Oregon State Ecampus Research Unit

Can Concept-mapping Exercises Enhance Learning in Online Courses?

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Abstract
Prior research has suggested that homework activities that encourage learners to think more conceptually about to-be-learned material can have positive benefits on overall content learning. Can such activities be implemented successfully in online coursework, and does it produce the anticipated benefit? In two sections of an online Psychology course, participants were asked to either complete a concept-mapping exercise or control exercise for each chapter. The type of exercise, by chapter, was counterbalanced across sections. Results indicate that while students might initially struggle to realize the purported benefit of concept-mapping relative to learning, this effect does seem to begin to emerge later in the term, perhaps once students have become more comfortable with the activity. Students also appear to rate both the educational utility and enjoyment in completing the concept-mapping homework similarly to control exercises, so these novel activities do not appear to strongly alienate students. As such, while concept-mapping does seem to have some positive aspects, the positive impact of such exercises is not without some important caveats.

Can concept-mapping exercises enhance learning in online courses?
In nearly all formal education contexts, learning takes place not only while 'in-class,' but also is delegated to other off-line activities, usually comprising homework or other outside learning activities. While online education has somewhat blurred the distinction between what is (and is not) in-class, homework activities still play a large role in online education, and often serve as one of the primary student touchpoints (Vonderwell, 2003). As such, it seems imperative to develop and implement homework activities in online coursework that are not only accessible to most learners, but also optimize potential learning performance. To this end, the goal of the current study was to examine whether more conceptual homework activities produce a marked benefit for class learning.

Concept-mapping as a tool
Prior research has suggested that encouraging learners to engage in more deep processing of content material can produce lasting benefits regarding overall understanding and retention (Chi, Feltovich, & Glaser, 1981; Schvaneveldt et al., 1985). One means of encouraging such efforts has been to assign learners concept-mapping activities as part of normal coursework (e.g., Novak, 1990). In concept-mapping activities (CMAs), learners are required to take conceptual facts or information and integrate them spatially into a concept map or web, whereas individual concepts are connected via links to other relevant concepts, etc. The rationale is that more related concepts would be linked together more densely than unrelated concepts, perhaps allowing important conceptual relationships to emerge as a function of making these 1-to-1 connections between concepts. This kind of visualization is common among theoretical representations of knowledge, and thus it is arguable that the construction of concept-maps might produce explicit analogues of how students might be fundamentally representing the information within their cognitive system.

The usefulness of concept-mapping has been established across multiple tasks and contexts in several meta-analyses (e.g., Horton et al., 1993 and Nesbit & Adesope, 2006). For example, it has been suggested that in terms of text comprehension, the act of creating such knowledge-maps forces learners to establish connections between concepts and links that they might not form otherwise (Weinstein & Mayer, 1986). These exercises also appear to produce enhancements in more general critical thinking skills (Wheeler & Collins, 2003), beyond just text comprehension. Concept-mapping also appears useful for assessment purposes as an alternative means of diagnosing how students are thinking about certain topics, especially in computerized learning environments (Stoddart, Abrams, Gasper & Canaday, 2000), and when learning from mobile technologies (Hwang, Wu, & Ke, 2011). Finally, this beneficial effect has even been demonstrated across multiple demographic groups, including

younger students (middle schoolers; Chang, Sung, & Chen, 2002) and even across cultures, as similar patterns are evident in Western, Eastern and African student populations (Nesbit & Adesope, 2006). However, an open question is whether these activities might be especially useful for online coursework, where homework becomes one of a very few formal opportunities for online instructors to interface with students to gauge their class performance. For example, as online education is by nature asynchronous and distal, it can potentially be difficult for instructors to pick up subtle cues that students are either not understanding the material at all or, even worse, misunderstanding it - cues that are perhaps more accessible in physical classrooms (e.g., looks of confusion). Thus, homework activities for online education should potentially be designed with two goals in mind: (1) enhance student understanding, and (2) provide a quick and easy way for instructors to identify conceptual difficulties. Given the visual simplicity and efficiency of concept-maps, these activities might be a useful opportunity to achieve both these goals simultaneously.

