ISSN: 2148-9955

International Journal of Research in Education and Science (IJRES)

www.ijres.net

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To cite this article:

Kersey, E., Max, B., Akarsu, M., Bloome, L., Suazo, E., & Hoffman, A. J. (2019). Use of written curriculum in applied calculus. *International Journal of Research in Education and Science (IJRES), 5*(2), 457-467.

International Journal of Research in Education and Science
Volume 5, Issue 2, Summer 2019 ISSN: 2148-9955

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Article Info

Article History

Received:
02 October 2018

Accepted:
19 January 2019

Keywords

Curriculum
Technology
Calculus

Abstract

The purpose of this mixed-methods study was to explore how undergraduate students in an applied calculus course used the written curriculum (i.e., textbook, online homework system, and previous exams). The study design included three phases: (a) an online survey, (b) individual observations, and (c) student interviews. Students' survey responses indicated that not many students referenced the required textbook, but all students accessed the online homework system, through which homework assignments were completed with immediate feedback available. A follow-up qualitative analysis of eight students revealed limitations of the usefulness of the feedback of this system.

Introduction

Online homework systems have increasingly become an important component in university calculus courses (Halcrow & Dunnigan, 2012; Hirsch & Weibel, 2003). In many cases, students must pay for access to a textbook as well as for their online homework system, which can be a significant expense. Benefits for using these systems include instant feedback for students and relief from grading for instructors. Researchers have studied the efficacy of the online homework systems, both quantitatively and qualitatively (e.g., Burch & Kuo, 2010; Halcrow & Dunnigan, 2012; Mathai & Olsen, 2013; Meletiou-Mavrotheris, Lee, & Fouladi, 2007; Smolinsky, Olafsson, Marx, & Wang, 2018; Zerr, 2007), but not how they are used by students. Traditionally, implementing an analysis of textbook use (e.g., Lithner, 2003; Weinberg & Wiesner, 2011) entails studying how the textbook is used. However, the shift brought on by online homework systems in what constitutes curriculum requires new studies.

In the spirit of the work of Williams and Clark (2012), where a variety of student actions were considered (i.e., textbook use, tutor use), this study explored the question: How do undergraduate students in an applied calculus course at a large Midwestern university use the written curriculum? *Written curriculum* is defined as the collection of instructional materials endorsed by the course coordinator to be used by students. It may include textbooks, documents, and resources such as an online homework system. Particularly, we sought to understand the interplay between the textbook and an online homework system. Neither textbook analyses nor evaluations of online homework systems addressed possible connections between these two curricular components. We used a mixed-methods approach to explore both how students in the course used written curriculum and why students used it in that manner. The data collection and analysis methods were shaped by existing studies about online homework systems and the use of textbooks.

Use of Curriculum

Researchers across disciplines have recognized the importance of investigating curricular use. For example, Lee, McNeill, Douglas, Koro-Ljungberg, and Therriault (2013) studied undergraduate engineering students' use of textbooks during problem solving. They used think-aloud problem-solving sessions and follow-up interviews to gain insights into ten students' problem-solving activities. The authors found that students often searched the textbook for *superficial ties* (i.e., task similarities unrelated to the central concept) to the problem at hand and worked backwards from goals instead of proceeding from known information. The authors found that the students did not use the textbook to build conceptual understanding of course topics; rather, students described the textbook as an adequate, not ideal, reference source. Peng (2009) reported similar findings when studying accounting students required to use an online homework system. While the instructor expected the online homework to increase learning, "the availability of the online homework system seems to provide a shortcut for

students who are less motivated to complete required homework" (Peng, 2009, p. 267). These studies highlight the importance of examining the use of textbooks and online homework systems.

Some authors have investigated the use of written curriculum in the context of mathematics. Williams and Clark (2012), in a study of university students enrolled in entry-level mathematics courses, looked at student actions broadly, including, for example, "what resources they used such as tutors, textbooks, online notes, and study groups" (p. 184). While they were primarily interested in topics such as the settings and times in which students studied, they also considered the use of an online homework system and textbooks. The only resource which received significant use was the online homework, and that only for the completion of homework; students did not read the online textbook. Hodges (2009) studied the self-regulation strategies of students in a mathematics course with no synchronous class meetings. Successfully completing online practice quizzes drove students' efforts and "goal setting and self-evaluating strategies" (Hodges, 2009, p. 235). In summary, the use of technology in mathematics courses presents new challenges in understanding the use of written curriculum, while pointing to traditional constructs such as self-regulation.

