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# Formative and Summative Analyses of Disciplinary Engagement and Learning in a Big Open Online Course

Daniel T. Hickey
Indiana University
Bloomington IN, 47401
01-812-856-2344
dthickey@indiana.edu

Joshua D. Quick
Indiana University
Bloomington IN, 4740
251-463-6070
jdquick@indiana.edu

Xinyi Shen
Beijing Normal University
Beijing 100875, China
86-159-0100-1713
shenxinyi1128@gmail.com

## ABSTRACT
Situative theories of knowing and participatory approaches to learning and assessment were used to design and then analyze learning in a "big open online course" ("BOOC") on educational assessment. The course was delivered using Google's Course Builder platform which was customized extensively to support both summative and formative analyses of disciplinary social engagement and individual learning. The course featured personalized "wikifolio" public assignments peer commenting, endorsement, & promotion, formal online examinations, open digital badges, and participatory learning analytics. The course was first completed by 60 students in 2013 and impressive levels of engagement and learning were documented. The course was further refined in 2014 with embedded streaming videos, embedded formative assessments, and streamlined learning analytics. Of the sixty students who registered for the course, 22 completed it. This paper illustrates the more formative learning analytics used to advance the shared discourse in the course as well as the other new features and provides detailed evidence of engagement & learning.

## Categories and Subject Descriptors
K.3.1 [Computers in Education]: Computer Uses in Education—*collaborative learning, distance learning*

## General Terms
Algorithms, Measurement, Performance, Design.

## Keywords
Personalized learning, learning analytics, assessment, social learning analysis, analytic approaches, analytic approaches.

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## 1. THEORETICAL ORIENTATION
Theoretically speaking, this research is rooted in the situative theories of cognition that emerged from the Institute for Research on Learning in the 1990s [3, 7] In contrast to the individually-oriented learning principles from human information processing and constructivism, situative theories lead to learning principles that focus on social participation: (1) *Learning is fundamentally social,* (2) *Knowledge is integrated in the life of communities,* (3), *Learning is an act of membership,* (4) *Knowing depends on engagement in practice,* (5) *Engagement is inseparable from empowerment,* (6), *"Failure to Learn" is the normal result of exclusion from participation,* and (7) *We already have a society of lifelong learners.* [1] These principles formed the "metatheory" within which more specific principles were used to design and analyze an open online course on the topic of educational assessment.

This work drew specific inspiration from Engle & Conant's notion of *productive disciplinary engagement* [5]. This work assumes that engagement is "productive" when it leads to new questions, clarifies misunderstanding, and leads to more successful engagement by more participants; engagement is "disciplinary" when it concerns to intended topic of the course. In this course, the disciplinary knowledge consisted of the *practices* (e.g., guidelines for constructing various assessments) *principles* (e.g., reliability and validity) and *policies* (e.g., standardized testing, teacher evaluation) concerning assessment in schools and universities. This disciplinary knowledge was provided in the course via a widely-used and well-respected textbook on the topic, as supplemented with various online resources associated with each of the weekly assignments.

In particular this work represents an effort foster interactive forms of online engagement with course content, instructors, and peers that exceedingly productive *and* disciplinary. The design of the course was directly shaped by Engle & Conant's four design principles for fostering productive disciplinary engagement: (1) *Problematize disciplinary content from the perspective of each learner,* (2) *Give students authority and position them as stakeholders and producers of disciplinary knowledge,* (3) *Establish disciplinary accountability and require students to*

[1] http://en.wikipedia.org/wiki/Institute_for_Research_on_Learning

*defend their positions,* and (4) *Provide ready access to disciplinary resources.*

This work drew more general inspiration from studies of online participatory culture [18] connectivism [21] The specific objective of this research is using these theories to foster productive forms of networked disciplinary engagement in open online university courses, while also (a) meeting prevailing content coverage expectations for formal post-secondary courses, (b) fulfilling addressing enduring accountability and achievement, and (c) meeting new objectives of scalability. The more general objective of this research is refining a model for fostering and analyzing engagement and learning that can be used by others in a wide variety of online course contexts, and illustrating the potential of disciplinary engagement for designing and analyze online learning.

