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Engagement in Interactive Web-based Courseware as part of a Lecture based Course and the Relation to Student Performance

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STUDENT USE OF OPTIONAL ONLINE COURSEWARE RESOURCES: FACTORS THAT AFFECT STUDENT SELF-REGULATION OF THEIR LEARNING

Introduction

Increasingly, learning resources beyond the textbook and instructor's lectures and office hours are available to students in engineering courses[1-5]. Students may find these resources independently or be informed about them by instructors. These can include for example readings, videos, simulations, and interactive exercises. Often, instructors may not know how much students access these resources, or whether they find them beneficial. Unlike assigned homework, for which students receive course credit, extra resources are typically accessed entirely at student discretion: initially via the student perceiving a need or opportunity, and, on an ongoing basis presumably if students find them of benefit. Of particular interest here, are learning resources that provide students opportunities for practicing concepts and skills learned, as well as feedback on their practice.

How might instructors encourage use of such a resource, if viewed as potentially valuable, in a course that contains other standard learning resources, such as lecture, homework, and so forth? Can we move away from the model in which all students are assigned the same amount of work, regardless of how they perform, and instead give them the opportunity to self-regulate their learning? In the model of Zimmerman and Schunk[6], self-regulatory learning involves a three-step process of planning, practicing, and evaluation for students to follow to independently monitor their learning. Learning resources that offer feedback may provide the evaluation upon which students can gauge their own learning and then choose to undertake additional activities, as suits their own needs. Here, we are interested in how such a resource might be introduced into a course, and how we can determine whether it has been used to good effect.

One opportunity to observe self-regulation is when students use to varying extents a learning resource that is not mandatory. We would view students as successfully self-regulating if they use the resource, *when needed*, to further their learning. In particular, we explore whether students self-regulate in the context of using online statics courseware materials, and we study the factors that influence students' use of the materials. First, we look at how much each student uses the resource and what was that student's corresponding performance in the course. Second, by surveying students, we seek to understand the various factors that influence them positively and negatively to use the resource, given that its use is largely voluntary. In the following sections we describe the resource, the contexts in which the resource was implemented in two different courses at two universities, how it was implemented with the goal of promoting self-regulation, and what were the usage and performance outcomes and student rationales for their usage.

Settings of study

Online course materials used in this study consist of the Open Learning Initiative (OLI) Engineering Statics course. As previously described[7-8] the OLI materials consist of twenty modules, akin to chapters. Each module is composed of several webpages, each devoted to a

single learning objective. Concepts and problem solving are explained using text and graphics, simulations, and interactive exercises with hints and feedback. For each of the learning objectives, there are Learn By Doing (LBD) exercises with which students can first practice the skills; at end of each page there are Did I Get (DIGT) exercises that further enable students to test whether they have mastered the concepts and skills, while again receiving detailed hints and feedback; these exercises are not graded. At the end of each module, there is a graded quiz.

OLI engineering statics course materials were used in lecture-based statics courses at two universities, Miami University in Ohio, a state university (School S) and a private research university, Carnegie Mellon University, (School P). In School S topics covered coincided largely with the material in OLI (12 of 14 exam problems involved material covered by OLI); there is also diversity of majors, with mechanical, manufacturing, bioengineering, chemical, electrical engineering, and management majors. In School P topics covered extended beyond the material in OLI (8 of 16 exam problem involved material purely found in OLI); the vast majority of students were mechanical engineering majors. In both cases, only the end of module quiz was required to be completed and students received credit based on their quiz score. At the start of the semester, it was made clear to students that they should use the interactive learning activities within a module before the quiz to learn the material in preparation for the quiz and for class exams. The number of pre-quiz activities undertaken, and students' performance on them, would not contribute directly to students' grades. Thus, students regulated their usage of LBD and DIGT activities, using the feedback, solely with the goal of learning the material, not fulfilling an assignment.

The two schools also differed with respect to the sequence of lecture and due dates of on-line modules quizzes. School S (Miami University in Ohio) followed a flipped or inverted order. Specifically, students were required to complete OLI module quizzes, using the with-in module activities as they saw fit, just prior to the lecture. The instructor had access to student performance in the module through the Learning Dashboard, and so could adjust class activities to take advantage of data on performance; class time was devoted to addressing any common difficulties revealed by the system's analysis of student work, and to additional activities, topics, and problem solving. Written homework on the same topics was due the week after the OLI module quiz was due, that is after class time devoted to the topic.

School P (Carnegie Mellon University) had followed the same flipped approach as School S, except in the most recent semester (Fall 2013) it followed a conventional order: a topic was covered in lecture during the week, and the OLI modules covering those topics were due at the start of the following week. Written homework on the same topics was due at the same time as the OLI module quiz.

