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**Do Web-Based Student-Contributed Question Systems Enhance Learning Outcomes? Evidence From a Large Enrollment Political Science Course[[1]](#footnote-1)**

The academic literature on teaching and learning provides compelling evidence that active and collaborative learning strategies, and frequent formative assessments with corrective feedback, significantly improve student learning outcomes. A central challenge faculty face in teaching large undergraduate courses (150+ students) is providing students with these types of learning opportunities without overburdening the teaching staff (instructors and their graduate student teaching assistants). To address this challenge, this study assesses the use of PeerWise, a freely available, web-based pedagogical tool that enables students to write, share, answer, and discuss multiple choice questions (MCQs) in a large enrollment political science course at UC San Diego. Using both quantitative and qualitative student data, it finds that student use of PeerWise is not only positively correlated with student learning gains at statistically significant levels (p = 0.001), but also that it promotes student perceptions of learning and motivation to learn.

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**I. Introduction:**

 The academic literature on teaching and learning provides compelling evidence that active and collaborative learning strategies (Damron and Mott 2005; Huerta 2007; Luxton-Reilly and Denny 2010; Wilson, Pollock, Hamann 2007), as well as frequent formative assessments with corrective feedback (Draper 2009; Roediger, Agarwal, Kang and March 2010), significantly improve student learning outcomes. A central challenge that faculty face in teaching large undergraduate courses (150+ students) is providing students with these types of learning opportunities without overburdening the teaching staff (instructors and their graduate teaching assistants). To address this challenge, this study investigates the use of PeerWise,[[2]](#footnote-2) an online pedagogical tool that enables students to write, share, answer, and discuss multiples choice questions (MCQs) in a large enrollment political science course and assesses its impact on student learning outcomes, student perceptions of learning, and student motivation to learn.

 The potential learning benefits of PeerWise for students are numerous. First, by writing, explaining, sharing, and discussing questions with their peers, students are transformed from “passive” to “active” learners, actively engaged in constructing their own knowledge and understanding of course content (Luxton-Reilly and Denny 1010; Denny, Luxton-Reilly, Hamer 2008; Denny, Hanks, Simon 2010). Second, by generating and answering multiple choice questions (MCQs) in particular, research finds students may engage in higher-order cognitive processes and “deep learning” in ways that other types of questions do not stimulate (Draper 2009; Davis 2009; Crouch and Mazur 2001). Third, by sharing, answering, and commenting on student-generated questions, students create a collaborative learning community, which research also finds is strongly correlated to enhanced learning outcomes (Damron and Mott 2005; Luxton-Reilly and Denny 1010; Draper 2009). Fourth, by providing students with an opportunity for frequent formative assessment and corrective feedback, students can check their understanding of course content at any time and receive immediate corrective and explanatory feedback, which some scholars claim is perhaps “the single most powerful factor in promoting learning” (as cited in Draper 2009. See also Roediger et al. 2010). A final additional benefit of PeerWise is that it requires virtually no additional time investment on the part of faculty and their teaching assistants. The question bank is entirely student generated and moderated. Given the challenges of creating active and collaborative learning communities in large enrollments course, in addition to the potential grading load of frequent formative assessments with feedback, PeerWise may be a valuable pedagogical tool in helping us address the learning needs of our students, especially in large enrollment classes. Prior research on PeerWise shows that level of student use is strongly and positively correlated with student learning gains. For example, a quantitative analysis of 460 lower-division computer science students at the University of Auckland, New Zealand in 2007

found that the level of student PeerWise activity strongly and positively correlated with final exam performance (Denny, Hamer, Luxton-Reilly, and Purchase 2008). Another study, conducted during winter and spring quarters of 2009 in the Computer Science Department at the University of California, San Diego, also found a strong positive relationship between level of PeerWise activity and student learning outcomes, as measured by change in class rank (Denny, Hanks, Simon 2010). Specifically this study found that “the most active student …improve[ed] their class rank by an average of 8 places in a class of 73 (Winter) and by an average of nearly 6 places in a class of 53 (Spring) (Denny, Hanks, Simon 2010).[[3]](#footnote-3)

The developers of PeerWise at the University of Auckland, New Zealand report that since they launched the tool in 2007, it has been used in disciplines as diverse as anthropology, biology, chemistry, computer science, engineering, physics, mathematics, and medicine at more than 100 learning institutions worldwide.[[4]](#footnote-4) Despite its widespread use, however, to date studies of PeerWise effectiveness as a pedagogical tool have been conducted only in computer science and engineering disciplines. This study replicates and extends central elements of these earlier studies to determine whether PeerWise might be a valuable pedagogical tool to enhance learning outcomes in undergraduate political science courses, and especially in large enrollment courses.

 The paper is divided into four sections. The next section, section two, describes the study, its methodology, and levels of student participation. Section three provides an analysis of the relationship between level of PeerWise student activity and academic performance. The fourth section reports on and analyzes student perceptions of learning based on qualitative student survey data and research findings from the literature on human cognition and learning. The final section of the paper reflects on the potential pedagogical benefits of PeerWise for undergraduate political science courses, especially large enrollment courses, where the challenges to creating active and collaborative learning communities, and frequent formative assessment opportunities, are formidable.

