Post-hoc analysis of questions asked in computer based tutorials or in audience response system enabled PowerPoint lectures: Testing while Teaching

Authors:

PK Schick, MD Burke, and JF Burke

From: Lankenau Medical Center and the Drexel University College of Medicine

Corresponding author: Paul K. Schick, MD FACP (E-mail: pksone@comcast.net)

Grant support: Main Line Health Cardiology Kitchen Fund, Sharpe-Strumia Foundation

Key words: Computer-assisted tutorials, Audience Response Systems, Medical Student Education, Medical Training Programs, Cardiology Fellowship Training Programs, Hematology Fellowship Training Programs, Cardiovascular Lectures, Hem/Onc Emergencies, Hematology Emergencies, Peripheral Smear, Blood Cell Morphology, Electrocardiograms.

Abstract:

We have carried out the analysis of questions asked in interactive computer-assisted tutorials and audience response system enabled PowerPoint lectures. This type of post-hoc analysis is not commonly carried out. However, it can sensitively assess participant knowledge that is critical for optimizing medical education. Our experience with post-hoc analysis in four studies is presented in this article: 1) A tutorial on electrocardiograms; 2) A tutorial on hematological disorders; 3) Comparison of lectures on hematological emergencies and blood cell morphology; 4) Evaluation of lectures given in an eight month long course on cardiovascular physiology and pathology. In these studies, knowledge was assessed, demographics of knowledge between residents at different stages of training and medical students were determined, and poor students were identified and remediation was recommended. Although these studies were very different, they strongly demonstrated the educational value of post-hoc analysis of questions asked in tutorials and lectures. How this information can be used to improve medical education and training programs is demonstrated in this article.

Formal testing and stand-alone exams can provide the same type of information. The downside of stand-alone exams is that it is difficult to use them frequently. The reasons are the time needed to prepare and administer the tests and the intimidation of students and trainees by continuous testing. The inability to test students and trainees frequently hinders the identification of poor students and delays the implementation of improvements in medical education. Post-hoc analysis is a reasonable alternative to formal testing. Computer-assisted or on-line tutorials and audience response system enabled PowerPoint lectures can be created to contain an ample number of questions. There is no need to write additional questions. Answers are easily stored and available for analysis. Post-hoc analysis of knowledge can be carried out as often as needed. Since questions asked in these tutorials and lectures introduce topics considered to be important, the questions usually comprehensively cover core and essential subjects.

1. Background:

Formal testing for knowledge using stand-alone test has been carried out in most academic institutions, medical schools and medical training programs. The information is used for grading and determination of competency. The downsides of stand-alone exams are that it is difficult to use them frequently due to the time needed to prepare and administer the tests as well as the intimidation of students and trainees by continuous testing. The limitation of the ability to test knowledge frequently can hinder the identification of poor students and delay addressing weaknesses detected by post-hoc analysis.

Post-hoc analysis is a reasonable alternative to standard formal testing. Advances in education include interactive computer-assisted or on-line tutorials and audience response system enabled PowerPoint lectures. In both of these educational innovations, questions are asked to challenge participant knowledge. Asking stimulating and comprehensive questions during lectures and tutorials promotes interactivity (1-7). Interactive computer-assisted or on-line tutorials and audience response system enabled PowerPoint lectures are widely used. However, it is not appreciated that the answers to questions asked in these tutorials and lectures can be stored and subjected to post-hoc analysis to define participant knowledge. As opposed to limitations in how often standard formal exams can be given, post-hoc analysis of knowledge can be carried out as often as needed. In addition, post-hoc analysis is more sensitive to participant knowledge than traditional examinations (6).

The purpose of this review is to present and discuss 4 studies that demonstrate the value of post-hoc analysis in optimizing medical education (1-5).

2. Methods:

In two of the studies presented in this review we used Microsoft Visual Basic 6 software to develop computer-assisted tutorials in which every topic was introduced with question about the topic. The tutorial was available on the Lankenau Medical Center computers. Participant responses to questions were stored in files that could be easily accessed and, transferred to Microsoft Excel worksheets for data analysis.

In the other two studies in this review, we used audience response system enabled PowerPoint lectures using Turning Point technology, 2008 version (Turning Point Technologies, LLC, New Braunfels, Texas). Every topic was introduced with questions about the topic. Participant responses to questions were stored and could be analyzed using Turning Point software. For analysis that could not be carried out by the Turning Point software, the data was transferred to Microsoft Excel for further analysis.

Statistical analyses were done when appropriate.

