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Focusing students' attention during lectures is a necessary condition for effective learning, but it is not a sufficient condition. Learning also requires interpretation, elaboration, and other active processes by the learner.

Successful Lecturing: Presenting Information in Ways That Engage Effective Processing

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The lecture has recently come into disrepute as a method of teaching. Active learning, cooperative learning, and student-based learning are in vogue, mostly for good reasons, while the lecture is viewed as a necessary—or maybe an unnecessary—evil. Viewing lecturing as second rate is unfortunate and inaccurate. It is unfortunate because lecturing is often indispensable, particularly in large classes with hundreds of students; it is inaccurate because an effective lecture—one that induces effective processing in one's students—can be a successful method of teaching.

In this chapter, we assume that the fundamental goal of the lecture is to increase the learning of students beyond what they can learn from reading a textbook. In different courses or in the same course at different times, the learning objectives may differ, ranging from the memorization of facts, to a change in students' structuring of knowledge, or even to increase students' enthusiasm for the subject, but the overarching goal is to increase learning. With that basic goal in mind, there exists a large body of research that is relevant to effective lecturing, specifically, research on the processes that enhance learning. (Bjork, 1979, is one of the first attempts to apply the research literature to the enhancement of teaching.) We outline here what

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Patricia deWinstanley acknowledges that the summation and integration of the disparate body of knowledge on memory phenomena into seven topics applicable to enhancing learning was first conceived of, written about, and lectured on by Robert Bjork. This chapter summarizes his ideas with a focus on enhancing lectures.

we consider some basic components of effective processing and then suggest tasks or ways of presenting information during the lecture that we think can induce such processing by students.

Components of Effective Processing

If asked, all of us who lecture to students would affirm that our goal is to have students learn from the lectures. If what we mean, however, is that the goal is to have students actually learn during lectures, as opposed to their learning (or not learning) from later activities, such as going over their notes from the lecture, we face no small challenge. By the very definition of learning, achieving such a goal requires that lectures trigger in students the types of processes that result in durable encoding of the concepts, facts, and ideas covered in the lecture—encoding of the type that will survive beyond the lecture period. Ideally, we would also like students to acquire a mental representation of the to-be-acquired knowledge that allows for flexible access to that knowledge—that is, the ability to generalize.

Toward achieving the goal of having students actually learn during lectures, it is important to remind ourselves of some fundamental properties of humans as learners. Learning does not happen, for example, through some kind of literal recording process. Rather, learning is an interpretive process: new information is stored by relating it to, or linking it up with, what is already known. The process is fundamentally semantic; new information is stored in terms of its meaning, as defined by its associations and relationships to existing knowledge. A second important property is that the retrieval of stored information is a fallible and probabilistic process. Whether stored information can be accessed (recalled) is heavily cue dependent. Information that is readily accessible given certain cues can be impossible to recall given other cues. A third important property is that the act of retrieving information from memory is itself a potent learning event—in the sense that the retrieved information becomes more recallable in the future than it would have been without having been accessed.

To trigger learning in students, then, requires that we trigger—during the lecture—the types of processes that facilitate the encoding of the to-be-learned information and subsequent access to that information. Some basic components of such processing, in our view, are attention, interpretation, elaboration, generation, and retrieval practice.

Attention. In a typical lecture, students must divide their attention between the verbal and visual information provided by the instructor, decide what information to write in their notes, and then write the notes. In addition, other activities, such as daydreaming, thinking about irrelevant information, or other "elemental psychic forces," to use Einstein's words, may compete for students' attention. It has been known for decades that divided attention results in poorer memory than full attention does (Griffith, 1976; Rabinowitz, Craik, and Akerman, 1982; Tyler, Hertel, McCallum, and Ellis, 1979), yet we continue to structure lectures in ways that divide students' attention. Modern teaching tools, such as PowerPoint and other computer-aided presentations, seem to make us more susceptible, not less, to creating divided-attention conditions for students (by, for example, requiring that they attend simultaneously to something we are saying and something else on a screen).

