Too much content, not enough thinking, and too little FUN!

Stephen E. DiCarlo

Department of Physiology, Wayne State University School of Medicine, Detroit, Michigan

DiCarlo SE. Too much content, not enough thinking, and too little FUN! *Adv Physiol Educ* 33: 257–264, 2009; doi:10.1152/advan.00075.2009.—Teachers often overrate the importance of their content and underrate their influence. However, students forget much of the content that they memorize. Thus, attempts to teach students all that they will need to know is futile. Rather, it is important that students develop an interest and love for lifelong learning. Inspiring and motivating students is critical because unless students are inspired and motivated our efforts are pointless. Once students are inspired and motivated, there are countless resources available to learn more about a subject. Thus, teachers must abandon the mistaken notion that unless they "cover the content" students will be unprepared for the future and they will have failed as teachers. Teachers must not worry about "losing" or "wasting" valuable lecture time for in-class discussion, collaborative problem-solving, and inquiry-based activities that take time away from covering content. Rather than worrying about covering content, teachers must design activities to focus student learning on how to use scientific knowledge to solve important questions. This is important because learning is not committing a set of facts to memory but the ability to use resources to find, evaluate, and use information. In fact, memorizing anything discourages deep thinking. Deep thinking is essential because understanding is the residue of thinking! To encourage thinking we must create a joy, an excitement, and a love for learning. We must make learning fun; because if we are successful, our students will be impatient to run home, study, and contemplate–to really learn.

teaching; education; learning; inspiration

I AM DEEPLY HONORED and pleased to present the 2009 Claude Bernard Distinguished Lecture. I would like to acknowledge Claude Bernard and all the individuals who presented before me and who have taught me so much (Fig. 1). For example, I learned from Dr. Vander "How important we are as teachers . . . since we will be interacting with several hundred students a year, nothing we will ever do in the research lab is as likely to impact so many lives" (45). Thus, the impact of our teaching will extend long beyond our lifetime because a small part of every teacher is in the students we touch (Fig. 2).

This reminds me of the teacher who passed away and, upon entering Heaven, met Saint Peter at the pearly gates. Saint Peter had the task of showing the teacher her new home. As they started their trek, they passed several beautiful homes. "Oh no" said Saint Peter, "these homes are for the firemen and policemen, the public safety personnel." Disappointed, the teacher continued her trek and came upon even more beautiful homes. "Oh no, these homes are for the healthcare providers, the nurses and doctors," said Saint Peter. Even more disappointed, the teacher continued her trek and came upon the most beautiful homes she had ever seen. These were the homes for the teachers. Of course, the teacher was delighted; however, she was concerned because she did not see anyone in the neighborhood. "Oh don't worry," said Saint Peter, "all of the teachers are down in He– at a teaching conference." Well, I am wondering what I can say to all of you angels so that this article won't seem like a teaching conference in, well, you know, He–?

Too Much Content

Let's begin with the concept that our courses have much, much, much too much content! For example, many students believe that history is much more difficult to learn today than it was when I was an undergraduate because so much more has happened since those ancient times (10). In fact, many students believe that the United States of America, yes all 50 states, consisted of 13 colonies when I was an undergraduate (10). Now consider the explosion of physiology knowledge over the decades. Physiology is much more complicated than originally thought, and continued research will undoubtedly uncover additional complexity. However, despite the knowledge explosion, many of us continue to teach the way we always have: "covering the content." In fact, if Rip Van Winkle were to awaken today, he would be amazed by all that he could see: cell phones, computers, the world wide web . . . but when he walks into a classroom, he will know exactly where he is: "Ahhh, this is a classroom," he would say, "we had these, only now the blackboards are white" (2).

This concept was documented by Silverthorn and colleagues (40) in an outstanding article published in *Advances in Physiology Education*. The authors documented how difficult it is for us to change the way we teach. Specifically, the authors documented that despite giving dedicated teachers the active learning modules and instructions on how to use them, the vast

Address for reprint requests and other correspondence: S. E. DiCarlo, Wayne State Univ. School of Medicine, 540 E. Canfield Ave., Detroit, MI 48201 (e-mail: sdicarlo@med.wayne.edu).