Data collection

The OLI system tracks, for each module, the fraction of available activities that each student initiated. We collected these values from the system and computed the fraction of activities initiated (averaged over all modules) for each student. For the purposes of this study, we take this fraction, referred to as *participation,* to quantify the usage of the online course materials by each student. We should note that *participation* is a somewhat crude measure of student engagement

with online materials since it reflects only initiation of an activity. *Performance* for the purpose of this study was measured by the total score on exam problems. At School S, exams constitute 75% of the final grade, while OLI quizzes are 10%; at School P, exams constitute 85% of the final grade, while OLI quizzes are 7.5%. Data on students' *participation* and course *performance* had been collected for the corresponding statics classes in Fall 2012 and for Fall 2013. Due to time constraints performance data from only Fall 2012 have been included in this paper. Data from students who took all exams were analyzed in this study: 105 from School S and 73 from School P.

Additionally students in each course in Fall 2013 were surveyed anonymously. Survey questions ask students to self-report their participation (fraction of activities undertaken within a module), and to choose which of a set of positive and negative motivations played significant roles in determining the number of activities they undertook. Students were also asked to comment on how their behavior would have changed if their participation (usage of the activities) were not optional. The survey was completed by 92 of 106 students in School S, and by 100 of 134 students in School P.

Results and findings

a. Performance versus participation

A scatter plot of performance (percentage correct on all exam problems) and participation (average usage) is shown in Figure 1 for School S and Figure 2 for School P, both for Fall 2012, since only these data were available in the timeframe of this paper. First, there is indeed a very wide distribution of participation: the participation for School S had a mean of 65% and standard deviation of 21%, while the participation for School P had a mean of 68% and standard deviation of 21%. For School S, one can view students as falling into three groups corresponding the four quadrants in the plot. Students in the upper right completed more activities in the resource and tended to have higher exam scores. Students in the upper left completed fewer activities in the resource but still tended to have higher exam scores. Students in the lower left completed fewer activities in the resource and tended to have lower exam scores. Thus, students in the upper two quadrants are successfully self-regulating their learning, that is, they are using the resource *as needed* to further their learning, while students in the lower left quadrant are not. Results from the survey described below will support this interpretation. There are virtually no students in the lower right quadrant for School S; most students who used the resource, performed well on the exams, perhaps because topics covered in the course in school S coincided largely with the material in OLI, and as a result 86% of exam problems involved material covered by OLI.

The results of performance versus participation for School P are quite different. There is little systematic variation with participation. Interestingly, however, the participation is quite comparable to School S. There are students who do many OLI activities, but do not necessarily perform well on the exams. This may be due to the significant number of topics covered in the course that go beyond OLI. As a result only 50% of exam problem involved material covered by OLI, as opposed to School S were 86% of exam problems involved material covered by OLI.

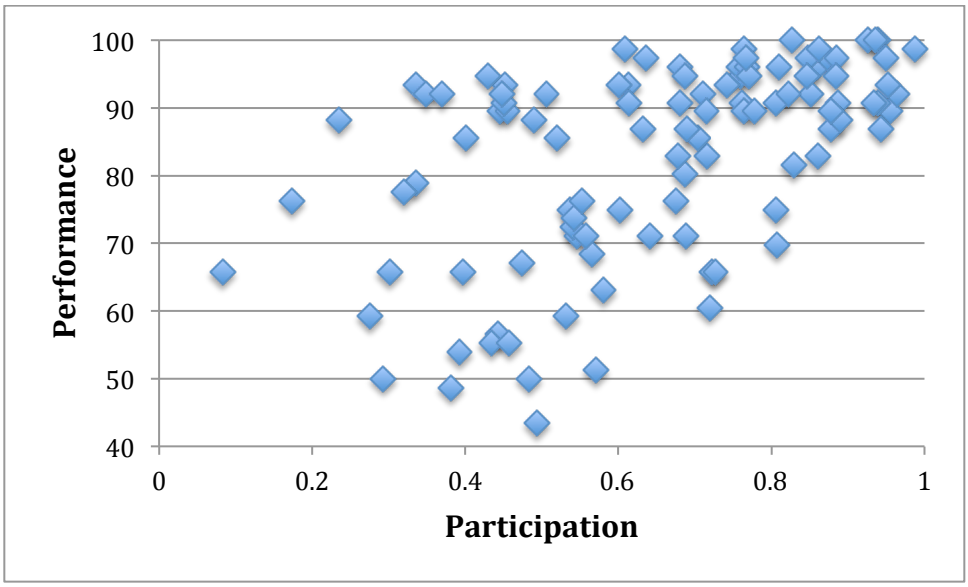

Figure 1. Score on exams versus participation in online activities for School S.