Some researchers have addressed these challenges. For example, Hauk and Segalla (2005) solicited opinions from more than 350 students in a college algebra course to better understand how online homework was perceived. Some students used paper and pencil homework, others used an online homework system. Among their results, the authors found that using the online homework did not impact whether students sought conceptual mastery or procedural fluency. Students reported spending more time on online homework because of the immediate feedback. However, some of that time was just spent guessing, as some students would make as many as 35 guesses before moving on to a different problem. More recently, Halcrow and Dunnigan (2012) interviewed students and instructors in a first-semester calculus course, some of whom used an online homework system. They found that the combination of instant feedback and the ability for students to redo incorrect problems was an important motivating factor for students to try to develop conceptual understanding.

This study backgrounds the question of which type of written curriculum is being used, instead focusing on the question of how written curriculum is used. *Use of curriculum* is defined to mean any action involving the written curriculum with the intention of accomplishing a goal. For example, a student may use the textbook to find a similar problem on which to model a solution. Or a student may use the online homework system to satisfy a course requirement. Superficial actions, such as the student opening a book without looking at it, were excluded. These definitions framed the study to investigate student access to a broad range of curricular materials and to what extent this access was coupled with meaningful actions.

Goal Orientations

Many researchers have documented the importance of understanding students' goals (e.g., Patrick, Anderman, Ryan, Edelin, & Midgley, 2001; Wolters, Yu, & Pintrich, 1996). Specifically, researchers have described two opposing goal orientations, though terminology varies. As described by Dweck and Leggett (1988) and Patrick et al. (2001), one possible goal orientation is that of *mastery*. This orientation is demonstrated by students who seek mastery of material for the sake of understanding. In contrast, students who have *performance* orientations set goals looking for external rewards and validation. Students with mastery goals focus their attention on the task, while students with performance goals focus more attention on measurement of their ability (Anderman & Maehr, 1994). For example, a student doing the homework to gain understanding has a mastery orientation, whereas the student doing homework to receive an "A" has a performance orientation. These constructs were applied to the current study's definition of curriculum use and to interpret students' actions.

Though much of the research on goal orientation has taken place in K-12 school settings, Bouffard, Boisvert, Vezeau, and Larouche (1995) showed that the goal orientations affect college students in similar ways to younger students. They administered a questionnaire to more than 700 Canadian college students in a variety of courses. Not only was goal orientation related to performance, but it was also related to self-regulation, an important factor when considering the use of curriculum.

Rise of Online Homework

Over the last two decades, many mathematics departments have implemented online homework systems as part of their curricula (Hirsch & Weibel, 2003). Beginning in the 1990s, colleges and universities posited that online homework systems in mathematics classes enhanced students' learning in their first-year courses (Kehoe, 2010;

Zerr, 2007). In these studies, learning was measured by students' self-reports on surveys and performance on standardized assessments. Evidence from these studies suggested that online homework systems have several important potential advantages: (a) students take their homework more seriously (Jacobson, 2006; Richards-Babb, Drelick, Henry, & Robertson-Honecker, 2011); (b) the homework system provides immediate feedback; (c) students have multiple attempts on problems; (d) numbers can be easily changed, superficially changing problems to prevent cheating and give additional practice; and (e) the system can be programmed to give detailed feedback related to common mistakes and misconceptions (Burch & Kuo, 2010; Halcrow & Dunnigan, 2012; Hauk & Segalla, 2005). To the latter point, Zerr (2007) highlighted that immediately giving a correct solution after students answer incorrectly is an important feature for some online homework systems. Zerr's (2007) survey results indicated that almost all students supported having online homework systems in their calculus courses. While analyzing students' self-reports can yield insights, it also has limitations. None of the aforementioned studies directly observed students using the online homework system.

Studies on the effectiveness of online homework determined either that there is no significant difference in standardized-assessment performance between online homework systems and traditional paper homework (Hauk & Segalla, 2005; Smolinsky et al., 2018), or that the use of an online homework system has a small positive effect on performance compared to traditional paper homework (Bonham, Beichner, & Deardorff, 2001; Burch & Kuo, 2010; Halcrow, 2012; Hirsch & Weibel; Zerr, 2007). Some researchers (e.g., Burch & Kuo, 2010) have pointed to specific features of the online homework system to explain results, such as repeated attempts at the same problem and the presence of hints. But without having direct observational data to show how students are using the online homework systems, there can be no certainty about how the features support student performance or learning.

