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Adaptive Courseware Implementation: Investigating Alignment, Course Redesign, and the Student Experience

Cover Page Footnote

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ADAPTIVE COURSEWARE IMPLEMENTATION: INVESTIGATING ALIGNMENT, COURSE REDESIGN, AND THE STUDENT EXPERIENCE

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INTRODUCTION

In 2012, the Bill and Melinda Gates Foundation (BMGF) made a commitment to helping low-income and first-generation college students achieve postsecondary success. Their aim is to remove barriers that contribute to the education gap including college readiness, affordability, and flexibility. In 2014, BMGF invested $20 million in a program they called The Next Generation Courseware Challenge (Gates Foundation, 2014). Educational technology companies selected for the challenge designed adaptive courseware that could be scaled for high-enrollment classes. Digital courseware is instructional content that is scoped and sequenced to support delivery of an entire course through software built specifically for educational purposes. It includes assessment to inform personalization of instruction and is equipped for adoption across a range of institutional types and learning environments. Specifically, digital courseware has three core elements:

1. Instructional content that is scoped and sequenced to support delivery of an entire course
2. Purpose-built software
3. Assessment to inform personalization of instruction

These three elements can be delivered in a single product or by the thoughtful integration of different products that collectively deliver a complete course, and that provide faculty with data which allows for further personalization of instructional strategies.

Research in the early stages of adaptive courseware adoption conducted by community colleges, technical colleges, and traditional universities indicated that adaptive courseware used in blended courses (involving some online and some face-to-face time) increased student success (Means, Peters, & Zheng, 2014). More research needs to be done, but the potential of courseware to ensure postsecondary education becomes more accessible to all students convinced the Gates Foundation to move forward with The Next Generation Courseware Challenge.

BMGF provided the Personalized Learning Consortium at the Association of Public Land Grant Universities (APLU) a grant to support large-scale implementation of adaptive courseware at public universities. After an initial RFP conducted in the summer of 2016, eight universities became part of the first grant cohort (APLU, 2017). In an effort to support the efforts of additional institutions to implement and scale adaptive courseware, universities in the original cohort are reporting results of student and faculty feedback on these digital learning tools.

In this paper, four institutions share student and faculty feedback on the implementation of adaptive courseware through a common case study: biology for non-majors. Additionally, each institution has provided a second case study of their choice. Together, researchers at Colorado State University in Fort Collins, CO, Portland State University in Portland, OR, University of Central Florida in Orlando, FL, and the University of Mississippi in Oxford, MS are considering the following questions: What do students perceive are the benefits to the implementation of adaptive courseware? How does the deliberate alignment between adaptive courseware and course organization and structure impact student experience?

University of Mississippi Case Studies

The University of Mississippi (UM) is an R1 research institution located in Oxford, Mississippi, and surrounded by rural areas. Four regional campuses and a medical center in the capital city, Jackson, make UM a dominant presence in the upper half of the state. The undergraduate student population of 17,000 comprises mainly traditionally aged students, 38% of whom are Pell-eligible and 22% of whom who are first generation college students.

Some faculty members at UM have been working with adaptive learning courseware platforms for over a decade, but it has been in the last three years that these digital learning tools have grown in popularity. Although student success is a universal goal, the university is proud to claim a first-year retention rate of 85% and a 6-year graduation rate of 65%. Most faculty adoptions of digital courseware systems result in cases in which a publisher has courseware that accompanies a textbook. In 2016, with the help of a grant from the Personalized Learning Consortium at the Association of Public Land Grant Universities, UM began supporting faculty members who wished to develop their own content on digital learning platforms, and who wished to better align publisher platforms to their course needs.

At the University of Mississippi, each year, courses that have implemented adaptive courseware account for nearly 18,000 general education enrollments. From the very beginning of the grant and continuing through today, the disciplines with the most enrollments in adaptive courseware have been STEM related, with the majority of these courses taught in the subject area of mathematics.

Figure 1

Enrollments by Field. Enrollments by field in courses using adaptive courseware at the University of Mississippi AY 2018-2019.

Field of study	Percent of UM total enrollments using adaptive courseware AY 2018-2019
Mathematics	25%
Biology	18%
Writing	18%
Chemistry	17%
Accountancy	12%
Economics	6%
Spanish	4%

Figure 2

Enrollments by Discipline. Enrollments by discipline in courses using adaptive courseware at the University of Mississippi AY 2018-2019.

Discipline Area	Percent of UM total enrollments using adaptive courseware AY 2018-2019
STEM	60%
Humanities	22%
Business	18%

Because the administration at UM defines courseware as a course material, faculty have autonomy in choosing courseware and of implementing it within their courses. As such, integration of adaptive courseware does not require oversight by IT, nor is courseware adoption considered a course revision overseen by a curriculum committee. Some departments engaged in a course revision to accompany courseware implementation, notably Writing & Rhetoric, which employs an in-house instructional designer and two college writing specialists. By and large, however, course revision remains faculty prerogative and is faculty driven. This means that in most departments, individual faculty who teach multi-section courses may revise their section without having to coordinate with faculty teaching other sections of the same course. However, course directors of multi-section courses tend to discourage instructors from making significant changes to their section of a course unless those changes can be scaled to all sections of the course. Without the technological and pedagogical support of instructional designers and learning specialists, the coordinated revision of a multi-section course can be burdensome to course directors. While faculty can get technical assistance for certain products such as the LMS through the Faculty Technology Development Center, and although The Center for Excellence in Teaching and Learning holds teaching-related trainings and workshops on a monthly basis, there is no centralized instructional design support at UM.

UM CASE STUDY ONE: BIOLOGY I: INQUIRY INTO HUMAN LIFE

Biology I is a course for non-majors who seek to satisfy a general education lab science requirement. It is a course taught by multiple instructors (7), in multiple sections (16 in the Fall 2019 semester). In Fall 2019, 1054 students completed the course. Only one instructor of Biology I is a research-track faculty member, while the other 6 are instructional-track faculty.

In the Spring of 2010, the publisher's textbook package included an ebook and a digital learning platform. Although the faculty agreed that having an on-line system would help students study, at that time they decided not to adopt the online system, for formal course integration, although they did not object to students independently leveraging the digital learning platform as an ancillary learning tool.

In the Fall 2012 semester, the Biology I instructors switched publishers and textbooks to McGraw Hill's *Biology: The Essentials. First edition* by M. Hoefnagels. The decision to switch to a new textbook was based on the strength of Hoefnagels textbook, but instructors saw the additional benefit of the package's test bank, slides and other lecture resources, as well as an online homework system.

