

The Benefits Of Instructor Provided Notes

Inspiration

In pursuit of my degree at the Harvard Extension School, I recently took multivariable calculus during the fall term followed by linear algebra in the spring. Both courses had about 80 students and took place in the same room at the same time, Thursday nights from 7:30-9:30. Both classes were taught by the same instructor. These courses were similar in that they supported each other and the order in which you took them did not matter. Both classes were fairly demanding and produced about 15 pages of notes each class. Despite these similarities, I found the two experiences remarkably different.

In the multivariable class I found myself frantically copying board after board of dense math notes. I was often a board behind the instructor and I felt it was too late to ask for clarification regarding something that I did not understand or simply could not read. My notes were not accurate. I would skip some things in an effort to catch up and be able to pay attention to the lecture. My notes were incomplete. My method was to copy every word on the board because most of the material was new, making it difficult to judge what was important. My notes reflected no original thoughts, insight or connections.

The following spring, linear algebra was a totally different experience. The instructor supplied full lecture notes several days prior to each class. The notes were well organized, accurate, complete and had nearly everything that would be on the board in the next class. Reviewing the notes prior to each class familiarized me with the new material and terms as well as with what to expect in the upcoming lecture. I was also able to pinpoint some areas that the book and notes were unable to make clear, I actually had questions. It was not necessary to copy notes during the lectures, and I felt free to listen and think about the material as the instructor presented it. This increased attention allowed me to annotate my provided notes with thoughtful comments on the material. I found that I was even asking questions, and at times able to catch a mistake by the instructor. I felt I was learning during the lecture. I found these instructor notes indispensable for homework and test review.

Why were instructor notes not available in any of my past math classes? What could possibly be the downside to instructor notes? These were the questions I had in the spring I took linear algebra. I was curious what present-day research had to say about note taking and instructor provided notes in these types of math classes.

Introduction

This paper aims to bring together research around the use of instructor provided notes in the larger, lecture style math related courses offered at most universities. Introductory calculus and linear algebra are prime examples of such courses because these lectures are typically fast paced and cover large amounts of dense, technical material. These elements create a challenging note taking environment. Key background literature on the complex and cognitive nature of note taking is discussed providing some understanding of why many students produce inadequate lectures notes. While independent findings show that complete notes are essential for review and positively linked to performance, the research overwhelmingly agrees that students typically take poor notes. In search of a solution, this paper brings together what research has to say about providing students with instructor notes. Results indicate there are potential benefits to having instructor notes prior to lecture as well as during lecture. In addition, the research agrees that the strongest benefits are in having instructor notes for review.

The Lecture

The lecture is the most common teaching style the world over for adult education, (Bligh, 2000). In spite of some education research and technology advancements that have aligned against the lecture style as a teaching method, it has remained relatively unchanged. (Bligh, 2000; Luo 2016). “Lecturing” is in our nature; our conventions have lectures, sermons are lectures, and political speeches are lectures. The lecture halls of our universities are full of tradition as well as students. It is an economical way to educate many. Even in secondary education, where education reform is the strongest, the lecture has its place. A recent Harvard Study, using data from the 2003 Trends in International Mathematics and Science Study (TIMSS), found that 8th-grade students in the U.S. performed better on math and science standardized tests when more time was devoted to lecture-style instruction than to problem-solving activities in groups (Riddell, 2011).

Introductory courses such as calculus and linear algebra are typically offered as lecture-based courses because of their size. Lectures are likely to remain a dominate teaching style throughout our educational system, and they breed the need for comprehensive notes. Note taking is the most common way students record the lecture information in these courses for future review (Friedman, 2014). There are, however, some serious issues with note taking.

Problems With Note Taking

The research shows that most students fail to take down significant amounts of important information when taking notes (Wilkinson, 2012), noting little more than one-third of the important lecture ideas (Luo, 2016). In particular, math notes foster inaccuracies. Johnstone and Su report that inaccuracies in student notes occur most frequently when the students are copying diagrams, numerical figures, and equations (Johnstone, 1994). Review of inaccurate notes can only be detrimental. Strichart and Mangrum characterize student notes as “incomplete, disorganized, illegible, missing essential information, and cannot be used to recreate presented information” (Strichart, 1997).

The poor quality of student notes is more easily understood when one considers the complexity of the note taking process. “Students must listen to the lecture, select important ideas, hold and manipulate these ideas in their memory, interpret the information, decide what to record, and then write it down” (Stefanou, 2008). The ability to perform this type of mental juggling is often attributed to the students’ level of working memory (WM). Jarrold and Towse show there is a very strong correlation between WM and higher cognitive skills (Jarrold, 2006), and lecture note taking is considered to be a complex and cognitively demanding skill (Bui, 2013). Bui also argues that WM is critical for effective note taking because it allows the student to accurately rephrase what is said into more meaningful and personal notes.

