AC 2008-424: ENHANCING LECTURE PEDAGOGY THROUGH TARGETED BREAKS

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Enhancing Lecture Pedagogy through Targeted Breaks

Abstract In this paper an approach to lecturing, that of Targeted Breaks, will be introduced. These are offered as a means to enhance the traditional lecture format so as to increase student comprehension, interest and the course's level of perceived worth. Targeted Breaks offer a multiplicity of benefits and these will be delineated in the text. Particular examples will be presented as well, with sufficient detail to allow interested professors to create their own personalized versions.

Keywords: lectures, pedagogy, learning

Introduction

In recent years the lecture format has taken a bit of a beating. One hears it denigrated as a non-interactive learning venue that pales when compared to smaller-scaled, active learning environments and the assertion is made that good teaching can't occur in situations for which the student/teacher ratio is high. Furthermore, as is well known, just such a high ratio has become common in many of our universities. Administrators, eager to achieve cost efficiencies and faced with limited instructional budgets, have often chosen to increase class size, changing the dynamic between lecturer and student as the number of students moves from 20 to 40 to 100 and so forth. Once the ratio becomes "large," an argument can be made that the class can be super-sized, that is, made "huge," with no real loss. The contention is that 50 to 1 and 200 to 1 are equally non-involving for the students and so why not go bigger?

If no thought is given to the problem, the result can be a process in which the student does indeed feel cut off from the process of learning, a passive observer of a self-contained performance. If the lecture is viewed as simply one man or woman standing in front of a sea of faces and presenting "the facts," then the endeavor certainly becomes dubious as an example of a rich learning experience. In such a case is there much difference between this form of "live" lecture and a pre-recorded lecture shown on a screen or computer monitor? The author thinks not. A lack of interaction between student and professor will act to reduce what was a rich give and take to something that can be well approximated by a webcast.

In the author's opinion this situation poses a serious threat to the professoriate. If it becomes accepted that one can obtain a similar education by simply viewing a pre-recorded webcast then the existence of the individual professor becomes somewhat optional. Why spend money for a professor when one can simply buy the complete set of "Dynamics for Engineers" and show it at regularly scheduled times?

An argument that could be used against lectures, that they are poor vehicles for knowledge transmission [2], misses the fact that the real beauty and power of a lecture isn't simply the passing of facts. As Lowman [3] writes, 'The lecture is probably most effective at motivating

students to learn more about a topic'. Lectures aren't simply fact transmission mechanisms but should be arenas in which the students are given a glimpse into the how and why of the material and motivated to continue this learning out of class.

The author feels strongly that a major point of attending a university is to obtain direct interactions with a professor - to benefit from the "professing" that gives professors their name. A key question, therefore, is how to retain this educational facet in the face of undoubted financial pressures that work to reduce it. As a result, the author has spent some years in experimenting with techniques to enhance and revitalize the traditional lecture format, bringing the sense of a small seminar into what so easily can become a one-way monologue.

In prior work the author has touched on aspects of how a large lecture can be made to feel more like a small seminar and how to involve students in the discussion [4]. In this paper a different concept is introduced, the Targeted Break. The Targeted Break is a 5 minute break in the lecture, occurring approximately midway through. During this time graphic imagery and/or videos are presented, accompanied by discussion between the professor and students. The material in the Targeted Break is separate from the lecture proper, complementary to it, and is carefully designed to achieve several objectives.

As constructed, the Targeted Break achieves both of the dimensions encompassed by Lowman's [3] two-dimensional model of effective college teaching, namely *intellectual excitement* (Dimension I) and *interpersonal rapport* (Dimension II). By carefully choosing the elements that go into the Targeted Break, the students see what surrounds, supports and flows from the material they're experiencing and by being an involved part of the short discussions they experience a stronger bond with the instructor.

Listed below is the SECRET that makes up the Targeted Break.