Method

Setting

This study took place in a large Midwestern university. The university offers several types of "first-year" calculus courses, of which this study focused on an *applied calculus* course. In contrast to the calculus courses for engineering/physics/chemistry/mathematics majors, applied calculus serves a variety of majors including management, agriculture, biology and technology. During the semester under consideration, there were more than 1,500 students in the course, divided into sections of around 30 students, most of which were taught by graduate teaching assistants. The study was conducted about three-fourths of the way through a 16-week semester. The research team was familiar with this applied calculus course because the fourth author was an instructor for two sections of the course. As a result, they were also familiar with the sanctioned written curriculum and course policies. The syllabus listed the textbook for the course and described the required online homework system: WebAssign. It is not known how the individual instructors positioned the necessity of the textbook or the online homework system.

WebAssign included all assignments for the course, typically six assignments per week. Students received bonus points for completing assignments 24-48 hours in advance of the due date. Students had three tries for most questions before points were deducted, with the exception that multiple-choice questions only allowed one attempt. Most questions were open-response. Two features available to students through WebAssign were Read It, which would direct them to the relevant section of the online textbook (if they had access to it – the e-textbook was not bundled with WebAssign), and Watch It, which allowed students to watch a video explaining a similar problem. Watch It was not available for every question. There was not an Ask my Instructor feature, so students needed to seek help in person if they needed individual assistance. Three different instructors taught the six sections from which participants were recruited, so not all students necessarily had the same level of support from their instructor for working with WebAssign. The questions on WebAssign were drawn from three different textbooks, so that some of the questions corresponded to ones in the textbook that students had purchased, but others did not.

Participants

When recruiting participants, the structure of the class was used in the sampling. Almost every instructor taught two consecutive classes in the same classroom, so instructors were randomly selected and students were recruited in both of their sections. In this way, all students taking the applied calculus course were potential participants. The fourth author, who was also an instructor, happened to not be selected. Therefore, potential

conflicts of interest were avoided. The sample of instructors spanned the range of times that the course was offered. We recruited participants from six different sections with a total of three different instructors. Recruitment took place on a review day for which attendance was optional so as to minimize disruption of content coverage. This resulted in low attendance for these sections, so that only 15-20 out of 30 students were present. Thus, approximately 100 students were invited to participate in this study.

Students in the sampled sections were invited to volunteer to complete the online survey and participate in the observation and interview portion of the project. Thirty-five students completed the online survey, and all of those students were invited to participate in the observation and interview portion of the study. Eight of those students volunteered to be observed working on the homework or studying and interviewed about their observed behaviors and experience with the written curriculum. Participants are referred to by gender-preserving pseudonyms.

Procedure

The aim of this study was to understand how students used the written curriculum in this applied calculus course through a mixed-methods approach. Towards this end, an online survey was used to collect a range of data and gain insight into how a variety of students used the written curriculum. However, to understand why students used the written curriculum as they did, observations and interviews were used to explore insights gained from the survey as well as allow for emergent patterns of use. The combination of these different data sources resulted in a rich supply of information that provided a more complete picture than would have been possible with a single method of data collection.

Survey

The survey was designed and distributed using Qualtrics software. Responses served as a baseline for descriptions of students' access to and use of written curriculum. Questions were designed to explore three different curricular materials: the online homework systems (WebAssign), textbooks (electronic or printed), and exams from a previous semester. For each of these materials, questions focused on exploring students' use and goals for use. For example, one question focused on describing use was: "Which of the following features of WebAssign do you access? Select all that apply. (a) Current online homework; (b) E-book/Read It; (c) Watch It; and (d) Looking ahead to future homework assignments." An example question focused on exploring goals for use was: "Which of the following reasons cause you to reference the textbook? Select all that apply. (a) Learning new material; (b) Reviewing material/doing suggested review problems; (c) Doing homework problems; (d) Seeking extra practice problems; (e) Finding worked examples; (f) Looking up answers in the back of the book; (g) Finding formulas or definitions; or (h) Other (please specify)." The survey consisted of a total of twelve questions.