# 2. PRIOR RESEARCH

From 2000 to 2010, iterative cycles of design-based research (Cobb, et al., 2003) and embedded quasi-experimentation (Cook & Campbell, 1979) were used to generate general principles of learning described above to refine and validate specific practices for supporting participatory learning in formal educational settings. This work consisted of an extended series of collaborations with learning technology innovators. These collaborations concerned educational multimedia [14], educational videogames [1,12] and hybrid instruction [13] This resulted in resolutely situated approaches to learning, grading, assessment, accountability and validity

Starting in 2009, this program of research was expanded into online instruction via design studies of the first author's own online graduate education courses on Educational Assessment and Learning & Cognition. As articulated [15], this effort was used to organize the various situative practices into more coherent and comprehensive course design framework that others might readily employ. This framework is currently called *Participatory Learning and Assessment* and currently consists of the following five course design principles: (1) *Let contexts give meaning to disciplinary knowledge,* (2) *Recognize and reward disciplinary engagement,* (3) *Grade disciplinary artifacts through reflections,* (4) *Assess disciplinary knowledge appropriately,* and (5) *Measure disciplinary achievement discreetly.*

These principles were further refined and validated in a "big open online course" ("BOOC") on educational assessment offered to up to 500 students in Fall 2013 using the Google Course Builder Platform (with the support of a grant from Google). Thirteen participatory learning features were refined in this course: (1) *Define personalized learning contexts,* (2) *assign networking groups,* (3) *identify secondary emergent networking groups,* (4) *post course artifacts publically,* (5) *rank relative relevance of concepts,* (6) *access personalized content,* (7) *public individualized feedback,* (8) *peer commenting & discussion,* (9) *instructor & peer endorsement,* (10) *peer promotion,* (11) *weekly participatory analytics and feedback,* (12), *appropriate accountability,* and (13) *web-enabled evidence-rich digital badges.* Most of these features had been originally refined as manually-completed activities in the instructors conventional online courses with 15-20 students. Extensive refinements to the existing Google Coursebuilder LMS (approximately 3000 additional lines of code) were necessary to build in more streamlined versions of these features. This made it possible for the instructor and two quarter-time teaching assistants to manage the course. Further refinements were carried out across the semester to further automate these features and refine them in order to support even higher levels of disciplinary engagement.

Ultimately, 460 people registered for the previous course, 160 completed the first assignment, and 60 completed the course. Summative analyses of the weekly wikifolios, peer endorsements & promotions, discussion comments, and achievement tests revealed levels of disciplinary engagement and learning that that appear to greatly exceed those obtained in other open online courses and many conventional online courses.

# 3. CURRENT RESEARCH

The Educational Assessment BOOC was again offered in summer 2014 in order to further analyze engagement and learning and pilot test several new learning design and analysis features. Each of the 12 weekly units was enhanced with streaming 10-15 minute videos of the instructor (the first author) and a new embedded formative assessment routine. New software routines were created for formative and summative analyses of engagement and learning, and several existing routines were further streamlined and/or automated.

Because the original grant funds were exhausted at this time, there was only minimal support for instruction and research beyond typical course delivery associated with the twelve students who paid tuition and enrolled in the credit bearing section of the course. While a teaching assistant was again used to keep the course manageable, much of the instructor's time was during the actual course was committed to creating slides and recording weekly videos for the new course. As such the course was not widely promoted and dozens rather than hundreds of students were expected. While this certainly tempers any claims that might be made about the scalability of the new features, it certainly allowed us to examine their feasibility of the new features, examine their effectiveness, and compare engagement, learning, and retention with the previous semester.

# 4. NEW COURSE FEATURES

## 4.1 Online Instructor Videos

The prior course included just two online video that introduced students to the course site[2] and the weekly wikifolio assignments.[3] The possibility of including online videos for weekly assignments had been debated extensively. On one hand, students *like* online videos and expect them in open courses. Students can watch video while commuting or exercising and they provide a more personal connection to the instructor. Many registrants in the first course balked at the required text (even though they able to buy used copies of the 2010 edition $5-10) and some presumably dropped immediately because they expecting the more typical video-short text-quiz format employed in many MOOCs.

On the other hand, weekly videos might lead some students to not purchase or engage with the textbook and their peers and are typically quite time consuming to create. Perhaps more importantly for this research, a participatory perspective worries that the reification and decontextualized delivery of course knowledge within typical "lecture" videos is at odds with the goal of helping students personalize their disciplinary knowledge of the course

[2] Revised 2014 version can be viewed at https://www.youtube.com/watch?v=dBKGdDkBbU8

[3] Revised 2014 version at https://www.youtube.com/watch?v=GP9F-1Pfrvk

against a curricular aim that embodies their own experience, interests, and aspirations.

