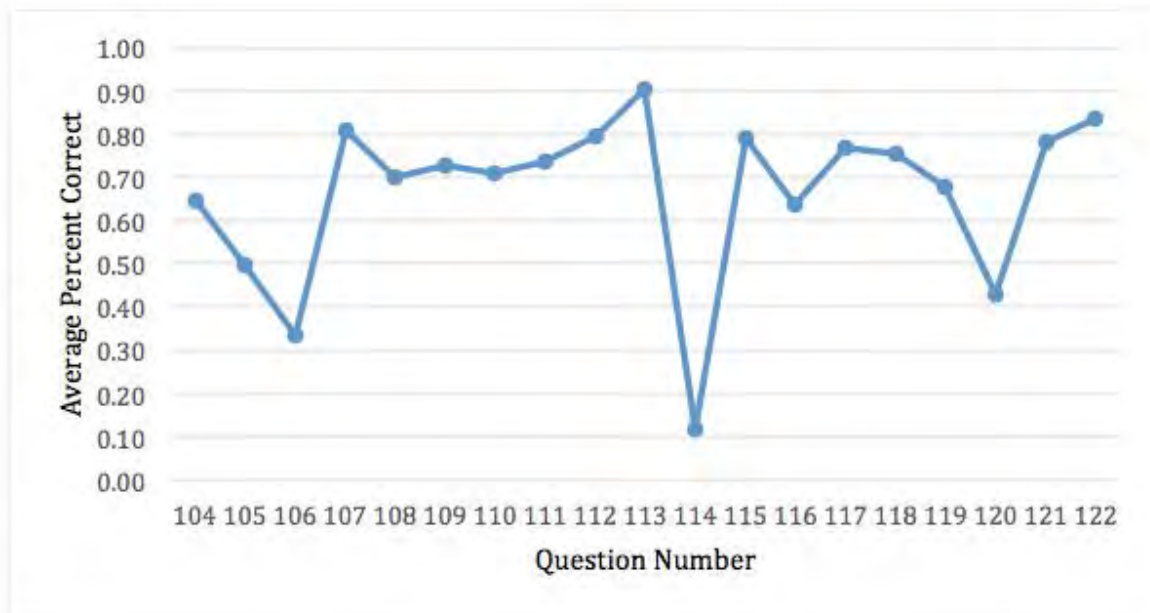
In the category of people, both questions 101 and 102 had the highest correct responses (82%) followed closely by question 88 (81%). The lowest scoring questions were numbers 98 and 86, which had correct responses of 28% and 29%, respectively. Refer to Figure 7. Questions 88, 101, and 102 may also be related, as they appear to have larger correlation coefficients (.52, .42, and .40) than other questions.

Figure (7) People Management: Average Percent Correct Responses by Question



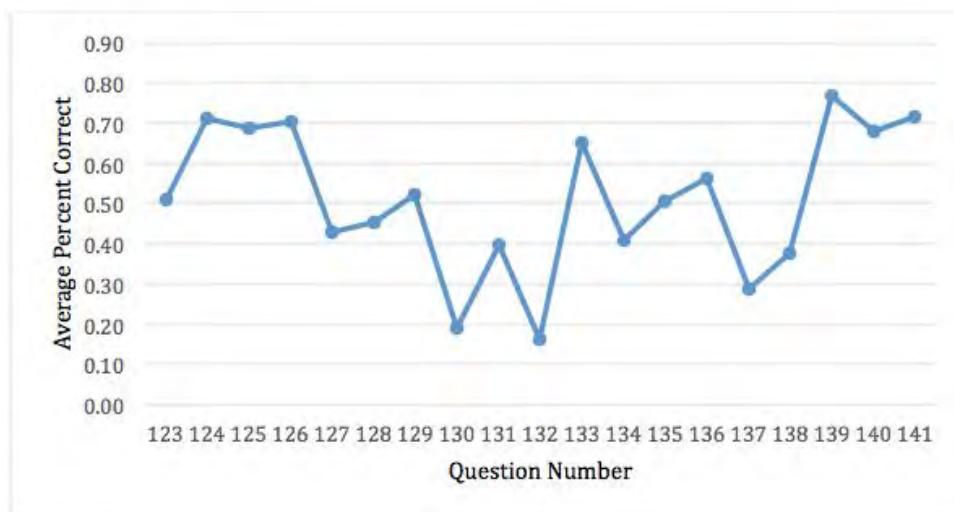
In the project category, question 113 had the highest correct responses (90%). The lowest scoring question was number 114, which had correct response of 12%. These two questions, coincidentally presented back-to-back on the exam, represented the highest and lowest overall average scores for the entire exam. See Figure 8. In addition, questions 108, 109, and 110 appear to be closely related, as their correlations were .64, .66 and .66. No other set of questions within a single category had this much correlation. This presents an opportunity for critical evaluation as these questions are likely measuring the same competency.