Initially, instructors did not require homework, and viewed the on-line system, LearnSmart, as a tool to help students study if they were willing to take the initiative to use LearnSmart. In the Fall 2015 semester, Biology I instructors adopted the second edition of the Hoefnagels textbook. Alongside this change, some of the faculty added assignments from the LearnSmart online homework tool to the course requirements and have progressively increased the graded weight of these homework assignments. In Fall of 2017, half of the instructors also began to assign homework and practice activities from the adaptive add-on to the homework system. As a result of this change, the weight of the four exams has gone down, and more points now are assigned to low stake assignments.

In the decade between 2009 - 2019, both the average grade and median grade in Biology I rose significantly from a C- to a B-. In that same period, the overall ACT score for first year students taking the course rose from 22.7 to 24.4. If we determine college readiness by ACT scores, students taking Biology I have been increasingly prepared for the course in the last decade. In addition, the average GPA for upper-class students taking Biology I rose from a 2.5 to 2.7 between 2009 and 2019, also indicating a higher predictor of student success in that class. While it is impossible to determine if the improved rates of student success are due to improved readiness, a change in the points distribution for assessments, or deeper learning based on digital courseware usage, student feedback in focus groups indicates students perceive the courseware is effective for helping them learn:

> I think [the courseware] really helps a lot because my instructor schedules the [learning modules] before she teaches it. Her doing that helps me learn what we are going to do next [in class].
>
> [The courseware] actually makes me have to study less because I am doing the homework. In other classes where I don't have a lot of homework, I definitely have to study a lot before the test.
>
> When you get certain questions wrong, [the courseware] goes back and tells you what you got wrong and why it is wrong and explains [the problem]. I think that is a lot more helpful than trying to find the answer [on my own] because I probably won't do it.

Students see benefits to use of the courseware in terms of increasing their preparedness for class, and building their confidence in test-taking by providing a realistic assessment of their knowledge and mastery of the material. However, the difficulty of the adaptive lessons that fail to provide feedback or guidance frustrates students. Many students also noted the high cost of the platform required for a one-semester course for non-majors. In the 2019-2020 academic year, purchase of the digital book and LearnSmart with the adaptive add-on, Connect, through the campus bookstore cost students $140.00 for 24 months of access. This price was negotiated by faculty as a way to allow students to use the same access code for a second, related course, Biology II: The Environment, even though only 45% of students who successfully complete Biology I register for Biology II. Students who purchased the Hoefnagels book and LearnSmart with Connect directly through McGraw Hill paid $86.00 for six months of access.

UM Case Study Two: General Chemistry Part 1

Chemistry I is part one of a two-part sequence of general chemistry required for majors in several degree pathways including engineering, computer science, and all health sciences. Chemistry I is taught by multiple instructors (7), in multiple sections (9 in the Fall 2019 semester). In the Fall of 2019, 747 of 921 students successfully completed the course, with 645 of those students going on to take Chemistry II. In any given semester, half of the faculty teaching general chemistry are research-track faculty and half are instructional-track faculty.

There is no coordination of Chemistry I outside of a common agreement among instructors to use the same textbook and to cover the same chapters during the semester to prepare students for Chemistry II. Faculty have full control over the content of their lectures, exams, homework, and practice activities. Faculty may choose to use or not use the digital courseware tied to the textbook. Faculty may choose how and when to assess their sections of Chemistry I, thus some sections may include graded homework, while others may not. Consequently, sections of the general chemistry sequence do not share the same homework, assessments, or lectures. However, all students who complete Chemistry I are required to take the American Chemical Society General Chemistry exam, which allows the department to measure student learning using a common assessment.

As textbook publishers began to include digital learning platforms in their course resources, Chemistry I faculty agreed that automated homework could help students better prepare for tests and could help reduce the number of students who came to ask questions about test prompts after each exam. In the Fall of 2009, the Chemistry I faculty adopted Pearson's Mastering Chemistry for the general chemistry sequence. By default, the faculty chose the accompanying textbook, *Chemistry: Structure and Properties* by Nivaldo J. Tro, since it was paired by Pearson with Mastering Chemistry. Every three years, the general chemistry instructors review the digital learning system and the textbook. They have renewed the current title and digital learning system three times since it was adopted in 2009.

The undergraduate student population grew 45% between 2006 and 2016, adding nearly 6,000 students to enrollments in general education classes. As classroom and instructor resources did not increase at that same rate, departments struggled to accommodate student enrollment requests. In response to this problem, the Department of Chemistry increased the minimum mathematics ACT score from 20 to 23, and eventually to the current threshold of 25. Raising math ACT requirements was a decision based on internal research regarding student performance in the general chemistry sequence.

In the decade between 2009 and 2019, both the average grade and median grade in Chemistry I rose from a C+ to a B-. In that same period, the minimum Math ACT score prerequisite for first year students taking the course was raised from 20 to 25. The rise in success grades (C and higher) also correlates with a decrease in failure grades (below C) during this same period, indicating an overall improvement in student learning. It is unclear whether student success increases are due to students being better prepared for the class, students learning more effectively on digital courseware, or both factors.

Despite these improvements in student success, student feedback on the implementation and use of the digital courseware has been mixed:

> It is like taking two chemistry classes. It is like one is based on the book and the homework and one is based on lectures and the test.
>
> I do like that [the courseware] gives you multiple tries and then, if you get it wrong, it will say "check on this" or hint you towards where you messed up.
>
> I think it would be helpful, too, if the adaptive follow up was like truly adaptive. It doesn't take into account how you could ace one section of the homework and then just get like get three questions wrong that were similar but it is still going to test you on the stuff that you aced. It would be helpful if [the adaptive follow up] just focused on the stuff that you needed more help on.

A major problem for students is a lack of alignment between the content of lectures and high-stakes exams, and the content and assessments in the digital learning platform. This problem could be addressed through a collaborative course revision in which instructors align their sections together and align the course content of all sections with the content and assessments in the digital learning platform. Additionally, many students in the focus group, and particularly those students who are non-STEM majors, had concerns about the cost of the digital learning platform. In the 2019-2020 academic year, students paid $243.00 for four-semester access to a digital version of the textbook, a loose-leaf text, and the digital learning platform. In 2019-2020c direct purchase through Pearson for a digital textbook and access to Mastering Chemistry for the same access period has been priced at $119.00.

Between 2017 - 2019, UM faculty using digital learning platforms designated as adaptive were supported by vendor training sessions, debriefing sessions with the grant program manager and grant administrators from the Personalized Learning Consortium at the APLU, and through faculty development workshops focusing on student engagement, active learning, and learning analytics.