Higher WM capacity students are able to adopt different note taking strategies more easily than lower WM students, resulting in higher quality notes (Friedman, 2014). Students with higher WM capacity are therefore able to benefit from both the notes they produce and the process of note taking. That is, they produce more complete notes for review as well as actually start the learning process while taking notes through the process of encoding.

“Encoding is the process by which a learner summarizes and integrates new knowledge with prior knowledge in order to make it individually understandable” (Faber, 2000).

Simply put, the encoding process that takes place during note taking is made up of the mental logistics involved in producing the thoughts to be recorded and the physical act of recording them. The fact that things are better remembered through the act of actually writing them is explained by the generation effect (Rabinowitz, 1986). Information is better remembered when it is generated in some way. One could generate the information by writing, as in note taking, or by talking if they were to tell someone the information. Slamecka and Graf consider generation an act of recall which is known for aiding memory (Slamecka, 1978). Encoding benefits are not realized when just listening to a lecture because there is no generation. Likewise, there is little encoding during verbatim note taking, because it is such a low cognitive process. The benefits of encoding realized by students who annotate or review notes in an active way will be discussed shortly, in the Annotation and Review sections of this paper.

Learning by the process of encoding and producing a set of notes are the two widely accepted functions of note taking identified by Sead more than 100 years ago (Armbruster, 1986). These benefits of note taking are commonly referred to as encoding and external storage (Armbruster, 1986).

Students with poorer WM simply do not have the cognitive ability required to take complete notes. They often resort to verbatim note taking, which offers shallower encoding benefits, because it requires little WM (Bui, 2013). Bui notes, “The relation between working memory and note taking can create a dire situation for individuals with lower working memory abilities who may be unable to take effective, organized notes.”

In addition, non-native English speaking students often struggle with the pace of lectures when taking notes as well as the inability to pick up on many verbal cues by the instructor (Lynch, 2011) to indicate something important. DeZure offers these examples of important instructor cuing phrases that students struggling with English may miss; “The four main arguments are...” or “A major development was...” (DeZure, 2001).

When looking for ways to improve the note taking skills of our students, it is reasonable to consider both note taking training as well as WM training.

Note taking skills are essential to every student’s educational and life skills (Wilkinson, 2012) but it is also a skill most students have to learn (Holliday, 1999). Despite its importance, note taking skills are rarely taught according to Wilkinson. We would do better by putting forth a more serious effort to implement such training in our secondary schools. Students should be introduced to different note taking strategies and techniques, early in their education. Grading notes or allowing open note quizzes

are ways to emphasize the importance of notes (Eades, 2007). Research shows training on note taking strategies and techniques is beneficial for students with low WM (Friedman, 2014).

Not so promising are efforts to improve the WM of students. WM training seems to offer only limited benefits and is expensive to implement (Redick, 2015). Jarrold and Towse conclude that WM training shows very mild gains on tasks that closely imitate the training itself but no advantage for academic achievement (Jarrold, 2006).

Instructor Notes

Given the overall poor quality of student notes, a way forward is to provide each student with a full set of instructor notes (Luo, 2016). In doing so, one must consider the downsides along with the benefits.

The loss of any encoding benefits while taking notes is one obvious downside to receiving instructor notes. Students able to take notes in a cognitive way do benefit from the encoding effect. Though these personal notes are often incomplete, they do have value in that students recall a higher percentage of their own notes than the instructors notes (Kiewra, 1985). This is attributed to the encoding effect mentioned by Kiewra above. It should be noted that encoding could have a debilitating effect in cases where students misunderstand lecture points and record false information. Overall, research shows the encoding effect of note taking is positive but modest. (Kobayashi, 2005).

Concerns that providing students with full instructor notes may diminish their attention or even attendance are founded and worthy of future research (Gee, 2011; Grabe, 2005). Some research has shown that students do, at times, use instructor notes instead of attending some lectures, but has found that this behavior does not affect the students' performance or achievement (Grabe, 2005). Instructors should inform students of the benefits of attending lectures and could even require attendance.

Finally, good listening and note taking are valuable life skills necessary for many professions. Stacy and Cain (Stacy, 2015) offer this example: "Without the valuable skills of listening and recording, students might fail to become competent practitioners who are able to listen, read, organize, integrate and utilize information in care of their patients." Is it right for an instructor to sidestep note taking by providing notes? When answering this question, one must consider the uneven playing field created by the differing note taking abilities of students as well as the overall poor quality of students

notes in general. The focus might be better directed at what works best to learn the math.