A decision in favor of videos came with the realization that videos might provide a salient way to demonstrate the personalized engagement expected in each weekly assignment and an efficient way for the instructor to personalize course content and go beyond the textbook. Specifically, most of the videos featured the instructor engaged in the process of considering the relative relevance of the various big ideas each week, in the context of his own professional work (e.g., teaching online courses in education),[4] while many of the videos featured the instructor taking positions that diverged from those in the textbook.[5]

## 4.2 "Drag and Rank" Wikifolios

One of the central innovations in this broader program of research was a simple scalable routine for engaging students with the disciplinary knowledge of the course. In this This engagement was organized around (a) the intuitional context and level indicated during registration and (b) a "curricular aim" that was drafted initially when registering and further refined in the first assignment. This accomplishes the first design principle in the both Engle and Conant (2002) and the Participatory Learning and Assessment framework. Specifically, each assignment "problematizes" sets of disciplinary ideas in the particular in terms of their relevance to each learners' context and curricular aim.

It turns out that the process of ranking relevance and justifying those rankings (typically for the "most relevant" and "least relevant") is a simple way of engaging students with otherwise-abstract course contexts; by doing so on publically viewable documents can foster remarkably deep social engagement as students compare their rankings with each other. However, some students would only partly complete the assignment (perhaps only providing a rationale for the first entry). A big problem for the instructor was that this information was very difficult to summarize and analyze for the social engagement feedback (described next).

In response, near the end of the prior course, a new routine in Coursebuilder was created whereby the edit window for each wikifolio presented the student with the to-be-ranked ideas, with an edit box directly below each set where they could draft personalized summaries of each idea and a rationale for the ranking. Because students could not save their edits without rearranging the boxes, student were, at some level, forced to engage in the ranking, and perhaps, more compelled to provide complete rationale for the ranking.

2-4 of these routines were included in each assignment, generally embedded with a larger set of activities (including extended activities that were required for the for-credit students but optional for the non-credit students. Figure 1 shows one example of this activity from one of the for credit students whose wikifolio posts were of average length for the for credit students (as summarized below). As described next, in addition to streamlining the activities for the students, this feature greatly streamlined what we view as one of the most important and innovative analytical processes in this course