As faculty members become increasingly familiar with digital learning platforms, and heard student feedback regarding the value of these platforms as learning tools, they have become more willing to experiment with various products, and are making more informed choices when adopting these products for their courses. Some faculty members who teach Chemistry I have been replacing publisher textbooks with Open Educational Resources that are freely online for student use, and some faculty members have been assigning low-cost online homework systems in place of those offered by large textbook publishers.

COLORADO STATE UNIVERSITY CASE STUDIES

Colorado State University (CSU) is an R1 university located in Fort Collins, Colorado, sixty miles north of Denver. CSU serves an undergraduate population of over 26,000 students and a total student population of over 33,000.

The APLU grant required institutions to scale the use of adaptive courseware to 15-20% of general education enrollments; CSU's target numbers were 12,291-16,288 enrollments within courses using courseware. As seen in Table 1, scaling the adaptive courseware quickly gained momentum and CSU was just shy of hitting the grant target at the end of the second year with 11,336 enrollments. Upon completion of the grant, CSU anticipates that over 40,000 students will have taken courses redesigned due to the grant (Table 1).

Table 1

Courseware use Fall 2016-May 2020

Academic Year	*Course enrollments and sections by year*	*Cumulative enrollments and sections by year*
2019 – 2020*	7,898 in 68 sections	33,980 in 322 sections
2018 - 2019	14,746 in 121 sections	26,082 in 254 sections
2017 - 2018	8,212 in 82 sections	11,336 in 133 sections
2016-2017	3,124 in 51 sections	
*Includes Fall 2019 data only		

Faculty members participating in the grant redesigned their courses with the assistance of instructional designers to maximize the use and effectiveness of adaptive courseware. In concert with restructuring the courses to include courseware, instructional designers used this opportunity also to incorporate research-based teaching practices. Grant funding provided faculty with a salary stipend in exchange for their participation.

CSU divided the courseware integration into three components, including: strategic implementation of courseware, backward course design, and the incorporation of research-based teaching practices. A team of three instructional designers partnered with faculty members during the course redesign process and assisted in the selection and implementation of adaptive courseware and research-based teaching practices including active learning, high-impact practices and, in some cases, peer educators (Learning Assistants).

Following the process of backward design (Wiggins & McTighe, 2005), the faculty and instructional design team surveyed adaptive platforms to identify the appropriate courseware based on course objectives and the instructors' teaching goals. The team then identified research-based teaching practices and developed activities, assignments and feedback opportunities to incorporate in the course.

In addition to the course redesign consultations, the instructional design team organized the Faculty Collaboration Group (FCG), a faculty learning community focused on the implementation of adaptive courseware and research-based teaching practices. The FCG met five times during the academic year and provided faculty from across disciplines a forum to talk and learn about teaching. The FCG was also used as a recruiting forum for faculty who were interested but were not ready to commit to adopting adaptive courseware at that time.

Once faculty members were confident that they were going to receive support needed to take on the adaptive courseware adoption and course redesign effort, they joined the grant. Overall, faculty reported that they enjoyed having a space to share teaching challenges, successes, and strategies related to implementing adaptive courseware and research-based teaching practices.

USING DATA ANALYTICS DURING THE DASHBOARD CHALLENGE

Faculty members have numerous responsibilities and the addition of the courseware and research-based teaching practices proved time consuming. Finding the time to use the analytic dashboard was a challenge for many faculty members. In an effort to shine a spotlight on the courseware analytics, faculty members were challenged to use the courseware analytic dashboard for eight-weeks during the Dashboard Challenge. The Dashboard Challenge provided incentive to:

1. explore how the dashboard analytics could provide insight to student learning,
2. determine which content might need to be reviewed, and
3. identify students that may need nudges.

Faculty members recorded the time spent, the data report used, the intervention (changes to the class content or student outreach) as well as the results of the intervention. Faculty participants in the Dashboard Challenge were asked to share their experiences with other members of the FCG, a sharing activity which enticed more faculty to participate in the Dashboard Challenge the following semester. While this approach increased the use of the dashboard, in the long-term, regular use of the analytic dashboard was inconsistent.

CSU CASE STUDY ONE: BIOLOGY 1 FOR MAJORS

Biology 1 at CSU consists of a sequence of two introductory biology courses for majors taught by tenure and non-tenure track faculty. Specifically, LIFE 102 Attributes of Living Systems is the first-term of the sequence and enrolls 325 students per section with a total enrollment of over 2400 students each academic year while LIFE 103 Biology of Organisms is the second-term of the sequence and enrolls 225 students per section with over 700 students enrolled each academic year. The faculty team was in the midst of a book selection process when they were first approached with the grant opportunity to adopt adaptive courseware. With the exception of using the same textbook, faculty in the Biology 1 sequence have autonomy in their teaching practices; for this reason, taking a team approach to the course redesign was a unique opportunity. During the adaptive courseware redesign, the Biology 1 team completed the following:

- Added adaptive courseware as a *graded* component of the course (a requirement of the grant);
- Organized an activity and media resource library to share resources;
- Collaborated on the development of new in-class active learning activities;
- Incorporated research-based teaching practices including: multiple in-class formative assessment techniques, low-stakes warm-up exams within the first four-weeks of the class, and metacognitive post-exam wrappers encouraging students to reflect on text performance;
- Integrated Learning Assistants (one section per semester) to assist with active learning; and
- Reviewed the data analytic reports to make decisions related to content instruction or student outreach (as part of the Dashboard Challenge).

The redesigned version of Biology 1: semester 1 has been taught for three semesters whereas the redesigned version of Biology 1: semester 2 has been taught for two semesters. The redesign phases have allowed faculty members time to refine changes made to the course.

As indicated in Tables 2 and 3 below, there was an increase in students' success rates in most of the Biology 1 course sections taught by faculty members using the Adaptive/Active (adaptive courseware plus research-based teaching practices) format. The association of adaptive courseware/active learning on student success should be evaluated on a case-by-case basis. While Biology 1: semester 1 (with Instructor X941) shows seemingly different student success rates for adaptive/active and non-adaptive sections (85.5% versus 79.7%), these rates are statistically similar (p-value > .05). Despite the lack of statistical significance, the difference may warrant some practical significance: the 5.8 percentage point higher student success rate in the adaptive/active sections equates to an additional 17 students passing the course, relative to the non-adaptive sections.