3. Results of post-hoc analysis of four studies:

Each of the following four studies describes the use and value of post-hoc analysis of computer assisted tutorials or Audience response system enabled PowerPoint lectures. Since the format and settings of each of these studies were

different, we decided to present the four studies separately in the Results section.

A) Critical analysis of a computer-assisted tutorial on ECG interpretation and its ability to determine competency. **(1)**

We used Microsoft Visual Basic 6 software to develop a computer-based tutorial to train to diagnose abnormal electrocardiograms (ECG). Forty residents, 6 cardiology fellows, and 4 experienced physicians participated. The tutorial was available on the Lankenau Medical Center computers. The tutorial emphasized recognition and understanding of normal and abnormal ECG features. Active learning and interactivity was promoted by asking questions prior to the discussion of ECGs and immediately providing anonymous feedback for the rationale for correct answers.

We had not planned to perform a post-hoc analysis. However, it became clear that the answers to questions could be stored in participant files and would be available for analysis. Hence, we carried out post-hoc analysis of the quality of the questions, and assessed baseline knowledge in trainees at different levels of training. We then decided to develop a computer-assisted posttest to assess improvement and to determine competency. The questions were found to be challenging, fair, appropriate and discriminative. This was important since the quality of questions is critical for the success of interactive programs. The analysis revealed strengths and weaknesses in the baseline knowledge of trainees at different levels of training. These demographic differences were used to adapt our training program to the needs of residents. We developed a posttest using Visual Basic 6 software. The posttest revealed that the tutorial contributed to marked improvement in feature recognition. Grades helped distinguish between residents with outstanding grades and those who needed remediation. The strategy for critical evaluation of answers to questions could be applied to any computer-based educational program, regardless of topic.

Participant feedback was very positive. A stand-alone test could have provided similar information about baseline knowledge. However, testing while teaching and post-analysis was more efficient and less threatening than standard stand-alone testing.

B) Strategy for Enabling Computer-Based Tutorials to Document Baseline Knowledge in Hematological Subjects That Can Improve Curriculum and Training Programs (2).

A computer-based tutorial was developed using Microsoft Visual Basic 6 software to simulate clinical management of hematological disorders. All topics were introduced by thought-provoking questions that covered essential or core knowledge necessary for diagnosing and managing hematological disorders. Six hematology fellow and seven medical residents used the tutorial. The following were emphasized in the tutorial: 1) Pathophysiology; 2) Choice of diagnostic tests; and 3) the management of disorders. In the sections on choosing diagnostic tests, 11 brief case histories were presented and participants had to choose appropriate tests from a list of 18 diagnostic tests that resembled laboratory order forms. In the section on management, there were 12 case histories and participants had to choose appropriate therapies from a list of 20

therapies. This format promoted decision making and simulated an office and hospital environment and was more challenging than answering multiple-choice questions.

Figure 1a and 1b: Fellows did adequately in pathophysiology (74.6%) and in diagnosis (85.3%) while residents had lower grades, 55% and 64.9 %, respectively. Surprisingly, both fellows and residents did poorly on choosing diagnostic tests, 52.8% and 36.1%, respectively. Likewise, both fellows and residents did poorly in the management of hematological disorders, 54.6% and 37.6%, respectively. Statistical analysis: Standard deviations were determined. P-values were determined by Student-T tests.

Interpretation: The data indicates that our training program must concentrate on the choice of appropriate laboratory tests to diagnose hematological disorders. Also, we have to emphasize the management of common hematological disorders.

A posttest was developed using Visual Basic 6 software to determine the educational value of the tutorial. The results are shown in Table 1a and 1b. The most striking data in the posttest was that both fellows and residents markedly improved in choosing diagnostic tests. Fellows and to a lesser extent residents improved in the management of hematological disorders. Although the posttest presented some of the same clinical scenarios used in the tutorial, we believe that the evidence for improvement was valid. More important is that the data indicates that ongoing emphasis on the choice of diagnostic tests and appropriate management can yield improvement and should be a major goal of our training program.

Choosing appropriate tests from a simulated laboratory order sheet and presenting clinical scenarios represented a clinical environment and tested decision making as well as knowledge.

Limitation of this study: The sample size was small and limited to 2 medical centers. The study was not carried out over several years. Hence, the information from the study was limited to the participants and our institution and could not predict the demographics of knowledge in other medical centers. Nevertheless, it was a pilot study that demonstrated the potential value of post-hoc analysis.