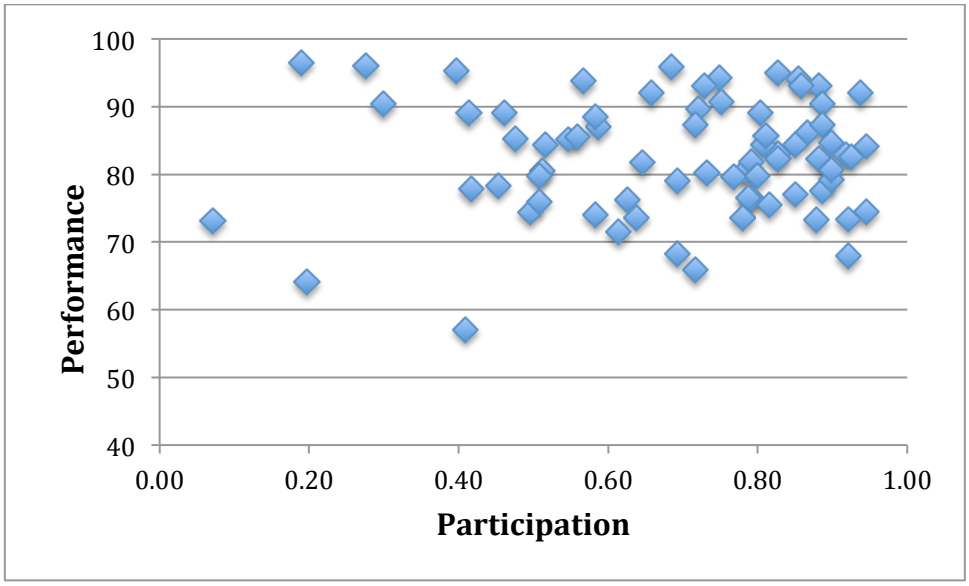

Figure 2. Score on exams versus participation in online activities for School P.

b. Students' perceptions

In the survey, students were asked to report, among other things, their usage of materials (participation) in OLI as being in one of four categories: 0 to 25%, 25% to 50%, 50 to 75%, or 75% to 100% of available activities. Figure 3 shows the percentage of students at each school reporting themselves within each of these categories.

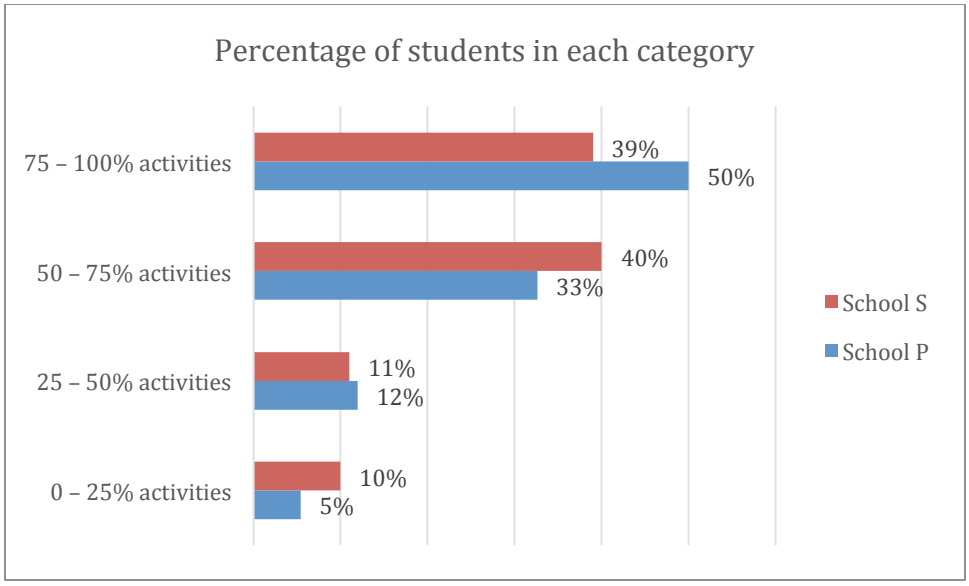

Figure 3. Percentages of students at each school that reported themselves as belonging to one of the four categories of usage.

Also in the survey, students identified from several choices the positive and negative reasons that reportedly influenced their level of usage. The frequencies of different reasons, positive and negative, cited by students are displayed in Figures 4 and 5 for each school, respectively. For each of the reason in each chart, there are 5 bars, from lower to upper, representing students who claimed to do from 0 – 25% of activities, 25 – 50% of activities, 50 – 75% of activities, and 75 – 100% of activities; the top bar correspond to the class overall. By and large the responses were similar for the two Schools. While we do not know students' individual survey responses, we know that the average usage is lower among non-responders than responders. Thus, students who did not respond to the survey are more likely to be in the categories of lower users (0 – 25% or 25 – 50%). But, we take the relative frequencies of reasons shown in Figures 4 and 5 to be typical of the respective groups.