Course Level Success by Adaptive Courseware/Active Learning Status

Tables 2 and 3 display the course success rates for each course and each instructor by adaptive courseware/active learning use. Comparisons are made at the instructor level to control for individual pedagogical differences. In Tables 2 and 3, bold text indicates instances when in which the success rates for adaptive/active sections are at least 1 percentage point (PP) higher than the non-adaptive sections. Additionally, the Pearson Chi-square p-value for each course/instructor pair is displayed; success rates with statistically significant differences (p-value ≤ .05) are marked with an asterisk (*).

Table 2

Adaptive/Active and Non-adaptive Student Success Outcomes in Biology 1: semester 1 by Instructor

Instructor	Headcount		A, B, C, or S		PP difference	Pearson Chi-square
	Non-adaptive	Adaptive/ Active	Non-adaptive	Adaptive/ Active		
W394	**748**	**749**	**77.8%***	**82.0%***	**4.2**	**0.04**
L298	610	303	75.1%	74.9%	-0.2	0.96
R419	**330**	**299**	**67.3%***	**79.6%***	**12.3**	**<0.01**
X941	**305**	**303**	**79.7%**	**85.5%**	**5.8**	**0.06**

* Statistically significantly different at $p \leq .05$

Bold text indicates instances when the success rates for adaptive/active sections are at least 1 percentage point (PP) higher than the non-adaptive sections.

Table 3

Adaptive/Active and Non-adaptive Student Success Outcomes in Biology 1: semester 2 by Instructor

Instructor	Headcount		A, B, C, or S		PP difference	Pearson Chi-square
	Non-adaptive	Adaptive/ Active	Non-adaptive	Adaptive/ Active		
W394	**275**	**271**	**88.7%**	**90.0%**	**1.3**	**0.62**
R214	**227**	**235**	**70.5%**	**74.0%**	**3.6**	**0.39**

Bold text indicates instances when the success rates for adaptive/active sections are at least 1 percentage point (PP) higher than the non-adaptive sections.

CSU CASE STUDY TWO: GENERAL CHEMISTRY FOR SCIENCE MAJORS

General Chemistry at CSU consists of a sequence of two introductory chemistry courses for science majors taught by non-tenure track faculty. Specifically, CHEM 111, General Chemistry I, enrolls 200+ students per section with an enrollment of approximately 2000 students each academic year while CHEM 113 General Chemistry II enrolls 200+ students per section and approximately 1200 students annually. Prior to joining the grant, the General Chemistry faculty were using the ALEKS platform in conjunction with an OpenStax book. In Spring 2019, the Chemistry team joined the grant and started using a textbook associated with LearnSmart; they continued to use ALEKS, such that students were using two different courseware options to address course concepts. The redesigned version of General Chemistry I has been taught for two semesters, allowing faculty members time to adjust the changes they have made to the course, whereas the redesigned General Chemistry II course has only been taught once.

While the General Chemistry I faculty used a common syllabus, instructors used a variety of teaching practices in the classroom. During the redesign, the Chemistry faculty took a team approach and shared materials and resources developed during the process. During the adaptive courseware redesign, the Chemistry team:

- Added LearnSmart as a *graded* component of the course (a requirement of the grant);
- Organized an activity and media resource library to share resources;
- Collaborated on the development of new in-class active learning activities including think-ink-pair-share, iClicker predictions, and instructor lab demonstrations;
- Incorporated research-based teaching practices including:
    1) identifying and sharing learning outcomes with students for each class session,
    2) using multiple in-class formative assessment techniques, and
    3) explicitly sharing common misconceptions and student errors with students;
- Used data analytic reports to make decisions related to content instruction or student outreach (as part of the Dashboard Challenge); and
- Piloted the use of Learning Assistants to assist with active learning in Spring 2020.

Student Perception Survey Results

Student perception surveys were administered to students at the end of the semester. In Fall 2019, over 2000 students responded to the eleven question survey. The qualitative data has been sorted by course (Tables 4 through 7) whereas the student comments have been combined.

Table 4

Student Survey Results in General Chemistry I by Platform

	No	*Somewhat*	*Yes*
LearnSmart was easy to use	7.2%	36.5%	56.3%
LearnSmart had technical problems that prevented me from completing my work	54.4%	27.6%	18.0%
LearnSmart helped me learn	11.9%	46.9%	41.9%
ALEKS was easy to use	14.2%	37.2%	48.6%
ALEKS had technical problems that prevented me from completing my work	50.6%	29.1%	20.3%
ALEKS helped me learn	8.0%	26.4%	65.7%

As indicated in Tables 4 and 5, students in the General Chemistry courses felt that both the LearnSmart and ALEKS platforms were easy or somewhat easy to use. About half of the students experienced technical problems with the two systems that may have made it difficult for them to complete the assigned work. Overall, more than half of the students indicated that ALEKS helped them learn.

Table 5

Student Survey Results in General Chemistry II by Platform

	No	Somewhat	Yes
LearnSmart was easy to use	12.1%	22.4%	65.5%
LearnSmart had technical problems that prevented me from completing my work	67.5%	18.2%	14.3%
LearnSmart helped me learn	26.0%	47.6%	26.7%
ALEKS was easy to use	17.7%	36.2%	46.2%
ALEKS had technical problems that prevented me from completing my work	52.5%	26.2%	21.3%
ALEKS helped me learn	14.1%	27.7%	58.2%

As indicated in Table 6, over 70% of students in both biology courses felt that the courseware was easy to use. Over 72% of students in both biology courses did *not* experience technical problems that prevented them from completing their work. Finally, as shown in Table 7, over 70 % of students in Biology 1, semester 2 and 90% of students in Biology 1, semester 1 felt that the platform was somewhat helpful to their learning.

Even though all four courses used the LearnSmart courseware, student responses to “ease of use,” “experience with technical problems,” varied greatly. Student responses to “helped me learn” were fairly consistent between the first course in a series (General Chemistry I and Biology 1, semester 1) and the subsequent course (General Chemistry II and Biology 1, semester 2). In General Chemistry and Biology 1 course series, the same textbook (and platform) were used for both courses within each series. Therefore, by the second course in a series, students may not have needed the same level of support they had needed during the initial course.

Table 6

Student Survey Results in Biology 1: Semester 1 by Platform

	No	Somewhat	Yes
LearnSmart was easy to use	2.8%	19.9%	77.0%
LearnSmart had technical problems that prevented me from completing my work	72.7%	19.6%	7.8%
LearnSmart helped me learn	8.5%	45.7%	45.7%

Table 7

Student Survey Results in Biology 1: Semester 2 by Platform

	No	Somewhat	Yes
LearnSmart was easy to use	0%	28.6%	71.4%
LearnSmart had technical problems that prevented me from completing my work	73.5%	16.3%	10.2%
LearnSmart helped me learn	22.5%	55.1%	22.5%

Open-Ended Student Feedback

The last question of the survey was "*Thank you for sharing your thoughts related to adaptive courseware. What should we know about your experience with [platform name] that we did not ask you?"*. This question prompted a variety of open-ended responses. While some students liked the instant feedback feature designed to encourage students to complete work they have not mastered, other students found the features to be frustrating.

