# FIVE TIPS TO IMPROVE YOUR TEACHING OF MEDICAL PHYSICS

George Starkschall, PhD, FAAPM, FACR

.

***Keywords*** *– Medical Physics, Education*

Teaching is a significant component of the responsibilities of many medical physicists, but few medical physicists have received any training in how to teach. While requiring medical physicists to receive a degree in education is not practical, some training on how to teach can be very useful. The purpose of this paper is to identify some ways in which medical physicists can improve their teaching.

Because this is a paper on the topic of education, I would like to start it with a brief quiz:

- **Question 1**: How are your present medical physics practice methodologies different from those you used five years ago?

Question 1 should be relatively easy to answer, given the many changes that have occurred in medical physics over the past five years, including new treatment and imaging modalities, as well as new types of equipment.
Here is Question 2. Question 2 might be a bit more difficult to answer.

- **Question 2**: How are your present teaching methodologies different from those you used five years ago?

In order to respond to Question 2, some medical physicists may update their lecture notes from year to year, but for many, the course content does not change, nor do the lecture notes. After all, not much has changed in the Compton Effect as it relates to medical physics since the derivation of the Klein-Nishina formula in 1928 [1]. I recall when I was a graduate student, one of my physics professors, a distinguished Nobel laureate, lectured from the same worn notebook he had used for at least twenty-five years, if not more. Needless to say, his lectures were not very stimulating.

**And what happens during these lectures?**

The professor writes their notes on the blackboard (or displays them as PowerPoint slides) and the students carefully copy the notes into their notebooks.

However, as one commentator remarked: "In the digital world, there is no longer any reason to use class time to transfer the notes of the instructor to the notes of the student (without passing through the brain of either)." [2].

In order to enable the medical physicist to answer the second question in a positive manner, I would like to suggest several ways in which the medical physicist teacher (or any other teacher) might modify their teaching methodologies to improve the quality of their teaching. So, here goes:

**1. Do not be afraid to use novel teaching methodologies in your classroom.**

Novel teaching methodologies such as flipped learning and problem-based learning move away from the traditional lecture format to more interactive means of teaching. In applying flipped learning, for example, one records the lecture in which information is provided to the student. The student listens to the lecture prior to coming to class, and the classroom time is used to work out problems, answer questions, and provide insight into the material presented in the lecture. In my own experience with flipped learning, I was able to ensure that the students listened to the lecture by giving them a short, online quiz on the lecture material prior to their classroom meeting.

In applying problem-based learning to the classroom, a problem is presented to the student, and, in order to solve the problem, the student has to learn the subject material. In that way, the student can immediately recognize the value of the information they are seeking and how that information is used to solve a problem.

**2. Test students' understanding of concepts in addition to their ability to solve problems**

All too often, a student learns new material in order to solve a problem set or demonstrate knowledge on an examination, but fails to understand the concept behind the information. Eric Mazur, a Harvard physics professor, makes the point that students come to class with a preconceived notion of how the world works, and often new material presented in class violates their preconceived notions [3]. Mazur continues that the best individual to aid the student overcome these perceptions is not the teacher, who has worked with the knowledge for many years, but the student

who has recently overcome these perceptions. Mazur thus advocates the use of fellow students to assist each other in understanding concepts presented in the classroom.

**3. Continually monitor students' understanding of material presented.**

One property of physics knowledge is that it is progressive, that is, understanding concept n+1 is based on understanding concept n. Conversely, if a physics student does not understand concept n, it is not likely they will understand concept n+1. Thus it is important for the physics teacher to verify that the student does not get lost in following the class. Continually asking students questions about the class material is one way for the instructor to verify that they are not leaving the class behind. Another method uses an audience response system (ARS) either to enable the student to answer questions posed by the instructor or to signal the instructor that the student has lost track of the subject material.

**4. Teach students how to guess input when precise input is not available**

How many physics problems given to students are of the "plug 'n' chug' variety? If the student knows (or can guess) the correct formula, all they have to do is plug the given input values into the formula, and out comes an answer. The real world is not generally that simple. The student should learn to seek input information if it is not given. If they are unable to locate the input information, they should be able to provide a good estimate as to the correct value, but be able to estimate the uncertainty of the resulting answer. The standard example of such a problem is the classic Fermi problem, "How many piano tuners are there in (name of city)?" It is quite surprising to find that many students enter a graduate medical physics program completely unable to move forward in solving such a problem.

**5. Base grading on performance expectations and not on how other students perform**

So-called "grading on the curve" is unfair to students, placing them in competition with one another. A course grade is a measure of the extent of course material the student has learned. Given a specific amount of course material learned, what justification is there to base a student's grade on the amount of course material learned by other students? Identify a set of learning objectives and evaluate the student based on the extent to which the student meets those objectives. If many of students do poorly, it means that either the expectations are too high or the instructor did not do a good job of teaching. Do not change the standards to meet the students' performance after the fact [4].

Incorporation of the tips that have been presented may take medical physics teachers out of their comfort zones, but the way we learn is by extending the boundaries of our comfort zones. In the clinic, we venture out of our comfort zone any time we implement a new technology; in an analogous manner we need to venture out of our comfort zone when we implement a new methodology in our teaching.

Most of all, we need to remember that our role as medical physics teachers is not to teach our students medical physics. Our role as medical physics teachers is to teach our students to learn medical physics.

## References

1. Klein, O; Nishina, Y (1929). "Über die Streuung von Strahlung durch freie Elektronen nach der neuen relativistischen Quantendynamik von Dirac". Z. Phys. 52 (11-12): 853 and 869. Bibcode:1929 ZPhy...52..853K. doi:10.1007/BF01366453.
2. H. Lewis, "Reinventing the Classroom," Harvard Magazine, Sept-Oct 2012
3. E Mazur, Peer Instruction, Prentice Hall, Upper Saddle River NJ (1997).
4. A Grant, "Why we should stop grading students on a curve," The New York Times, September 10, 2016.