Figure (8) Project Management: Average Percent Correct Responses by Question



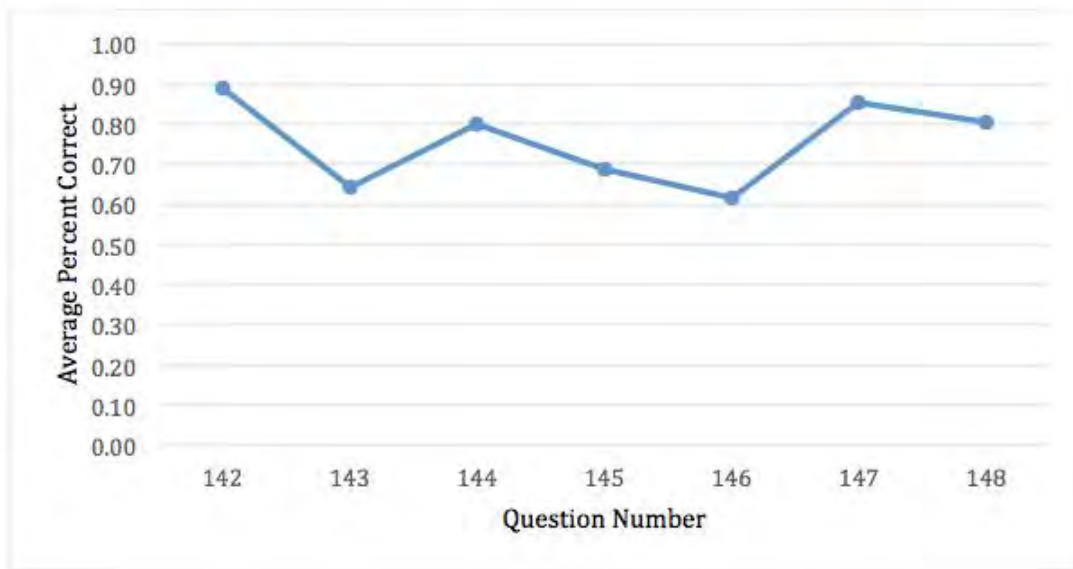
In the quality category, examinees answered question 139 correct 77% of the time. The lowest scoring question in this category was number 132, being answered correctly only 16% of the time, which was the second lowest of the entire exam. As previously indicated, this category had the lowest overall average. See Figure 9.

Figure (9) Quality Management: Average Percent Correct Responses by Question



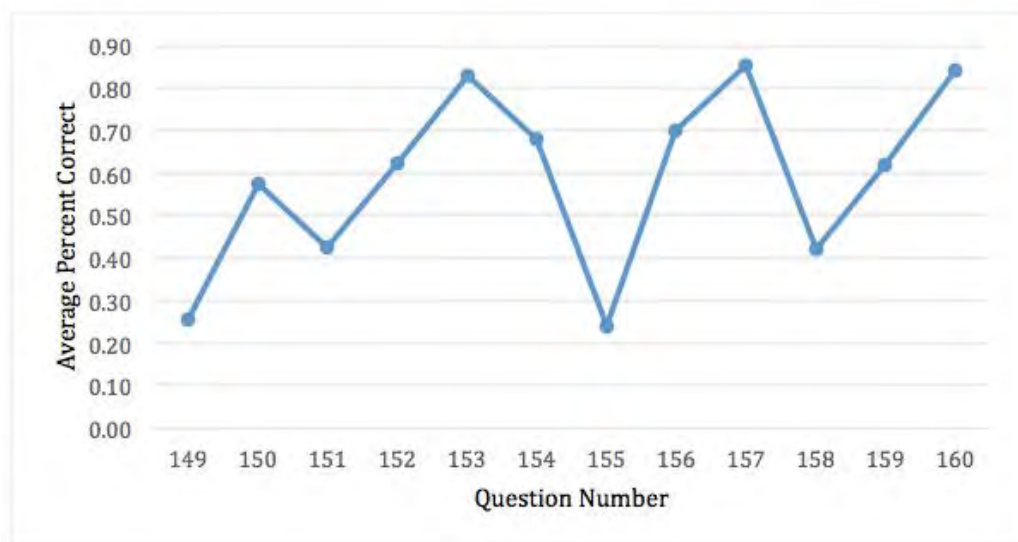
In the category of risk, which consisted of only seven questions, number 142 had the highest percent of correct responses (89%) with number 146 scoring lowest. As mentioned earlier, this category had the highest overall average with the lowest standard deviation of any category topic. See Figure 10. Question 142 may be related to question 147 with a coefficient of .49.

Figure (10) Risk Management: Average Percent Correct Responses by Question



The final category of safety had question 157 as the highest scoring (86%) with two questions (155 and 149) scoring 24% and 25%, respectively. Stating once again, this category had the highest standard deviation of all the topics. Refer to Figure 11. Questions 153, 157, and 160 may be related with correlation coefficients in the low .40s.

Figure (11) Safety Management: Average Percent Correct Responses by Question



Discussion and Interpretation

The topic categories with the highest (risk) and lowest (quality) percent scores and the highest (safety) and lowest (risk) standard deviation were the categories in which 100% the previous exam questions were retained. Based on future exam results, these questions may need to be further revised to reflect current practice in the discipline. In addition, the categories of safety and risk appear to have related questions that may measure similar knowledge. The categories of people and self-management should also be analyzed for redundant concepts. However, the project management category appears to need the greatest amount of revision as it includes both the highest and lowest scoring questions on the exam and three questions appear to be measuring the same construct.

In terms of overall performance on the exam, ATMAE should discuss and determine if a grand average of 60% with an average standard deviation of 16% is acceptable. As the certification cut-off score is slightly below this average, the Association may want to raise or lower the threshold to build membership or conversely increase prestige. An evaluation of the second and third year results will likely assist the ATMAE Certification Board in these discussions. On a question-by-question basis, preliminary data of second year results seem to indicate a very close relationship to first year results. This would suggest the exam has high reliability. A recommendation for future study would be to administer the exam to a control group as a repeated experiment over some predetermined and meaningful time period. As more data points are collected, another study could set control limits on the averages for each question to determine if any exceed the expected normal distribution of mean and standard deviation. Obviously, a stable examination would need to be in place before this could occur.

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