Student Comments for Faculty

> It was a good tool that ensured that I learned and interacted with the information I was given in the textbook for the week. In other words, it kept me accountable in my learning.
>
> The courseware was easy and fun to use. I used it mostly as a review for me as I knew most of the material already.
>
> I liked being able to test my learning and practice even after I submitted the assignment.
>
> I really liked the instant feedback I was able to receive when answering the homework questions.

Student Recommendations for Vendors

> You should get rid of the little person who pops up every minute telling me to read more.
>
> It seems that this program allows professors to assign more homework than they normally would.
>
> Many [sic] of the time the software is finicky and will not let you continue due to a misspelling even if you know the material. It is extremely frustrating.
>
> Disliked when the homework quizzes told me to read more. It just further frustrated me when I was doing poorly.
>
> I think it's a good tool but I would REALLY love a way to turn off the little speech bubble that tells me when to answer questions and when I should read more. The software glitches a lot but that's to be expected.

PORTLAND STATE UNIVERSITY CASE STUDIES

Portland State University is a public, urban university located in the heart of downtown Portland, Oregon. PSU has seven colleges, 211 undergraduate and graduate degree programs, approximately 25,000 students and 1800 research and instructional faculty. The University was interested in participating in the APLU grant program to pilot the use of adaptive learning platforms for several reasons. As Oregon's most diverse campus, Portland State is home to many students from underrepresented backgrounds. Nearly half of PSU students are the first in their families to attend college, approximately 43% are students of color, and 70% of all students receive financial aid. In addition to coursework responsibilities, many students work significant hours, and come to introductory courses with various levels of preparation. Student feedback indicates that the cost of course materials is also becoming a stressor, and students with significant work and/or family obligations outside of class find it more difficult to get timely assistance with homework than their peers with fewer outside responsibilities.

The adaptive learning project was administered and supported through PSU's Office of Academic Innovation (OAI). OAI is an educational development office of 24 staff, combining expertise areas of postsecondary education, curriculum development, instructional technologies, instructional design, digital learning, high impact practices, and assessment. OAI's mission is to "promote and support effective student learning at PSU by building sustainable instructional capability, collaborating with educators across campus to come up with innovative instructional solutions, and fostering creative communities committed to teaching and learning". OAI sent a call for participation to the campus, titling the project "Active and Adaptive," to reinforce the goal of course design that would incorporate active learning strategies as a result of students having mastered foundational concepts prior to attending class.

Each participating faculty member in the adaptive project partnered with an OAI team. A project manager was responsible for coordination management across the various course projects. The partnerships with OAI often made a difference in how challenges were addressed and successes built upon. For example, assessment staff shared timely results from student experience surveys with faculty members, who could meet to discuss any appropriate modifications with an OAI consultant who was already familiar with (and had helped to design) the course. This was especially important for faculty members who had less experience with just-in-time modifications to course structure based on immediate student learning data, as will be discussed below.

PSU CASE STUDY ONE: BIOLOGY FOR NON-MAJORS

In Winter quarter of 2017, Biology for non-majors at Portland State joined the active and adaptive grant at Portland State University (PSU) with the goal to make learning more personal for students in large enrollment courses (Dziuban, Moskal, Johnson, & Evans, 2017). A team of three -- professor, user experience (UX) designer, software representative -- began collaborating over a period of 12 weeks to build the first of a series of three Introductory to Biology courses for non-majors. This process included the development of resources for onboarding 500+ students for the academic year to the new adaptive learning platform, ingesting and building content into the adaptive platform, and adding digital resources such as images, charts, and videos and interactive quizzes. Overall, the process was informed by research which indicates that students benefit from technology when they use it frequently and in a variety of ways (Kuh & Hu, 2001; Freeman et al., 2014). The primary feedback from the initial course pilot in Spring quarter of 2017 focused mainly on the need for alignment of the open educational resource (OER) materials to the faculty member's lecture and in class activities (Geith & Vignare, 2008).

For summer of 2017, a graduate research assistant was hired to develop and work with the instructor with redesign of the Introductory to Biology course to update and align content. Throughout the full Fall 2017- Spring 2018 academic, students used the adaptive platform in Biology and were introduced to more active learning during in class sessions (Freeman et al., 2014). To support a new active and adaptive teaching modality, the Biology professor reviewed daily and weekly student progress reports in the adaptive system and adjusted her lectures and in-class clicker questions based on areas in which the system indicated students needed extra review. Active learning was organized as in class group work wherein students were asked to address problem-solving tasks in class (Freeman et al., 2014; Kerns, 2019). Continuously throughout the first-year deployment, extensive student feedback was collected, reviewed, evaluated and used to inform future decisions regarding the design and the structure of the course. Now in the third year of delivery, the adaptive Biology sections are fully self-sustained by the faculty member without support from an internal team at PSU.

PSU Case Study Two: General Physics

The Physics department at Portland State University (PSU) has long struggled with the challenge of teaching large classes of diverse students. Coming from a variety of socio-economic and educational backgrounds, students begin the sequence with a largely disparate amount of prerequisite knowledge and variable levels of motivation for learning the material. Recognizing this issue, in the summer of 2018, the Physics team at PSU began the process of redesigning a three-course series of PH 201-203, known as General Physics, to create a resource that would support the students' long-term success without burdening them with the high cost of the homework platforms being used at the time.

After a review of a variety of adaptive learning platforms, the Physics team chose to develop in CogBooks, a platform that would give students the opportunity to review content relevant to the class sessions, but also would provide students the chance to engage with the concepts through multiple media integrations, including videos, simulations and problem solving. CogBooks also provided students with the agency to move through the materials as they chose, while still offering recommended paths based on students' self-assessed understanding of the topic being presented. Creating materials that would not be cost-prohibitive to students was also key; instead of paying out of pocket for a textbook, video platform, clicker, and a separate homework platform (which totaled just over $250 per year), the Physics team aimed to create a tool that would be home to all of their course content and homework, including open source lessons, videos, and simulations authored or adapted by the instructor; these curricular materials were provided to the student at a significantly lower cost.