It should be noted that instructors may have professional concerns around the property rights of their notes. Though this may be less of a concern than providing full video lectures for a course, it is valid to consider this matter. Instructors create, test and revise their lecture notes over the course of years. Once perfected, these notes are a valuable asset. Instructors need assurance that sharing these notes will not just make them more replaceable.

It is reasonable to assume that most instructor notes, having been thoughtfully constructed and combed for accuracy over the years, are superior to student notes. They reflect more accurately the main ideas and material of the class (Kiewra, 1985). In general, they contain 100% of the lecture points as compared to only 35% contained in student notes (Luo, 2016). Providing instructor notes would benefit all students and could help level the playing field for the many students unable to produce a good set of notes. The three major areas in which instructor notes can influence learning are preview, note annotation and review.

Preview

The organization and completeness of instructor notes make them a good means to prepare for class. Previewing instructor notes will introduce the student to new terms, definitions and formulas as well as their applications. This familiarization allows the student to be more attentive to the class discussion (Maida, 1995). To some extent, the lecture becomes the second time through the material and preview gives the student a basis of what to listen for. Previewing instructor notes also gives the students the chance to jot down initial questions.

It should be mentioned that some lessons are better taught when the students do not have preconceived notions of the material. Maida and Paula say that in some situations, it is better to learn by discovery. They cite a lesson where the students learn the concept of pi in this way (Maida, 1995). 'A-ha' moments are less impressionable when the punch line is already known. In such cases, instructors may simply offer supplementary notes following these lecture sections.

Annotation

Instructor provided notes free the student from the burden and mental juggling required by note taking. This freedom, in turn, leaves cognitive resources available for attending to the lecture, thinking about what the instructor is saying and making connections with prior knowledge (Stefanou, 2008). Students may now benefit from the encoding effect of annotating the instructor notes with these thoughtful ideas (Grabe, 2005). In part, making up for encoding benefits forfeited by not taking notes through the lecture. In addition, annotating the instructor notes will help personalize them.

Advances in technology add a new dimension to annotating instructor notes. Mobil devices such as tablets with note taking applications (apps), allow students to import and annotate instructor notes as PDFs with digital handwriting. While note taking with computers has long been an option in many subjects, math has had to wait for this handwriting technology. Handwriting is the only real option for notes that involve graphs, equations, numbers, shapes and symbols. Because handwriting allows this flexibility, most college students prefer it over typing (Luo, 2016). Math note takers are confined to handwriting, so it should be comforting to know that recent research confirms the encoding benefits of handwritten to typed notes (Mueller, 2014).

Note taking apps permit students to write and draw upon PDFs. Annotations can be made in any color and even resized and moved to fit where needed and editing is easy. Note taking apps allow students to annotate their instructor notes in a cognitive and personal way (Stacy, 2015). Many note taking apps are reviewed in 'Comparison of note taking software' on Wikipedia.

Review

The most important function lecture notes serve is their use for review (Wilkinson, 2012). Wilkinson notes; Students who reported high and moderate levels of note review scored significantly higher on math posttests than those students who reported little to no review of notes. In fact, students who reviewed their lecture notes performed better on performance test than students who did not review the notes in 24 studies conducted by Hartly and Kiewra (Kobayashi, 2005). Simply, students who review their notes have higher achievement on performance-based assessments than those who do not review (Armbruster 1986).

While it is hardly surprising that studying personal notes leads to better achievement, it does raise the question; How would instructor provided notes affect achievement? A study by Kiewera (Kobayashi, 2005) showed better achievement on delayed tests of factual knowledge for students reviewing instructor provided notes than for students reviewing their own notes. In fact, a study by Knight and McKelvie showed that students who did not even attend a lecture but reviewed instructor provided notes prior to a delayed test scored significantly higher than the students reviewing their own notes from the lecture (Knight, 1986). These results are due to the superior completeness, accuracy, and organization of the instructors notes (Eggert, 2001). The research suggests that the true value of notes lies not so much in the taking of good notes as in the having of good notes for review (Kiewra, 1985). The superior quality of instructor notes enables the student to get the most out of the review process.