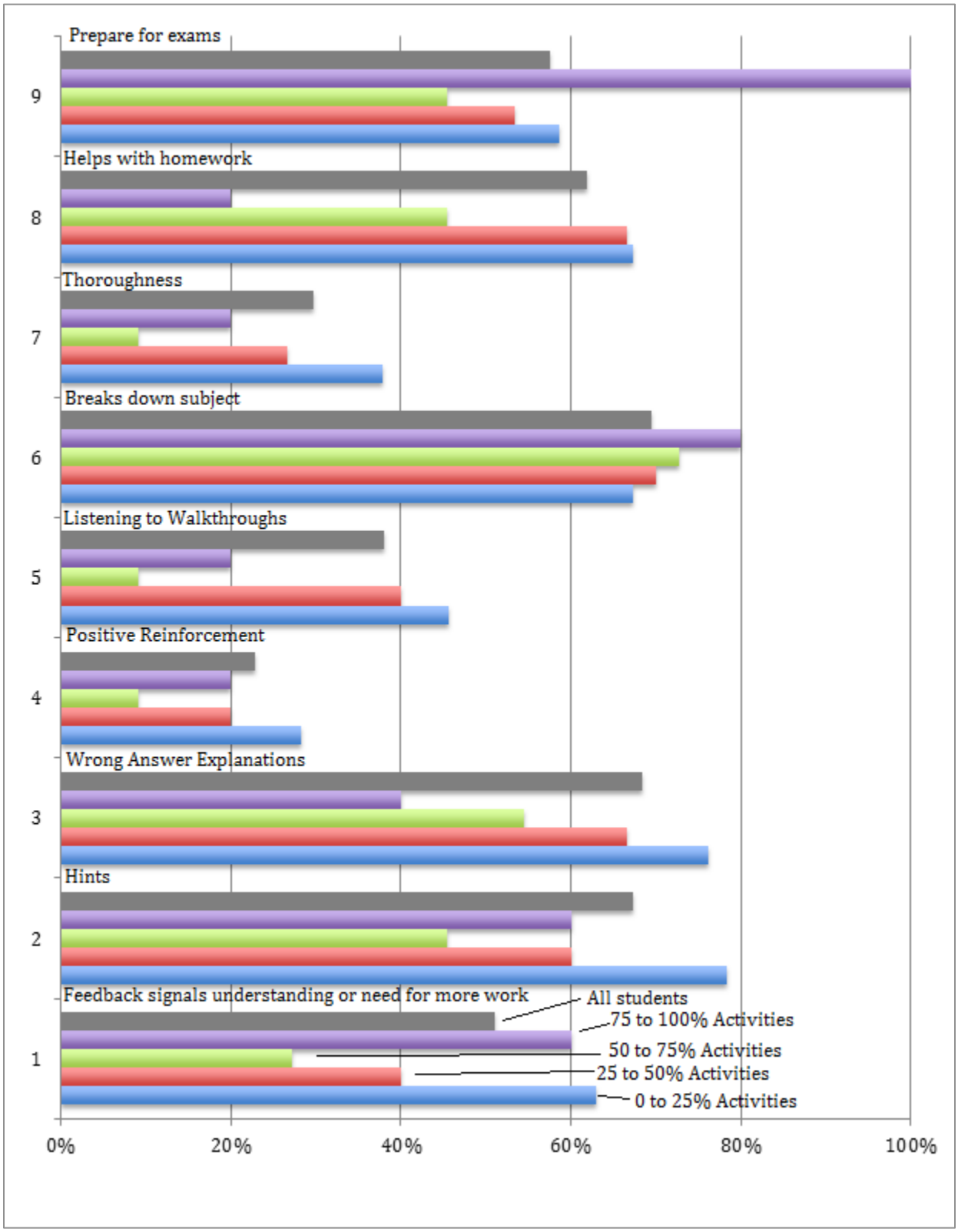

Figure 4a. Positive reasons cited for using OLI grouped by students from School S who claimed to complete various numbers of activities within a module.