Table Ia: Fellow Subsections (n=6)			
	Baseline	Post-test	P-values
Pathophysiogy	74.6 +/- 9.7	76.8 +/- 10.2	Not significant
Coagulation tests	52.8 +/- 10.8	83.5 +/- 12.6	0.011
Diagnosis	85.3 +/- 15.1	Not tested	N/A
Therapy	54.6 +/- 11.4	77.1 +/- 14.6	0.012

Table Ib: Residents Subsections (n=7)			
	Baseline	Post-test	P-values
Pathophysiogy	55.0 +/- 16.9	66.4 +/- 11.4	Not significant
Coagulation tests	36.1 +/- 14.5	71.4 +/- 14.5	0.0005
Diagnosis	64.9 +/- 14.4	Not tested	N/A
Therapy	37.6 +/- 14.3	64.3 +/- 18.3	0.01

C) Schick, PK and M. Burke. Post-hoc analysis of audience responses-enabled PowerPoint slides used in conferences on Hematological Subjects. (3)

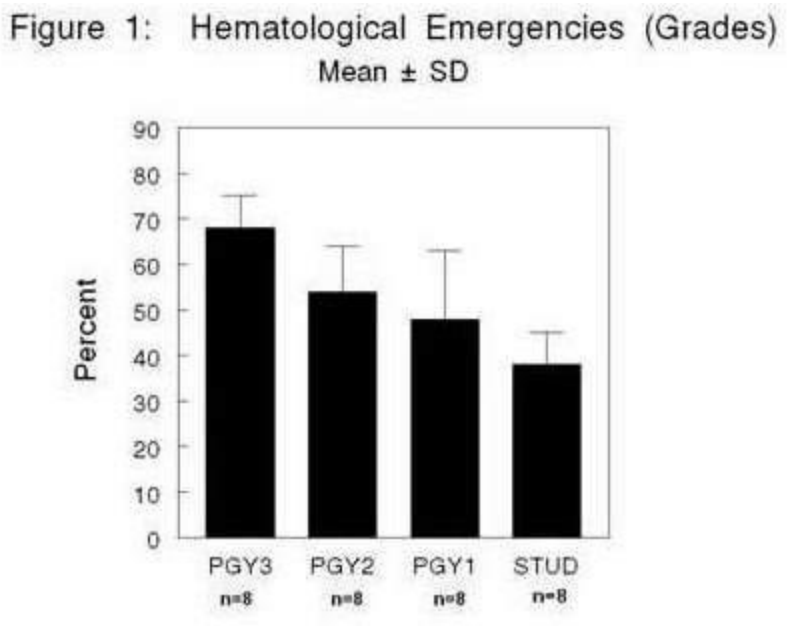
Two audience response systems enabled PowerPoint lectures using Turning Point technologies, 2008 version, were given to medical residents and medical students at the Drexel University College of Medicine. Questions were displayed in PowerPoint slides introduced prior to the discussion of each topic. Participants chose answers using clickers. Graphs of answers were shown immediately to provide feedback and correct answers. This promoted interactivity. Responses were anonymous and students were not intimidated, the Turning Point program stored all answers and provided software for the post-hoc analysis of the answers.

The first lecture was on the hematologic emergencies. There were a total of 36 participants, 8 third year residents, 8 second year residents, 8 first year residents, and 8 medical students.

Demographic analysis of the first lecture on Hem/Onc emergencies are shown in Figure 1. The data revealed that there were significant differences in grades between residents at different levels of training and medical students. Except for the difference in grades between the grades of PGY1 and PGY2, the other differences were significant. The data was statistically evaluated by an ANOVA and Scheffe analysis.

The second lecture was on blood cell morphology was given a few weeks after the first lecture. There were 24 participants, 18 residents and 6 medical students. Most of the residents and medical students had attended both conferences, but there were minor differences in the audience due to clinical rotations and the inability to attend the lecture due to involvement in clinical care. However, the demographics of participants at different levels of training were similar in both lectures.

Results of the analysis of the comparison of resident and medical student knowledge in both lectures are shown in Table II. The data revealed that in contrast to differences in resident and fellow knowledge about Hem/Onc emergencies, there were no differences in between resident and medical student knowledge about blood cell morphology. The data was statistically evaluated by a Student-T test.