**II. The Study, Methodology, and Student Participation:**

In this study, PeerWise was introduced into a large (204 students) upper-division political science course, *Politics of Developing Countries*, at the University of California, San Diego during winter quarter 2012. The class met twice per week for 80 minutes during a ten-week quarter. Learning objectives for this course include: (1) to critically evaluate dominant conceptions and theories of development in the political science literature; (2) to assess the relative value of these theories by applying them to specific case studies drawn from three regions of the developing world: Latin America, Sub-Saharan Africa and Southeast Asia; (3) to compare and critique patterns of development across these three regions; and (4) to further develop students’ skills as social scientists in formulating and testing hypotheses concerning the causes and consequences of development and underdevelopment. Course requirements included a midterm exam (week 5), a final exam (final exams week, week 11), and a research project (due week 9) focused on a development problem of student choice in a case study drawn from one of the three regions. The research project had four intermediate deadlines: (1) a research proposal; (2) an annotated bibliography of five peer-reviewed journal articles or academic press books; (3) a first draft; and (4) a critical review of a peer’s first draft.

 Replicating central elements of previous studies, PeerWise was introduced immediately after the midterm exam and these exams scores were used as a baseline performance indicator. To motivate students to use PeerWise, the instructor explained why and how the system is designed to promote student learning. She also reported on evidence of recent studies that have found statistically significant relationships between level of PeerWise activity and student learning gains (Denny, Hamer, Luxton-Reilly, and Purchase 2008; Denny, Hanks, Simon 2010). To further motivate students, three percentage points of extra credit were offered on the final course grade, if students fulfilled a minimum set of requirements. These requirements included writing a total of five multiple choice questions (MCQs) with explanations of correct and incorrect[[5]](#footnote-5) responses, and answering a total of ten questions. For full credit, first questions had to be submitted by the end of week 7, second questions by the end of week 8, third questions by the end of week 9, and the final two questions could be submitted at any time prior to the assignment deadline, which was the last week of the quarter, week 10. Questions could be answeredany time prior to the assignment deadline. Finally, the instructor explained that she would include five highly rated student-generated questions on the final exam, in addition to five short answer/essay questions.

 From Tuesday of week 10 (the extra credit deadline) to Tuesday of final exams week (week 11), when students took their final exam, PeerWise remained “open” for student use, but no extra credit points could be earned during this period. Replicating earlier studies, this period is referred to as the “exam study period” in order to assess whether students found sufficient learning value in the PeerWise system to use it voluntarily for exam preparation without receiving course credit for its use. Thus, there are three separate time periods examined in the study: **t1,** the overall period of student PeerWise use, from its introduction during week 6 through the final exam, week 11; **t2**, the “exam study period,” from Tuesday of week 10 through Tuesday of final exams week, week 11; and **t3,** the initial extra credit period, week 6 through week 10.

 During **t1,** the overall use period for PeerWise, 154 of 204 students, 75% of the class, was active on PeerWise. During **t2**, the “exam study period,” 129 students, 63% of the class, used PeerWise, and during **t3,** or the “extra credit period,” PeerWise was used by 95 students, 45% of the class. Of these 95 students, 69 students, or 37% of the class met the extra credit requirements for PeerWise use. These results are reported below, Table 1.

**Table 1:**

**PeerWise Use in Upper-Division Political Science Course (204 Students Total)**

**Student Use During Total Use Period, 7 weeks, (T1):**  154 Students (76% of students)

**Student Use During Exam Study Period, 1 week (T2):** 129 Students (63% of students)

**Student Use During Extra Credit Period, 6 weeks (T3):** 96 Students (47% of students)

As was reported in earlier studies, PeerWise was heavily used during the volunteer exam study period (t2), and many of those students who used PeerWise during the extra credit period (t3) exceeded the minimum requirements for participation. Specifically, of the 69 students who earned extra credit, 61 of these (88%) answered more than the minimum of 10 questions, with an average of 9.4 additional questions being answered by these students. As earlier studies also report, students were much more likely to participate by answering, rather than submitting, questions. Only seven of 69 students (10%) contributed more than the minimum number questions, with an average of 2.1 additional questions being submitted. This general pattern of participation is also observed in the overall use period, t1. During this 7-week period (weeks 6 – 11), students answered an average of 42.1 questions, but submitted only an average of 2.5 questions.[[6]](#footnote-6) Student levels of participation varied considerably, however, with two of 154 students answering no questions (but submitting 1 – 2 questions each), and fifteen students answering 100 or more (SD = 47.0).[[7]](#footnote-7) Overall these findings suggest that students were highly motivated to use PeerWise on a voluntary basis (no course credit was earned) for exam study, and that they preferred to use PeerWise as a means to “drill and practice” through answering questions, rather than writing/submitting questions.