- **S**ubliminally **E**ducate
- **C**ontextualize
- **R**echarge
- **E**ntertain
- **T**ransition

SUBLIMINALLY EDUCATE

The Targeted Break gives us the opportunity to inject some education beneath the student's radar, the utility of which should not to be underestimated. People are often more likely to learn when they don't realize that they actually *are* learning. What sort of education might this be?

Consider the current ABET process. Students are now asked at the end of the semester to assess whether they've learned the tools and techniques needed for them to be effective engineers. Left to themselves, they might or might not realize what this means and whether they've gotten these tools or not. Contrast that with a semester in which they've experienced a multiplicity of Targeted Breaks. In the bulk of these they can be shown engineering applications and then hear how, thanks to what they're learning that current week, they'll be able to do such things themselves. Or perhaps, at one layer removed, how the material they're learning will allow them to learn item such and so, which will allow them to do what they're seeing on screen.

The essential point is that they're seeing, very clearly, real engineering uses of the theory and are being told quite directly how what they're learning enables the doing of the activities. There will be no doubt in their minds that, yes, they've been shown how to approach and accomplish engineering tasks.

In addition, the material in the Targeted Breaks are designed to be very wide-ranging and to stimulate interest in areas beyond the current course. Without realizing it the students are imbued with a desire to push further and extend their learning. They're not being told that they should take, for instance, Math 124 because "it's good for them" but are motivated to take it because they see what it can do for them.

CONTEXTUALIZE

This is perhaps the most important aspect of the Targeted Break. One of the most common complaints/comments heard from students is that they have no idea *why they should care* about the theoretical material being presented. In a sophomore math class this results in juniors who claim never to have seen or heard of an eigenvalue because it was simply an obscure bit of formalism in their linear algebra lectures. A dry exposition of dynamical theory in an early dynamics class leads to the same end result - a student who has no idea how to approach the simplest dynamics modeling problem they're presented with in a capstone design course.

If the students don't know the why of the material they're naturally going to lack the motivation to internalize the material. Telling them "Trust me, you'll be glad you remember this in a couple of years" isn't likely to be particularly persuasive.

Show them, however, and it's a different story. By taking a break from the lecture proper the professor can present a memorable graphic example in a few minutes (by picture or video), one that doesn't just attempt to get the student to understand with words but by letting

them see it on the screen.

Both the cognitive and and affective domains, as delineated by Bloom [1], are addressed. The students' cognitive domains are immediately involved on a variety of levels. People learn through a variety of avenues and the Targeted Break material, by employing both static and dynamic imagery, serves as a visually arresting way to let the students "see" the material in ways that equations on a blackboard simply cannot supply. Their affective domains are equally stimulated. Having a graphical reinforcement of "why this stuff is so darned interesting" increases their appreciation of the material and encourages them to expand their own thinking about the topics. When they can say "Hey, that's really cool - I didn't know such and so related to engineering" they have a chance to know the material on a new level - one that's separate from the straight "learn it because it'll be on the final" mentality.

"Don't tell me - show me" is a well known phrase that goes along with "Seeing is believing." Both strike at the core of contextualization - showing students so that they can believe.

RECHARGE

What's now become the Targeted Break began life several years ago as a simple break, a five minute interruption of the lecture during which the students were free to do whatever they chose. The reason for this break was the belated discovery by the author (from various papers, not personal research) that students (and people in general) have a rather limited capacity for sustained attention. Many studies have been done with regard to this subject and all have the same findings - namely that a high degree of attention can be initiated and sustained for a brief time and then, in general, the mind inevitably begins to wander.

The length of time over which one could expect reasonable levels of attention vary from study to study but twenty minutes appears to be a "normal" time span. Given the fact that the normal lecture ranges from 50 to 80 minutes, it became obvious that providing some sort of break might enhance the overall "knowledge throughput" even though it would reduce the absolute amount of time the lecturer was lecturing.

The break proved to have the desired effect. It allowed students to mentally recharge, just as a short break between sets allows a weightlifters muscles to recharge themselves, readying them for further exertions. In the early days students simply read the paper or chatted during this break. Reluctant to see 5 useful minutes going to "waste," the author was motivated to think about how even more utility could be introduced, a process that led to the Targeted Break.