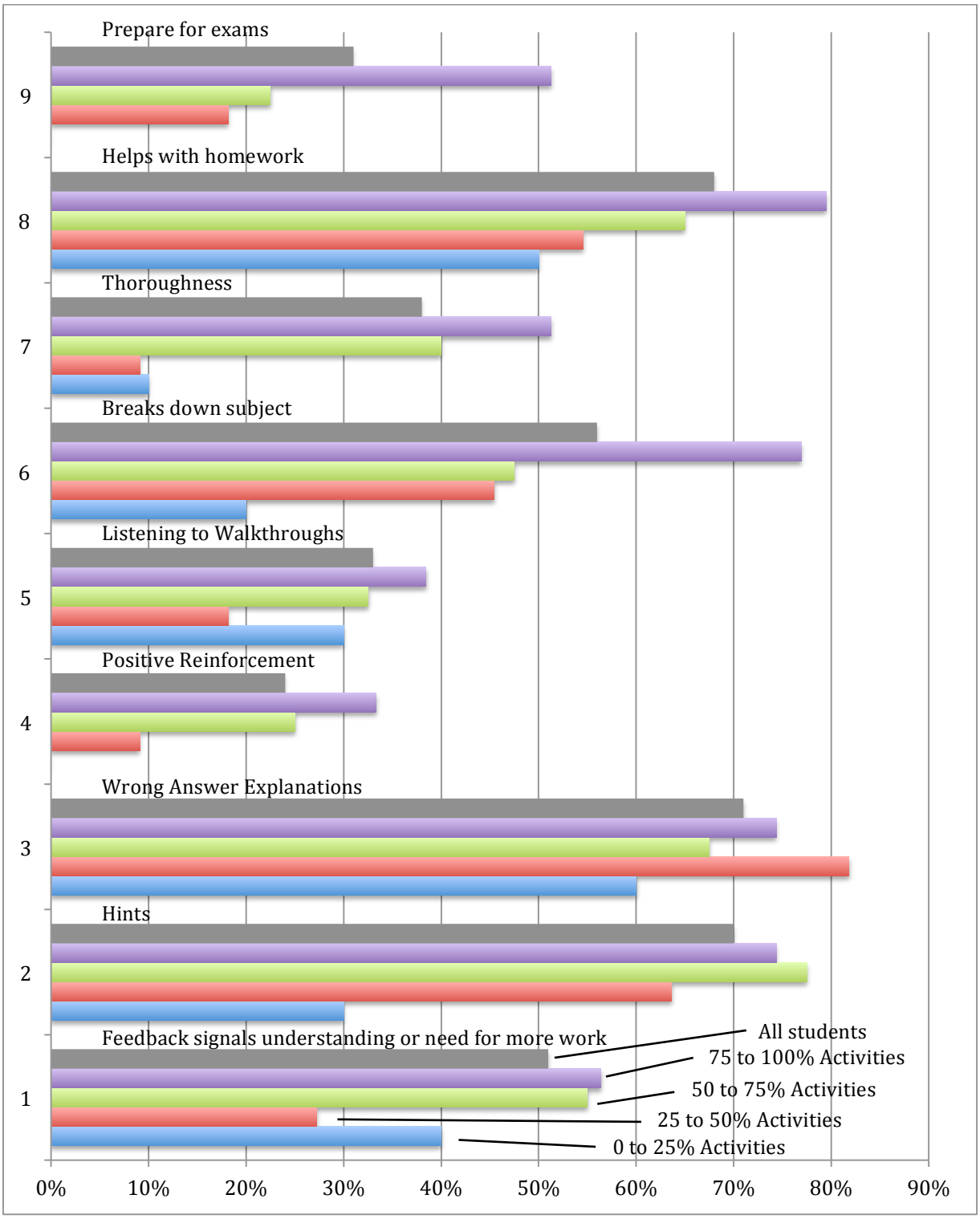

Figure 4b. Positive reasons cited for using OLI grouped by students from School P who claimed to complete various numbers of activities within a module.