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|  **Figure 1: Student Participation by Quintile** |
| Number of Questions Answered by Students |

To facilitate comparison among groups of students with similar levels of participation, and following previous work, this study groups students into quintiles based on the number of PeerWise questions answered. As is shown in Figure 1 above, the first quintile is comprised of the least active PeerWise users, or students who answered nine or fewer questions (64 students);[[8]](#footnote-8) students in second quintile (39 students) answered between 10 – 29 questions; students in third quintile (37 students) answered 30 – 59 questions; students in the fourth quintile (30 students) answered 60 – 79 questions; and students in the fifth quintile (34 students) answered more than 80 questions.

**III. Relationship Between Level of PeerWise Activity and Academic Performance:**

Prior studies have investigated whether student participation in the PeerWise system relates to change in academic performance across the same time period. Although final exam score or other similar measures of absolute student performance are reasonable candidates for indexing class performance, differences across students in these measures may be driven largely by individual differences in ability or interest (e.g. for the current sample, final class grade and cumulative GPA correlate highly, r = 0.60, p< 0.001). Because the PeerWise system was made available after the class midterm, *change* in performance as a function of participation in PeerWise provides a more isolated measure of the potential effects of using the PeerWise system. For the following analyses, students’ change in rank from the midterm to the final exam was used to measure any changes in class performance during that same time period with a positive rank change indicating that a student ranked higher on the final exam than the midterm exam. Importantly, students’ cumulative GPA had no detectable relationship to rank change in the class, r(202) = 0.02 p = 0.69.

Although performance gains are unlikely to be linearly related to participation in the PeerWise system, ordinary linear regression provides an initial and straightforward approach to testing for monotonic changes in class rank as a function of participation. Participation in the PeerWise system was positively, and statistically significantly, related to measures of academic performance as measured by change in class rank from the midterm to the final exam, b = 0.27, r(202) = 0.23, p = 0.001, see Figure 2, below.

**Figure 2: Change in Rank by Number of Questions Answered**



Consistent with the results from the linear regression above, the overall analysis of variance comparing change in class rank for the participation quintiles was statistically significant, F(4,199) = 5.68, p < 0.001, providing evidence that the average change in class rank differed across the participation quintiles. (See Figure 3, below.). Protected post-hoc analyses using the Tukey-Kramer HSD procedure[[9]](#footnote-9) revealed no statistically significant differences between the highest three participation groups (those students answering between 60-307 questions), but did provide evidence that highly active students increased their class rank significantly more than students in the lowest participation group (5th vs 1st quintiles: p = 0 015, 4th vs 1st quintiles: p = 0.003, 3rd vs 1st quintiles: 0.002). As shown in Figure 3 (below), students in Q1, the least active PeerWise users (answering 9 questions or fewer), saw their class rank *decrease* an average of 21 places in a class of 204 students, whereas students in the most active group, Q5 (answering 80+ questions) *improved* their class rank an average of 16 places. Interestingly, students in the next two highest participating groups, Q4 (answering 60 – 79 questions) and Q3 (answering 30 – 59 questions) improved their class ranks an average of 23 and 22 places respectively. The second least active PeerWise user group, Q2 (answering 10 – 29 questions), saw their class rank decrease, but only by an average of 1 place. Overall this suggests that performance gains do diminish after a certain amount of participation, but there are substantive gains in learning for students up to that point.

**Figure 3: Change in Rank by Group**


 Mean +/- 95% Confidence Intervals

 Although observational data such as these cannot speak to any causal relationship between PeerWise activity and academic performance, it does provide suggestive evidence that participation in PeerWise may enhance learning. Because overall ability (as measured by cumulative GPA) shares no relationship with the outcome measure (change in rank), the relationship between participation in PeerWise and change in class rank is not directly attributable to differences in student ability. However, participation in PeerWise and overall ability (via GPA) do share a relationship, r(200)=0.25, p < 0.001; thus, it is conceivable that the PeerWise system provides those students with higher ability or interest a mechanism to enhance their own learning.

**IV. Student Perceptions of Learning with PeerWise:**

To better understand why we find such a strong and positive correlation between levels of student PeerWise activity and academic performance, this section examines student perceptions of learning with PeerWise and the ways in which they believe PeerWise may have impacted their motivation to learn, their ability to learn, and their attitudes toward learning.

 Students who used PeerWise were asked to complete an end-of-quarter evaluation related to their experience on the last day of class (week 10). These evaluations were anonymous and conducted by two student volunteers while the instructor remained outside the classroom. Completed evaluations were collected by student volunteers and held in confidence by an administrator in the political science department until final grades were submitted. The first part of the survey was comprised of eight rank survey questions of which five are reported on here:[[10]](#footnote-10)

 (1) I found PeerWise valuable for my learning.