ENTERTAIN

What place is there for entertainment in an engineering course? Everywhere. The fact is that people are motivated to learn when they're enjoying the process. Of course, by entertainment the author isn't suggesting anything like the vacuous experience of watching

television. The brain has to be involved and challenged as well as entertained. The student who listens raptly just because the professor is dryly presenting valid and correct formulae is a rare exception to the norm. The professor needn't be a professional entertainer, putting on an hour long routine for the class. By using the Targeted Break she can break away from the strict pedagogy of the lecture and show something fun. Knowing that this Targeted Break exists gives the students another powerful reason to come to class - just to hear what new "thing" will be presented for their benefit.

Just to be sure that the Targeted Break doesn't become overbearing the author doesn't try to imbue every single Targeted Break with extreme course relevance. Sprinkled in there will be times in which something completely off topic, but *interesting* will be presented. The observation has been that an interested student is a student who comes to class - and that's a primary goal of the undertaking.

One other aspect of the ENTERTAIN component is that students who might be too afraid or inhibited to ask questions during a normal lecture often feel comfortable with participating during a low-stress, entertaining moment during the hour. Often this experience is enough to break the mental barrier and empower the student to participate during the lecture proper.

TRANSITION

This aspect of the Targeted Break is related to the prior item in that it's designed to maintain interest in the class and motivate students to want to come to lecture. The way in which it works is by explicitly crafting a series of Targeted Breaks such that one leads into another. They don't necessarily have to be sequential either - it's enough for the students to be aware that a follow-on is coming up. By transitioning from one Targeted Break to one that builds upon the former, the students are made to realize that "good stuff" is awaiting them in a future lecture. This gives additional impetus to come to class rather than simply assuming that they can get the notes from a friend. The end result is an increase in the number of students involving themselves in the lecture.

EXAMPLE CONTENT FROM SOME TARGETED BREAKS

This section will present some Target Break content and explain how the displayed imagery is used to achieve the aims delineated earlier in the paper. Note that the examples given occurred in dynamics and vibrations courses but the approach of a Targeted Break applies equally well to any discipline.

Rigid body acceleration

Figure 1: Initial acceleration of a vehicle

Our first example is very clearly tied to 2D dynamics and doesn't really require much in the way of explanation. This is not to say, however, that no commentary is given - quite the contrary in fact. The basics are that we're observing a sports car beginning to move forward. The particular car shown in Figure 1 (carefully chosen for the example) is a BMW M roadster. What the instructor would ask the class is whether they could tell that the car was accelerating forward, rather than braking, or perhaps just traveling at a constant speed.

The obvious answer is that one *can* tell because the body/tire gap at the rear is markedly less than at the front. The body is rotating clockwise - squatting on its haunches. This example is one that can very easily be put up on the board and analyzed with very little effort. When this occurs (and it should definitely occur in the class) the professor can allude back to the M roadster break and explicitly comment on how they're now able to understand the basics of vehicular dynamics and how further study would allow them to participate as engineers at a car manufacturer or, if they're lucky, a Formula 1 team. This conversation provides both contextualization and subliminal education. The students now *know* that they're learning useful tools that will enable their success in their engineering careers.

With just this small example, forces and reactions have thus been contextualized - the students see something from the real world and immediately see how their analyses can be used to understand its behavior. Can we go further though? Absolutely. When presenting a picture like this the author wouldn't simply say it's an M roadster and leave it at that. The

first question would be "Does anyone know what sort of car this is?" No matter the response, this would allow a very short description of how racing cars differ from normal passenger cars and several aspects would be highlighted with the assurance that the students would be seeing more details (as they indeed would) in later breaks. They're primed to look forward to the next example and are therefore being pulled along through a well thought out transition.