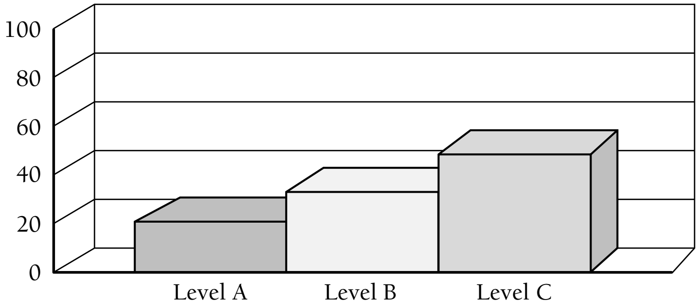
Recent research shows divided attention to be most detrimental during encoding having little or no impact during retrieval (Iidaka and others, 2000; Naveh-Benjamin, Craik, Gavrilescu, and Anderson, 2000). Lectures represent one of the primary encoding opportunities for students and the only encoding opportunity that an instructor controls (the other encoding opportunity is during subsequent study). Because divided attention is particularly detrimental to encoding, and lectures represent the first and perhaps best opportunity to encode information, focusing students' attention during a lecture on the information to be encoded is a prerequisite for the other components of effective processing.

In addition to its having a strong negative impact on encoding, divided attention has been shown to have much larger effects on direct, or explicit, tests of memory than on indirect, or implicit, tests of memory (MacDonald and MacLeod, 1998; Szymanski and MacLeod, 1996). The implication is that divided attention during a lecture may leave students with a subsequent sense of familiarity, or feeling of knowing, or perceptual facilitation for the presented material but without the concomitant ability to recall or recognize the material on a direct test of memory, such as an examination. As a consequence, students may misjudge the amount of time needed for further study.

Dividing students' attention during a lecture therefore poses a double threat. First, information is learned less well when attention is divided. Second, one's feeling of knowing or processing facility remains unaffected by divided attention, which may result in the assumption that information is learned well enough and no further study time is needed (see Bjork, 1999, and Jacoby, Bjork, and Kelley, 1994, for reviews of the literature on illusions of comprehension and remembering).

Interpretation and Elaboration. Focusing students' attention during lectures is a necessary but not sufficient condition for effective learning. Learning requires accurate interpretation and thorough elaboration. Interpretation occurs when new information fits with what is already known. For example, imagine attempting to memorize Figure 3.1 without knowing something about the data represented in the figure; memorization of the graph is quite difficult. Figure 3.1 represents the types of results one might obtain in a study examining the learning advantages of interpretive encoding. Level A represents learning after partial interpretation, Level B represents learning after full interpretation, and Level C represents learning after interpretation and elaboration. Once the additional information is known, the figure can be understood as showing that interpretation and elaboration lead to better memory than does interpretation alone and that

Figure 3.1. Interpretation Requires Prior Knowledge



complete interpretation leads to better memory than partial interpretation. An interpreted figure is one that is easily remembered. Indeed, any information that can be interpreted though associations with preexisting knowledge, schemas, or structures will be easier to learn than noninterpreted information.

Elaborative processing, and the closely related idea of encoding variablity (see Martin, 1968), requires that information be thought of in a number of different ways, that interconnections be made with other information, and that the implications of the information be considered. Elaborative processing and variable encoding allow students to apply what they learn during lectures to other contexts within courses, perhaps even to real-life situations. Elaborative processing deepens understanding, and processing information in a number of different ways results in more retrieval routes to the information. Students may fail to access their memory for a verbal statement made in lecture, for example, but succeed at accessing the visual information that was provided to support or illustrate that statement.