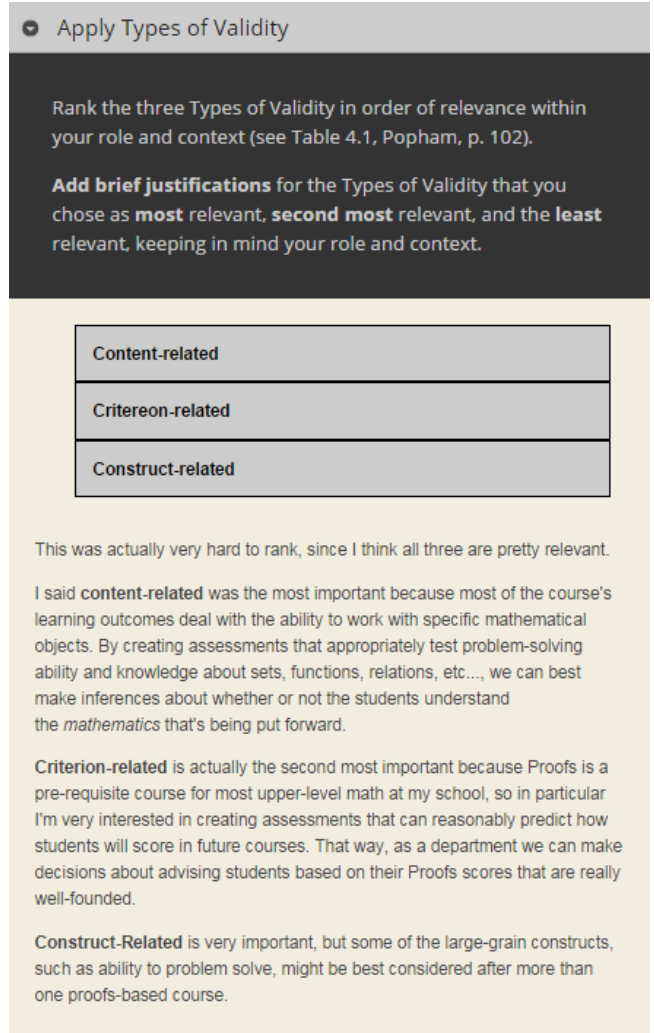


**Figure 1: An example of a completed "drag and rank" wikifolio assignment**

## 4.3 Streamlined Participatory Analytics & Feedback

One of the most appealing aspects of this overall approach is that it makes it possible to analyze patterns of disciplinary participation across different types of learners. Specifically, each week the patterns with which each of the professional networking groups found different ideas more or less relevant helped them appreciate the otherwise nuanced and abstract difference between those ideas. For example, with the part of the validity wikifolio shown in Figure 1, the educators overwhelmingly selected *content-related* evidence as most relevant but most of the administrators selected *criterion-related evidence* as most relevant; just a handful of students found *construct-related* evidence and most of them were researchers or graduate students who were interested in things like self-efficacy. Summarizing this data each week and providing it in the weekly

[4] See for example the discussion of guidelines for creating constructed-response items starting at 6:00 on https://www.youtube.com/watch?v=0mzY1x6J5uI&feature=youtu.be

[5] For example, starting around 1:50 on the *Test Preparation* video: https://www.youtube.com/watch?v=eNjw2fvQ1MU

feedback along with links to exemplary wikifolio that did a nice job articulating the various rationale appears to be a powerful tool for helping learners deeply appreciate otherwise abstract and confusing concepts.

The problem with this strategy in the first course is that it was terribly laborious. Each week the teaching assistant had to manually review all of the completed wikifolios and then summarize that data in a table for the students. The new routine generated that table automatically and all was required was the addition of exemplary posts. Efforts are now underway to further streamline this feature by generating graphs the present this information in real time as students complete the assignments, and automatically presenting links to posts in each networking group that have been cited by classmates as being exemplary.

## 4.4 Required Questions to Peers

Peer discussion is central to the underlying course design. As elaborated below, it is assumed that student and instructor discussion directly on student-generated artifacts is likely to be much more productive and much disciplinary than typical discussion forum. Particularly in open courses, discussion forums have a tendency to go off in many different directions that are only loosely related to the assignment or even the course. Nonetheless, students need to read each other's work and post comments for this disciplinary engagement to occur. To this end, the wikifolio assignments instructed students to post at least one question to their classmates on their own wikifolio and to review and post comments and question on at least three of their peer's wikifolios. Reflecting the participatory nature of the model, the number and nature of comments were not graded or evaluated in any way and there was no accountability for peer interaction.

While the average number of comments per wikifolio in the previous course was over four for the non-credit students and over seven for the for-credit students, participation in peer commenting was quite uneven across students. In fact, across the 841 wikifolios posted across that course, one third had no questions and no comments, while another sixth included a question to peer and no comments.

In response, to uneven participation in peer questioning and commenting, a new feature was added to the Assessment BOOC that essentially required students to post at least one question to their peers in order to post a completed wikifolio. This question comment was prominently featured at the bottom of the wikifolio and was highlighted prominently in order to draw attention to it. One question asked in the current research was whether this rather significant change in the practices of commenting changed the nature of the comments.

## 4.5 Embedded Formative Assessments

The fourth principle in the Participatory Learning and Assessment design framework is *Assess disciplinary understanding appropriately*. This reflects the assumption that a primary function of high-quality classroom assessment is helping students and teachers evaluate the effectiveness of the learning activities that led up to them. Such "curriculum-oriented" assessments are "proximal" in that they directly target the disciplinary knowledge the course targeted. The larger point here is that instructors need to avoid aligning their courses so closely to classroom assessments that students focus on the narrow decontextualized representations of disciplinary knowledge necessary for most classroom accountability purposes.

The earlier traditional online version of this course had included timed open ended essay items as part of the midterm and final examinations for this purpose. These items were scored individually by the instructor. This was manageable with a small course but was still quite time consuming; this was prohibitive when attempting to scale up that course to the BOOC. No such assessment were included in the 2013 Assessment BOOC. In the 2014 version, each wikifolio include a practice assessment with 4-6 open ended items. Students had to enter a response to each item in order to see the scoring key for the item. The formative assessments were entirely voluntary. While the system scored student responses, they were not formally evaluated as part of the instruction.