With a backward design approach in mind (Wiggins & McTighe, 2005), the Physics team first identified the learning objectives for each of the topics to be covered in the courses. Scaffolded activities were then designed to provide students with learning paths that offered opportunities for further exploration of the concepts. To support an active classroom, the team designed the materials such that students would be required to complete a portion of the content and activities on a given topic before coming to the lecture covering that topic. This pre-class exposure to the content and activities related to a topic would help students familiarize themselves with the topic of the subsequent lecture and provide them with questions that would help the students assess their own understanding. Based on their performance, students could then opt to review additional materials that expanded on the topic in an attempt to better prepare themselves for each upcoming class session. In this way, students could come to class with a better understanding of the topic, allowing for more targeted discussions and the opportunity for students to participate in group activities, leading to an engaged classroom centered on active teaching techniques.

The process of redesigning this course sequence began with identifying open source resources that could be used to create a cohesive and well-aligned curriculum. These resources were then adapted and organized to align with the instructor's course outline. Each of the three courses were developed in the term prior to its delivery with the support of the main instructor, an instructional designer, a UX designer and two former Physics students. During a twelve-week design cycle, content and questions were created, tested and then revised by the team to prepare for delivery. The team also reviewed student feedback at regular intervals to inform changes made to future development. After the first year of delivery, a more extensive review of the student data and comments informed further updates and changes to the materials. Now in the second year of delivery, the Physics team is continuing this iterative design approach, further refining the materials and how they are being used.

STUDENT SURVEY DATA RESULTS

The 'Active and Adaptive Implementation Student Survey' was created in an effort to collect student feedback on the impact adaptive courseware had on their overall learning in active and adaptive courses. The student survey comprised 14 Likert scale questions and two open-ended questions. Table 8 and Table 9 provide student responses for seven of the 14 rating scale questions for biology and physics active and adaptive courses conducted from Fall 2018 to Fall 2019 across four academic quarters. The seven selected survey questions represented in Table 8 and Table 9 provide student ratings regarding how CogBooks impacted student learning for the course as well as students' perceptions of the connections between the content in the courseware and class activities.

Table 8

Student Responses on Active and Adaptive Implementation Survey for Biology Courses from Fall 2018 – Fall 2019 (1 = Strongly Agree; 6 = Not Applicable (N/A))

		Percentage of Total Responses per Item (n=206)				
Statement	*Strongly Agree*	*Agree*	*Neither Agree nor Disagree*	*Disagree*	*Strongly Disagree*	*N/A*
1. CogBooks helped me prepare for class.	47.74	39.50	5.29	5.54	2.21	0.00
2. CogBooks helped me prepare for quizzes and exams.	45.52	38.23	9.03	5.90	1.10	0.00
3. Feedback in CogBooks helped me stay on track.	37.08	30.39	21.26	8.61	1.49	1.43
4. CogBooks helped me to identify what I am struggling with.	44.04	30.94	16.02	6.94	2.04	0.50
5. Using CogBooks increased my confidence in my own learning.	39.05	25.61	25.60	7.31	2.69	0.00
6. The work I do in CogBooks and class activities were connected.	47.84	41.44	5.56	3.04	1.20	0.70
7. I would take a course in the future that uses CogBooks.	42.17	37.32	15.13	4.31	1.10	0.00

Table 9

Student Responses on Active and Adaptive Implementation Survey for Physics Courses from Fall 2018 – Fall 2019 (1 = Strongly Agree; 6 = Not Applicable (N/A))

		Percentage of Total Responses per Item (n=218)				
Statement	*Strongly Agree*	*Agree*	*Neither Agree nor Disagree*	*Disagree*	*Strongly Disagree*	*N/A*
1. CogBooks helped me prepare for class.	30.56	42.95	9.56	10.42	6.74	0.00
2. CogBooks helped me prepare for quizzes and exams.	34.06	40.84	10.52	10.70	3.67	0.00
3. Feedback in CogBooks helped me stay on track.	20.53	28.19	22.04	15.4	12.75	1.09
4. CogBooks helped me to identify what I am struggling with.	21.35	29.61	17.53	19.07	12.10	0.34
5. Using CogBooks increased my confidence in my own learning.	20.35	28.67	19.68	18.30	12.76	0.00
6. The work I do in CogBooks and class activities were connected.	35.97	53.48	4.23	4.25	0.75	0.35
7. I would take a course in the future that uses CogBooks.	22.43	31.24	18.14	12.42	14.60	0.40

An examination of student survey responses to prompts regarding the impact of CogBooks to their overall learning in the biology active and adaptive courses (Table 8), students selected statement 6, “The work I do in CogBooks platform and class activities were connected” as the highest rated ‘*Strongly Agree’* item at 47.84%. Conversely, students selected survey statement 3, “Feedback in CogBooks helped me stay on track” as the lowest rated *‘Strongly Agree’* item at 37.08%. Analysis of student survey responses regarding the impact of CogBooks to their overall learning in the physics active and adaptive courses (Table 9) reveals that students also selected statement 6, “The work I do in CogBooks and classroom activities were connected” as the highest rated *‘Strongly Agree’* item at 35.97% and statement 5, “Using CogBooks increased my confidence in my own learning” as the lowest rated *‘Strongly Agree’* item at 20.35%.

In addition to the rating scale survey questions outlined in Table 8 and Table 9, students in the adaptive courses were also asked the following open-ended questions in the active and adaptive implementation survey:

1. What aspects of the course, if any, increased your learning?
2. What aspects of the course, if any, were barriers to your learning?

Thematic analysis of repeating ideas raised by the biology and physics course students who responded to these two open-ended questions revealed the following themes:

Self-paced learning. Students reported that, through the use of CogBooks, they were able to go through content at their own pace, get feedback in real time, and continuously practice concepts for understanding and mastery. As stated by a student in an active and adaptive biology course, “Mostly [I valued] the practice of reading and answering questions, especially when one that I got wrong before pops up again, it feels good to get a second chance at the question, also, being able to have the text on the side of the question with no point-penalty decreases any possibility of test anxiety.”

Platform navigation and depth. Students in the biology and physics active and adaptive courses reported that CogBooks provided helpful resources, robust knowledge checks, and visual tracking of their process through engaging modules. A student in one of the active and adaptive physics courses stated, “CogBooks is the best tool for me in learning the material of this course.” However, platform navigation and complexity were areas about which students reported mixed sentiments, specifically, concerns with technical glitches and difficulty navigating through the platform interface. As stated by a student, “CogBooks at times was difficult to work with.” Another student stated, “CogBooks did not show work and answers for questions you get wrong.”