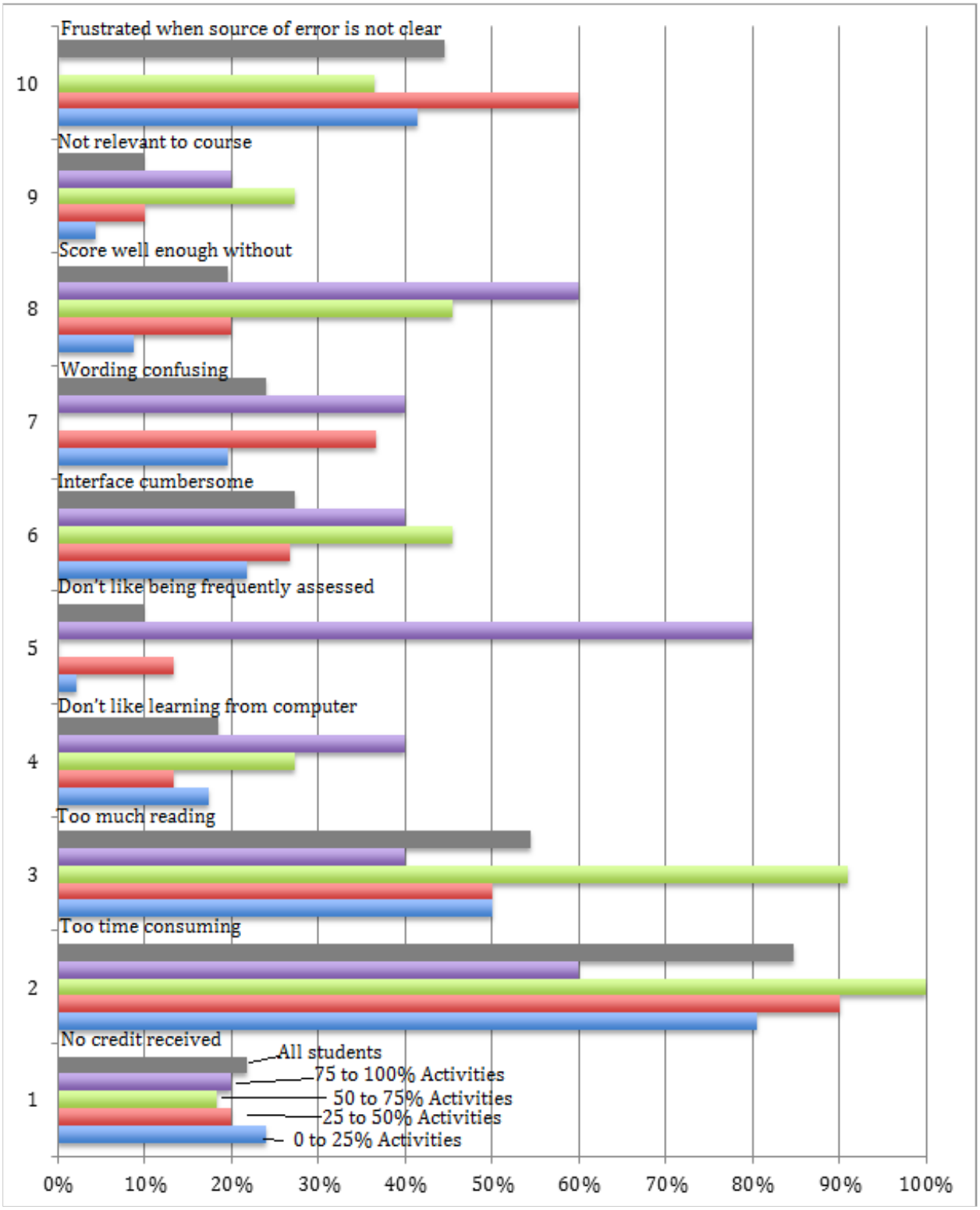

Figure 5a. Negative reasons cited for using OLI grouped by students from School S who claimed to complete various numbers of activities within a module.