# 5. THE CURRENT COURSE

A total of 187 students enrolled in the current course. Figure 2 displays the primary professional networking groups that students were assigned to based in the survey they completed when registering for the course.

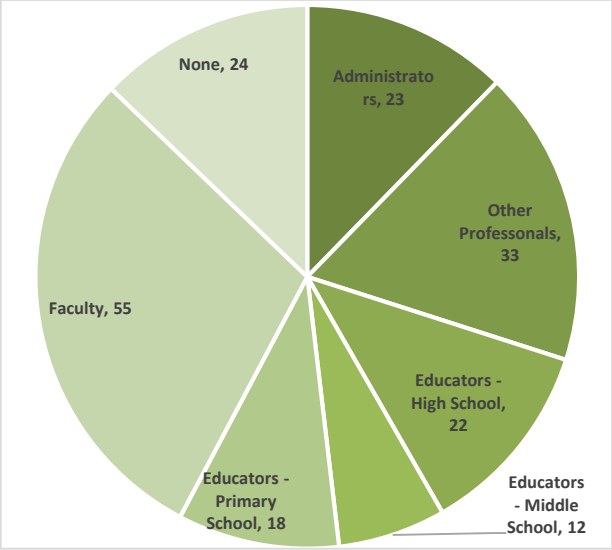


**Figure 2. Initial Registrants by Networking Groups**

The 187 initial registrants included 12 tuition paying students who had enrolled in the course for graduate credit towards an MA or PhD. Of the initial registrants, 76 (41%) completed the first assignment. As is typical with open courses, students gradually dropped out. Eventually, 22 students completed course, 11% of the registrants and 29% of the students who completed the first assignment.

Each of the 11 weekly wikifolios included required elements. This including reframing of personalized context and goal, one or more applications of course concepts, several relevance rankings, and a summary of the "big ideas" in the chapter and related online educational resources. Each wikifolio also included several optional elements that were required for the for-credit students. These included additional activities, responses to the "self-check" and discussion questions in the chapter, and a set of three well-specified reflections.

Each week, students were instructed (but not required) to endorse at least three peer wikifolios as being "complete" by clicking on corresponding button (Figure 2). Reflecting the second principle in the design framework (*Reward disciplinary engagement*) students were also instructed (but not required) to highlight one

(and only one) of their classmates work for being exemplary by clicking on the corresponding button and entering a warrant for what was exemplary about the particular artifact.

The course was divided into three units: *Practices*, *Principles*, and *Policies*. Posting a wikifolio that was endorsed by at least one peer as being complete and completing a time-limited multiple choice achievement test automatically generated a digital badge which was compliant with Mozilla's Open Badges Infrastructure. The earner could choose to share that badge out over various social networking sites or email, and could choose to include links to their actual completed assignments and the number of peer endorsements and comments, and/or their exam scores. Students in each networking group who earned the most peer promotions earned a version of the badge whose image said *Leader*. The criteria section of the Leader badge indicated that the earner's work had been deemed exemplary by peers and the earner had the option of including the warrants for the peer promotions in their badges as well. Students who earned all three badges and completed the final exam earned an *Assessment Expert Badge* that contained the three badges and all of the evidence therein.

Reflecting the third course design principle (*Grade disciplinary artifacts through reflections*), the content of the wikifolios and the comments were not directly graded for the 12 for-credit students. Rather their reflections were graded for evidence of *consequential*, *critical*, and *collaborative* engagement. This practice is intended to sidestep the formal evaluation content of artifacts and comments as evidence of evidence of enduring knowledge. Doing so is presumed to (a) undermine participation in disciplinary discourse around those artifacts, (b) result in dubious evidence of knowledge, (c) lead to unstainable individualized formative feedback on artifacts, and (d) lead to unstainable summative grading demands on instructors. Essentially the model relies instead on conventional assessments and tests to evaluate disciplinary knowledge and achievement; in practice, students who post a complete draft by the deadline and post coherent reflections receive full points for their 11 wikifolios, which count towards 55% of the final course grade.

# 6. CURRENT COURSE RESULTS

The aforementioned resource limitations precluded some of the more laborious analyses carried out with the previous course data and directed our attention towards aspects or engagement and learning that could be automatically analyzed, and focused our more laborious analyses on the 22 students who completed the course.