While students have different study habits, research generally supports the following recommendations:

- Revise your notes and annotations during lecture pauses or soon after class: Luo, Kiewra, and Samuelson refer to revision as the missing link between note taking and the review of notes (Luo, 2016). Revision leads to more complete notes by cuing. When students review their notes and annotations during pauses or soon after the lecture they are cued by what they have noted to additional points that were not recorded (Luo, 2016; Wilkinson, 2012). Note taking apps allow for easy and very creative revision of instructor notes. This is especially true when margins are small and annotations must be resized.
- Review your notes within 24 hours: Retention drops after 24 hours and you are relearning material rather than reviewing it (Wilkinson, 2012).
- Review frequently for shorter intervals: Long-term memory of material is improved by spacing out study sessions over a longer period of time. (Winerman, 2011).
- Review actively: Practices such as self-testing and summarizing are more valuable than the passive practice of rereading notes (Friedman, 2014).

Instructor's Role

The instructor plays a key role in making the class a successful learning experience for all the students. In respect to this study, the instructor is the designer of the notes provided to the students. It is paramount that these notes be organized, accurate and complete. In addition, the instructor controls many aspects of the lecture that influence the quality of notes and annotations of the students. Lecture qualities that lead to better annotations and notes taken by students are:

- Organized ideas and lecture flow which follows provided notes.
- Clear and legible presentation.
- Lecture pace: A lecture pace should allow students the opportunity to process lecture points and ideas for recording in their notes. The relative pace is slower and more comfortable for students using instructor notes than for students taking their own notes (DeZure, 2001).
- Lecture pauses: Revising or taking notes during lecture pauses has been shown to be more effective than waiting until after the lecture (Luo, 2016; Grabe, 2005; DeZure, 2001). Pauses do not have to be long to be effective and can be used to break the lecture into separate learning segments.
- Cuing: Cuing is considered one of the most successful methods for alerting students to important lecture points and ideas (DeZure, 2001). Visual cuing as well as verbal cuing helps students unfamiliar with the lecture material gauge the relative importance of new material.

Summary

Many students do not or are simply unable to take complete notes during lecture. This is especially true in fast-paced lectures with dense material such as introductory calculus and linear algebra classes. Insisting that students make due with their note taking abilities comes at a high cost. Students are distracted from the lecture by the demands of note taking and also end up with poor notes for review.

The research shows that review of complete notes is the most important factor contributing to student success on achievement tests. Providing instructor notes ensures that all students have complete notes for review. Given this opportunity, achievement is more squarely placed in the students' hands.

Use of instructor provided notes is voluntary, leaving any student free to continue note taking practices that have been successful for them in the past. Instructor notes may, however, be used in the ways students see helpful. Students can prepare for a lecture by previewing instructor notes. During a lecture, students are free from the burden of extensive note taking and are more able to annotate instructor notes in thoughtful, cognitive ways. Finally, students benefit most from the review of complete, accurate and organized nature of instructor notes.

Future Research

Little research has been published on note taking in mathematics classes. It would be helpful if more study was devoted to the unique challenges presented when note taking involves graphs, pictures, numbers, formulas, integrals, matrices and the like. In particular, some research should be conducted on the causes and consequences of inaccurate note taking in mathematics classes.

Annotating provided notes is another area sparsely studied. Research should study the style and quality of annotations, made by students, to instructor notes. The annotations made by students with low working memory capacity would be especially interesting.

Finally, research should focus on how and to what effect students are using new digital handwriting technology for note taking in mathematics classes. Digital handwriting technology has only recently become available for mobile devices marking the first time in history math notes can be taken without pencil and paper. Ironically, instructors know little about this technology leaving students to pioneer how to put it to best use.

References

Armbruster, B. B., Illinois, U. O., Bolt, Beranek, & Newman, Inc, National Institute, O. E., & Anderson, T. H. (1986). *The value of taking notes during lectures* / Thomas H. Anderson, Bonnie B. Armbruster

Bligh, D. A. (2000). *What's the use of lectures?* (1st [Jossey-Bass] ed., 1st U.S. ed. ed.). San Francisco: Jossey-Bass.

Bui, D. C., Myerson, J., & Hale, S. (2013). Note-taking with computers: Exploring alternative strategies for improved recall. *Journal of Educational Psychology*, 105(2), 299-309.

Chen, P. (2013). The effects of college students' in-class and after-class lecture note-taking on academic performance. *The Asia-Pacific Education Researcher*, 22(2), 173-180.

DeZure, D., Kaplan, M., & Deerman, M. A. (2001). Research on student notetaking: Implications for faculty and graduate student instructors. *CRLT Occasional Paper*, (16)
Di Vesta, F. J., & Gray, G. S. (1972). Listening and note taking. *Journal of Educational Psychology*, 63(1), 8-14.

Dündar, S. (2016). Does writing have any effect on mathematics success? *Journal of Education and Training Studies*, 4(1), 1-10.