Generation and Retrieval Practice. Producing information, whether it is the information to be learned or the reproduction of information that has already been learned, is a powerful method of learning. The generation effect, which refers to the finding that producing information leads to better learning than being presented with that information, is one of the most robust findings in the experimental psychology literature (Slamecka and Graf, 1978). Generation effects have been shown for the solution to mathematical problems (Lawson and Chinnappan, 1994; McNamara and Healy, 1995), answers to trivia questions (deWinstanley, 1995; Peynircioglu and Mungan, 1993), reading comprehension tasks (Wittrock, 1990), and in multiple other domains. Even something as simple as producing a word from a fragment (for example, try to incorporate g-n-r-t-ng into your lecture) as compared to reading it in bold letters (for example, try to incorporate **generating** into your lecture) results in better learning of the precise wording of an answer (deWinstanley and Bjork, 2001).

Whereas *generating* refers to producing new information, associations, or interconnections from cues or partial information, *retrieval practice* refers to retrieving—from memory—information presented earlier. Retrieval practice has been shown to be a powerful learning tool (Cull, 2000; Bjork, 1988). Retrieving (successfully) at one point in time enhances the likelihood of recall later. An additional benefit of retrieval practice is that students become explicitly aware of when they do not know the answers to questions and thereby may spend more time studying the information outside a lecture (see Stone, 2000, for a review of calibration and self-regulated learning). In a report on one application of incorporating retrieval practice into lectures, Etkina (2000) also describes benefits to the instructor, such as becoming aware of what his or her students as a group do not know, enabling the allocation of more time to that information in future lectures.

Presenting Information to Engage Students in Effective Processing

Teachers can promote long-term retention of information presented in lectures by using strategies that require a high level of student engagement.

Spacing Repetitions of Information Within and Across Lectures. Spacing multiple opportunities to study, learn, and be tested on information over time is a powerful method of enhancing effective processing (see Bjork, 1979, and Dempster, 1988, 1996, for discussions of the educational implications of spacing phenomena). The spacing effect—that long-term recall is enhanced by distributing rather than massing the presentations of to-be-remembered information—is one of the most robust and general effects in experimental psychology.

Spacing effects also have been found outside traditional laboratory experiments and with intervals and materials that from an educational standpoint are more realistic than the relatively simple materials and condensed time frames that characterize most laboratory experiments. Bahrick, Bahrick, Bahrick, and Bahrick (1993), for example, manipulated the spacing of study sessions in the acquisition and long-term retention of foreign-language vocabulary items. In their study, they spaced their learning and relearning sessions at intervals of fourteen, twenty-eight, and forty-six days and found large advantages of spacing that endured as long as five years. Smith and Rothkopf (1984) found the content from statistic lectures was remembered better when the lectures were spaced over four days rather than massed on the same day. Spacing practice sessions also has been found to enhance the acquisition of complex skills (Shebilske, Goettl, Corrington, and Day, 1999).

Theoretically, spacing phenomena have proven complex to interpret, probably because several different types of processing dynamics may play a role in producing such effects. There is evidence, for example, that participants allocate more attention and effort to learn during a second study opportunity that occurs at a delay rather than immediately (Shaughnessy, Zimmerman, and Underwood, 1972). Other findings suggest that spacing study opportunities encourages variable encoding—that is, after a delay and intervening events, information is likely to be encoded in a somewhat different way than it was initially (Glenberg, 1979). Still other findings suggest that delaying the repetition of material to be learned induces study-phase retrieval processes that enhance later recall (Thios and D'Agostino, 1976).

In principle, then, spaced repetitions of key information within and across lectures should have multiple good effects on the efficiency and productivity of students' processing of that information. The findings cited suggest that compared to a massed repetition of a key concept or information, a spaced repetition has the potential to enhance attention, produce variable encoding, and induce retrieval practice. The prevailing practice by virtually all of us who teach, though, is to mass the coverage of a topic within a lecture or across lectures. From our standpoint as teachers, grouping lectures by content, or blocking or massing the coverage of a point within a lecture, seems eminently sensible, yet the research on spacing effects suggests that doing so is far from optimal in terms of students' learning.