## 6.1. Raw Individual Engagement

Given that there are no requirements of length of responses to the weekly wikifolios, the sheer number of words written in each weekly wikifolio is an important indicator of student engagement. Not surprisingly, the for credit students average significantly more words per wikifolio (2820) than the open students who completed the course (1377) and the open students who did not complete the course (1081). These were similar levels and patterns as found in the previous course; as shown in Figure 3, a clear pattern emerged whereby the length of student wikifolios rises and falls with the competing demand of the unit exams.

Given that nature of the wikifolio assignments, nearly all of this engagement is "disciplinary". There are really very few opportunities for student wikifolios to stray from the topic of the corresponding chapter, must less stray from the topic of assessment. Given that a central goal in this work was maximizing disciplinary engagement, these raw finds are continued support for the argument that this approach is capable of generating levels of individual disciplinary engagement that have proven elusive in online courses.

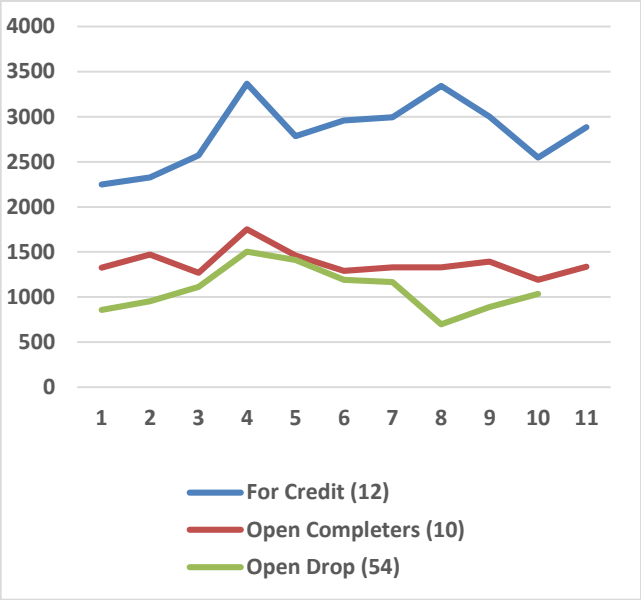


**Figure 3: Average Number of Words per Wikifolio by Unit and by Enrollment Status**

## 6.2 Raw Social Engagement

Another relevant analysis of engagement concerns social interaction via comments posted on student wikifolios. Figure 4 show the average number of comments per wikifolio for the for-credit students and the open students. This is roughly 2/3rds of the number of comments attained in the previous course. This suggests that the change to requiring students to post questions to their peers may have actually undermine more natural participation in peer commenting.

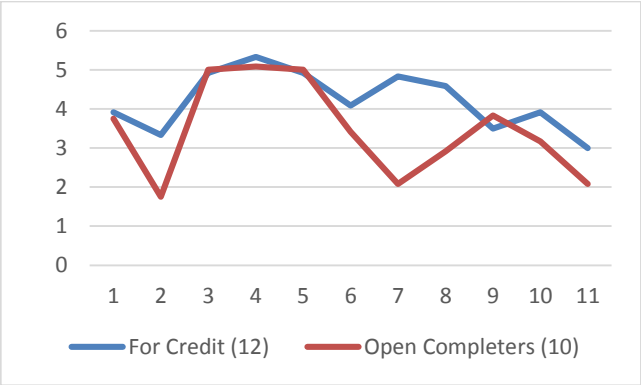


**Figure 4: Average Number of Comments per Wikifolio by Unit and by Enrollment Status**

Figure 5 shows the average number or words per comment by wikifolio. This is comparable to the length of the comments posted in the previous course. In other words, while the number of comment in the current course declined, the length of the comments did not. While this might be worth further investigation, there were

quite a few other variable across the two courses that could not be controlled for to make any strong conclusions. In particular the engagement of the teaching assistant (who was quite active in encouraging commenting, and whose data is not included in the previous graphs) was significantly less active in the current course.