To begin this investigation relative to the utility of using concept-maps as a tool for online education, a study was conducted in two online sections of an upper-division Psychology course (PSY 340: Cognition). Students enrolled in these sections were asked to complete homework activities that were either concept-maps, or instead control activities (writing definitions). Activity was counterbalanced across chapters and course sections. In other words, all students completed examples of BOTH homework activities; for example, in even numbered chapters they might concept map, and in odd-numbered chapters they would complete the control activities. This pattern was reversed for the second section. Given the previously observed impact of concept-mapping, it was expected that for those chapters that students completed such homework activities, they should produce a significant learning gains as measured by exam scores, compared to students who instead completed a control activity.

Participants

Students enrolled in two separate sections of a 300-level Psychology course (PSY 340: Cognition) were solicited for participation in the current study. Of the 82 enrolled students, *N*=60 consented to participate in the research project (70% participation rate). Participants received no compensation for their participation.

Materials

For each of the 13 chapters covered during the term, participants completed one of two homework exercises; a concept-mapping exercise, or instead a chapter definitions exercise. All students in the two course sections completed these homework exercises, although only those who consented to participate in the study were analyzed. The type of homework did alternate across chapters for every student, so every student completed examples of both concept-mapping and chapter definitions exercises. For example, in one section, even numbered chapters required concept-mapping, while odd numbered chapters required chapter definitions. This pattern was reversed in the second section (i.e., even: chapter definitions, odd: concept mapping).

Concept-mapping exercise

In the concept-mapping exercise, participants were given an alphabetical list of terms from each chapter, and they were asked to connect the terms together to form an inter-connected map that was representative of their understanding of the chapter material. Examples are available in Figure 1. There were three simple rules for this concept-mapping exercise: (1) all terms must be used, (2) no term may have more than five connections to other terms, and (3) use as few links as possible to connect all terms appropriately. These rules were designed to force learners to form webs of knowledge, rather than avoiding terms or centering their understanding around a single term/terms. After completing and submitting this exercise, learners were then given a completed expert map, which demonstrated how a practicing expert in the field constructed their own version of the map, and asked to answer two questions: (1) *"Name 2 things that are different across maps, and*

explain why you agree or disagree," and (2) *"Name 2 things that you would change to make your map better."* These expert comparison exercises were meant to provide learners the opportunity to provide self-correction to their understanding, and hopefully address any misunderstandings or other issues. Finally, participants then rated on a scale of 1-10 (1 being lowest), how well they thought the concept-mapping exercise helped them learn the material in the chapter. The only feedback participants were given pertained to whether they had violated one of the concept map rules, or failed to completely answer either of the above questions.