***Classroom and adaptive learning alignment*.** Students in the biology and physics active and adaptive courses reported that the active and adaptive alignment provided an opportunity to work through the course material within CogBooks at their own paces and solidified concepts through active learning in the classroom. A student in one of the active and adaptive biology courses stated, "Doing the CogBook exercises before class helped me get ready for the class and have a good understanding of what we are about to learn that day." This was also an area in which some students reported mixed sentiments, specifically, a slight variance in when the materials were provided. As stated by one student, "CogBooks activities were very well connected to class in content, but it would tend to be ahead of the class by about a class period (because we would have to do it before the lecture, so in a sense, we would have to teach ourselves how to do those types of problems, in order to do the homework, before we learned how in class)."

Overall, the student survey responses provided the active and adaptive research team at Portland State University with an opportunity to examine potential impacts of the integration of adaptive courseware on student learning both in the classroom and through self-paced learning.

UNIVERSITY OF CENTRAL FLORIDA CASE STUDIES

The University of Central Florida (UCF) is an R1 public research institution within the State University System of Florida located in metropolitan Orlando. With 13 colleges and more than a dozen locations, UCF offers over 220-degree programs to over 69,000 students. Almost half of the student population are minorities, and UCF has been recognized as a Hispanic-Serving Institution. In the 2018-19 academic year, nearly half (47.4%) of the total university Student Credit Hours (SCH) were delivered online or blended, and nearly one-third (31.4%) were fully online. In that same academic year, 85.1% of all students took at least one online or blended course. Both measures (SCH and headcount) have grown steadily in recent years.

The Center for Distributed Learning (CDL) is a service organization dedicated to supporting online and blended learning for UCF faculty and students. In addition to offering technical support for both faculty and students, CDL also offers faculty instructional support services such as instructional design and professional development as well as multimedia services including video, graphics, and captioning support. Specific to this study, within the CDL instructional design team there are a group of instructional designers who are dedicated to assisting faculty members with the design and development of courses using adaptive learning systems. Also housed within CDL is the Pegasus Innovation Lab (iLab), which serves as a project management office for institutional level initiatives that foster innovation in digital learning. As such, the iLab served as the project lead for this grant project; two instructional designers who specialize in adaptive learning were assigned to work directly with the instructors.

Based on UCF's historical success with online, blended, and adaptive courses, the university's Board of Trustees also made a strategic investment in a Digital Learning Course Redesign Initiative. The goal of this initiative was to impact student learning by increasing successful course completion (reduced DFW rates), particularly in General Education Program (GEP) & STEM courses, and to improve First Time in College (FTIC) & Transfer student persistence through a strategic course redesign process that leverages the benefits of online, blended, adaptive, and active learning. The courses described in the following case studies were included in the over 100 course redesign projects, of which almost half were focused on adaptive learning implementations.

UCF Case Study One: Biology for Majors

Biology I is a major's biology course, but typically about 85 percent of the students are majors from other science disciplines such as actuarial science, computer science, sports and exercise science, psychology, and nursing. Normally Biology I is offered in five to seven sections a year with 450 students per section, which results in an annual population of 7,000 - 8,000 students. The venue is a fixed seat auditorium. Due to TA and UTA staffing constraints, active learning can be supported only every other week, but there is a desire to increase that frequency.

The course was redesigned as a blended class using the Realizeit adaptive platform as the online content delivery method to allow for active learning in the classroom meetings based on best practices established in pilot courses (Chen, Bastedo, Kirkley, Stull, & Tojo, 2017). The online instructional content was built from the ground up with every module using instructor authored content and OER resources. Eleven of the fourteen chapters are taught using the adaptive platform. The initial three modules in the course involve new and remedial information to allow for unification of skills within the class. As one example, acids and bases, properties of water and pH/pOH problems are taught within the initial three course modules.

The modules from Proteins (Macromolecules) through the end of the semester material present only new content. Case studies are utilized to help students master the material and foster increased engagement (Hinkle & Moskal, 2018). Light Board videos are provided to highlight more complex problem-solving techniques. Although traditional types of questions are also included in each module, many compound and varied questions are utilized. Due to the number of students, most of the questions are randomized and contain a wide range of variables. This allows students to collaborate, yet still learn the content without compromising question banks and assessment outcomes.

Students are expected to read the e-book, do the adaptive modules in Realizeit, and then come to class for active learning exercises every other week, followed by an in-lecture quiz assessment to determine their progress. The students have confided that using the adaptive platform is such a complete help to them that they rarely need to read the e-book now.

When students flag a question, the instructor uses that input as an opportunity to initiate a virtual chat with the student to determine the depth of the student's understanding. The information from flagged questions allows the instructor and TAs to see exactly what students do not understand regarding any concept and to analyze the precise way in which the student has arrived at a misunderstanding. This information can then be utilized to correct any misconceptions. From these analytics the instructor also can see trends within the entire class.

Over time, UCF course designers have progressed in using more complex functions of the Realizeit adaptive system, such as alternative learning pathway opportunities. These complex functions now support three occasions during the semester when students are learning several topics online using solely the adaptive platform and, as such, now these topics are never covered in lecture.

After the course was first taught in the new format, an "Introduction to the Realizeit Adaptive Platform" module was added to better acquaint students with the many opportunities the software affords them to learn in different ways. As a result, students have requested that adaptive modules remain accessible to them after the due date for active learning has passed, so that they may use these modules as a study tool for exams and can refer to them throughout the semester.

The use of information from student reported emojis in Realizeit has also been incorporated into the course redesign. That information has been used successfully to detect students who are having academic challenges. Based on the students' reported affective emojis, the instructor and TAs invite the students to get help via email or in person. One future goal will be to place TAs in the adaptive system, in real time, to work with the students.

Institutional level student success, withdrawal, and satisfaction data have been collected for each course. Biology I results are reported in Table 10. Student success is defined as a final course grade of A, B, or C. Success and withdrawal data is reported as a percentage of the total class enrollment. Ideally after a course redesign, the date will reveal a desired increase in student success and a desirable decrease in withdrawal rates. Student satisfaction is measured by the overall course ratings students submit on course evaluations, reported as the class mean on a scale of 1-5 where 1 is poor and 5 is excellent.

