“Chunking” Semester Projects: Does it Enhance Student Learning?

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Students, like everyone else, have limited memory with which to take in, process, store, and recall information. In this paper, this limitation is examined within the context of a semester project in which students were tasked to complete a network design project based on a case with which they were presented. Two back-to-back semesters in which the project was first presented as a single, overall semester project that was compared against the second semester in which individual project deliverables were due throughout the semester were compared. Results and implications are discussed.

INTRODUCTION

Semester-long projects are commonplace in university classes. They allow students time to delve deeper into their understanding of a particular topic and demonstrate this understanding through formal reports, presentations, and so on. Problem statements are typically defined early in the semester and allow students several weeks with which to formulate their deliverables. However, when the results one expects in terms of student performance are not met, an examination of the techniques used to teach a particular topic require examination as do the deliverables with which students demonstrate their knowledge. Consistent with the Association to Advance Collegiate Schools of Business’s (AACSB) efforts to encourage innovation, in this case as it relates to teaching, the traditional, monolithic approach to semester projects required examination and a new technique to be examined (Association to Advance, 2016).

Chunking, as an instructional design technique, is a process whereby information is broken down into smaller “chunks” so that they can be more easily remembered and understood. This concept of “chunking” stems from George A. Miller’s 1956 seminal paper “The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information” (Miller, 1956). In it, Miller describes the limitations on an individual’s ability to receive, process, and remember information. To address this limitation, Miller (1956) argues that “by organizing stimuli” into a sequence of chunks, we can extend or stretch one’s ability to receive, process, and remember information.

One’s ability to receive and process information occurs within their short-term memory. Due to the short-term nature of such memory, our capacity is limited. In order to be able to receive and process more complex pieces of information, Cognitive Load Theory (Sweller, 1994) suggests that through instructional design techniques, information can be presented in such a way as to balance cognitive load against the material to be learned. By “chunking” learning materials, people will be able to more effectively receive and process information and thus, be able to better recall and apply information later. The objective in this research is to examine the role of “chunking” within the context of a network design project in an introductory networking class.

LITERATURE REVIEW

In 1956, George A. Miller's seminal paper The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information" posited that short-term memory acts as a bottleneck, constricting what one can learn (Miller, 1956). According to Mathy and Feldman (2012), many more recent studies suggest that the number of items one can process using short-term memory is closer to four, plus or minus one (Cowan, 2001). Regardless of the precise number, these studies help to illustrate that rather than trying to process information as a single, monolithic piece of information, breaking it down into smaller "chunks" can assist one in being able to process and convert information from short term memory into long term memory.

This concept of "chunking," or breaking down larger, more complex tasks into smaller, more manageable tasks has existed within the field of information systems for some time and is commonly referred to as a top-down approach or top-down design. The concept can be applied to programming projects, database design, web design, etc. (Hambley, 1994; Kurose and Ross, 2012). It has even been applied to network projects, but to our knowledge, not in the academic sense to assess academic performance. To illustrate the necessity of reducing large-scale projects to smaller, more manageable components, one need only look at Fedora's Linux 9. Coming in at just over 200 million lines of code, it represents an extremely complex piece of software (Vaughan-Nichols, 2008). Rather than tackling such a large task as a whole, such projects are broken up into smaller parts, which become much more manageable and, in the particular case of open source software, worked on in a collaborative, distributed fashion.

As it relates to using chunking in an educational setting, Xu and Padilla (2013) examined students' ability to recall Chinese characters using a quasi-experiment. The control group was taught using the traditional approach of rote memorization. The treatment group was taught using a chunking approach. Results indicated that those taught using the chunking approach enhanced student learning and retention. As it relates to communication-related skills, Bodie, Powers, and Fitch-Hauser (2006) found that by combining educational theories including chunking, priming, and active learning, student retention of more complex communication skills was enhanced. They concluded that chunking was a key component "for learners to acquire, retain, apply, and improve communication skills" (Bodie et al., 2006).

Within the field of information systems, there has been limited research on the value of chunking and its use as an instructional technique. However, one example of such research is by Carstens, Malone , and McCauley-Bell (2007) who applied the theory of chunking to the development of strong passwords for authentication purposes. They found that students were able to recall strong passwords more effectively when chunking techniques were applied to the construction of those passwords. Syn and Batra (n.d.) applied chunking techniques to improve student learning of the Unified Modeling Language (UML) and the construction of sequence diagrams. However, the author was unable to find any research related to the chunking of semester projects in general much less the chunking of network design projects specifically.

This leads us to the research question below. As discussed above, by taking larger, more complex subjects and breaking them down into smaller chunks, students should be able to more effectively process and recall the information that they learn in each chunk. Therefore, if given a semester project in pieces whereby they are able to process and further develop their understanding in a more manageable way, student performance should increase. Therefore the research question is: Will student performance increase when presented with a semester project in chunks?

