AC 2012-5140: THE EFFECT OF STUDENT NARRATION ON SENIOR-LEVEL ENGINEERING CLASSES

Lt. Col. Donald William Rhymer Ph.D., U.S. Air Force Academy

Donald Rhymer is an Assistant Professor and the Deputy for Curriculum in the Department of Engineering Mechanics at the U.S. Air Force Academy in Colorado. He is a 1995 graduate of the academy with a bachelor's of science in engineering mechanics and holds both an M.S. and Ph.D. in mechanical engineering from the Georgia Institute of Technology. He has taught mechanical engineering for more than five years at the Air Force Academy and while his graduate research and teaching emphasis is in the mechanics of materials, he has just as high a passion for excellence in education. His wife Dawn is a 1997 graduate of the academy, and they raise five children. In his free time, Rhymer runs the falconry program at the Air Force Academy.

Dr. Richard T. Buckley Ph.D., U.S. Air Force Academy
Dr. Daniel D. Jensen, U.S. Air Force Academy

Dan Jensen is a professor of engineering mechanics at the U.S. Air Force Academy where he has been since 1997. He received his B.S. (mechanical engineering), M.S. (applied mechanics), and Ph.D. (aerospace engineering science) from the University of Colorado, Boulder. He has worked for Texas Instruments, Lockheed Martin, NASA, University of the Pacific, Lawrence Berkeley National Lab, and MSC Software Corp. His research includes design of micro air vehicles, development of innovative design methodologies, and enhancement of engineering education. Jensen has authored approximately 100 papers and has been awarded more $2.5 million of research grants.

The Effects of Student Narration on Senior Level Engineering Classes

Abstract

Narration (having students read text aloud, recite the main points, followed by thinking about the implications of the points) has been shown in many cases to develop deeper, more critical thinking in students at the K-12 level. Significant research in this area has not been accomplished at the college level where, particularly in engineering, textbooks are used by students primarily to solve problems in a rote manner, not to aid their overall understanding of how to solve problems or give them a background as to the beneficial applications of solving problems. By asking senior students in an instrumentation mechanical engineering class at the Air Force Academy to narrate, recite, and reflect on a pertinent engineering text in class, the authors hypothesized that students would demonstrate an increase in conceptual understanding of course material. Additionally, the authors believed the students' perception of the narration method might have an impact on the technique's success. Thus, the study, using two control classes and two research (narration) classes, investigated whether performance was impacted by the incoming GPA of the student, participation in the narration condition, and the students' overall qualitative impression of the narration technique's perceived benefits.

In comparing performances on conceptual exam questions covering material introduced via student narration in the classroom, the narration students performed more poorly than the control group students who did not narrate. Because the narration group began with lower GPAs on average, we used GPA as a covariant; however,, the means were still significantly different, with the research group scoring an average of 5.8% lower across two exam sets of questions ($p = 0.028$). The qualitative data also suggest a less than positive impact of using narration; the students' opinions of the narration became more negative as the semester progressed. Specifically, as the semester progressed the students had less faith that narration would aid their learning, with many believing that having the instructor cover the material would be as good or better than using narration. While it may seem counter-intuitive based on the above results, we are continuing our investigation of the incorporation, but will increase the use of narration time per lesson so that it more closely matches previous research where the results were more positive. This follow-on work has also begun honing assessment exam questions to more closely correlate with concepts targeted using narration, and ensuring instructor emphasis in teaching the concepts is controlled (equivalent emphasis whether using narration-discussion or traditional instructor lectures). While still preliminary, the initial results from implementing these changes have indicated the largest learning increases for narrating students, followed by smaller increases for students participating in post-narration discussion over those not participating.

Background

Narration is defined here as the practice of a student reading a passage of text, summarizing the key points, and concluding key thoughts from the text. It has shown to be successful at the K-12 levels at developing not only learning but personalizing the learning for the student[1]. The use of narration as the primary pedagogical method in elementary education was instituted by Charlotte Mason[1] (1842-1923). She was a 19th century school teacher from England who developed principles of education and psychology that eventually founded a college and system of education based on the practice and

"art" of narration. Specifically, she had her elementary and secondary students read portions of text and then tell or retell portions of what they read back to the class and teacher. Not only would the students retell the information, they would also state conclusions and points of application that could be made from the information. She called narration the "act of knowing", such that by retelling the information in the students' own words and having the students' own conclusions formulated, the material would not only be internalized but personalized[1].