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| (2) Developing new questions helped me learn.  |
| (3) Answering other students’ questions helped me learn.(4) PeerWise will be useful for my exam review this term.(5) I would like to use PeerWise again in a future course. |

There was an 89% response rate among students who used PeerWise during this period.[[11]](#footnote-11) Overall, students found the PeerWise system valuable. Only two students (2.4%) disagreed with the statement that PeerWise was valuable for their learning, and only four students (4.8%) disagreed that developing new questions helped them learn. In response to whether answering other students’ questions helped them learn, again only two students (2.4%) disagreed with this statement, and another two students (2.4%) strongly disagreed. There was also very little disagreement that PeerWise would be useful for their final exam review, with two students (2.4%) disagreeing, and one student (1.2%) strongly disagreeing. More students disagreed with the statement regarding whether they would like to use PeerWise again in a future course, but again, the numbers were small, with only one student (1.2%) strongly disagreeing and seven students (8.2%) disagreeing.

 Although these assessments provide some insight into the extent to which students felt PeerWise was valuable for their learning and why, the survey’s open response questions provide much greater insights into student perceptions of learning gain. Five open response questions were asked on the survey:

(1) What do you believe is the biggest benefit of using PeerWise? Or, what aspects of using PeerWise did you find most useful/interesting/enjoyable?

(2) What do you believe is the biggest problem with PeerWise? Can you recommend something that would make PeerWise more valuable or effective for learning?

(3) If you contributed more than the minimum requirement (either by developing more questions or by answering more questions than you were required), what was your main motivation for doing so?

(4) How much time did it take you to write a typical PeerWise question?

(5) What is the most difficult part about writing questions?

Analysis of student responses to these questions reveals three key learning mechanisms at work through student use of PeerWise: (1) active learning through multiple choice question writing; (2) collaborative learning through peer sharing, evaluating, and discussion of student-generated questions; and (3) “deepened” student learning through frequent formative assessment with corrective and explanatory feedback. The following section examines each of these learning mechanisms with reference to student responses and the theoretical literature on human cognition and student learning.

**Multiple Choice Question Writing as an Active Learning Strategy:**

When asked “What do you believe is the biggest benefit of using PeerWise?” approximately two-thirds of students commented on the value of writing questions, and multiple choice questions in particular, as an active learning strategy. Specifically, students commented on how question writing required them to actively engage course materials (readings and lecture notes) in ways that deepened their understanding and helped them think more critically about course content. Sample student comments include:

* “The biggest benefit is having to think critically about the course content to develop a question.”
* “Developing questions causes you to analyze a topic . . .”
* “It made me think critically about the topics.”
* “The greatest benefits of PeerWise were thinking through topics to generate questions . . .”
* “Because it required [writing an] explanation [for questions], it helps you understand concepts more in-depth.”
* “[The greatest benefit was] writing questions, most importantly. [Constructing] answer choices [distractors for multiple choice questions] really shows if you’ve understood the material . . . ”
* “Being forced to think about a topic to [write] a clear question or provide a clear explanation. There is no better way to learn than to teach.”
* “The greatest benefit of using PeerWise was writing my own questions and getting them rated.”

These student responses support one of the most robust findings in the academic literature on teaching and learning that “active” rather than “passive” learning strategies are linked to higher-order cognitive processes and enhanced learning outcomes (Damron and Mott 2005; Huerta 2007; Wilson, Pollock and Hamann 2007). As Wilson, Pollock and Hamann (2007) explain: “anything that simulates students’ active engagement in the learning process will enhance their learning compared to their memorizing facts by heart and reciting them at exam time” (131). As Huerta (2007) points out, “[t]he key is that students are not passive participants in their learning; rather they are engaged and active in the learning process” (238).

Student responses also support the findings of a growing body of research that examines the role of question writing, and multiple choice question (MCQ) writing in particular, as an effective active learning technique (Davis 2009; Draper 2009; King 1992; Luxton-Reilly and Denny 2010). In her 1992 study, King, for example, finds that question writing as a study strategy, compared to note-taking and summarizing strategies, results in “deeper” learning and greater long-term retention of material (King 1992). Although she finds that both question writing and summarizing strategies were effective when students were tested immediately after exposure to material, only the question writing strategy resulted in greater retention when students were tested again after one week (King 1992, 317). What explains this outcome? As King comments, “[r]esearchers have found that different [study] strategies have different effects on students’ cognitive processing and on the way in which information is represented in memory, and both research and theory concur that the more completely information is processed, the better it is remembered over time” (317). From this she hypothesizes that question writing promotes greater long-term retention “because it increase[s] cognitive processing” in ways that other study strategies may not (317).

For example, as King explains, question writing can encourage students to “generate specific kinds of idea relationships such as comparison and contrast, cause and effect, strengths and weaknesses” (318), and students who process course materials “by making these specified connections between or among ideas . . . construct different kinds of meaning” than other types of learning or study strategies (318). Thus, question writing can enable students to construct representations of course content in long-term memory in ways that are “more richly integrated –more complete” than other study strategies (318). As King reports, research has found that this type of learning activity can “enhance recall because the information is encoded more precisely and more meaningfully” (318). This finding also supports a large body of theoretical literature on constructivist theories of learning. As King explains, students who engage in question writing must “reformulate[e] given information or generat[e] new information based on what is provided” and this helps students “build extensive cognitive structures connecting new ideas together and linking them to what the student already knows” (304).