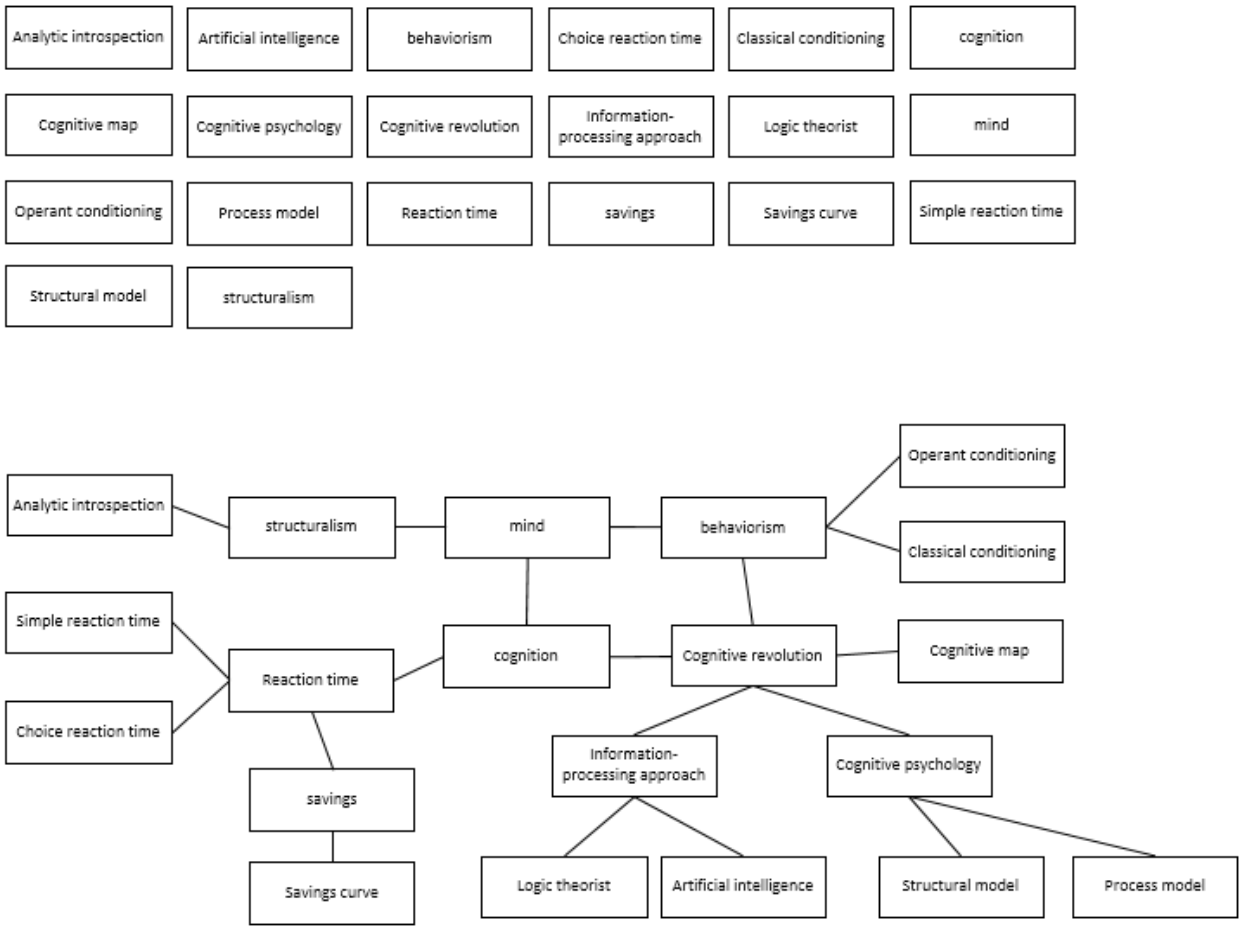

Figure 1: Example concept-map exercise and corresponding expert map

Chapter definitions exercise

In this definition exercise, participants were given the same list of terms, and asked to define them for their weekly homework. Participants were instructed to define each term in their own words, and to not copy the definition from the book. This exercise was designed to serve as a comparison condition for the concept-mapping exercise. Participants were only given rudimentary feedback which simply identified terms for which they had provided an incorrect definition. Participants were not given the correct definition, but could look them up on their own.

Midterm exams

All participants completed three midterms, each of which examined a subset of course material. For example, the first midterm 1 covered chapters 1-5, and the third midterm covered chapters 10-13. Each of these exams were 25 questions long and comprised entirely of multiple-choice questions. On each midterm, the questions were evenly

distributed across the relevant chapters, and the % correct for each chapter was computed.

End of term ratings

At the end of the term, participants were also asked to rate on scale from 1-10 (1 being lowest): (1) how much they thought both the concept mapping and the definitions helped them learn, and (2) how much they enjoyed the different types of homework.