The author would also mention the particular torque/horsepower characteristics of this vehicle and get some interaction with the students as to what these might mean. Again, there'd be the promise, always fulfilled, that it would be looked into in more detail and this process will deepen subliminal education, contextualization, and transitioning. Of course, recharging and entertainment occur as well, without any explicit prompting.

Photographic effects

The next example is one that seems on the surface to be very off-topic. The reality, however, is that it can easily be related to dynamics and thus strongly delivers both entertainment value as well as a broader contextualization than the first example provided.

Figure 2: Vampire eyes

What's shown in Figure 2 is an actual photograph, taken by the author. What's very obvious is that the subject looks like a vampire, his eyes being very catlike and non-human. The common reaction of viewers is that it's been photoshopped. The reality is that it hasn't been - it's straight from the camera. And yet, unless there's something more special about the author's son than he's aware of, the picture isn't of a vampire and the irises "should" be round. But they're not. Why?

This picture provides an excellent opportunity to show how motion affects the world and how devices that we think we understand (cameras) are not always doing what we think. In this case, the author's son initiated a horizontal eye movement at precisely the same time

the the shutter was activated. The result is that the photons received on the camera's sensor included information from both positions, including the overlap of the two extremes. More photons equals more image - cat eyes.

Of course, more discussion is possible here as well. One can look at traditional film cameras with reflex shutters or with shade-type shutters. One can ask how point-and-shoot digital cameras work and how they differ from digital SLR cameras. The fact that optics is being discussed opens the way for a discussion of Sir Isaac Newton, how his work on optics changed the world, and how he developed both his theories for optics and dynamics at roughly the same time.

Vibration reduction

The subject of the next Targeted Break is the Porsche Cayman. Note that this particular Targeted Break works best in a vibrations class, although it can also be used in dynamics as a good way to motivate students to go on and *take* vibrations (subliminal education).

Figure 3 shows the opening slide - that of the vehicle itself. The obvious point is to grab the students' interest and get some "wow, nice car" comments from them. The author would then ask if there's anything wrong with the car and likely get "nothing but that it's too expensive" as a response.

Figure 3: Porsche Cayman

The author's rejoinder would be "Not so fast. Many, many owners have complained that there's a loud thunk from the trunk when driving over a bump. And why in the world might this be?" The answer is seen in Figure 4, a view of the underside of the trunk lid with the carpeting removed. Hiding near the bottom of the picture is a small rectangle containing two silver disks.

A closeup of this object (Figure 5) reveals that it's a hunk of iron that's actually hanging from a rubber support. It's a passive vibration absorber!

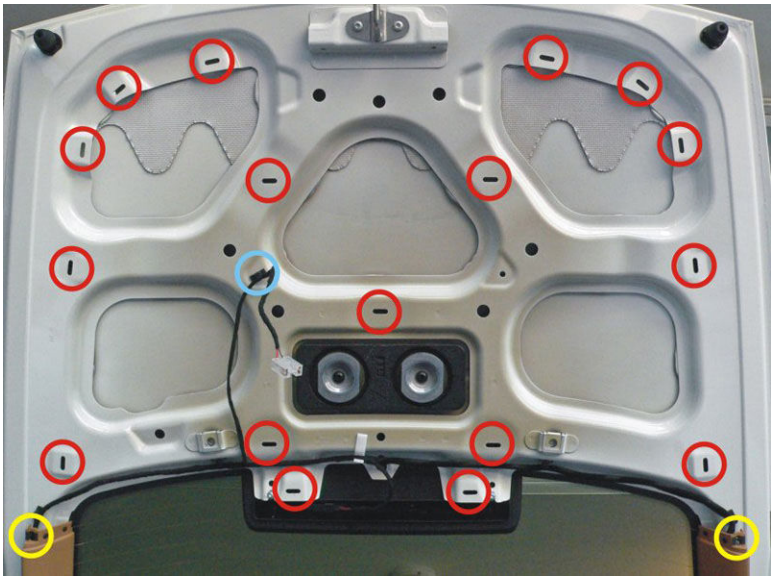

Figure 4: Trunk underside

Figure 5: Trunk Spring-Mass damper

In this case the passive vibration absorber was clearly designed to counter flexing of the shallow shell structure of the trunk lid. The problem is that the engineers at Porsche suspended the mass with the thought that its motion would be purely translational. As can be seen from the final picture, though, the soft rubber mounting allows a good deal of rotation - enough so that when encountering a bump the iron block can rotate enough to strike the lid. This causes the annoying thunk that the driver perceives.