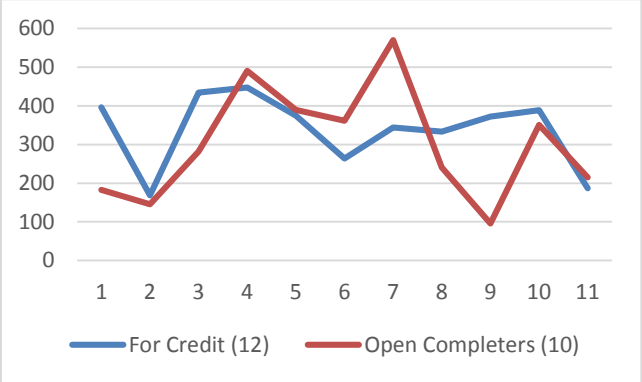


**Figure 5. Average Length of Comments by Unit and by Enrollment Status**

## 6.3. Disciplinary Engagement

Of crucial concern is the extent to which the individual and social engagement represented *disciplinary* engagement. All of the comments posted by the students who complete the course were coded by the third author as to the extend they addressed the topic of the particular chapter (3 points), assessment in general (2 points), or education in general (1 point), or something else (0 points). Twenty percent of the comments were coded by the second author, yielding an inter-rater reliability of .85. This revealed that the level of disciplinarity was again high for both the for-credit students (2.91) and the open students who completed the course (2.78). These levels are comparable to the levels observed in the prior course.

## 6.4 Contextual Engagement

As argued in the introduction, a participatory perspective on learning suggests that anchoring disciplinary course knowledge to personally meaningful context is crucial to learning that knowledge in ways that will endure and transfer to subsequent learning and performance contexts. To this end, all of the comments on the wikifolios posted by the for credit students and the open students who completed the course were coded as to whether the referenced a specific educational context—typically the goal and context of either the student who posted the wikifolio and the goal and context of the student who posted the context. Comments that referenced a specific context were coded as 1, while comments that did not reference any context of practice were coded as 0. Just .22 of the comments from the for-credit students referenced specific contexts in the current course, while .28 of the comments of the open students who completed the course referenced specific contexts. These are substantially lower than the .45 and .43 obtained in the previous course.

## 6.6. Disciplinary Achievement

The current BOOC included three 20-item unit exams and a 30-item comprehensive final. While item-level feedback was not provided, participants were allowed to take the exams twice in three hours and take the final twice in four hours. Participants were required to complete the exams and final to earn digital badges, but the original 80% criteria was relaxed. Participants were able to choose whether they included their exam performance on their digital badges, and exam scores were factored into final course grades for the for-credit students.

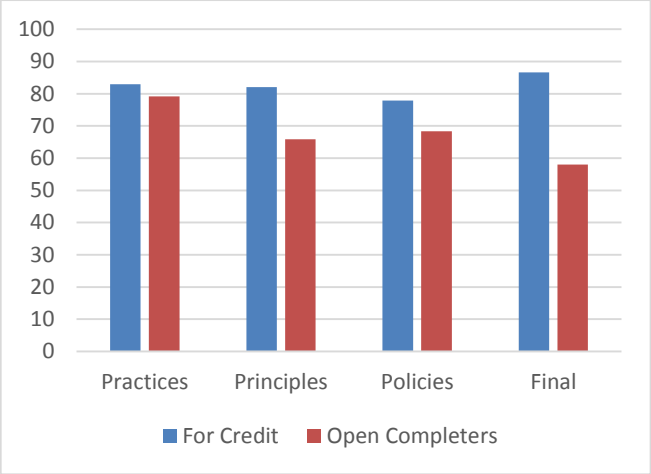


**Figure 6: Percent Correct for Each Exam by Enrollment Status**

Figure 6 presents the achievement scores for each of the three midterms and the final exam for the current class. These scores are similar to the scores for student in the previous course (88%, 83%, 78%, and 82% for the for-credit students and 84%, 76%, 78%, and 75% for the non-credit completers. The one notable difference is the poor performance of the open completers on the final exam.

# 7. SUMMARY AND CONCLUSIONS

In summary, the overall levels of engagement declined somewhat from the previous course to the current course, but this did not appear to have a strong impact on student achievement.

Given the many features of the course that were changed across the two versions, it is difficult to make any strong conclusions as to what was ultimately responsible for the changes across the two courses. While some features were streamline to make them less demanding on the instructor, a significant reduction in instructional resources and the added burden of producing a new video each week consumed substantial amount of instructor energy that would have otherwise been committed to fostering and encouraging disciplinary engagement.