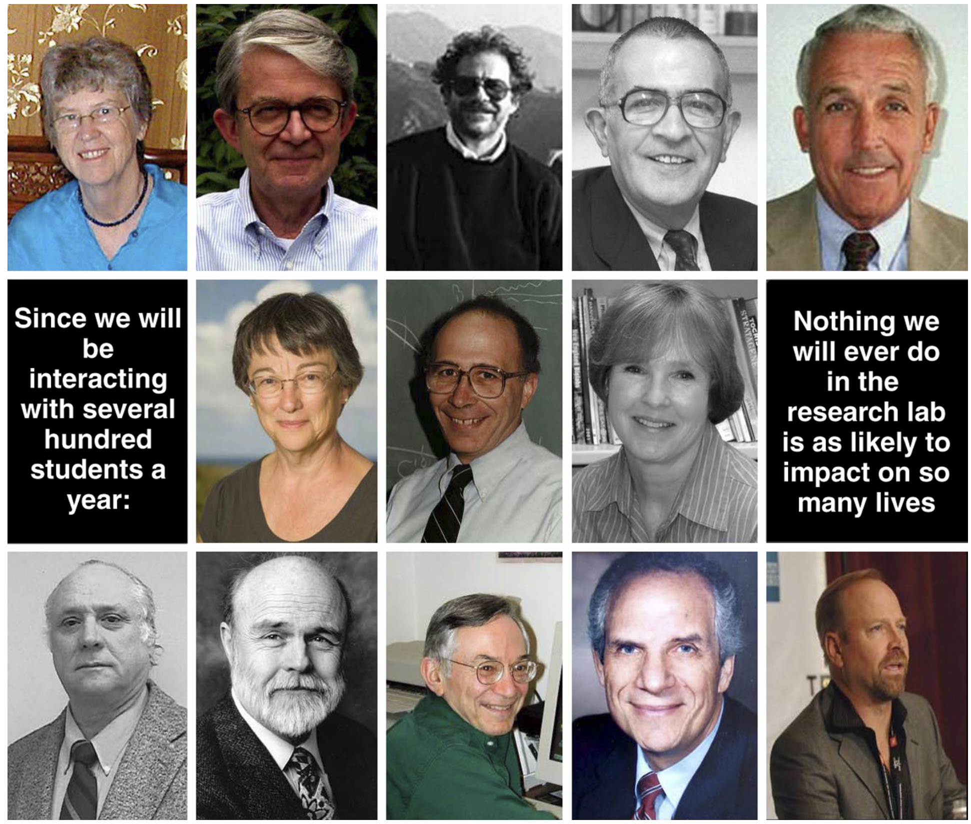

Fig. 1. The highest honor within the Teaching of Physiology section is to be selected to present the Claude Bernard Lecture during the Experimental Biology Meeting. Past awardees include the following. *Top* (from *left* to *right*): Ann J. Sefton (2005, University of Sydney), Howard Barrows (1995, Southern Illinois University), John D. Bransford (2003, Vanderbilt University), Stanley Schultz (1996, University of Texas), and Donald Frazier (1998, University of Kentucky). *Middle* (from *left* to *right*): Penelope A. Hansen (2002, Memorial University), Arthur Vander (1994, University of Michigan), and Dee Silverthorn (2006, University of Texas). *Bottom* (from *left* to *right*): Harold Modell (2004, Physiology Educational Research Consortium), Clyde F. Herreid (2000, State University of New York at Buffalo), Joel A. Michael (2001, Rush Medical College), Hilliard Jason (2007, University of Colorado), and Randy Olson (2008, Prairie Starfish Productions).

majority of teachers reverted back to teaching the way they always have, "covering the content."