This example is a great one from which to explain how many engineering approaches exist for a given problem and how each one may well have unexpected problems associated with it. In this case, a solution to reduce noise actually created a different type of noise.

By mentioning how automobiles employ a multiplicity of vibration absorbers, similar in intent if not in form, the students again gain important insights that help them contextualize and that reinforce the idea that they are fully capable of understanding the designs being used in state of the art vehicles such as this Porsche.

Figure 6 shows that this example isn't limited to road cars. Formula 1, a sport that involves *many* millions of dollars, recently had a rules violation that garnered quite a bit of attention. Hopefully of great interest to the students is the fact that the system causing the controversy was conceptually identical to the one they saw in the Porsche Cayman. In the Formula 1 case the damper wasn't there to quell structural vibrations but rather to enhance the car's grip in corners.

F1 TEAMS FIND EXTRA GRIP WITH NEW DAMPER SET-UP

SEVERAL FORMULA 1 teams have been using a 'mass damper' this season in order to damp out tyre bouncing frequencies through corners and thereby keep the grip more consistent.

Renault and Red Bull are known to be using such a system and it's believed that Ferrari and Williams – and perhaps others too – also have it fitted. It's a simple mechanical device comprising a weight (believed to be of around 9kg) on a spring.

Anderson

Gary Anderson explained its purpose: "You see a car bouncing, such as when it hits a kerb. This will be at around 8-9Hz on the tyres. This device will get an equal frequency going in the opposite direction. It's a bit like a tall building designed to withstand an earthquake where they put the water tank on the roof – so that when the building sways, the water is going in the opposite direction at the same frequency.

"In this case, as the car is going up, the tyre is going down and vice versa. With this, the car will still bounce at the same frequency but the amplitude will be damped down. If you take an average tyre contact load and assume say 1000kg, you'd typically see a variation of 9-1100kg. But the driver needs to feel sure of what he's got as he goes into the corner. Is that 900 or 1100? With a weight of around 10kg you can maybe get the variation down to 950-1050kg, so he's got a more constant load. It's a very good idea. It would also be easy to set-up on a seven-post rig, balancing mass against damping. I reckon it would take no more than 15 minutes to set it up. On the downside it adds a bit of weight quite high up in the car."

Figure 6: Mass Damper Controversy

This example again reinforces the student's perception that they *can* understand engineering and also provides a springboard for a wide-ranging discussion including such issues as *Why does it help?*, *Are vibration absorbers the only solution?*, *Are there active approaches as well?*, *What's the consequence of not having the device?*, and so forth.

Hummingbirds

Figure 7 shows a photo of a hummingbird sipping nectar. This picture falls under the entertainment category (something the class may well never have seen) and is supported by a discussion of hummingbird behavior. But dynamics isn't ignored as it's clear that the wings are a blur of motion. This opens the door to a discussion that introduces the students to limits and scaling. Fun facts such as how the heartbeat rate of a hummingbird (1200 bpm in flight) show how smaller objects can exhibit much higher speeds/rates than we're accustomed to on a human scale. This observation then allows us to segue to the micro and nanoscale and discuss the behavior of MEMS devices. Subliminal education is at work. The students are snared by a pretty picture and end up experiencing an array of engineering without quite realizing how it happened.