Observation/Interview

Observations of students using the written curriculum and interviews of those students provided the main sources of data. Eight participants were observed working on their homework assignments or studying for an exam for up to 30 minutes. Immediately after finishing the observation, each student was interviewed for up to 30 minutes. Most interviews took between ten and twenty minutes. The format was that of a guided interview (Patton, 1990). Ten questions were created before the interview, and others were informed by the observation. For example, a planned question asked of all participants was: "Some students assert that WebAssign is only helpful for staying accountable, not learning new material. What do you think about that?" The interviews and observations provided more insights as to what the students were thinking and why they were choosing to use the written curriculum in a certain manner. Two authors were present for each observation and interview. One author took the lead for the interview, and both took field notes during the observations. The interviews were audio-recorded.

Analysis

Each interview was transcribed by one author and checked by another. Field notes were typed up and shared with the research team. The field notes and interview responses were then coded with respect to the most

relevant survey question. For instance, responses to the interview question, "What causes you to open your textbook?" were paired with the survey question listing reasons for referencing the textbook. The remainder of the data, which did not match up with any survey questions, was examined for interesting insights but was ultimately determined to be irrelevant to the research question. The interview questions allowed student-generated responses and an opportunity to follow up on interesting responses. These responses were used to paint a more detailed picture of how certain students used the written curriculum.

Findings

Use of Textbooks

Of the 35 participants who responded to the survey, 34 (97%) had access to either a physical or digital version of the textbook or both. Of these 34, only 15 (44%) participants reported referencing the textbook at least once per week (see Table 1). Amongst students that referenced the text at least once per week, the most common reasons reported for referencing the textbook were finding worked examples (73%), finding formulae or definitions (73%), and doing homework problems (67%) (see Table 2). Participants were allowed to select more than one reason (hence percentages do not sum to 100) and were not asked this question if they did not report using the textbook at least once a week.

Table 1. Students' frequency of textbook use

Frequency (per week)	Responses	Percentage (out of 34 students)
0 times	19	56%
1-2 times	10	29%
3-4 times	4	12%
5-6 times	1	3%
7 or more times	0	0%

Of the eight participants who were observed and interviewed, three had only a physical copy of the textbook, two had only the e-book, two had access to both, and one had no access to the textbook. The participant who did not have access to the textbook (Manny) sometimes wished that he had access, while two of the participants who did have access never used it (from Brendan: "It's been sitting in my room collecting dust"), and the remaining participants reported rarely using it. Brendan initially tried to use the textbook to find similar problems to those on the homework, but found, "It never corresponded with the problems I was having." Kristen reported, "When we were told we had to get it, I thought we would be assigned problems out of it, but we're not."

Table 2. Students' reasons for referencing the textbook

Reason	Responses	Percentage (out of 15 students)
Finding worked examples	11	73%
Finding formulae or definitions	11	73%
Doing homework problems	10	67%
Learning new material	7	47%
Reviewing material/Doing suggested review problems	7	47%
Seeking extra practice problems	7	47%
Looking up answers in the back of the book	4	27%

Uses for the textbook reported in the interviews included going through worked examples (one participant), learning new material and reviewing concepts (one participant), and using review problems to study for exams (two participants). Participants who reported using the textbook while doing homework frequently reported referencing extra-curricular online sources before turning to the textbook. During the observations, only one participant, Cathy, used the textbook. She looked for an example of how to solve a problem but did not find what she wanted.

Use of Online Homework System

Each of the 35 participants reported having access to WebAssign and logging in at least 3-4 times per week. This particular course typically had six homework assignments due each week. Just over one-third of the students reported logging in more than nine times per week, which implies that it took multiple logins to complete each assignment for 51% of students surveyed. Not surprisingly, then, because of the number of times students reported logging into WebAssign, 77% of students reported spending at least two-three hours doing WebAssign homework per week (see Table 3).

Table 3. Time spent per week on webassign homework

Amount of time	Responses	Percentage (out of 35 students)
Less than 1 hour	3	9%
1-2 hours	5	14%
2-3 hours	12	34%
More than 3 hours	15	43%

The interviews provided more specific findings as to the amount of time participants reported spending on WebAssign. Brendan estimated that he spent roughly an hour on WebAssign on an average day, but further added that some days were "outliers," citing recent assignments as taking less time. Kristen similarly reported spending no more than one hour per day on WebAssign, and Ben and Cathy also estimated spending about an hour on WebAssign per day. Esther reported spending 3 hours on WebAssign each week, approximately 30 minutes per assignment, as did Manny, John, and Jessica.