Legend to Figure 1: Demographics in baseline knowledge in the lecture on Hematologic Emergencies. PGY1, PGY2, PGY = 1ST, 2nd and 3rd year residents. STUD = Medical students. ANOVA and Scheffe analysis were performed. (n=36)

Table II: Comparison of resident and medical student grades (p-values by a Student-T test)			
	Resident grades	Medical student grades	p-values
Hem/Onc emergencies	52.3 +/-14.7 (n=24)	38.8 +/- 7.4 (n=8)	<0.02
Blood cell morphology	44.9 +/-15.9 (n=18)	44.9 +/-13.7 (n=6)	Not significant

Interpretation:

The ability to manage hematology emergencies increases with the length of training. However, the ability to interpret normal and abnormal peripheral blood smears did not differ between medical students and residents at all levels of training. Hence, the ability to interpret peripheral smears was established in medical school and did not improve with residency grading. This information revealed a deficiency in our medical teaching. Residents rely on the laboratory to interpret peripheral smears and usually do not look at peripheral smears. Hence, their skills do not improve. This is a weakness in our and most likely most training programs that should be addressed by having residents rotate through clinical laboratories. In contrast, residents are constantly involved in managing medical emergencies. Therefore they improve their skills in handling hematologic emergencies. This information has helped us modify our training program to emphasize the interpretation of normal and abnormal blood cells in peripheral smears.

The analysis of questions in the two lectures also identified demographic differences in strengths and weaknesses in knowledge:

- Hematologic emergencies: Weakness was evident in several topics. For

example, the grades in 3 of these questions in Hematologic Emergencies were due to lack of experience in managing Sickle Cell Anemia and Hemophilia. Low grades in the other two questions were surprising since residents had managed low platelet counts and nutritional anemia during their training program.

- Blood Cell Morphology: The analysis of two questions revealed that participants did not understand the differential diagnosis of large blood cells and did not know that sickle cells are usually not seen in the peripheral smear in sickle cell trait;

- Differences in knowledge between medical students and residents: We also identified three questions in the lecture on Blood Cell Morphology and three questions in the lecture on Hematology/Oncology Emergencies in which resident and medical student performances were markedly different. For example, in the lecture on Hem/Onc emergencies, medical student grades were considerably lower than resident grades in the following: indications for transfusions, 0% and 75%, respectively, and the management of fever in patients with cancer with low white blood counts, 13% and 75%, respectively. In contrast, medical students were more skillful than residents in interpreting abnormal blood morphology and laboratory results.

Conclusion:

As mentioned above, the composition of the participants in the two lectures were similar, and therefore, the results could be compared. Post-hoc analysis was sufficiently sensitive to show differences in knowledge between residents at different levels of training and medical students. The identification of specific strengths and weaknesses has enabled us to emphasize these subjects to improve our training program. Knowing differences in resident and medical student knowledge has helped us target training for students and residents.

More detailed analysis of strengths and weaknesses revealed poor knowledge in sickle cell anemia and hemophilia because our training program does not have access to centers that treat these disorders. There were marked differences between residents and medical students the management of patients due to lack of exposure. Many of the differences in knowledge between medical residents and medical students may be unique to our institution. Post-hoc analysis is helpful and should be done when possible in all training programs to reveal strengths and weaknesses so that they can be addressed.

D) We published two articles (4,5) on the value of post-hoc analysis of audience response system enabled PowerPoint lectures in an eight month long course on cardiovascular physiology and pathology.

We used audience response technology in our eight month long course on cardiovascular physiology and pathology to train cardiology fellows. A total of 36 subjects were discussed. Each subject was covered in two lectures, an introductory lecture and a review lecture that was given one week later. An in-training examination was administered 2 to 6 weeks after the review lecture. Twelve cardiology fellows attended these lectures.

Audience response enabled PowerPoint slides were only used in the review lecture. This was a pivotal time point in the lecture series. The questions in the review lecture assessed the comprehension of the introductory lecture as well as general knowledge of the topic. Immediate feedback was given to the participants.

The questions in the review lectures were asked using audience response technology. There were a total of 18 review lectures and 1293 questions were asked. The answers were subjected to post-hoc analysis.

Post-hoc analysis of answers to questions in the review lectures revealed outstanding and poor knowledge in lectures shown in Table III. Outstanding lectures were identified if the grades were above the mean grade plus one standard deviation. Poor grades were identified if the grade was below the mean minus one standard deviation.

There could be several reasons for poor grades in the review lecture: 1) Poor general knowledge of the subject; 2) Inadequate introductory lecture; 3) lack of exposure to the subject in the training program. We modified our training program to place more emphasis on topics that were poorly understood. Relevant to our training program is that most of the poor lectures were on congenital heart disorders that are not seen in our medical center, and rotation at medical centers that manage congenital heart disease would increase knowledge of these disorders.

Post-hoc analysis also revealed that two of the twelve fellows had significantly lower grades. They were informed that their grades were inadequate; one fellow dramatically improved by self-study and the other required faculty intervention. The questions were also evaluated. Eleven questions were found to be ambiguous or unfair and were not graded.