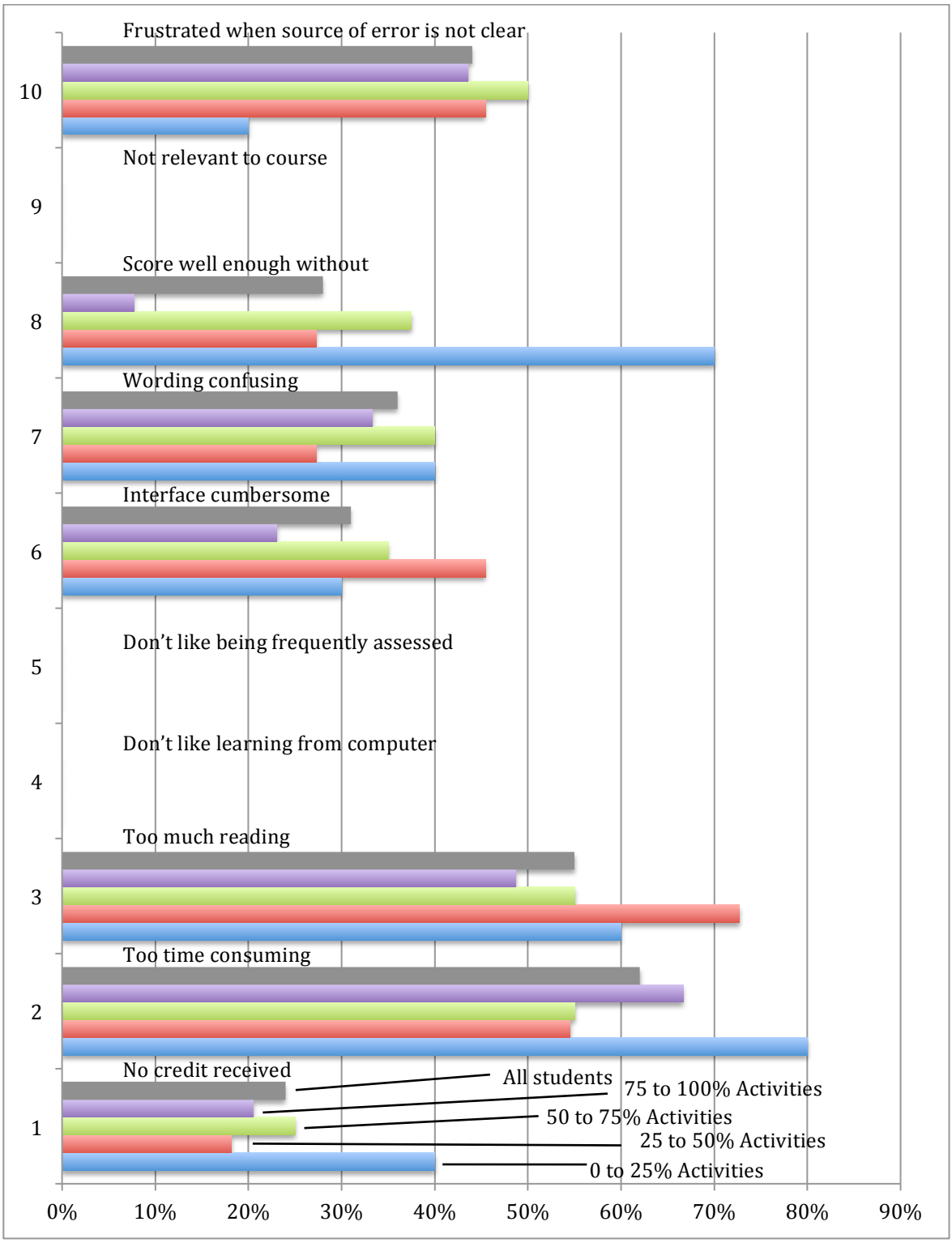

Figure 5b. Negative reasons cited for using OLI grouped by students from School P who claimed to complete various numbers of activities within a module.

The single notable difference between the two schools was that many students in School S viewed OLI as highly useful in studying for exams, while fewer students in School P found it to be useful. This is consistent with the differences in coverage pointed out above: that the topics covered in School S, and corresponding exam problems, closely overlapped with the OLI modules, while more topics (and exam problems) covered in School P extend beyond OLI.

Some of the negative reasons were not chosen at all: students in School P did not object to learning from computer, to being assessed frequently, nor do they think the materials are irrelevant to the course. Students in School S cited these negative reasons very infrequently, except for the lowest users (very few in number) who both objected to learning from the computer and to being assessed frequently. Some of negative reasons were cited roughly equally by all groups. A large majority of students viewed the amount of time required and the amount of reading between activities as a significant negative factor. Fewer students were bothered by interface issues or confusing wording. Lower users claimed they could do well enough on the quiz without doing many activities with greater frequency than did higher users. This should come as no surprise: the quiz is the incentive for students to learn about the resource. For some students, doing well on that quiz weighs highly as a goal of using the resource; other students may see and extract the broader benefits (learn more deeply rather than merely to receive credit towards a grade). Indeed, quiz scores in School P are uniformly high, so if performing well on the quiz is the sole motivation, the resource's value would not be that compelling to these students. The absence of credit was cited by relatively few students, although more so by the lowest users in School P.

All positive reasons offered were chosen by at least some students. Some of those reasons were cited roughly equally by all groups: the benefit of feedback, the explanations that came with wrong answers, and the help it gave in solving (written) homework problems. Higher users were more likely to cite thoroughness in studying all materials and the positive reinforcement; the differences were less for School S, although in no case were thoroughness or positive reinforcement highly cited. Two reasons - the availability of hints and the breaking down the material into concepts – were frequently cited, except for the lowest users. By contrast these were frequently cited by all groups at School S.

In the survey, students were also asked to imagine a scenario in which activities within a module were no longer optional, but required and carried credit; they were asked to choose one of the following: they (1) already did most so nothing would change, (2) did some and would benefit from more, (3) did some and would not benefit from more, (4) did few and would benefit from more, (5) did few and would not benefit from more. The results for this survey question are shown in Figure 6. Half of students at both schools indicated they were already doing most. Of students who could have done more, more than 61% of students at School S indicated that they *would* have benefited from being forced to do. That is, by their own account these students were not satisfied with self-regulation of their learning. This appears consistent with the finding in Figure 1, where a number of students did not complete many activities and did not perform well on exams. By contrast, in the case of School P, among the remaining students who could have done more, only 26% thought they would benefit from being compelled to do more. Thus, most of the students at School P who omitted many of the activities seemed to be satisfied with their decisions regarding usage. Because there appears no pattern in the *Performance* versus

Participation plot for School P in Figure 2, unlike School S, there is no obvious relation between their apparent satisfaction with usage decisions and the actual exam performance versus usage.