Although King makes a compelling case for why question writing may be an effective active learning strategy, some have expressed concern that the multiple choice question (MCQ) format itself is “associated with the lowest kind of learning of disconnected fact.”[[12]](#footnote-12) A growing body of research has countered this claim and provided compelling evidence for the pedagogical value of both writing and answering MCQs in developing higher-order cognitive skills and in stimulating deep learning (Draper 2009; Crouch and Mazur 2001; Beatty, Gerace, Leonard, and Dufresne 2006; Butchart and Handfield 2009; Davis 2009). In fact, Draper (2009) asserts that the most recent research finds that “[t]he most dramatic evidence of quantitative learning gains . . . centrally involve[s] the use of MCQs in class . . .” (286). As evidence, Draper cites the large and growing body of literature on Peer Instruction (PI), a pedagogical technique developed in the 1990s by Eric Mazur, a physicist at Harvard, which predominantly uses the multiple choice question format.[[13]](#footnote-13)

 Research on the effectiveness of Peer Instruction consistently finds impressive learning gains, including greater retention levels, deeper conceptual understanding, and stronger problem solving skills at statistically significant levels.[[14]](#footnote-14) Specifically, Draper cites two influential studies on the effectiveness of MCQs in Peer Instruction pedagogy. The first is a 1998 study by Hake, which surveyed 62 courses and over 6000 students and produced strong evidence in learning gains, as measured by standardized pre- and post-tests, by using MCQs and “interactive engagement” in the classroom (Hake 1998, as cited in Draper 2009, 286). The second is a 2001 study by Crouch and Mazur, which reports more than doubled learning gains through use of MCQs and Peer Instruction pedagogy (Crouch and Mazur 2001, as cited in Draper 2009, 286).

 Draper develops a persuasive evidence-based argument for how and why writing and answering MCQs can promote “deep” as opposed to “shallow” learning.” For Draper, “deep” versus “shallow” learning refers to the structure of knowledge that student establish through the learning process (287). From this perspective, “deep learning” is characterized by “learning multiple relationships between items that can support multiple uses (i.e., transfer tasks) better” (287). He asserts that MCQs have the potential to result in “substantial learning advantages by stimulating the learner into making more links, e.g. between a ‘fact’ and a reason for it” (287). For example, he explains the potential learning value of “assertion-reason” MCQs, where students are required to read a factual assertion, then choose between competing theoretical principles, or reasons, that would explain the observation provided in the question stem. By requiring students to think about the relationship between and among ideas, and making course content “their own” through writing multiple choice questions, Draper finds that they both deepen learning and improve retention.

 Luxon-Reilly and Denny’s 2010 study supports Draper’s findings on the potential pedagogical value of writing MCQs as an effective active learning strategy (Luxon-Reilly and Denny 2010). As they explain, in order to write a high quality MCQ, students have to write both an appropriate question stem and come up with effective “distractors,” that is, plausible, but incorrect answers. As Davis (2009) explains, “[e]ffective distractors represent errors commonly made by students: statements that include errors of logic or interpretation, statements that are too general or too specific for the requirements of the problem, statements that are accurate but do not fully meet the requirements of the problem, and incorrect statements that will seem correct to the poorly prepared student” (395). As Luxon-Reilly and Denny report, generating high quality distracters is perhaps the most challenging part of writing MCQs since “the best alternatives are one that reveal possible misconceptions” (152). Through the process of generating appropriate questions stems and high quality distractors, they find that students engage course content (readings and lecture notes) in a “deep and meaningful way” that promotes student learning (2010, 152).

This finding in the literature is also strongly supported by qualitative student survey data in this study. In response to the fifth open response question (“What is the most difficult part about writing questions?”), a majority of students (approximately 60% of students who answered this question) commented specifically on the challenge of constructing high quality distractors. An additional 30% of students commented simply on the difficulty of writing high quality questions (not explicitly mentioning constructing distractors) and the necessity of understanding course materials well in order to write a high quality question. The remaining students (approximately10%) commented on the challenge of explaining correct and incorrect (distractors) answers to peers.

A final way that question writing can promote active learning is simply through creating incentives for more active listening and reading practices. That is, anticipating that they will later need to write questions on readings or lecture material, students may more actively engage course content while reading or listening to lecture. Although this was not reported by students in this study’s survey, in her study 1992 King hypothesizes that perhaps simply the process of thinking about course content in question form may result in students engaging and thinking about the material more actively–“identifying important ideas, speculating on relationships among those ideas, predicting outcomes, and evaluating the significance of concepts” (319) and, in so doing, may deepen learning and improve retention (318 – 319). In particular, King focuses on the potential value of this active learning technique for underprepared college students, who often have not had the opportunity to develop these cognitive and metacognitive skills.