Procedure

Based on class enrollment, for every chapter in the course, participants either completed a concept-mapping or chapter definitions exercise. Each exercise was counterbalanced across course sections, and also alternated across chapters, in an attempt to provide a more broad comparison of the exercises while attempting to control for content material and class enrollment. For example, the first class 1 (Fall 2017) completed concept-mapping exercises for all even numbered chapters (e.g., 2, 4, 6, 8, 10, 12), and completed chapter-definition exercises for all odd numbered chapters (e.g., 1, 3, 5, 7, 9, 11, 13). This was reversed for the second class (Winter 2018). Performance on the corresponding midterm exam was then totaled for each exercise across classes and compared.

Results

To begin, learners were only included in the following analyses if they successfully passed all three midterms with an average grade of 61% or better. As low levels of performance (in this case 'F' or 'Failing') could be a result of numerous factors outside of the manipulation, to provide a more balanced consideration of the magnitude of the effect, these very-low performing students were omitted. As such, only 37 of the 60 consented participants are included in the subsequent analyses (62%). Further, due to an error on the syllabus, Chapter 5 was omitted from the midterm analyses as it was mistakenly communicated to students that this chapter would be on the second midterm, rather than the first midterm in one of the course sections.

Learning results

To analyze the results, a 3 (midterm) x 2 (exercise) repeated measures ANOVA was conducted on % correct for each exam. Overall results are visible in Figure 2. First, as is visible in Figure 2, there was a significant main effect of midterm ($F(2, 72)=11.31$, $MSe=.01$, $p<.001$, $\eta_p^2=.24$) suggesting that performance was different across the three midterm exams. This main effect appears largely driven by the higher level of overall performance for the first miderm, although post-hoc

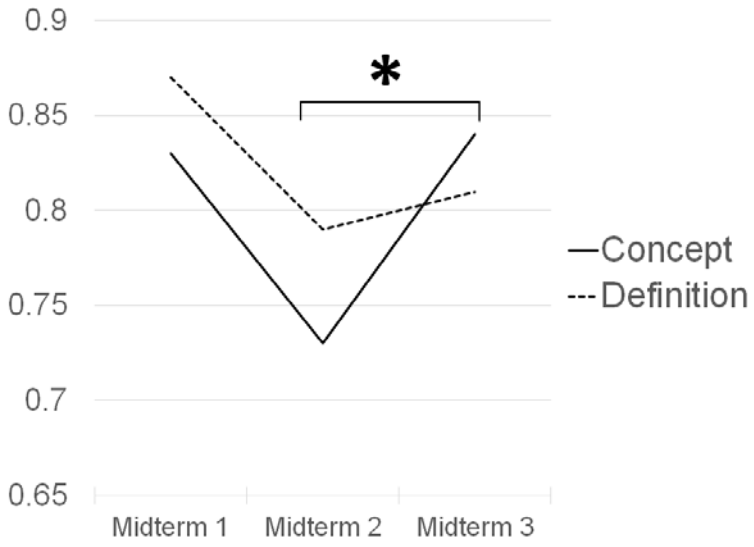

Figure 2: Learning by midterm and homework activity

comparisons determined that the appearance of higher initial performance was not statistically reliable (different) across midterms.

There was no significant main effect of homework exercise ($F(1, 72)=1.91$, $MSe=.01$, $p=.18$, $\eta_p^2=.05$), which suggests that there was no statistically reliable difference overall across homework exercises. In other words, there was not a broad beneficial effect of concept mapping over the control exercises. However, there was a significant interaction between midterm and homework exercise ($F(2, 72)=3.09$, $MSe=.01$, p-.05, $\eta_p^2=.08$), which suggests that the homework exercises were differentially useful across performance on the midterm exams. It appears that the concept mapping exercises proved *less* useful in the initial stages of the course, however became more useful towards the end of the class. For example, if one were to look solely at performance on the second and third midterms, after participants had not only adjusted to the new term, but also the novel format of the homework, the pattern of results becomes even more clear.