Nevertheless, these represent significantly higher levels of disciplinary engagement than have been reported for online course, including both conventional and open. Continued refinement of these features is called for, as is further refinement of the various formative and summative learning analytic tools.

# 8. ACKNOWLEDGEMENTS

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## 9. REFERENCES


[1] Barab, S, Zuiker, S., Warren, S, Hickey, D., Ingram-Goble, A, Kwon, E., Kouper, I, & Herring, S., 2007. Situationally embodied curriculum: Relating formalisms and contexts. *Science Education, 91,* 750-782.

[2] Brinton, G. C., Chiang, M., Jain, S., Lam, H, Liu, Z., & Wong, F. M. F. (2013). *Learning about social learning in MOOCs: From a statistical analysis to a generative model.* Cornell. http://arxiv.org/abs/1312.2159.

[3] Brown, J. S., & Adler, R. P., 2006.. Open education, the long tail, and learning 2.0. *EDUCAUSE Review, 43,*1, 16-20.

[4] Cobb, P., Confrey, J., Lehrer, R., & Schauble, L., 2003. Design experiments in educational research. *Educational researcher, 32,* 1, 9-13.

[5] Engle, R. A., & Conant, F. R..2002. Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom. *Cognition and Instruction, 20* 3, 399-483.

[6] Gee, J. P., 2004. *Situated language and learning: A critique of traditional schooling*. New York: Psychology Press.

[7] Greeno, J. G., 1998 The situativity of knowing, learning, and research." *American Psychologist 53,* 1, 5-26

[8] Greeno, J. G., and Gresalfi, M. S., 2008. Opportunities to learn in practice and identity." In Moss, P. (Ed) *Assessment, equity, and opportunity to learn*. New York: Teachers College Press: 170-199.

[9] Gresalfi, M., et al., 2009 Virtual worlds, conceptual understanding, and me: Designing for consequential engagement. *On the Horizon 17,* 1, 21-34.

[10] Hickey, D. T., 2003. Engaged participation vs. marginal non-participation: A stridently sociocultural model of achievement motivation. *Elementary School Journal, 103,* 4, 401-429.

[11] Hickey, D. T.. 2012. A gentle critique of formative assessment and a participatory alternative. In P. Noyce & D. T. Hickey (Eds.), *New frontiers in formative assessment* (pp. 207-222). Cambridge, MA: Harvard Education Press.

[12] Hickey, D. T., Ingram-Goble, A., and Jameson, E., 2007. Designing assessments and assessing designs in virtual educational environments. *Journal of Science Education Technology, 18,* 187-208.

[13] Hickey, D. T., McWilliams, J. T., & Honeyford, M. A., 2011. Reading Moby-Dick in a participatory culture: Organizing assessment for engagement in new media. *Journal of Educ. Computing Research, 44* (4), 247-273

[14] Hickey, D. T., Tassoobshirazi, G., Cross, D., 2012. Assessment *as* learning. Enhancing discourse, understanding, and achievement in innovative science curricula. *Journal of Research in Science Teaching, 49,* 1240-1270.

[15] Hickey, D. T., & Rehak, A., 2013. *Wikifolios and participatory assessment for engagement, understanding, and achievement in online courses. Journal of Educational Media and Hypermedia, 22,* 4, 229-263.

[16] Hickey, D. T., & Zuiker, S. J., 2012. Multi-level assessment for discourse, understanding, and achievement in innovative learning contexts. *The Journal of the Learning Sciences, 22,* 4, 1-65.

[17] Ito, M., et al., 2010 *Hanging out, messing around, and geeking out: Kids living and learning with new media*. Cambridge MA: MIT Press.

[18] Jenkins, H., 2009. *Confronting the challenges of participatory culture: Media education for the 21st century*. Cambridge MA: The MIT Press.

[19] Middendorf, J, and Pace, D. 2004. Decoding the disciplines: A model for helping participants learn disciplinary ways of thinking. *New Directions for Teaching and Learning, 98,* 1-12.

[20] Oremus, W. 2013 Online class on how to teach online goes laughably awry. *Slate* (February 5, 2013), 1.

[21] Siemens, G., 2005. Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning, 2,* 1, 3-10.

[22] Woolf, B. P. 2010. *A roadmap for education technology.* Computing Research Association, Washington, DC.