Our current research question is whether implementing students' narration of key passages in an engineering class at the college level can deepen such student conceptual learning. Narration continues to be used at the K-12 level, but the literature is silent on its impact at the college level, where lecture-based instruction is the norm. Success of college-level narration could not only positively alter the way engineering is taught, but students could change their attitude about the course text as well as improve their depth of understanding of the material.

Deep, conceptual-level learning is difficult and the oft-used remedy at many colleges to keep students interested and active in a specific class is typically to give more assignments or graded events. By scheduling quizzes, preflights, and prelabs in between the major exams and labs, the faculty seek to lengthen/deepen the attention span in their subject, keep the interest high, and hope learning and the respective grades are high. And while students will naturally spend more time for a given course with more graded events, this at best leads to more procedural knowledge (i.e. how to solve problems), especially in engineering. Further, by focusing their time on assignments, students spend less time in reflection over the course material, which is unfortunate because reflection is more likely to lead to depth in conceptual understanding and critical thinking about the material[2, 3].

Evidence that the traditional collegiate-level strategies are not successful in developing deep, critical thinking in college students has been making national headlines. The recently published "Academically Adrift" by Arum and Roksa[4] concluded that colleges and universities graduate students with no significant increase in critical thinking. Meanwhile, over the past few decades, the author cites that average GPAs are on the rise. Albeit critical thinking isn't the only lens to view success (nor is the Collegiate Learning Assessment used in "Adrift" insulated from criticism), this book and others book put academia on notice about a paradigm needing change and perhaps confirmed what many have suspected: our graduates are not as sharp as they should be.

Within the engineering education community, recent studies[5] suggest that the courses that emphasize (and reward) the association of problem identification with equation use don't lead to students with deeper conceptual understanding. In addition, using a "rich learning environment" with multi-media conducive to multiple learning styles doesn't seem to solve the issue either. Taraban et al.[6] showed that teaching thermodynamics through a combination of text readings, listening to narration, and using computer-simulations and solved-problems through software doesn't lead to deep cognitive understanding (although it does increase cognitive activity). Jensen et al.[7] showed that use of multi-media in demonstrating conceptual understanding in introductory engineering is helpful, however it can be extremely instructor dependent.

When Charlotte Mason began her style of education in the late 19th century, it was based on treating students (K thru 12) as people who needed to experience their education as part of an atmosphere (or their surroundings), as a discipline of good habits, and the idea that everything learned was a part of interpreting life (not just memorization of facts). Her methods involved using actual novels and books

instead of a disjointed textbook, and the narration process was the primary method used in the classroom.

While the approach may seem overly simplistic, J.C. Smith concluded Mason's narration technique has proven profitable for "spatial memory" (basically creating a vehicle for cognitive mapping) and sequencing at the 4th grade level and for improving writing at the middle school level[8]. His conclusions were that narrating is a natural learning device that "increases the opportunity for children to digest the knowledge" without "trying to find the answer the teacher wants."

The premise of the current research is that such a learning tool doesn't only have benefits at the elementary and secondary levels. And as Smith also points out, narration allows students to personalize the information as they experience it, rather than regurgitate it. While some might call this method at the college level too much "hand-holding", it will actually force the students to learn to actively read the text at a deeper level by developing their ability to pull the major points from the readings. Implementation of narration could reap greater benefits in deep learning than additional "plug-and-chug" assignments would produce.

Research Overview

The goal of the present study was to investigate the impact of adding narration-based discussion to the beginning of some class periods on student conceptual exam question performance. Specifically, we compared students' conceptual understanding of course material between a research group using narration with a control group who received traditional lecture-based lessons. Additionally, the students' subjective impressions of narration, were captured, as we recognized the potential for students to resist new pedagogical techniques[9].

All four class sections of the senior level engineering course "EM 460: Experimental Mechanics" at the Air Force Academy were used in the research, involving 52 students. Two of sections, involving 22 students, were used as the research group, while the remaining 2 sections comprised the control group totaling 30 students. Two instructors taught the course, each having 1 research group section and 1 control group section, in order to isolate any instructor-specific impact. For the control group, both instructors taught their class using traditional lecture (narration was not used nor directly referred to during class time.) Note that the key conceptual sections of the text were still referred to in the control group classroom, where a main point of the author would be highlighted by the instructor and the students would be asked to draw conclusions. However, per the aforementioned definition, the students did not participate in narration. The research sections used narration for 3-5 minutes at the beginning of approximately half of the lessons, primarily during the first half of the semester (the course focused on project work toward the end of the semester).During narration, the randomly chosen student read the portion of the text aloud, concluded his/her own main thoughts about what was read, and discussed these points with the instructor/rest of class.