Well, how should we teach this vast amount of content to our students; how should we cover the content? The logical answer is that we cannot, and therefore we should not even attempt this Herculean task (10). To attempt to "cover the content" would limit students to simply learning facts without the ability to apply their knowledge to solve novel problems. However, learning is not about committing a set of facts to memory but the ability to use resources to find, evaluate, and apply information. As stated more profoundly by Jules Henri Pioncaré (1854–1912), the French mathematician: "Science is built with facts as a house is with stones. But a collection of facts is no more science than a heap of stones is a house" (31).

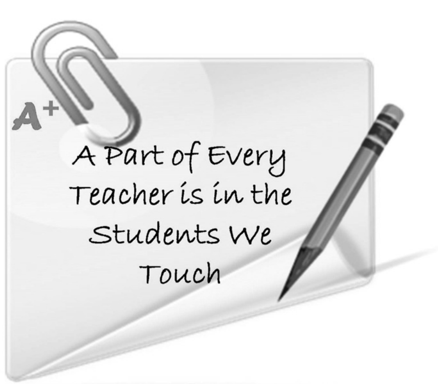

Fig. 2. The impact of our teaching will extend long beyond our lifetime because a small part of every teacher is in the students we touch.

In fact, memorizing facts mainly teaches students how to take exams [a skill not used in real life unless one is a game show contestant (18)] and primarily prepares students for more school (school prepares students for more school). Furthermore, memorizing facts leaves little time for students to develop lifelong skills such as critical thinking, problem solving, communication, and interpersonal skills.

However, teachers can encourage these processes by carefully considering the type and organization of information as well as the instructional strategy they use (44, 48). For example, we all realize that reading a recipe is not as useful as preparing a meal when learning how to cook (10). How then do we change our approach from reading to doing?

First, we must think about the idea that "how we teach is much more important than what we teach" (11) because nothing reduces enthusiasm for a subject faster than poor teaching. Teaching is the unique and central mission of institutions of higher learning. Teaching is not just an addendum to research. It is not an obligation that comes along with the job. Teaching is the continuation of a culture, the continuity of what we have done and known, the substance of our intellectual life. What kills a subject is the lack of good teaching, the inability to communicate whatever once gave it vitality (41). You can test this assumption: before attending the next scientific meeting (e.g., before attending Experimental Biology 2010) but after reviewing the program, count the number of sessions that you are excited to attend because you think the session will be interesting. After attending the sessions, count the number of sessions that actually held your interest. Poor presentations and poor teaching will reduce interest in even the most interesting topics.

Not Enough Thinking

My experience suggests that <20% of the sessions will actually hold my attention, even though I am excited by the content. This may be due, in part, to what Horace Davenport was alluding to when he stated that "there is a great difference between teaching and learning: there is too much teaching and not enough learning" (15).

For an example of the difference between teaching and learning, meet George, my cat (Fig. 3)! I taught George to purr the national anthem, that's right, I taught George to purr the national anthem! However, despite all my teaching, he never learned it (George was more interested in having fun). So for George and many of my students, there was much, too much content and not enough thinking (on George's and my student's parts) and too little fun.

This is not rocket science or brain surgery; the classes in most American medical schools are teacher-centered experiences rather than dynamic student-centered experiences that engage students in deep thinking. In this setting, the teacher assumes the responsibility for presenting a common body of knowledge to all students, and the students assume the responsibility of repeating it on demand. That is, too often information is transferred from the notes of one person to the notes of another person without going through the minds of either person. The teacher perpetuates the process by transferring knowledge to students through lectures and note taking rather than through active involvement and personal investment in the process (10, 11). In this setting, most of the effort is devoted to filling the mind rather than preparing and developing it. However, filling the mind does not work (15). Furthermore, the emphasis on overinstruction and repeating what the teacher thinks is important has a stifling effect on creativity. We must not forget the wisdom of Mestrius Plutarch (45–125 AD), priest of the temple of Apollo at Delphi, "A mind is a fire to be kindled, not a vessel to be filled," because filling the mind does not work.