Eades, C., & Moore, W. M. (2007). Ideas in practice: Strategic note taking in developmental mathematics. *Journal of Developmental Education*, 31(2), 18-26.

Eggert, A. (2001). An investigation of note taking as a predictor of course performance and course evaluation. (Ph.D., University of Tennessee). (Dissertations & Theses: Full Text database. Publication No. AAT 3022721)

Faber, J., Morris, J., & Lieberman, M. (2000). The effect of note taking on ninth grade students' comprehension. *Reading Psychology*, 257.

Friedman, M. (2014). Notes on note-taking: Review of research and insights for students and instructors. (Harvard Initiative for Learning and Teaching". Harvard University.

Gee, K. (2011), Rogers R., Felton M. and Laraway S.(Eds.), The impact of instructor-provided lecture notes and learning interventions on student note taking and generative processing.

Grabe, M. (2005). Voluntary use of online lecture notes: Correlates of note use and note use as an alternative to class attendance. *Computers & Education*, 44(4), 409-421.

Hembrooke, H., & Gay, G. (2003). The laptop and the lecture: The effects of multitasking in learning environments. *Journal of Computing in Higher Education*, 15(1), 46-64.

Holliday, W. (1999). Teaching note taking. science scope, [Retrieved from Education Research Complete database. (Accession No. 21378528)] *Science Scope*, 23(1), 16.

Jarrold, C., & Towse, J. N. (2006). Individual differences in working memory. *Neuroscience*, 139(1), 39-50.

Johnstone, A. H., & Su, W. Y. (1994). Lectures- a learning experience, education in chemistry, 31 (1), 75-76, 79. *Education in Chemistry*, 31(1), 75.

Kiewra, K. A. (1985). Providing the instructor's notes: An effective addition to student notetaking. *Educational Psychologist*, 20(1), 33-39.

Kiewra, K. (1989). A review of note-taking: The encoding-storage paradigm and beyond. *Educational Psychology Review*, 1(2), 147-172.

Knight, L. J., & McKelvie, S. J. (1986). Effects of attendance, note-taking, and review on memory for a lecture: Encoding vs. external storage functions of notes. *Canadian Journal of Behavioral Science*, 18, 52.

Kobayashi, K. (2005). What limits the encoding effect of note-taking? A meta-analytic examination. *Contemporary Educational Psychology*, 30(2), 242-262.

Luo, L., lluo@huskers.unl.edu, Kiewra, K., & Samuelson, L. (2016). Revising lecture notes: How revision, pauses, and partners affect note taking and achievement. *Instructional Science*, 44(1), 45-67.

Lynch, T. (2011). Academic listening in the 21st century: Reviewing a decade of research. *Journal of English for Academic Purposes*, 10(2), 79-88.

Maida, P. (1995). Reading and note-taking prior to instruction. *Mathematics Teacher*, 88(6), 470-73.

Mueller, P. A., & Oppenheimer, D. M. (2014). The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science*.

Pardini, E. A., Domizi, D. P., Forbes, D. A., & Pettis, G. V. (2005). Parallel note-taking: A strategy for effective use of web notes. *Journal of College Reading and Learning*, 35(2), 38-55.

Peeverly, S. T., Ramaswamy, V., & Brown, C. (2007). What predicts skill in lecture note taking? *Journal of Educational Psychology*, 99(1), 167-180.

Redick, T., Shipstead, Z., Wiemers, E., Melby-Lervåg, M., & Hulme, C. (2015). What's working in working memory training? an educational perspective. *Educ Psychol Rev* (2015) 27, 27, 617.

Riddell, J. B., Schwerdt, G., & Wuppermann, A. C. (2011). Harvard study shows that lecture-style presentations lead to higher student achievement. *Education Next News*.

Stacy, E., & Cain, J. (2015). Note-taking and handouts in the digital age.

Stefanou, C., Hoffman, L., & Vielee, N. (2008). Note-taking in the college classroom as evidence of generative learning. *Learning Environments Research*, 11(1), 1-17.

Wilkinson, G. A. (2012). The impact of structured note taking strategies on math achievement of middle school students. (ProQuest LLC. ProQuest Llc, ProQuest LLC.) 789 East Eisenhower Parkway, P.O. Box 1346, Ann Arbor, MI 48106. Tel: 800-521-0600; Web site: <http://www.proquest.com/en-US/products/dissertations/individuals.shtml>)

Winerman, L. (2011). Study smart makes the most of your study time with these drawn-from-the-research tips. *GradPSYCH Magazine*, (November), 25.