**Collaborative Learning and Peer Interaction:**

Interestingly, the second most frequent response to the question “What do you believe is the biggest benefit of using PeerWise?” was the peer/collaborative learning aspects of PeerWise and sense of community this generated. Approximately 45% of students who answered this question discussed the comradery that developed among students though giving and receiving feedback, and how this contributed to their learning. Sample student comments include the following:

* “[The greatest benefit of using PeerWise is] . . . students helping each other learn.”
* “[PeerWise] creates classroom discussion/ interaction with each other, which is hard especially for big classes like ours.”
* “Comments are very helpful to authors. Seeing what others feel is important. Feels like a community!”
* “You learn what other students think is important…[it] helped me learn.”
* “I liked the discussion forum [and] interactive nature of PeerWise.”
* “The biggest benefit was knowing you’re on the same page with everyone else, and if not, you could use it to get on the same page.”
* “Learning from different perspectives; seeing how other students understand the material.”
* “The most useful thing is that PeerWise offers an idea of what other students are thinking about and what they also did/did not think was valuable. It re-enforces my own thought processes.”

 These student responses are also supported by research findings in the pedagogy literature. As Damron and Mott (2005) report, “because many political science courses are lecture-dominant, students can remain relatively anonymous, isolated, and consequently uninvolved in the knowledge-building process” (369). Moreover, large lecture courses in particular “tend to curtail student opportunities to talk about, to collectively process and to apply the ideas and concepts presented to them” (369 – 370). They find that perhaps one of the most effective ways of addressing some of these challenges is to introduce learning activities that not only allow for active engagement of course materials, but also provide students with opportunities to work together (Damon and Mott 2005). Ultimately they find that cooperative learning creates incentives for greater engagement of course content and higher levels of participation, and in so doing, enhances learning outcomes.

 Draper’s study (2009) also finds that “interactive engagement” among peers is critical to explaining the large demonstrated learning gains in use of MCQs through Peer Instruction pedagogy. As he explains, “[c]entral to [this] method . . . is a use for MCQs in teaching to promote peer interaction” (Draper 2009, 290). That is, a critical part of the learning process is the peer interaction involved in writing, sharing, explaining, and commenting on questions. As Draper explains, requiring students to write MCQs that will be helpful to their peers results in “a partly internalised form of peer instruction” (290). As students create questions, they “imagine the objections and responses of [their] audience rather than needing them to be present in peer discussion” (290). An advantage of PeerWise is that is that it also allows for peer discussion through the process of students answering and commenting on questions, and authors then having the opportunity to provide a response to these comments. As two students insightfully explain: “The greatest benefits of PeerWise were thinking through topics to generate questions, then receiving feedback from responses” and “Comments are very helpful to authors. Seeing what others feel is important. Feels like a community!”

 The collaborative/peer learning feature of PeerWise also enables students to reach out to other students for further clarification or explanation of questions. Studies have found that these types of interactions not only strengthens students’ communication skills, but that they also deepen student learning and build metacognitive skills through self-explanation (Aleven and Koedinger 2002). In addition, as Luxon-Reilly and Denny (2010) report, peer feedback can improve the quality of PeerWise’s questions repository and help build student confidence. For example, one student posted this comment in response to a classmate’s questions: “Wow, I skimmed this and managed to get this question wrong then went back and you were right. Good question!” Thus, both student survey data and research findings suggest that the collaborative/peer interactive aspects of PeerWise are valuable mechanisms for enhancing learning outcomes, increasing student motivation to learn, and creating positive attitudes toward learning.

**Frequent Formative Assessment With Corrective and Explanatory Feedback:**

The third most frequent student response to the question “What do you believe is the biggest benefit of using PeerWise?” focused on the learning benefits availed by being able to frequently test their understanding of course materials through using the student-generated question bank for drill-and-practice. Approximately 40% of students believed that this deepened their understanding of course material, helped focus their exam study, and built confidence in their mastery of the material. Approximately 15% of these students commented that in addition to the learning benefits of answering questions, they simply found it “fun.” Sample student responses include:

* “Answering questions reinforces understanding.”
* “I found it helpful to read and understand other students’ questions.”
* “Answering practice questions helped me learn.”
* “Answering questions made me review all the things I learned.”
* “Answering questions [and] seeing what others have posted helped me prepare”
* “I wanted to reassure myself that I knew enough.”
* “I was over-answering to make sure I really understood course materials.”
* “I answered more questions because it was good practice.”
* “I answered more question to gain a better understanding of course materials.”
* “I found that once I started answering questions, getting them correct, and re-enforcing my thoughts, I wanted to answer more to continue the re-enforcement!”
* “I answered more [questions] because it was easy and fun.”
* “Multiple choice questions with no repercussions [for my grade] are fun.”
* “Answering questions was fun!”
* “Answering questions can be addicting ☺ like a game”
* “Answering questions was addicting and helpful, so I kept going.”
* “I enjoyed it and it was educational.”