Figure 7: Hovering behavior

Just so the students don't start to think *everything* has a hidden agenda, the author also presented Figure 8. A hummingbird made its nest in an easily discovered place and because of this happenstance the author was able to take some very closeup pictures. This one shows the mother on the nest. And, not content to simply be a picture, it also allowed the discussion of nesting behavior, nest construction, the size ratio of bird to nest (which could then be contrasted with highly dissimilar species), and so forth. The class was part of a chronicle of the birth and fledging of the two eggs, something that clearly fed into transitioning. If they didn't come to class they'd never see the hatching, growth and ultimately the fledging.

Figure 8: Nesting Anna's Hummingbird

The picture in Figure 9 was taken some days later and shows an extreme closeup of the baby hummingbird's face. The quills that enclose the developing feathers are clearly visible, as are the different feather types on the head. Obviously, a discussion of feather morphology and evolution could easily occur at this point. Feathers are held in place by micro-barbules, and a discussion of this point could seamlessly segue to other naturally occurring micro and nano-scale structures, such as the nano-cilia that enable geckoes to walk up walls and which are being synthesized to produce new superglues.

Figure 9: Hatchling Anna's

These are just a few of the many different topics covered during the 5 minute Targeted Breaks. Taken together they create a widely varied and engaging miniature "course within a course." The reaction of students to this concept is taken up in the next section.

Assessment

One indirect measure of success is that fact that the author experienced close to a 100 percent attendance throughout the semester. The issue of non-attendance is a real one at the author's institution and committees have been formed to determine why such a low number of students tends to actually attend class. Of course it can't be claimed that the Targeted Breaks are the sole reason for this being a non-issue in the author's classes but it's a positive observation nonetheless.

The question of assessment is a very important one and one that was examined as best as could be accomplished under the prior course constraints. The author's institution only permits professors to address large lecture classes once every 2 years. The first time in which all elements of the Targeted Break were present was during the author's most recent undergraduate dynamics offering, a class that had all the students in a single room. Given the fact that everyone was present for every class, it was impossible to do a controlled study in which half the class experienced Targeted Breaks and half didn't. The next time the author offers dynamics this doesn't have to be the case - two sections of 80 students each can be offered, one with Targeted Breaks and one without.

Regardless of future work, however, distributing a questionnaire at the end of the semester provides a means of assessing the students' impressions of the break. Fairly obvious questions would include "Did the short break enhance your ability to pay attention to the class material?", "Did the content of the breaks enhance your understanding of engineering and how the class material relates to it?" and "Did the break make the class experience more enjoyable?"

The written feedback was overwhelmingly positive, with nearly 100 percent of the students in favor of the break (one student bemoaned anything that took away from lecture time). Students lauded the concept, independently echoing many of the author's reason's for implementing it. Two (typical) comments illustrate their enthusiasm: "The break was great! I can't believe all my other classes don't do this. Benson should spread the word." "I really like the break halfway through. It's the reason I come to class!"

Number one on the list of comments was the fact that the scheduled interruption of the lecture let them recharge and regroup. This small mental relaxation was seen as highly effective in allowing a high degree of attention to be paid to the latter half of the lecture. Many commented that in more traditional classes their minds began to wander midway through and the Targeted Break helped alleviate this problem. This was even more impressive considering the fact that many did *not* consider dynamics itself to be an inherently interesting body of material in the first place.

Quite a few students admitted that they were not mechanical engineering students but rather from civil engineering and were taking the course only as a way of satisfying a requirement, not because they had any interest in the material. Gratifyingly, they noted that they were surprised to find themselves enjoying the class. One of the components in this enjoyment were the Targeted Breaks, which allowed them to relax and see how what was previously

viewed as a useless requirement was actually a useful body of knowledge.

Summary and Conclusions

The examples displayed in this paper show some of the many ways in which engineering, physics and the world around us can be woven together in such a way as to grab the student's attention and cause them to *want* to come to class rather than being forced to do so. And, because the discussion takes place during a break, the students re-enter the class proper with the energy to finish it out, refreshed and revitalized by a little bit of brain shakeup. In the future the author will look more closely at the effect of the Targeted Break and try to assess whether its presence actually increases end-of-term content mastery or simply serves to make the lecture more enjoyable.

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