In sum, instructors should consider structuring courses with information presented across a number of lectures and intervening unrelated topics. Structuring a course with spaced repetitions of information across lectures may seem disjointed, but the likely benefits of spacing presentations are large. At a minimum, the most difficult and central topics in a course should be covered more than once in a spaced manner and from more than a single approach.

Inducing Encoding Variability. Presenting key concepts from more than one standpoint and demonstrating the relevance of key ideas in multiple contexts have the benefit of encouraging encoding variability, which can enhance long-term retention and, especially, the generalization of knowledge. In principle, the combination of spacing and variation in the presentation of key concepts should enhance not only students' long-term retention of those concepts but also their ability to see the broader relevance of the concepts.

In an effort to maximize spacing and encoding variability, Robert Bjork once taught an honors introductory psychology course twice in one term. Up to the point of the midterm, the basic concepts of introductory psychology were covered using a textbook that adopted a history of psychology approach and emphasized the contributions of key individuals in the history of psychology, such as Pavlov, Freud, and Skinner. After the midterm exam, the basic concepts were covered again, this time using a textbook that adopted a brain mechanisms approach. The goal was to have key concepts come up in each half of the course (spacing) and from a different standpoint (variation).

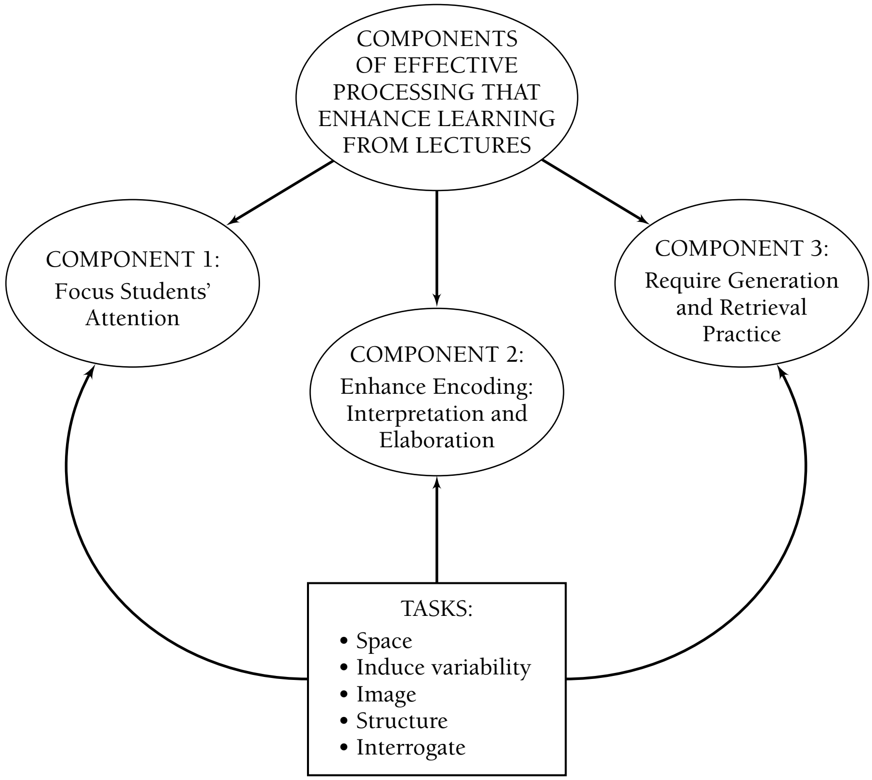
Whether students profited from that structure is difficult to say because there was no control group. From Bjork's perspective as the instructor, the students seemed to acquire a more sophisticated representation of the field, but that subjective judgment is probably of little value. In their evaluation of the course, the students had quite different reactions to the two halves of the course. They thought the first half of the course was okay, if not more than that, and they thought the second half of the course was terrific. Perhaps that evaluation was veridical, but it seems likely that had the course been taught again with the same materials but with the halves reversed, students would have preferred the historical approach half. That is, the first half of the course may have facilitated students' perceived ease of understanding and comprehension during the second half of the course, which they may have then misattributed to the instructor and the textbook used in the second half.