METHODOLOGY

To address the research question, a quasi-experiment was conducted to compare the results between a control group and a treatment group. The control group consisted of a section of an introductory networking class presented with a traditional semester project due at the end of the semester. The project was an individual assignment in which students were given a case and asked to develop a logical design, a physical design, a wireless design, a security design, and financial analyses. Students were provided a detailed rubric which signaled expectations for each component of the semester project and provided detailed feedback after submission. At the end of the semester, each item on the rubric was scored from 0-2 where 0 represented “failure to meet expectations,” a 1 represented “meets expectations,” and a 2 represented “exceeds expectations.” This format was used for consistency with the college’s Assurance of Learning efforts. Throughout the semester, students were exposed to networking principles through a variety of different teaching styles including lecture, labs, simulations, etc. and assessed using labs, quizzes, and exams.

The following semester represented the treatment group. They were given a similar case around which to prepare the aforementioned deliverables. Rather than requiring the project to be developed over the entire semester and presented as a whole at the end, the project was “chunked” such that they submitted the logical design a few weeks into the semester, followed by the physical design a few weeks later, and so on. The rubric used the previous semester was deconstructed to only focus on the content being submitted for each “chunk.” Feedback was provided after the submission of each component, allowing students the opportunity to process and incorporate expectations for future submissions.

The goal was to be able to compare each component/chunk to determine what, if any, changes occurred as a result of the change in instructional design. Per the hypotheses listed below, it was anticipated that scores from the treatment group would improve, indicating that the chunking approach improves student learning.

- H1: Student scores on their logical designs will improve in the experimental group
- H2: Student scores on the physical designs will improve in the experimental group
- H3: Student scores on the wireless designs will improve in the experimental group
- H4: Student scores on the financial analyses will improve in the experimental group
- H5: Student scores on the security designs will improve in the experimental group
- H6: Student scores on their overall projects will improve in the experimental group

RESULTS

In order to make comparisons, a simple t-test was run for each component/chunk. Because these were back-to-back semesters and there were no significant differences between the overarching samples, equal variances were assumed. Each class was approximately the same size (control group = 25 students; experimental group = 26 students). Each class was dominated by white, male students under the age of 25 years. Results between the components of the semester project submitted by students as a traditional semester project and those submitted in chunks were somewhat mixed. As shown in Table 1 below, only H3 and H4 were statistically significant, indicating a statistically significant increase in student scores using the chunking approach.

TABLE 1
RESULTS

	Control Group	Treatment Group	p-value
Logical Designs	Observations: 25 Mean: 1.45 Variance: .26	Observations: 23 Mean: 1.30 Variance: .22	.15
Physical Design	Observations: 25 Mean: 1.20 Variance: .33	Observations: 24 Mean: 1.33 Variance: .41	.22
Wireless Design	Observations: 25 Mean: 1.44 Variance: .42	Observations: 23 Mean: 1.74 Variance: .38	.05
Financial Analyses	Observations: 25 Mean: 1.12 Variance: .19	Observations: 21 Mean: 1.57 Variance: .36	.00
Security Design	Observations: 25 Mean: 1.32 Variance: .48	Observations: 22 Mean: 1.50 Variance: .26	.16
Overall Results	Observations: 25 Mean: 1.29 Variance: .19	Observations: 26 Mean: 1.45 Variance: .15	.08

DISCUSSION

Despite the lack of significance for H1, H2, H5, and H6, there were some other encouraging signs from the results. For example, with the exception of H1, the mean score for students increased for each "chunk." Also encouraging was the decrease in variance on each "chunk" with the exception of H2 and H4. However, this only tells part of the story. An examination of instructor-conducted course evaluations completed at the end of each semester provides some additional insight into student satisfaction with the course as it relates to the appropriateness of readings and assignments, technological tools, instructor feedback and communication, course organization, clarity of outcomes and requirements, and content format (Rothman, Romeo, Brennan, & Mitchell, 2011). Using a 5-point Likert scale for items in each factor, students were asked to rate each item from strongly disagree, disagree, neutral, agree, and strongly agree. For each factor, the control group was fairly evenly split between agree and strongly agree. For example, students were evenly split between agree and strongly agree on effective instructor feedback and communication. However, the treatment group overwhelmingly strongly agreed that instructor feedback and communication was effective. This same pattern held for the remaining factors as well. So, for the treatment group, student satisfaction with the course improved in every category.

CONCLUSIONS

The inspiration for this research was born out of frustration with student scores on their semester projects in their undergraduate networking class. Despite the lack of overwhelming statistical support for chunking the semester project, the positives outlined in the results section as well as the discussion section suggest that this was a worthwhile endeavor. It affords students the opportunity to obtain feedback earlier in the semester regarding the level of work and expectations regarding their submissions. The results are that in some cases, student understanding of material increases on subsequent works and in all cases, student satisfaction with the course increases.

Implications

The results presented here potentially have implications for not just computer networking semester projects, but semester projects in general. Chunking semester projects generally seems to improve student learning. It provides opportunities for students to receive feedback earlier in the semester about content, format, and instructor expectations. As a result, higher order thinking skills can be further developed throughout the semester resulting in the opportunity to cover more complex topics towards the end of the semester than otherwise might be able to be covered using the traditional approach to semester projects.