Table III. Lectures in which trainees received outstanding and poor grades

Outstanding lectures (mean grade + SD) (81% or more)	**Poor grades (mean grade minus SD) 65% or less**
Cardiovascular physiology (84%)	Physical Exam (65%)
Revascularization (82%)	Atrial septal defect (58%)
Mitral stenosis (83%)	Ventricular septal defect (65%)
Pericarditis (81%)	Congenital disorders I (56%)
Tetralogy of Fallot (84%)	Congenital disorders II (52%)

Feedback for three of the studies:

Table IV: Participant Feedback 1 to 5 (1 is best)

Hematological disorders	1.53
Hem/Onc emergencies	1.45
Blood cell morphology	1.58
Cardiovascular course (Audience response technology)	1.58

We were very pleased with the feedback from fellows. Our tutorials and audience response enabled PowerPoint enabled lectures were well received. Any grade that approaches 1.5 (1 is the best out of 5) indicates that fellows were very satisfied. Also, they were not intimidated by having to answer questions during lectures or when using a computer-based or web-based tutorials. In the course on cardiology essentials, fellows were asked "were you comfortable with our monitoring your knowledge". Mean response was 1.6.

4. Discussion:

Our experience in the four studies article indicate that post-hoc analysis of questions asked is valuable and post-hoc analysis is a reasonable alternative to standard and end-of-term examinations. Especially, since post-hoc analysis can be carried out as often as needed. Since questions asked in these tutorials and lectures introduce topics considered to be important, these questions usually comprehensively cover core and essential subjects. Anything can be evaluated: strengths and weaknesses in knowledge, demographic differences of knowledge, competency, identifying participants who need self-study or remediation. Individual lectures or courses can be evaluated. The strategy of post-hoc analysis can be tailored to assess unique aspects of lectures and training programs and the composition and nature of the audience.

The limitations of our studies presented above were: 1) They were not done at other medical centers; 2) They were not repeated over several years. One of the studies, the management of hematological disorders (2) only had 7 participants. However, much of the data were statistically significant. Information generated by our post-hoc analysis was limited to the training programs that was assessed and not necessarily to training programs in other institutions. The information was also limited to the years the programs were assessed.

Participant feedback indicated that testing during tutorials and lectures was not threatening.

Post-hoc analysis of questions asked in our tutorials and audience response enabled lectures was more efficient than stand-alone exams. Also, post-hoc analysis can be carried out as frequently as needed as opposed to standard stand-alone exams that cannot be given too often. Since questions asked in these tutorials and lectures introduce topics considered to be important, the questions usually comprehensively cover core and essential subjects.

A previous study supported our conclusion since it also found that the analysis of questions asked by audience response systems yielded a better assessment of knowledge than end-of-term examinations (6).

We found it easier to carry out post-hoc analysis in audience response enabled PowerPoint lectures than in computer based or on line tutorial. The reason is that in tutorials, one has to develop a computer assisted tutorial, establish a database, and then create a worksheet to assess the data in the database. In contrast, software provided by Turning Point technologists can be used to carry out post-hoc analysis of answers to questions and one does not have to establish a database.

References:

1) J. F. Burke, E. Gnall, Z. Umrudden, M. Kyaw & PK Schick Critical analysis of a computer-assisted tutorial on ECG interpretation and its ability to determine competency. Medical Teacher, Volume 30: e41-e48 (2008)

2) Schick PK and M. Burke. Strategy for Enabling Computer-Based Tutorials to Document Baseline Knowledge in Hematological Subjects That Can Improve Curriculum and Training Programs. The Internet Journal of Hematology. Volume 7 Number 1. (2009)

3) Schick, PK and M. Burke. Post-hoc analysis of audience responses-enabled PowerPoint slides used in conferences on Hematological Subjects. Internet Journal of Hematology, Volume 6, Number 2. (2008)

4) P Schick, S Abramson, E Gnall, S Fine, J Burke. The Value Of The Post-Hoc Analysis Of Responses To Questions Asked By Audience Response Technology. The Internet Journal of Medical Education. Volume 2, Number 2 (2012).

5) Paul Schick, Sandra Abramson & James Burk. Audience response technology: under-appreciated value of post hoc analysis. Medical Education 45: 1157–1158. (2011)

6) StraubBode S C, Giesler M, Biller S, Forster J, Krüger M. Audience-response systems for evaluation of pediatric lectures--comparison with a classic end-of-term online-based evaluation. GMS Z Med Ausbild. 32(2) (2015).

7) Fernández-Alemán JL, López-González L, González-Sequeros O, Jayne C, López-Jiménez JJ, Carrillo-de-Gea JM, Toval A .An Empirical Study of Neural Network-Based Audience Response Technology in a Human Anatomy Course for Pharmacy students. J Med Syst. 40(4):85. (2016)