How do we know that filling the mind does not work? For a short demonstration, I would like to teach the Chinese language (Fig. 4). Figure 4, *left*, shows the questions, and Fig. 4, *right*, shows the answers. Please learn the answer to each of the questions. If presented with a quiz that asked the questions from Fig. 4, *left*, could you match the answer with the question? Of course you could. However, would you know the Chinese language? Of course not; you would know the answers, but you would not understand the questions or the significance of the question. Thus, there would be no meaning, and without meaning, there is no meaningful learning or learning with understanding (23, 38). This results in students who know more but understand less.

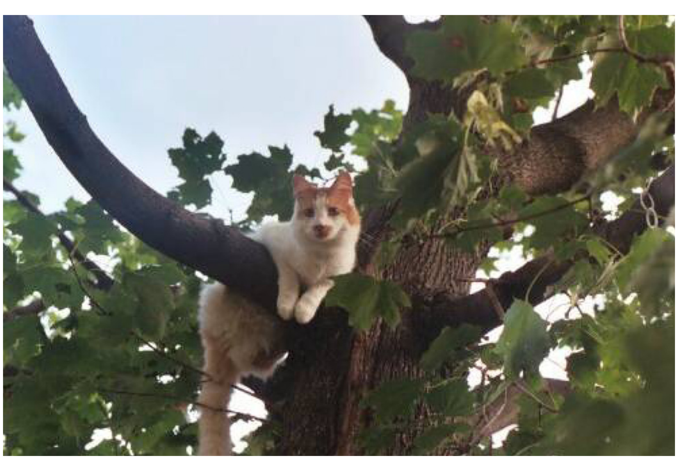

Fig. 3. Meet George, my cat! I taught George to purr the national anthem! However, despite all my teaching, he never learned it! So for George and many of my students, there was much, too much content, and not enough thinking (on George's and my student's parts) and too little fun.

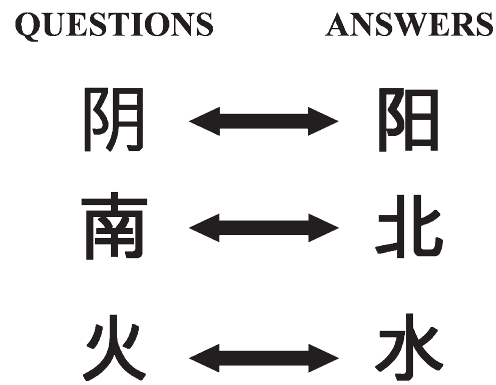

Fig. 4. *Left*: questions; *right*: answers. Please learn the answer to each of the questions. If presented with a quiz that asked the questions, could you match the answer with the question? Of course you could. However, would you know the Chinese language? Of course not; you would know the answers, but you would not understand the questions or the significance of the question. Thus, there would be no meaning, and without meaning, there is no meaningful learning or learning with understanding! This results in students who know more but understand less.

And this occurs because, once again, too often information is transferred from the notes of one person to the notes of another person without going through the minds of either person. That is, we spend too little time thinking about the information. This is important because active processing of information, not just passive reception of that information, leads to learning. That is, we understand the information we think about (47) because understanding is the residue of thinking (Fig. 5).

Well, if understanding is the residue of thinking, why do we spend so little time thinking? We spend so little time thinking because thinking is difficult (47). As stated by Henry Ford, "Thinking is the hardest work there is, which is why so few people engage in it" (16a).

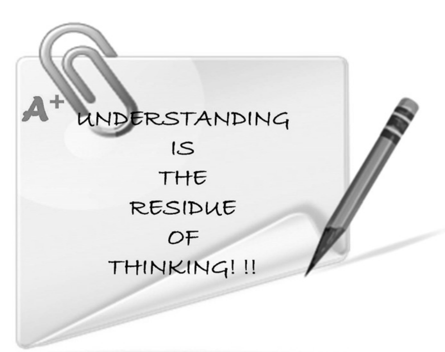

Fig. 5. Active processing of information, not just passive reception of that information, leads to learning. That is, we understand the information we think about.