While there was little shift in performance in learning when using the definitions exercise ($p>.05$), the concept mapping exercises produced a significant improvement from midterm 2 to midterm 3 ($F(1, 36)=19.83$, $MSe=.01$, $p<.001$, $\eta_p^2=.36$). As these scores are composites, counterbalanced across chapter material, it does not appear that this benefit was merely a function of easier material per se, but likely an enhanced conceptual learning due to the homework exercises themselves.

Concept-mapping utility

For every concept map completed, participants were asked to rate the educational utility of the exercise. Averaging these ratings across classes, in temporal order, indicated a very stable rating towards these exercises (Figure 3). Across the six concept maps that each class section completed, while there was a slight decline in ratings of usefulness as the term progressed, this was not statistically reliable ($F(5, 155)=1.80$, $MSe=1.61$, $p=.12$, $\eta_p^2=.06$). Thus, it appears that participants view of the educational usefulness of the concept-mapping homework did not change significantly over time.

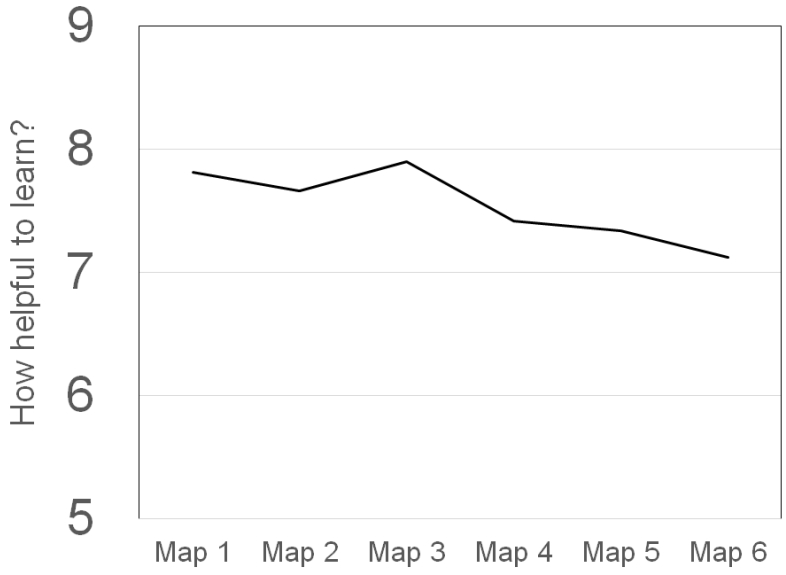

Figure 3: Ratings of how helpful the concept-mapping exercises were for learning the chapter material (1-10, 1 being lowest), in temporal order

Further, end-of-the-term ratings also indicated that there was no difference in either perceived usefulness ($t(36)=1.64$, $p=.11$) or enjoyment ($t(36)=1.25$, $p=.22$) across the different homework exercises. In other words, participants did not prefer one homework over another when considering either its usefulness or how enjoyable it was.

Discussion

While it was expected that concept-mapping would have a broad significant impact on learning the material presented in these online courses, this was not realized. In fact, while there does appear to be some educational benefit related to concept mapping, this benefit does seem to only emerge after participants have gained some familiarity with the concept-mapping homework. As a case in point, only concept-mapping exercises were related to a significant increase from the second and third midterms, while there was very little shift across the three midterms for the definition exercises. Thus, while this is a partial confirmation of the benefit of concept mapping in online settings, further research is likely needed to make more conclusive insights regarding how helpful these activities can be. Given that students do not have an overwhelming familiarity with such mapping exercises, it might be that students do need additional training or experience to realize the full benefit of concept-mapping. This seems to correspond well with participant ratings of usefulness, as they likewise seem to struggle to fully appreciate the benefits that they themselves are experiencing across the term. Anecdotally, the number of violations of the rules of the concept-mapping exercise did seem to decrease as the term progressed, somewhat supporting this need for learners to warm up to the structure and format of the homework.