Time of day was controlled, as Instructor A's morning section was the control group while his afternoon section was his research group. The opposite was the case for Instructor B, with his morning section being the research group and his afternoon section was his control group. Incoming GPA was recorded for each student for possible correlation to student success.

Students were informed that 5% of the course points were based on the student's proficiency of narration throughout the semester in order to motivate effort. Effectively all students who participated

with reasonable effort were deemed proficient and no student grades were ultimately changed significantly based on their actual narration and summarization of the information.

Because executing narration was expected to be unfamiliar to students, and such unfamiliarity often causes stress and anxiety, the first two classes of the semester were used to give some explanation of the narration technique and the grading criteria, as well as a demonstration and practice with no grade impact. Beginning on lesson 3 students' scores were recorded. Further, in order to increase student control (a factor associated with positive coping with stress), each student was allowed one "free pass", i.e. one opportunity to not participate in narration during the semester without penalty.

Assessment

To test conceptual knowledge, there were two exams given in the course. Each exam had some open-ended questions that were conceptual in nature and that had been introduced to the students via narration and subsequent discussion in the research group, or taught via traditional lecture for the control group. Performance on these questions, rather than overall exam performance, was used in the analyses.

In order to determine the impact of narration on student perceptions, subjective feedback was collected from the students at the beginning and toward the end of the semester. In order to ensure anonymity, there was no tracking of which specific student had what perception(s). The questions were:

1) *Do you believe the incorporation of narration will help / has helped your learning of the course material? (strongly agree / agree / disagree / strongly disagree) Please explain.*
2) *Do you believe the incorporation of narration will provide / provided useful background for your mini-labs and labs? (strongly agree / agree / disagree / strongly disagree) Please explain.*
3) *Do you believe the incorporation of narration will provide / provided useful background for your Project Test Plan? (strongly agree / agree / disagree / strongly disagree) Please explain.*
4) *Do you feel comfortable participating in narration during class? (strongly agree / agree / disagree / strongly disagree) Please explain.*

Results

Conceptual Learning

Scores on the conceptual portion of both exams were compared between the narration and control groups. A review of incoming GPA showed that, while not significant ($p = 0.099$)the overall narration group GPA was lower than the control group's; thus, we included GPA as a covariate in the analysis. A 2 (group) x 2 (exam) ANCOVA resulted in a significant main effect for group, $F(1) = 4.96$, $p < 0.03$, with the control group scoring higher than the narration group. There was a trend for a main effect of exam, with the students overall performing worse on the second exam, $F(1) = 3.71$, $p<.06$, and there was no interaction. See Table 1 for unadjusted and adjusted means.

When comparing the different instructors and morning vs. afternoon class offerings, there were no statistically significant differences. The only other significant difference in group performance occurred with strong students (those with an incoming GPA at/above 3.0) outperforming weaker

students (below 3.0). However, this would be expected and this effect was accounted for by including GPA as a covariate in the ANCOVA results already discussed.

Table 1. ANCOVA Results for Exam Scores Including Incoming GPA Adjustment

Raw Exam Averages			
	Control Group (No Narration)	**Research Group (Narration used)**	**Overall**
Exam 1	**88.9%**	**83.3%**	86.6%
Exam 2	**85.1%**	**76.9%**	81.7%
Overall	87.0%	80.2%	84.1%
Adjusted Exam Averages (using Incoming GPA as covariant)			
Exam 1	**88.5%**	**83.9%**	86.6%
Exam 2	**84.7%**	**77.6%**	81.7%
Overall	86.6%	80.8%	84.1%
P=Value on Differences	**P=0.0282 on difference between Adjusted Control and Research Group Exam Averages**		

Subjective Student Opinions

The feedback from the student opinions of the effects of narration were collected on the 3rd lesson of the semester (denoted as pre-semester) and on the 21st lesson (mid semester), following the first exam. It should be noted that while there are 40 total lessons in the course, the last 10 were used as final project work time, thus there were only 30 true lessons of lecture. The answer range to each of the questions (strongly agree, agree, disagree, or strongly disagree) were given numerical weights of 3, 1, -1, and -3, respectively, and the answers to each question were averaged.

Table 2 summarizes student opinion results. For all questions, students showed a decrease between pre- and mid-semester. Overall, they began the semester with a moderately positive impression (averages less than 1 but above 0.5) of how narration might help them learn and prove useful for class assignments, and they did not seem trepidatious about using the technique. By mid-semester, while still slightly positive about narration's ability to help them learn, they became slightly to moderately in disagreement with the perception that narration would help with the labs and project, respectively. However, they remained comfortable participating in the narration activities.