To demonstrate the concept that thinking is difficult, Willingham (47) used the following problem:

> *In an empty room are a candle, some matches, and a box of tacks. The goal is to have the lit candle about five feet off the floor. Please attempt to solve this problem.*

As you attempt to solve the problem you are probably coming to the conclusion that the problem is difficult to solve! You are also realizing that solving the problem is effortful and slow and that you are uncertain about the solution to the problem (47). Specifically, the solution was not immediately obvious (slow), it took some work (effortful), and you were never certain the solution would work (uncertain). Therefore, most often we do not think (because it is too difficult). Rather, we rely on our memory. For example, if you encounter this problem in the future you will no doubt know the solution immediately (dump the tacks out of the box, tack the box to the wall 5 ft above the floor, light the candle, and place the candle into the box).

Too Little FUN

However, when we teach students to rely on their memory, we have students who are often confused, unaware, disengaged, and unable to solve novel problems. If thinking is so important to prevent this, how do we get our students to think? When considering this question, we should first remember the wisdom of Albert Einstein when he said "It is nothing short of a miracle that modern methods of instruction have not entirely strangled the holy curiosity of inquiry." I am not sure, but I am pretty certain that Dr. Einstein was thinking that rather than telling students what we know, we should show students how we learn.

When considering the question of how do we get our students to think, we should also heed the wisdom of Alfred North Whitehead when he stated, "As far as the mere imparting of information is concerned, no university has had justification for existence since the popularization of printing in the fifteenth century." Once again, I am not sure, but I am pretty certain that he meant that we need to inspire and engage our students. As stated profoundly by Prof. Robert Lee Madison (1867–1954), Founder of Western Carolina University, "The true value of a teacher is determined not by what he knows, nor by his ability to impart what he knows, but by his ability to stimulate in others the desire to know" (Fig. 6). Therefore, we must create a joy, an excitement, and a love for learning. We must make learning fun (Fig. 7). Because if we are successful, our students will be impatient to run home, study, and contemplate–to really learn (15). If we are truly successful, we will have students who are engaged, inspired, and really learn. Students who are able to solve novel problems.

Fig. 7. We must make learning fun because if we are successful, our students will be impatient to run home, study, and contemplate–to really learn.

To achieve these goals, we must *1*) reduce the amount of factual information that students are expected to memorize, *2*) reduce our use of the passive lecture format, and *3*) help students become active, independent learners and problem solvers (67).

Reducing the amount of factual information that students are expected to memorize. We must reduce the amount of factual information that students are expected to memorize because *students are going to forget that information* (Fig. 8). That is, students do not remember or, more importantly, understand much of what they memorize. For example, Miller (26) reported that students forget much of what they learn in anatomy and biochemistry courses before they graduate. In addition, after a short time, students who had high grades in a subject knew no more about that subject than students who had lower grades (26). Similarly, Swanson and colleagues (43) documented very low retention of basic science information by fourth-year medical students. Furthermore, Richardson (34) reported that, compared with naive students, experienced stu-

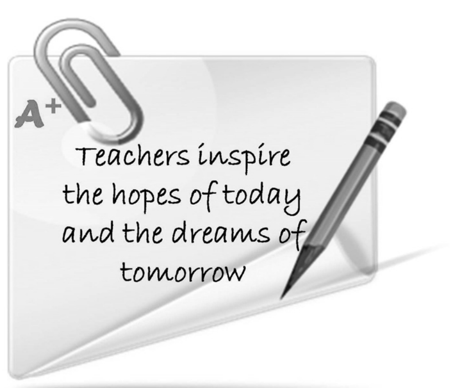

Fig. 6. The true value of a teacher is determined not by what he knows, nor by his ability to impart what he knows, but by his ability to stimulate in others the desire to know.