This research also has implications for instructors trying to maximize their scores on the course evaluations. There is a clear, positive relationship between the chunking of the semester project and improved course evaluation scores. Instructors who utilize semester projects and desire improvement in this area should consider chunking their semester projects.

Limitations

Like all research, this research has its limitations. Perhaps the most obvious is the limited sample size. This could certainly affect the statistical results and as a result, interpretation of those results should be used with caution. Another limitation stems from the use of a quasi-experiment to examine the phenomenon. Because the control group and the treatment group were different students, their incoming knowledge of networking could have potentially been different. While their specific incoming knowledge of networking was not known, their scores on a computer self-efficacy test given at the beginning of the semester were very similar. Additionally, students were given a pretest to determine their general understanding of networking at the beginning of the semester. The control group averaged 9.68 out of 12 while the treatment group averaged 9.11 out of 12. The difference was not statistically significant so it can be assumed that the students' incoming knowledge of computing in general and more specifically networking were similar.

Future Research

Future research should center on replicating the study with a larger sample size. Again, while results were generally positive and supported the use of chunking semester projects, the limited sample size requires caution when interpreting the results. Another avenue for research could be to expand the interpretation of student learning beyond improved scores of their semester project to examine the effects of traditional semester projects and chunked semester projects on final exam scores and overall course grades, both of which tend to exemplify broader examples of student learning. Still another opportunity for extending research in this domain includes examining computer networking projects on an individual basis versus group work and the effects on final exam scores and/or final course grades. Nelson (2011) discussed the positive effects of group activities in terms of encouraging higher order thinking.

AACSB has place more emphasis on engagement, innovation, and impact (Association to Advance, 2016). Examining the teaching methods employed in the classroom and online requires innovative approaches to maximize student learning, particularly in fast-moving fields such as information systems. Based on the findings in this research, chunking is a useful, innovative technique, which can improve student learning on semester projects and help to exemplify innovativeness in teaching.

REFERENCES

Bodie, G.D., Powers, W.G., & Fitch-Hauser, M. (2006). Chunking, priming and active learning: Toward an innovative and blended approach to teaching communication-related skills. *Interactive Learning Environments*, 14(2), 119-135. doi:10.1080/10494820600800182

Carstens, D.S., Malone, L.C., & McCauley-Bell, P. (2007). Applying Chunking Theory in Organizational Password Guidelines. *Journal of Information, Information Technology & Organizations*, 297-113.

Cowan, N. (2001). The magical number 4 in short-term memory: a reconsideration of mental storage capacity. *The Behavioral and Brain Sciences*, 24(1), 87-114.

Association to Advance Collegiate Schools of Business (AACSB). (2016). *Eligibility Procedures and Accreditation Standards for Business Accreditation*. Retrieved from http://www.aacsb.edu/-/media/aacsb/docs/accreditation/standards/businessstds_2013_update-3oct_final.ashx?la=en

Hambley, A.R. (1994). *Electronics: A Top-Down Approach to Computer-Aided Circuitry Design*. Upper Saddle River, NJ: Prentice Hall PTR.

Kurose, J.F., & Ross, K.W. (2012). *Computer Networking: A Top-down Approach Featuring the Internet*. Harlow: Pearson Education. Print.

Mathy, F., & Feldman, J. (2012). What's magic about magic numbers? Chunking and data compression in short-term memory. *Cognition*, 122(3), 346-362. doi:10.1016/j.cognition.2011.11.003

Miller, G.A. (1956). The magical number seven plus or minus two: some limits on our capacity for processing information. *Psychological Review*, 63(2), 81-97.

Nelson, T. (2011). Assessing Internal Group Processes in Collaborative Assignments. *The English Journal,* 100(6), 41-46. Retrieved from http://www.jstor.org/stable/23047879

Rothman, T., Romeo, L., Brennan, M., & Mitchell, D. (2011). Criteria for assessing student satisfaction with online courses. *International Journal for e-Learning Security*, 1(1-2), 27-32.

Sweller, J. (1994). "Cognitive Load Theory, Learning Difficulty, and Instructional Design." *Learning and Instruction,* 4.4, 295-312.

Syn, T., & Batra, D. (n.d). Improving Sequence Diagram Modeling Performance: A Technique Based on Chunking, Ordering, and Patterning. *Journal of Database Management*, 24(4), 1-25.

Vaughan-Nichols, S.J. (2008, Oct. 22) "204.5-Million Lines of Code Equals One Great Linux Distribution." *Computerworld*. Computerworld. Retrieved from http://www.computerworld.com/article/2480960/desktop-apps/204-5-million-lines-of-code-equals-one-great-linux-distribution.html

Xu, X., & Padilla, A.M. (2013). Using Meaningful Interpretation and Chunking to Enhance Memory: The Case of Chinese Character Learning. *Foreign Language Annals*, 46(3), 402-422. doi:10.1111/flan.12039