Most students (97%) reported using WebAssign for working on current homework. A majority of students (68%) also used WebAssign for looking ahead to future homework assignments. However, few students made use of the Read It feature (35%) or the Watch It feature (15%). None of the participants were observed using the Watch It or Read It features. One feature of WebAssign that participants were observed using, but which was not included in the survey, was checking previous (incorrect) responses. It was common for students to report completing WebAssign homework assignments days in advance (77%) and a smaller percentage of students reported completing WebAssign homework assignments hours in advance (23%) of the due date. The large percentage of students completing homework early is consistent with the fact that students received a 20% bonus for completing homework assignments 24 to 48 hours before the due date.

Students also reported consulting WebAssign when studying for exams (65%), learning new material (94%), and studying for quizzes (88%). Brendan reported keeping copies of his work in OneNote to review when studying for exams, including keeping incorrect work and marking it as such to avoid making those same mistakes, and Kristen reported that when using WebAssign to study for exams, she would "try to think of problems I had difficulty with and maybe go back through them." Cathy reported: "Just before the exam I will do the WebAssign again, go through all of them," because she felt that the problems in WebAssign were accurate indicators of material that would be on the exam.

Students' reasons for accessing WebAssign typically centered on completing mandatory homework assignments, but other goals emerged during the interviews. Students appreciated the practice problems (Brendan, Cathy), use as an organizational tool (Manny, Kristen), and immediate feedback that WebAssign offered (Jessica, Kristen), but others preferred written homework (Esther) because there could be partial credit offered and viewed the online platform as not actually supporting learning the material (Manny). John reported that WebAssign was helpful in budgeting his time because of the predictability of the homework schedule.

There was variation in how confident students were in answering questions in a format that WebAssign would accept. Using a seven-point Likert scale, (1 being Very Certain, 7 being Very Uncertain), 60% of students responded with unease (Somewhat Certain/Somewhat Uncertain) about entering their answers into WebAssign. The response distribution for this item was bimodal with peaks at 3 (somewhat certain) and 5 (somewhat uncertain; see Table 4).

These results show that students had mixed feelings about the technical difficulties that came with entering answers into WebAssign. The interviewed participants each had these types of experiences and elaborated on the types of difficulties. These issues ranged from unclear notational convention (e.g., whether or not to capitalize the constant of integration following an antiderivative, whether to enter "pi" or π, whether to include

parentheses) to not being able to see the entirety of a fraction in the answer box. In particular, Kristen reported that these types of issues occur roughly once per homework assignment.

Table 4. Student certainty in entering answers into webassign

Certainty	Responses	Percentage (out of 35 students)
1 (Very Certain)	2	6%
2 (Certain)	8	23%
3 (Somewhat Certain)	12	34%
4 (Neutral)	2	6%
5 (Somewhat Uncertain)	9	26%
6 (Uncertain)	1	3%
7 (Very Uncertain)	1	3%

Students were asked to rank the strategies they were likely to employ when WebAssign marked an answer incorrect, with the mostly likely strategy ranked at 1, down to the least likely strategy at 5. Respondents were required to rank all strategies, as we were asking about the likelihood they would use these strategies rather than how often they actually used these strategies. Students reported being most likely to look for mistakes in their work, closely followed by trying the same answer in a different format. For full results, see Table 5.

Table 5. Student strategies for retrying problems

Strategy	Mean ranking (1-5)
Look for any mistakes in my work	1.56
Try the same answer in a different format	1.85
Reference textbook or Read It feature	3.35
Reference the Watch It feature	4.03
Give up	4.21