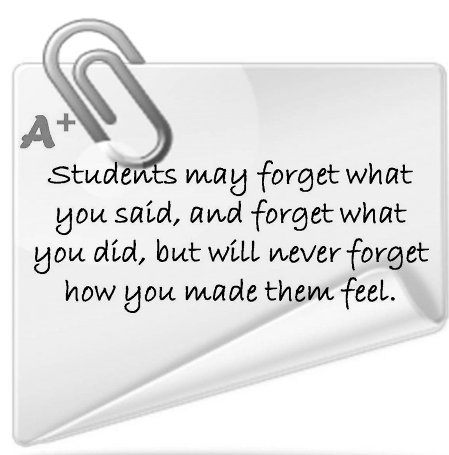

Fig. 8. We must reduce the amount of factual information that students are expected to memorize because students are going to forget that information.

dents who completed an elementary physiology course did not have a greater knowledge level of physiology or perform better in an upper-division physiology course. In short, a prior course in physiology did not enhance performance on a precourse test or on a postcourse test (34). It is also well documented that science-based undergraduate education has no effect on academic performance by medical students (13). Finally, we have documented that retention of acquired knowledge is short lived (9).

Thus, we don't remember or understand much of what we learn in the classroom, and even if we did, it would not help us in our future careers because much of the knowledge that will be used in the students' future careers is not known today and therefore must be learned after graduation (46). Furthermore, only a small portion of what is known can be taught in 4 yr, and not all that is taught is learned or remembered. Some of what is taught is erroneous, and other material will soon be obsolete. Therefore, students must be capable of working together and gathering evidence, evaluating it, and learning from it. However, much of what we do in classes with large numbers of students conflicts with our goals. These activities do not prepare students for solving novel problems because many of these activities encourage the memorization of detailed information. As a result, the retention of acquired knowledge is short lived, and grades do not correlate with problem-solving abilities (8, 9).

For example, in many schools, students think that classes involve an endless list of independent, unrelated facts; a series of unrelated phenomena where faculty members encourage the memorization of detailed information. For example, consider the seemingly unrelated letters in the following row (17):

$$E_8\ A_3\ B_8\ R_{13}\ C_1\ R_{11}\ D_5\ E_6\ E_9\ R_{10}\ L_2\ D_{14}\ U_4\ N_{11}\ A_{12}\ \_\_{}_7$$

Although it would be difficult to memorize this row of letters, all of us could, and we could also repeat it back for the exam! However, even if we did, we would not remember the letters for long, and they would have no meaning.

However, our responsibility as teachers is to take these seemingly independent, unrelated facts and place the facts into an appropriate context. All of us have content knowledge; we understand our subject. However, few of us have pedagogical knowledge, an understanding of how to place the material into a context that promotes meaningful learning (learning with understanding). Meaningful learning (7, 22) occurs when the learner interprets, relates, and incorporates new information with existing knowledge and applies the new information to solve novel problems. For example, please place the letter, using the corresponding number, into the space matching the number:

_ _ _ _ _ _ _ _ _ __ __ __ __ __
1 2 3 4 5 6 7 8 9 10 11 12 13 14

Having completed this task, what does this exercise emphasize? This exercise emphasizes the futility of memorizing seemingly independent facts and illustrates the importance of placing facts into the appropriate context. These seemingly unrelated letters have significant meaning, and the learner will remember the letters when we apply our pedagogical knowledge.

To reinforce this concept, please consider the following example. Please take 10 s to memorize the following row of letters:

A O H L B A F N S C I B D S N F W P

Without looking at the letters, please recall as many letters as possible. Please write the number of letters you recalled in the following space: _____.

Now, please take an additional 10 s to memorize the following row of letters:

A P S N F L C B S F B I D N A W H O

Without looking at the letters, please recall as many letters as possible. Please write the number of letters you remembered in the following space: _____.

Did you recall more letters from the first row or second row of letters? Although the letters in the two rows are identical, all students recalled more letters from the second row. This short exercise emphasizes the importance of background knowledge and the limitations of our working memory for meaningful learning.

Importance of background knowledge for meaningful learning. This exercise emphasizes the importance of background knowledge for meaningful learning. Specifically, background knowledge is essential for learning new concepts. For example, "APS" is meaningful only if you already know what APS is. An example that Willingham (47) used to reinforce this point is the following sentence:

"I am not trying out the new recipe when the boss comes to dinner."