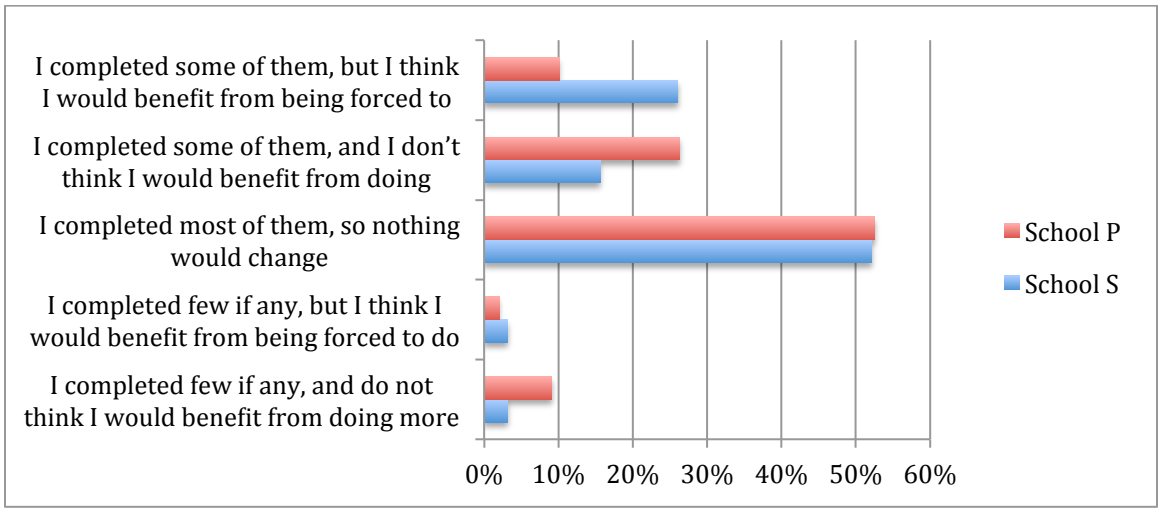

Figure 6. Responses to question on whether students would have benefited had they been forced to do more activities.

Some lessons might be gleaned from the results. From our interpretation of Figure 1 and students responses regarding whether they would do more, it appears that some students in School S may need more incentive to explore the resource. For example, it may be possible to make the DIGT mandatory, along with the quiz; the LBD exercises would then be optional. It may also be useful to share with future students the results depicted in Figure 1. As part of the survey, we also asked students what advice they would give to future students regarding OLI. By and large, these comments spoke to the value of OLI, and we could share all of those comments with future students.

In the case of School P, the results shown in Figure 2 do not allow us to conclude anything regarding self-regulation. Clearly, some students at all performance levels found it valuable enough to use, while others did not. The finding that the lowest users tended to be relatively less positive regarding the value of hints and breaking down into concepts suggests that some improvements in the implementation at School P may help. Students are left to discover the capabilities of the courseware on their own, and some may not be aware of the hint feature. It may also be possible to use some of lecture time to explain how the various conceptual pieces fit together, something that could benefit all students.

Summary and conclusions

Online resources with activities that involve practice while receiving feedback can present students with an enhanced opportunity to self-regulate their learning. That is, if the incentive structure permits, students can choose which activities to work on as they perceive fits their learning trajectory. Whether the resource is successfully used in this fashion is dependent on the

materials themselves, but also on the details of the context in which they are used in a class, including the incentive structure, and on the students in the class.

To study students under conditions that present the opportunity to self-regulate, we considered two classes at different institutions that had access to the Open Learning Initiative Engineering Statics course materials. At both institutions, student had to complete a quiz at the end of each module, forcing them to open up each module. However, the bulk of the available activities were optional, with students choosing to use them as they saw fit to succeed in the quiz and to further their learning. Students were surveyed and asked to report, among other things, on their approximately level of usage, on the factors that significantly affected their use, and how a change to mandated usage would have affected the outcome. In addition, data on actual usage and performance were culled from the same course in the previous year.

At both schools, we observed a wide range of usage of the resource. At School S, where the topics covered in class followed the OLI topics, with two small additions, an interesting pattern of exam performance vs usage was found. Among students who performed well on exams, there was a broad range of usage. Those students could be said to have self-regulated their learning successfully. But, there were also students who did not use the materials to a significant extent and performed poorly on exams; these students did not seem to have self-regulated their learning. Interestingly, a sizable number of students in School S, when surveyed, indicated that they would indeed have benefited from being forced to do more. By contrast, in School P, more topics covered in the course went beyond what was covered in OLI. In that school we found among high and low exam performers both light and heavy users of the materials, without any strong pattern. Many fewer students in School P indicated that they would have benefited from being mandated to use the materials more, apparently suggesting that they were satisfied with their self-regulation. Perhaps they thought that they understood the concepts treated by OLI sufficiently well and that the other topics were more challenging.

From the survey we also learned which factors significantly affected, positively and negatively, students' usage of the materials, and how these varied across different levels of self-reported usage. For one school, from the chosen factors, we were able to identify some minor changes in implementation that might raise the perceived value for lower users. Interestingly, however, the frequencies with which different factors were chosen were by and large remarkably similar for the students at both schools. The similarities suggest that the students at the different institutions do not view the materials differently. Rather their different usage vs performance characteristics, and their differing judgments of their own self-regulation, may be due to differences in the students themselves, their prior learning of relevant material and learning goals, and the overlap between topics covered in their courses and the online materials. It is hoped that future work will reveal the roles played by these important factors.

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