Brendan reported that he either discussed difficult homework problems with friends or checked his own computations. Finally, he reported posting on an online class forum to ask for help on the occasion that he suspected his answer was marked incorrect by WebAssign due to formatting. Under observation, Manny demonstrated that he either used a calculator or online resources to search for errors in his work if WebAssign did not accept a response. In the interview, he stated that he checked his work for either conceptual or calculation errors in such instances. Esther was observed going back over her notes, checking arithmetic on her calculator, and moving on to other problems when WebAssign marked an answer wrong. She discussed this in the interview, where she said that she first looked for errors she might have made, be they computational or by misreading the problem. In her interview, she reported that she questioned whether there were errors in her work or in her formatting when trying to improve on answers that WebAssign does not accept. John reported checking his work as a first strategy, and then consulting extracurricular online resources if necessary, before finally consulting the textbook. Jessica reported using a similar pattern of strategies to that of John, however she reported consulting her instructor in place of the textbook. Similarly, during the observation, Kristen referred to notes, her calculator, and Wolfram|Alpha (an online resource) in responding to WebAssign scoring an answer as incorrect. Ben checked the class discussion board and used an online calculator resource after WebAssign deemed an answer incorrect. In his interview, he said that in these cases, he typically looked for errors in calculations and concepts in a cyclical fashion. Finally, Cathy reported turning to her peers for assistance after checking her work for errors. John and Jessica reported that they would sometimes question WebAssign's accuracy, despite not recalling a case where WebAssign was actually incorrect. Related to this result, the most popular setting in which students reported doing homework was alone (88%). However, a majority of students also reported doing homework in peer groups (56%).

Use of Previous Exams

Another curricular resource available to students was the exams used during the previous semester the course was offered. Perhaps not surprisingly, 82% of participants reported using these previous exams primarily to study for upcoming exams, while only 18% reported using them to study for weekly quizzes and 9% reported using them to learn new material. All participants who were interviewed reported using the previous exams only

to study for midterms and the final exam. Manny reported using the previous exams to gauge how many of each type of problem there would be on the exam. Ben reported that he wanted to "see what kind of questions would come up on the exam." Brendan used the previous exams to gauge the difficulty of upcoming exam problems and how many of each type would be used, but felt that they did not do this sufficiently well.

Brendan was observed using the previous exams to study for the final exam. He had already worked through them when studying for midterms, and so he would refer to his prior work when he could not remember how to do a problem. He would highlight questions he wanted to review again later. Manny reported that he would take the practice exam under exam-like settings: "I keep a clock with me, I remove everything out, I just keep calculator, I do have a pencil with eraser." Only after working through the entire exam would he check the answers. Esther also reported taking the practice exam "like I was taking the exam," only afterwards checking the answers and finding mistakes or asking her instructor to explain the solution. Ben and Cathy would treat the previous exam as a set of sample problems and check the answers after each question.

Other Resources Used

Some of the resources that the observation and interview participants used which were not counted as written curriculum for the purposes of this study included lecture notes, calculators (one-line, two-line, and online graphing calculators), WebAssign's discussion board, and calculus textbooks from high school calculus courses. Several students also used Internet search engines and specific websites to find definitions, evaluate integrals, or look for advice on how to solve a problem. Many students relied on these resources to complete their assignments, but they were not a focus of this study.

Discussion

Once a major pillar of written curriculum, this study shows that the textbook no longer holds a place of privilege (cf. Lee et al., 2013). Less than half of the participants surveyed reported accessing the textbook weekly. With few exceptions, the class met three times a week and there were six homework assignments due per week. Thus, for most students, neither lectures nor homework consistently prompted use of the textbook, a finding in line with Williams and Clark (2012). Nevertheless, it may be that the textbook was used irregularly by the majority of students; the lone participant without access to it revealed in his interview that there were a few times he wished he had purchased it.

The lack of textbook use may be partially attributable to its inconsistent integration into this particular course. Alignment between the taught, tested, and written curricula significantly impacts students (Squires, 2012). The interviews uncovered a student who tried to use the textbook but found it unhelpful. Another student attributed the lack of use to the fact that problems were not assigned directly from the book. In fact, none of the assessments for the course were taken directly from the textbook. Those students who were using the textbook used it merely as a reference for finding worked examples, formulas, and definitions, not to learn material, a finding consistent with those of Lithner (2003), Lee et al. (2013), and Williams and Clark (2012). Thus, in general, student use of the textbook did not seem to be in pursuit of mastery goals; rather, the textbook seemed to exist as a peripheral tool for performance goals.

Across the written curriculum, many actions were perceived to be motivated by performance goals, but this was especially true with actions in the online homework system. Even though WebAssign offered ways to master the material (Watch It and Read It features), most students were just using it to satisfy the course requirement, as found by Williams and Clark (2012). Interestingly, a majority of students in the survey reported working ahead, but it is not clear how students are interpreting "ahead." They maybe have been referencing the bonus-points policy; extra points were awarded for completing homework the day of its corresponding lecture. In this case, though it may have been completed ahead of the due date, homework was not completed ahead of lectures' coverage. The interviews gave evidence that these bonus points impacted students' self-regulation, thus adding a new dimension to the results of Hodges (2009).