All of us have the essential background knowledge for understanding this sentence. We understand that the author wants to impress his boss, and we also understand that everything may not go well, or as planned, the first time we try a new recipe.

Another example used by Willingham (47) to illustrate the importance of background knowledge for meaningful learning is the following sentence:

"Physical model for the decay and preservation of marine organic material."

Although I understand all the words, I do not have the essential background to understand the meaning of this title. Thus, background knowledge is essential! You can easily test this assertion. To test this assertion, attend a seminar outside your area of expertise and estimate your level of understanding.

The limitations of working memory for meaningful learning. The demonstration above also teaches us about working memory (47). Working memory is where we think, where we combine and manipulate information. However, space in working memory is limited, which is the reason we could only remember five to seven of the letters in the first row of letters. However, space in working memory depends on the number of meaningful objects, not the number of individual objects, which is the reason we could remember all of the letters in the second row of letters.

Thus, combining individual objects increases space in the working memory and enhances our ability to transfer knowledge to long-term memory. As an example of the limited space in working memory, please solve the following function in your head (47):

$$\begin{array}{r} 15 \\ \times\ 6 \\ \hline \end{array}$$

Most of us can solve this problem in our heads. However, now, please solve the following function:

$$\begin{array}{r} 15{,}623 \\ \times\ 67{,}477 \\ \hline \end{array}$$

Few, in any of us, can solve the second function in our heads. Why not? Both problems required the same process. However, because of the limited space in working memory, it is impossible to keep track of all of the numbers.

These examples teach us about the importance of relating what is unknown to what is known and placing the material into context (19, 25). This is critical because one of the most important factors influencing learning is what the student already knows. The student must consciously and explicitly link new information to concepts they already know. In this way, existing concepts are identified and new linkages are formed between concepts.

Reducing our use of the passive lecture format. We must reduce our use of the passive lecture format because the passive lecture format is *boring*, mind numbing for students and monotonous for teachers. No one is engaged or inspired when practicing the ancient art of sleeping with their eyes open (Fig. 9). Students' attention in lecture classes wanes dramatically after 10–15 min (30, 42), and there is a weak correlation between lecture attendance and course grades (14). These studies suggest that students do not learn by simply sitting in a classroom listening to the teacher, memorizing assignments, and spitting out answers. Students must talk about what they are learning, write about it, relate it to past experiences, and apply it to their daily lives (6). Students who are actively involved in learning retain information longer than when they are passive recipients of instructions (9). Furthermore, students prefer active-learning strategies to the traditional lecture (4).

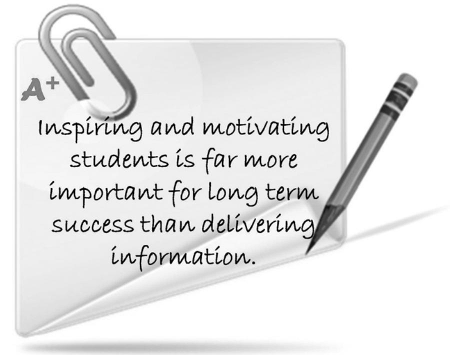

Fig. 10. Inspiring and motivating students is critical because unless students are inspired and motivated our efforts are pointless.

Active involvement also improves students' conceptualization of systems and how they function and increases students' levels of retention (12, 27, 36). Therefore, all teachers are encouraged to reduce or eliminate the passive lecture format!

Helping students become active, independent learners and problem solvers. We must help students become active, independent learners and problem solvers because it is clear that active processing of information and not just passive reception of that information leads to learning. That is, we understand and remember the information we think about! Specifically, learning with understanding requires time. Teachers must be realistic about the amount of time required to learn complex concepts and provide the time to achieve the goal. Students need time to explore underlying concepts and to generate connections to other information. Students must have time to "grapple" with specific information relevant to the topic. Thus, learning cannot be rushed; the complex cognitive activity of information integration requires time.