Providing Structure. Spacing repetitions of information applies to the overall structure of a course across several class meetings. In addition to this type of cross-lecture structure, one must think of the best way to provide structure within a lecture to facilitate learning (see Bower, Clark, Lesgold, and Winzenz, 1969, for a classic study demonstrating the benefits of presenting information in a way that activates existing knowledge structures).

One of the easiest ways to add structure to a lecture is to provide an outline. Kiewra and others (1995) found that taking notes on an experimenter-provided outline resulted in better notes, better performance on a relational test, and more ideas recalled from a lecture than did note taking without an outline. Outlines containing only headings and subheadings are maximally effective in that they encourage note taking, whereas outlines that provide too much detail inhibit note taking (Morgan, Lilley, and Boreham, 1988). Another way of adding structure is to provide a knowledge or concept map. Figure 3.2 is an example of a knowledge map of the information presented in this chapter. Hall and O'Donnell (1996) found that providing students with knowledge maps not only facilitated learning but also increased motivation and attention during learning. Even simply providing a title (or topic of focus) has been shown to facilitate allocation of attention during the processing of text by reducing the number of eye movements to previously attended material and by facilitating the processing of ambiguous words (Wiley and Rayner, 2000).

Such findings suggest that instructors can enhance student learning by making the topic of the day's lecture explicit and then providing an outline or knowledge map of the lecture. To optimize note taking, the outline or knowledge map should include the key words for each heading and subheading. Teaching students how to generate their own outline or knowledge map of the lectures is important, because additional benefits are realized when learners generate their own outlines. Foos, Mora, and Tkacz (1994), for example, found that students who generated their own outlines or study questions learned more from a lecture than did students who used materials provided by the experimenter (or instructor).

Figure 3.2. Knowledge Map



Researchers also have demonstrated that allowing students to listen during some or all parts of the lecture, deferring note taking until later, enhances students' learning (for an examination of the benefits of listening versus note taking during a lecture, see Aiken, Thomas, and Shennum, 1975; Hadwin, Kirby, and Woodhouse, 1999; and Morgan and Puglisi, 1982). Posting outlines in the library or on the Internet provides access to lecture information, allowing students to feel less anxious about deferring note taking during the lecture.

Using Visual Images, Mental Imagery, and Other Mnemonic Techniques to Enhance Effective Processing. Presenting visual images, encouraging the use of mental imagery, and engaging other mnemonic devices increases encoding variability. A mnemonic device is, by definition, anything that assists memory. Mental imagery has long been identified as a particularly effective mnemonic device (see Bellezza, 1996, for a review of the mnemonic literature with a section on the application to education). One way to encourage mental imagery is to enhance lectures with vivid examples; another is to instruct students in the use of a mental imagery technique, such as the method of loci, which has been shown to benefit the learning of orally presented text (Cornoldi and De Beni, 1991).

In addition to encouraging students to form interactive mental images, instructors can provide actual visual images, such as graphs, figures, pictures, slides, or films, to enhance learning (Pavio, 1986; Weaver, Cotrell, and Michel, 1985). Sedlmeier (2000) demonstrated that reasoning about probabilities benefited from learners' producing Venn diagrams or gridlike diagrams of probabilities. Along the same lines, Scevak and Moore (1998) found that providing learners with a map plus text, versus text alone, facilitated learning, provided that participants' attention was directed to the map through an active learning manipulation. It is perhaps optimal to provide access to complicated graphs and diagrams outside the classroom, because the burden on students to capture a complicated diagram or figure in their notes can detract from their ability to attend to what the instructor is saying.