 Perhaps one of the most robust findings in the literature on pedagogy is the value of providing students with frequent opportunities for formative assessment with corrective and explanatory feedback. “Formative,” as opposed to “summative” assessments are designed to “enhance, rather than evaluate, learning” (Beatty, Gerace, Leonard, and Dufresne (2005, 33). Recent research on human cognition and learning provides compelling evidence for the value of frequent formative assessments with feedback in improving student learning outcomes (Roediger, Agarwal, Kang and Marsh 2010; Draper 2009), with some scholars going so far as to claim that formative assessment is “the single most powerful factor in promoting learning” (as cited in Draper 2009, 285). Beatty, Gerace, Leonard, and Dufresne (2005) also assert that “[f]ormative assessment is perhaps the most effective instructional ‘innovation’ ever studied” (33).

 Roediger, Agarwal, Kang and Marsh (2010) find that tests have both indirect and direct effects on student learning. The indirect effect is that by providing more tests, students study more and, thus, learning gains are simply a function of greater time on task. The direct effect is a robust finding in the literature on human cognition that “effortful retrieval” of information while taking tests results in deeper learning and greater retention then other forms of study. This result is referred to in the literature as the “testing effect.”

 As important as “effortful retrieval” of information is for enhancing learning and long-term retention of information, equally important, these scholars assert, is providing corrective and explanatory feedback to learners. Feedback is defined as “information provided following a response or recollection, which informs the learner about the status of current performance, often leading to improvement in future performance” (Roediger et al. 2010; Roediger et al. 2008). Morena (2004) also finds that “explanatory feedback (e.g. providing student with the correct answer and an explanation) increased final retention and transfer relative to corrective feedback (e.g., only providing students with the correct answer)” (cited in Roediger et al. 2010, 22). Thus, the strong recommendation that emerges from this literature is that to improve student learning outcomes “teachers should implement more frequent testing . . . using test formats that entail effortful retrieval . . . and provide feedback to correct [and explain] errors” (Roediger et al. 2010, 21).

 This research finding raises the practical question of how instructors can provide students with opportunities for frequent formative assessment, and corrective and explanatory feedback, in large enrollment courses of 150+ students, without overburdening themselves and/or their teaching assistants. As this study demonstrates, PeerWise provides these opportunities to students while placing virtually no additional work demands on the teaching staff, since the question repository is entirely student generated and moderated. As students report, it enables them to test their own knowledge against their peers’ as frequently as they would like, and whenever they like. As one student reported, “[I liked PeerWise because] it’s an easy way to study between classes, while eating, etc.” Moreover, once they submit their answers, they are provided with immediate feedback of the author’s answer and explanation, as well as a display of the most popular answers to questions, and students’ comments and discussion threads on questions.

Although only 37% of students responded to the open response question asking what they perceived as the “biggest problem with PeerWise,” of these nineteen students (25%) were frustrated by low quality questions; six students (19%) reported redundant questions as a problem; five (16%) students felt overwhelmed by the number of questions in the question repository (there were 387 total questions generated by the end of the term); and four students wanted confirmation from the instructor that answers posted to questions were indeed correct.[[15]](#footnote-15)

In theory, the student-generated rating and tagging system in PeerWise is designed to help students navigate the large question repository. When students write questions, they are asked to enter key words to enable other students to sort questions by topics. In addition, students “rate” the quality of questions on a 6-point scale (0 – 5) and these ratings can be used by other students to help them decide which questions to study. Similar to previous studies on the learning effectiveness of PeerWise, this study also finds that, while the quality of questions in the repository varied, comparison of quality ratings to frequency of student responses reveals a strong correlation between questions that were highly rated and those that were responded to most frequently. (See Figure 4, below.) This finding is consistent with results of previous PeerWise studies (Denny, Hamer, Luxton-Reilly, and Purchase 2008; Denny, Hanks, Simon 2010).

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| --- |
| **Figure 4: PeerWise Questions: Quality vs. Number of Responses** |
|  |

**V. Conclusion:**

This paper has investigated the use of PeerWise, a freely available online pedagogical tool that provides students with the opportunity to write, share, answer, and discuss multiple choice questions, in a large enrollment political science course (204 students). Although previous studies in computer science and engineering disciplines have found evidence that level of PeerWise activity is positively correlated with improved academic performance at statistically significant levels, this is the first study to examine the potential effectiveness of PeerWise to enhance student learning outcomes in a political science course. Specifically, the study assesses the impact of PeerWise on student academic performance, as measured by change in class rank between midterm and final exams, and student perceptions of learning, as reported by students on an end-of-term anonymous survey.

Using both quantitative and qualitative student data, the study finds that student use of PeerWise is not only positively correlated with student learning gains at statistically significant levels (p = 0.001), but that it also valuably contributes to student perceptions of learning and motivation to learn. Analysis of qualitative student survey data finds three key learning mechanisms at work in student use of PeerWise: (1) active learning through multiple choice question writing; (2) collaborative learning through peer sharing, evaluating, and discussion of student-generated questions; and (3) “deepened” learning through frequent formative assessment with corrective and explanatory feedback. These student responses to questions about the perceived learning benefits of PeerWise are supported by the academic literature on teaching and learning.