In the future, it would be useful to explore the benefits of concept mapping in other educational contexts such as contexts that are perhaps less difficult or challenging. As nearly 38% of the consented participants had to be omitted from the final analyses due to failing one or more of the midterms, it is possible that the substantial loss of participants may have obscured or attenuated relevant patterns of results. Further, the interleaved nature of the counterbalancing of homework assignments (e.g., alternating between concept-mapping and definitions throughout the term) may have likewise exacerbated learning or utility ratings. Finally, it may also be useful to consider the benefits of concept mapping from the instructor perspective. Anecdotally, the concept-mapping exercises were not only much faster, but also much less tedious to grade for completion. Even if one dismisses the small observed benefit of concept mapping relative to learning, the pragmatic benefits of grade-ability may be a hidden benefit of such activities. While students may not demonstrate a large overall positive (or negative) effect, this could very well make the instructors' duties more palatable, freeing time for other class activities or even larger enrollments.

In conclusion, while concept mapping does demonstrate some benefit, it does appear that the emergence of this benefit does require some exposure, or perhaps additional training with the tool. Initially it appears that students do not experience any positive benefit for concept mapping, but this benefit seems to increase as they become more familiar with the exercise. Students also seem receptive to such novel homework activities. The reduction of instructor effort is an additional benefit of implementing these types of dynamic homework activities.

References

Chang, K. E., Sung, Y. T., & Chen, I. D. (2002). The effect of concept mapping to enhance text comprehension and summarization.*The Journal of Experimental Education*, *71*(1), 5-23.

Chi, M. T., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, *5*(2), 121-152.

Horton, P. B., McConney, A. A., Gallo, M., Woods, A. L., Senn, G. J., & Hamelin, D. (1993). An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education*, *77*(1), 95-111.

Hwang, G. J., Wu, P. H., & Ke, H. R. (2011). An interactive concept map approach to supporting mobile learning activities for natural science courses. *Computers & Education*, *57*(4), 2272-2280.

Nesbit, J. C., & Adesope, O. O. (2006). Learning with concept and knowledge maps: A meta-analysis. *Review of Educational Research*, *76*(3), 413-448.

Novak, J. D. (1990). Concept mapping: A useful tool for science education. *Journal of Research in Science Teaching*, *27*(10), 937-949.

Schvaneveldt, R. W., Durso, F. T., Goldsmith, T. E., Breen, T. J., Cooke, N. M., Tucker, R. G., & De Maio, J. C. (1985). Measuring the structure of expertise. *International Journal of Man-Machine Studies*, *23*(6), 699-728.

Stoddart, T., Abrams, R., Gasper, E., & Canaday, D. (2000). Concept maps as assessment in science inquiry learning-a report of methodology. *International Journal of Science Education*, *22*(12), 1221-1246.

Vonderwell, S. (2003). An examination of asynchronous communication experiences and perspectives of students in an online course: A case study. *The Internet and Higher Education*, *6*(1), 77-90.

Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. Wittrock (Ed.) *Handbook of research on teaching* (pp. 315-327). New York: Macmillan.

Wheeler, L. A., & Collins, S. K. (2003). The influence of concept mapping on critical thinking in baccalaureate nursing students. *Journal of Professional Nursing*, *19*(6), 339-346.

About the Research Unit at Oregon State Ecampus

Vision

The Ecampus Research Unit supports Oregon State University's mission and vision by conducting world-class research on online education that develops knowledge, serves our students and contributes to the economic, social, cultural and environmental progress of Oregonians, as well as national and international communities of teachers and learners.

Mission

The Ecampus Research Unit (ECRU) makes research actionable through the creation of evidence-based resources related to effective online teaching, learning and program administration toward the fulfillment of the goals of Oregon State's mission. Specifically, the research unit conducts original research, creates and validates instruments, supports full-cycle assessment loops for internal programs, and provides resources to encourage faculty research and external grant applications related to online teaching and learning.

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