Most students also filled in comments with these surveys. In looking for the reasons why students agreed or not as to whether it would help them understand the material better, (Q1), even some students who checked "agree" reported feeling that it would have been just as helpful to have the teacher just teach the material, with more indicating this sentiment on the second survey. Specifically, out of the 19 narration group students returning the pre-semester surveys, 4 of them (21%) had a negative belief about the methods benefits in learning the material, with 2 of the 4 stating specifically they thought their instructor could help them learn better using traditional lecture methods. Of the 15 who responded positively, there was 1 student stating a caveat to his "Agreeing that narration would help" with a comment that their instructor would do it just as well. Thus, one could state that at the start there were 5/19 (26%) who would prefer a traditional classroom lecture to narration for key concepts.

Table 2. Average Student Opinion Feedback on Perceived Value of Narration

	Students chose between: Strongly Agree (weighted value = 3), Agree (weighted value = 1), Disagree (weighted value = -1), or Strongly Disagree (weighted value -3)		
	Pre-Semester Average	Mid-Semester Average	Shift During Semester
Q1: Do you believe the incorporation of narration will help / has helped your learning of the course material?	0.8	0.33	-0.47
Q2: Do you believe the incorporation of narration will provide / provided useful background for your mini-labs and labs?	0.72	-0.375	-1.095
Q3: Do you believe the incorporation of narration will provide / provided useful background for your Project Test Plan?	0.92	-1.26	-2.18
Q4: Do you feel comfortable participating in narration during class?	1.66	1.33	-0.33

On the mid-semester surveys, (N=17) there were 6/17 (35%) who indicated a negative view of narration's benefits to conceptual learning, with 3 of the 6 specifically stating a preference for an instructor's emphasis/explanation of the concepts over narration, and 1 of the 6 stating that narration wasn't incorporated for a enough time to be beneficial. Of the 11 positive responses on narration's perceived benefits, 3 also stated the caveat that they didn't think the benefit was better than the traditional instructor lecture. So, by mid-semester, 9/17 (53%) of the narration students indicated some preference for the traditional lecture over the narration-based instruction, which almost doubles the impression they had on the pre-semester forms. However, it is also important to note that a large percentage of students remained positive about the technique, stating comments such as "Emphasizes key points in reading and guides analysis of said points", "It helps to dig into the materiel more, help understand the vocabulary and concepts", and "It's nice hearing them out loud and thinking about them".

Conclusions

It seems clear that the initial manner and context by which we incorporated narration led to no substantial learning benefit. More specifically, statistically there is evidence that narration might have been a hindrance to exam performance compared to a traditional instructor-led lecture. In addition, the subjective student opinions suggest that approximately half of the research group would have preferred the instructor to simply introduce the material and explain it themselves rather than have a student

narrate. However, there is still promise that the narration approach can be beneficial, particularly in considering other factors that might have influenced the results.

One factor is the relative benefits for those students who actually participated in the narration compared to those students who listened to the narration. It is possible that the act of narration is what leads to the deeper and more conceptual learning, because it is the directly participating student who is put "on the spot" to read and process the material. Those not narrating would be similar to students passively listening to a traditional lecture. Unfortunately, precise tracking of which student narrated which concept was not recorded, and thus, we are not able to specifically compare performance of those narrating versus those listening to specific concepts. However, a subsequent study is underway in a different engineering course in which narration, discussion participation, and non-participation is being tracked for each concept. First, quiz performance shows scores increasing as level of participation shifts from simply listening, to joining in discussion, to leading the narration.

Second, in the narration case, the listeners received information from a novice rather than an experienced instructor, which might decrease their understanding of the concepts when compared to the students in the control group. While the instructors guided the narration process and made sure that the concepts were ultimately presented accurately, if listeners were not actively engaged in the process but were simply waiting for a concise statement of a concept, then the narration use of class time would be less beneficial.

The less efficient use of class time also might have led to the observed shift in student opinion about the narration process, which might in turn have further disengaged the students, leading to a vicious cycle of decreased engagement. More specifically, a commonly reported tendency is for students to "tune out" when other students ask questions or are responding to a question from an instructor. So, even before much experience with the activity, some students would be less likely to participate, and thus, learn less during the activity. As time went on and more students came to believe that the time would be better spent having the instructor explain the material, more students would be likely to disengage, and benefit less during those portions of class time. Not all students reported negative opinions, and both instructors reported that some of the other students in the class seemed to attend to the student who was narrating and actively participate in the discussion following the initial narration. However, the significant difference in performance could have been caused by an increase in the number of students who didn't engage. Because the feedback forms were anonymous, we were unable to determine if opinion about narration correlated with performance.