Despite these general patterns, Brendan stood in clear contrast. He seemed unconcerned with getting full marks on all the assignments and kept meticulous notes from his homework. As Williams and Clark (2012) described successful students doing, he used the homework as a chance to master the concepts and kept a record of work to which he referred long after the assignment was due. Yet unlike the homework journals seen in Williams and Clark (2012), this student worked entirely on digital devices.

The digital nature of online homework systems allows for instant feedback. This is often cited as a major advantage, in terms of both lessening the grading load for instructors (e.g., Halcrow & Dunnigan, 2012) and the enhancement of student learning (Hauk & Segalla, 2005; Kehoe, 2010; Smolira, 2008; Zerr, 2007). However, this study provides evidence that there are reasons to be concerned with the quality of the feedback. First, as in the study by Darrah, Fuller, and Miller (2010), a student expressed displeasure with the lack of partial credit afforded by the online homework system. More importantly, students were concerned about being able to correctly format answers, similar to participants in Halcrow and Dunnigan (2012). Over a quarter of the survey respondents rated themselves as at least somewhat uncertain in their ability to format answers correctly; only two respondents considered themselves very certain. All students interviewed expressed some concern with this matter. It is important to note this was after the class was roughly three-quarters complete at the time of this study, and thus one would expect students' confidence in their abilities to format answers in a way that WebAssign would recognize to be higher than it would be earlier in the semester. If students are not confident that the computer is evaluating their intended answer, then any feedback has limited value. More evidence for this concern came when students were asked what they do with the feedback. The second most common response to feedback about incorrect answers was to submit the same answer in a different format. Students considered using other parts of the written curriculum as a last resort. If the system's feedback was reliable, then an incorrect answer would trigger a reevaluation of understanding. Instead, in the observations, students spent considerable time looking for formatting and computation errors before seeking resources to support further understanding of the material.

As issues of feedback are considered, there is also the matter of students' conceptions of mathematics. Putting aside the matter of partial credit, there may be real consequences of online homework's necessarily binary feedback. Questions are marked right or wrong without acknowledgement of students' procedures, concepts, or reasoning. What students believe constitutes the practice of mathematics may be impacted by this narrow feedback. Mathematical skills such as modelling are unable to be fully evaluated by online homework systems; therefore, students may have limited access to the full range of mathematical activities and experiences. If students are only presented mathematical feedback in terms of correctness, a performance goal orientation would not be a surprising consequence. This could explain the lack of actions taken with the written curriculum that were perceived to be motivated by mastery goals.

Conclusion

In conclusion, students relied on the required written curriculum as perceived by the course coordinator: the textbook (although infrequently), the online homework system (i.e., WebAssign), and previously used exams. Course coordinators for these types of courses should strive for coherence amongst the elements of the written curriculum, including the features of WebAssign and use of the textbook. This study found that students did not use the textbook often, and, if they did use it, it was to look for worked examples, formulas, or definitions. Students' use of the old exams was similarly limited, specifically to studying for exams or finals. For example, students in this study used the old exams to experience test-like conditions or to do practice problems.

That students use the written curriculum in limited ways is not itself new (cf. Lee et al., 2013), but it is important to understand how online homework systems affect the use of curriculum. This study found that WebAssign did not prompt students to engage with the textbook to master the material. In fact, while WebAssign saw broader use than the other aspects of the written curriculum, it seemed to promote performance goals. While there were some features like Read It and Watch it that could have helped students develop conceptual mastery, there was little evidence that students were aware of or interested in accessing these features.

As others have found, students seemed to appreciate the instant feedback provided by the online homework system yet complained about the difficulty of formatting answers in an acceptable manner. Students' overwhelming concern was being able to correctly format the WebAssign answers instead of trying to develop conceptual mastery of the mathematical content. Even if other online homework systems have fewer formatting issues, there will always be limits on how detailed the systems can be in their feedback. Future research should focus on how different kinds of feedback impact students' perceptions of mathematics and their goal orientations. Perhaps WebAssign cannot provide the types of feedback that produce perceptions about mathematics that instructors desire. Another direction is understanding how online homework systems are integrated into curricula and how this affects students' use. As we continue into the 21st century, we must

embrace the affordances of technology while remaining critical of unintended effects such as performance goal orientations.

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