One of the central challenges faculty face in teaching large enrollment undergraduate courses is providing students with opportunities for active and collaborative learning, and frequent formative assessment, without overburdening themselves and/or their teaching assistants. This study provides evidence that PeerWise may be an effective tool for engaging students in these ways with virtually no additional workload for the teaching staff. Perhaps most encouraging was students’ reported enjoyment in using PeerWise. As the literature on teaching and learning has found, student motivation to learn and positive attitudes toward learning are critically important to enhancing student learning outcomes.

 Ultimately our goal as educators is to provide the resources, feedback, and guidance to enable our students to become life-long learners, not simply to perform well on exams. To achieve this goal, we need to provide them with opportunities for independent learning, allowing them control over when, how, and what to study. As the discussion and analysis above demonstrates, PeerWise may be a valuable pedagogical tool in this respect. By engaging in question writing and self-explanation, monitoring correct and incorrect answers through question answering, and providing constructive feedback to their peers through question comments, evaluations, and discussion, PeerWise may help students better understand how and why they learn best. As the research on teaching and learning also has shown, development of these metacognitive skills is essential not just to improving learning outcomes in a single course, but to promoting life-long and independent learners –our ultimate goal.

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1. UCSD Human Research Projection Project #120770XX. [↑](#footnote-ref-1)
2. PeerWise is a freely available online pedagogical tool developed by faculty researchers in the Computer Science Department at the University of Auckland, New Zealand in 2007. It can be accessed at: http://peerwise.cs.auckland.ac.nz/ [↑](#footnote-ref-2)
3. This study divided student into quartiles based on the number of PeerWise questions they answered. Mean performance for students in each quartile were compared with a one-way ANOVA on the data to test for significant difference between quartiles. This showed that significant difference existed between quartiles, and a Bonferroni corrected pairwise t-test was then conducted and showed that the differences between rank change in the most and least active quartiles was highly significant (p=0.004). Although differences between quartiles where not shown to be significant using a one-way ANOVA on the spring data (although it was close, p = 0.06), the study notes that the probability of both courses exhibiting a monotonic trend is less the 0.7%. Thus, the fact that in both cases the trend was monotonically decreasing is taken as evidence of a strong and positive relationship between student activity and improvement in class rank (Denny, Hanks, Simon 2010). [↑](#footnote-ref-3)
4. See the home page for PeerWise: http://peerwise.cs.auckland.ac.nz/ [↑](#footnote-ref-4)
5. That is, “distractors” – plausible, but incorrect answers. [↑](#footnote-ref-5)
6. A total of 385 questions were created by 154 students during the entire use period. [↑](#footnote-ref-6)
7. The top student in the class answered 307 questions. [↑](#footnote-ref-7)
8. The minimum requirement for extra credit was ten questions. re were 64 students in this group. [↑](#footnote-ref-8)
9. Like all protected post-hoc procedures, the Tukey-Kramer HSD facilitates comparisons among groups without increased risk of a Type-I error; however, unlike Bonferroni corrected t-tests, the Tukey-Kramer procedure does not require that comparisons be planned in advance and provides a more powerful test when many possible pairwise comparisons are possible. [↑](#footnote-ref-9)
10. The last three of the rank survey questions overlapped with some of the first five questions, and student responses were nearly identical, so we report only on the first five questions. [↑](#footnote-ref-10)
11. Of the 96 students who used PeerWise during this period (weeks 6 – 10), 85 students (89%) responded. [↑](#footnote-ref-11)
12. This perspective is cited in Draper 2009, 285. Draper’s work provides powerful evidence that counters this claim (Draper 2009). [↑](#footnote-ref-12)
13. Rather than extended 60 – 80 minute traditional lectures, Peer Instruction pedagogy divides the class period into a series of “mini-lectures” of approximately 10 - 15 minutes each, after which a short “ConcepTest,” or a brief conceptual question on the material just presented, is posed to the class. Questions are framed in either a multiple choice or true/false question format, and students are allowed approximately one minute to think about the question before individually committing to an answer. If most students answer the question correctly, the instructor moves forward with the lecture. If not, students break into discussion groups of three to five students and engage in “peer instruction.” Mazur refers to these as “convince-your-neighbor discussions,” and the group is allowed another one to two minutes to reach a consensus within their group. The instructor then re-asks the question and students again record their answers. This process is repeated, sometimes with additional instructor explanation of the concept or topic, or clarification of the question, until a majority of students answer the question correctly. The instructor then explains the correct answer to the class (Mazur 1997). [↑](#footnote-ref-13)
14. For example, see Wieman 2009, and Crouch and Mazur 2001. [↑](#footnote-ref-14)
15. Draper (2009) reports that, from a learning perspective, however, peers responses, even if incorrect, provide a greater “stimulus” for learning “because you respect them enough to think they could be right, but you are not at all sure whether they are, whereas teachers tend to elicit unthinking acceptance and so actually tend to suppress deep learning” (289). [↑](#footnote-ref-15)