Another possible conclusion is that narration wasn't used extensively enough to have a significant impact. Even one student observed that we didn't spend enough time narrating for them to tell if it helped. Smith's dissertation on Charlotte Mason's use of narration showing its positive impact stated that it was used pervasively for large portions of class time[8]. However, in our implementation, the narration activity and follow-on discussion rarely lasted for more than five minutes during each class, with only one or two students narrating each time (rotated across the semester). So while conceptual exam questions were directly tied to subjects narrated, it is plausible that a few minutes narrating are not enough time to have any true impact on the student's learning. In the above-mentioned follow-on study, the time spent focused on narration and follow-on discussion has increased, which might explain the initial positive impact on quiz grades.

Finally, there is likelihood that the assessment method was not adequate to highlight narration's effectiveness. While the exam was intended to test concepts discussed in class (narrated or not) the

exams were also open book and open note. Further, 5 of the 11 conceptual questions asked across the two exams could have been answered fairly easily by simply finding and copying the answer from the text rather than requiring the student to synthesize and make their own conclusions. Thus, the questions actually may have been assessing the ability of a student to search and find the answer rather than testing the students' conceptual understanding. Once students realized that many of the exam questions did not require high-level conceptual understanding, they might have been even less enthusiastic about the more effortful narration technique for learning.

Lessons Learned and Recommendations for Future Work

Narration must form a significant portion of a class period as the main means a teacher uses to introduce material to students (as classically done by Charlotte Mason and today's Ambleside K-12 schools) in order to lead to deeper conceptual learning. Narration used only sparingly in a primarily lecture-based, technical course is not beneficial especially if assessments do not obviously require conceptual understanding.

Our data also suggest that the students' perception of the narration method might have had a significant impact on the method's success. It is difficult to mitigate this effect. However, the aforementioned point of spending more time narrating (be it longer sections, or more time spent discussing the points resulting from narration) and more obvious alignment of conceptual thinking expectations on exam questions are likely to assist in the student's appreciation of the benefits of narration. The follow-on narration study has made this change with post-narration quizzes.

Finally, an instructor's skill at guiding the narration is important. While the process of the student narrating and summarizing the information guides itself for the most part, in order for the rest of the class to benefit from the student's narration and conclusions, the instructor must be able to draw out the "so what?" and engage the other students.

The authors believe that narration can be beneficial, rather than a hindrance, to college-level learning. However, as with any pedagogy, time and practice with the method, both for the instructor and students, are crucial for its success, and the assessments used to measure such success must be scrutinized with great care.

Acknowledgements

We acknowledge the support of the Directorate for the Scholarship of Teaching and Learning (SOTL), in particular, Dr. Lauren Scharff, whose insight proved invaluable at all stages of this work. Additionally, the authors acknowledge the Department of Engineering Mechanics at the U.S. Air Force Academy, where cadet learning is the primary focus. Any opinions, findings, or recommendations are those of the authors and do not necessarily reflect the views of the sponsors.

1. Mason, Charlotte. Home Education. (Tyndall House ed.) Wheaton, Ill: Tyndall House Publishers, Inc. 1935.

2. Watkins, K., and Marsick, V. Sculpting the Learning Organization: Lessons in the Art and Science of Systemic Change. First Edition. Jossey-Bass, Inc. 1993

3. Loh, B. "Using Articulation and Inscription as Catalysts for Reflection: Design Principles for a Reflective Inquiry." Doctoral Dissertation. Northwestern University. Evanston, IL, 2003.

4. Arum, R. and Roska, J. Academically Adrift. The University of Chicago Press, 2011

5. Montfort, D., Brown, S., and Pollock, D. "An Investigation of Students' Conceptual Understanding in Related Sophomore to Graduate-Level Engineering and Mechanics Courses" Journal of Engineering Education, April 2009 p. 111-130.

6. Taraban, R., Anderson, E., Definis, E., Brown, A., Weigold, A., Sharma, M. "First Steps in Understanding Engineering Students' Growth of Conceptual and Procedural Knowledge in an Interactive Context." JEE, Jan 2007, 57-68

7. Jensen, D., Self, B., Rhymer, D., Wood, J., Bowe, M., "A rocky journey toward effective assessment of visualization modules for learning enhancement in Engineering Mechanics", Educational Technology & Society, v5, n3, July, 2002.

8. Smith, J. C. "Charlotte Mason: An Introductory Analysis of Her Educational Theories and Practices." Dissertation, Virginia Polytechnic University, 2000.

9. Ebest, Sally B. "When Graduate Students Resist," Writing Program Administration, Vol 26. Fall/Winter 2002.