Another method of increasing encoding variability is to provide learners with analogies (Donnelly and McDaniel, 1993; McDaniel and Donnelly, 1996). Bulgren, Deshler, Schumaker, and Lenz (2000) describe an easily learned routine for implementing analogical instruction during a lecture, requiring the construction of a table with the characteristics of the known concept (analogy), the characteristics of the new concept (target of instruction), and a list of shared characteristics. Note, however, that learning in a familiar domain may be interrupted by the use of analogies (Donnelly and McDaniel, 1993, 2000).

Even humor has been shown to be a mnemonic technique. Schmidt (1994) found that sentences written in a humorous style were remembered better than those same sentences written in a nonhumorous style. Kintsch and Bates (1977) found that extraneous comments made during a lecture (for example, jokes) were remembered better than topic statements, a result that suggests that if jokes are to be effective as a learning device, the material to be learned must be the focus of the joke.

Another useful mnemonic device is the strategic placement of enthusiasm to refocus students' attention on the lecture. Wood (1999) examined the effects of teacher enthusiasm on attention and encoding during a videotaped lecture. Enthusiasm was interjected during the entire lecture (uniform), only when important points were being made (strategic), or randomly. A control condition with low enthusiasm throughout the lecture was included. Only strategic interjection of enthusiasm resulted in better learning than the control condition, suggesting that the placement of enthusiastic comments is more important for student learning than the overall enthusiasm of the instructor.

Typical fifty-minute lectures—to say nothing of seventy-five-minute or two-hour lectures—can surpass students' ability to sustain focused attention. Including mnemonics, such as humor or strategic placement of enthusiasm, is particularly important during the middle of lectures when students may find it more difficult to sustain attention. One useful heuristic for the fifty-minute lecture is to lecture for twenty-five minutes; then—in order to energize students and refocus their attention—insert a five-minute demonstration, class exercise, or other mnemonic activity; and then lecture for the final twenty minutes.

Interrogating for Elaboration. Elaborative interrogation goes beyond simple questions and answers requiring students to explain the underlying reasons behind their answers. For example, a learner trying to memorize the following fact—*elaborative interrogation produces deep processing, thereby facilitating memory*—learns the fact better if required to explain why elaborative interrogation leads to deeper processing. Willoughby, Wood, McDermott, and McLaren (2000) demonstrated that students learned information better when they used elaborative interrogation as compared to evaluating experimenter-provided elaborations, regardless of whether they studied interactively in a group or independently. Students who studied in a group and listened to another member of the group's elaborations did not perform as well as the students who actually generated the elaborations. Thus, instructors incorporating evaluative elaboration into their lectures should ensure that all students have plenty of time to generate their own elaborations.

Sokoloff and Thornton (1997) employed a variant of elaborative interrogation, requiring students to predict the outcomes of physics experiments before being told the results. They found that making predictions helped students to overcome misconceptions about the physical laws being taught. Providing students with general rules and strategies for deep processing, such as elaborative interrogation, has been shown to benefit transfer of learning within the domains of algebra (Robertson, 2000) and physics (Dufresne, Gerace, Hardiman, and Mestre, 1992).

Posing real questions (as opposed to rhetorical questions) and ensuring that all students at least attempt to answer the questions is a simple way to make a lecture an active learning experience. When feasible, instructors can facilitate student learning by requiring students to answer questions during lectures, produce or modify an existing outline of a lecture, generate specific terms, and make predictions.

Conclusion

Lecturing has been criticized as ineffective relative to other methods of teaching that involve students as active participants in the learning process, not as passive observers. Lectures, though, are a fact of academic life. They are the most widely used method of teaching in colleges and universities (McKeachie, 1994) and likely—for practical and other reasons—to remain so.

Given that fact, it is incumbent on those of us who lecture to consider ways that the lecture can be made more conducive to learning. In this chapter, we have suggested ways to make the lecture a more effective setting for learning, given what is known about the fundamental properties of humans as learners. Lecture presentations need to trigger in students the types of processes known to enhance the encoding and subsequent retrieval of the information that is to be learned. The potential to invigorate the lecture, in our view, is limited only by our creativity and our commitment to our students.

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