Active-learning strategies reach all types of learners in the visual, auditory, read/write, kinesthetic, and tactile schemes. With active-learning strategies, visual learners are targeted by

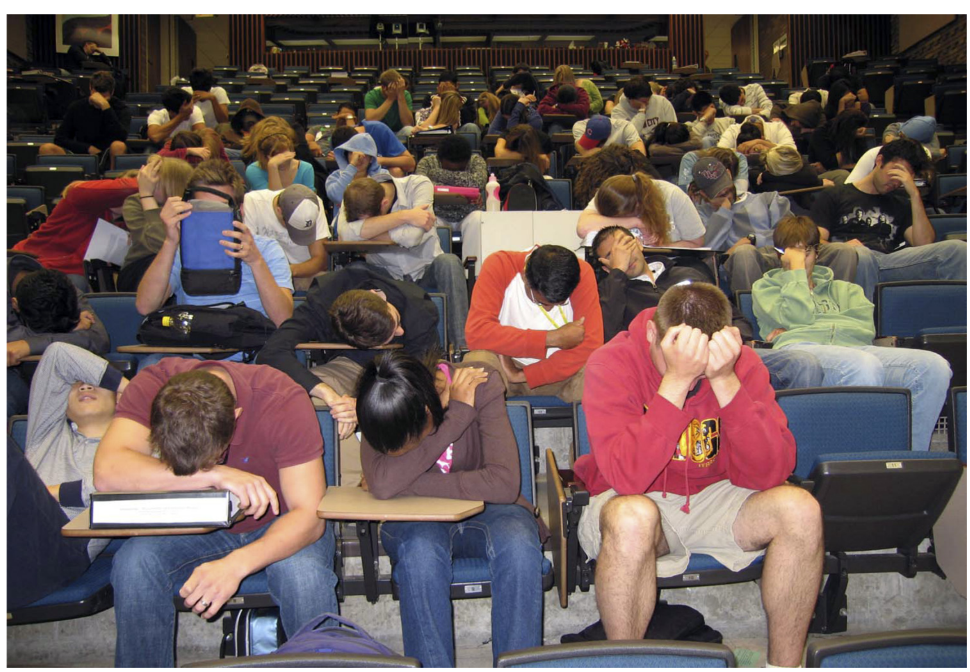

Fig. 9. The passive lecture format is *boring*, mind numbing for students and monotonous for teachers. No one is engaged or inspired when practicing the ancient art of sleeping with their eyes open.

the presence of models and demonstrations. Auditory learners are reached through discussion during peer instruction (8, 32), debates (37), games (1, 24, 28, 29), and answering questions. Manipulating models (5, 35, 39) and role playing (16) satisfy kinesthetic and tactile learners.

It is generally thought that students have better retention and understanding of knowledge when taught by active as opposed to passive methods (19–21, 33). If this is true, the curriculum must be changed to active methods that provide educational experiences designed to develop lifelong learners and students who are capable of solving novel problems: in short, self-educators (45).

Conclusions

There is too much content, not enough thinking, and too little fun in many of our courses. Remember the wisdom of Mark Twain (Samuel Clemens) (1835–1910), the American writer and humorist, when he wrote in the Hannibal Courier-Post, on March 6, 1835: “Few sinners are saved after the first twenty minutes of a sermon” (presumably because no one is listening after 20 min). When we focus on content and limit time for thinking, our students function as parrots, repeating what they believe the teacher wants to hear. In this setting, students forget much of the information they learn and are unable to solve novel problems. We must change this approach so that students develop an interest and love for lifelong learning. Inspiring and motivating students is critical because unless students are inspired and motivated our efforts are pointless. Once students are inspired and motivated, there are countless resources available to learn more about a subject. Inspiring and motivating students is far more important for long-term success then delivering information (Fig. 10). Therefore, we must create a joy, an excitement, and a love for learning. We must make learning fun, because if we are successful, our students will be impatient to run home, study, and contemplate–to really learn (15).

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