Table 10

Biology I: Comparison of Student Success, Withdrawal, and Satisfaction in Redesigned Spring 2019 Course Compared to Last Section Taught Prior to Redesign

	Number of Students (n=766)		
Measurement	*Spring 2019*	*Previous Course Offering*	*Change*
Student Success (Final Grade A, B, or C)	84%	73%	+11%
Student Withdrawal	2%	4%	-2%
Student Satisfaction (End of Course Evaluation on a scale of 1-5)	4.55	4.22	+0.33

After fully implementing the redesigned course with online adaptive learning and active learning in the classroom, student success as measured by a final course grade of A, B, or C increased 11 percentage points from 73% prior to redesign to 84% in Spring 2019. The withdrawal rate decreased from 4% to 2%, and student satisfaction as measured on the end of course evaluations increased significantly.

Students were also asked to complete an anonymous feedback survey at the end of the course. Table 11 summarizes the quantitative feedback from 110 respondents.

Table 11
Student Responses on Personalized Adaptive Learning Anonymous Survey for Biology I

		Percentage of Total Responses per Item (n=110)				
Statement	*Strongly Agree*	*Agree*	*Neither Agree nor Disagree*	*Disagree*	*Strongly Disagree*	*Not sure or No Answer*
1. Overall, Realizeit helped me learn the course material better than not having Realizeit.	21%	51%	16%	3%	2%	7%
2. Realizeit provided me with the necessary feedback to help me stay on track with the course objectives.	6%	51%	25%	6%	1%	10%
3. The instructions in Realizeit were clear.	12%	54%	21%	2%	1%	11%
4. The ability levels reported by Realizeit were accurate.	9%	52%	18%	6%	1%	14%
5. Realizeit became personalized to me over time.	12%	34%	29%	5%	3%	18%
6. The grading accurately reflected my knowledge.	12%	55%	16%	6%	1%	10%
7. The Realizeit assessment exercises were effective in measuring my learning.	11%	52%	21%	4%	2%	11%
8. Realizeit increased my engagement with the course content.	15%	48%	19%	5%	2%	11%
9. Realizeit was easy for me to use.	29%	45%	15%	2%	1%	9%
10. Given a choice, I would take another course using Realizeit.	20%	40%	22%	5%	1%	12%

Overall, the student feedback was very positive. In particular, it should be noted that 72% of respondents agreed or strongly agreed that the adaptive delivery helped them learn the course material better than learning without the adaptive platform. Also, only 6% reported that they disagreed or strongly disagreed with the statement "Given a choice, I would take another course using Realizeit." When students were asked what they liked most about the adaptive platform, a clear theme around ease of use emerged. This theme was reinforced by students' responses to item 9 shown in Table 11; 74% of respondents agreed or strongly agreed that the adaptive platform was easy to use. Several open-ended responses also related to the personalized experience:

> I like that it covers the content and it is personalized to my learning ability and it focuses on what I need to go over rather than going over everything.
>
> It went back and taught me if I missed a question.
>
> It gave second chances.

Another student comment reads as follows: "*It gave me a great way to practice problems before an exam.*" This premise was reinforced anecdotally by the instructor. Students' responses to open-ended questions also revealed a theme: Many students wanted more practice problems. This theme reflects students' levels of engagement and the value they see in using this adaptive system.

UCF Case Study Two: Spanish Two-Course Sequence

Two instructors collaborated on the redesign of Elementary Spanish Language & Civilization I (Spanish I) and Elementary Spanish Language & Civilization II (Spanish II) to be delivered fully online with adaptive learning in Realizeit using all Open Educational Resources (OER). This course redesign allows students to progress through the material at a pace and level that is comfortable for them and that reflects their actual prior knowledge. Although Spanish I assumes no knowledge of Spanish, the reality is that many students have some prior knowledge of the language; the reasons for this are varied: they took Spanish in school at some point before entering UCF, they live in an area where Spanish is spoken (Miami, for example), and/or they have family members who speak Spanish. Adaptive Learning using Realizeit allows students to create their own learning path and concentrate on the concepts for which they need more knowledge and practice. In the past, students have not been stimulated by publisher content or practice activities. Using adaptive learning and OER content in their course redesign allowed the instructors to design the courses to be more personal, more appealing, and more meaningful to students. OER-infused adaptive learning allowed the instructors to highlight real world application of the material they were presenting to the students. Students entering the course had repeatedly stated the goal of applying what they learned in the course to their lives in the real world, to use Spanish in a real-world context.

Using an adaptive learning tool allows instructors to monitor student progress more closely, and to supplement where necessary. Instructors can guide individuals more successfully based on the results set forth in the Realizeit adaptive platform and can help students with strategies for success. Before adopting the use of adaptive courseware, it had been possible, but far more difficult for Spanish instructors to determine each student's individual strengths and weaknesses, and to assess the strength and weaknesses of the class population, as a whole. In the first semester during which the redesigned course was implemented, students completed (and repeated) the Realizeit sections for each lesson even though redoing the work was not required or connected to a specific or separate percentage of the grade, and these students repeatedly reported how helpful and intuitive the found this learning approach.

There is often a struggle to connect with students in online courses, even when instructors are using all the online teaching and learning best practices and strategies they've learned. A tool like Realizeit helps them identify pockets of need early on, leading instructors to attend to their classes in a way that is much more proactive and effective. There are also features of the adaptive platform that allow students to self-report via emojis how they are feeling as they progress through the material and course. This is valuable because the use of emojis allows instructors to identify potential similarities among students' self-reported moods. Knowledge of mood trends gives an instructor the opportunity to address student issues personally or to contact students individually to discern why they might be feeling a certain way.

Students often view Spanish language courses as just "something to get through" since the courses meet language requirements. Many students struggle with the online delivery mode, either because it is new to them or because the publisher content and/or platform is not user friendly or has technical problems and glitches that are frustrating. These obstacles negatively impact student success, satisfaction, and retention. They also make it challenging for the instructor to encourage students to declare a major or minor in Spanish language studies. Another factor that impacts student attitudes toward these courses is the cost of the textbook and publisher LMS. Previously, students were spending about $275.00 for the textbook and LMS package. Because the Realizeit license has been paid by the university, students have not been required to spend any money.

Institutional level student success, withdrawal, and satisfaction data were collected for each course; Spanish I results are reported in Table 12 and Spanish II results are reported in Table 13. Student success is defined as a final course grade of A, B, or C. Success and withdrawal data are reported as a percentage of the total class enrollment; ideally after a redesign and increase in student success and decrease in withdrawal would be desirable. Student satisfaction is measured by the overall course rating on the student end of course evaluation, reported as the class mean on a scale of 1-5 where 1 is poor and 5 is excellent.

Table 12

Spanish I: Comparison of Student Success, Withdrawal, and Satisfaction in Redesigned Spring 2019 Course Compared to Last Section Taught Prior to Redesign

	Number of Students (n=67)		
Measurement	*Spring 2019*	*Previous Course Offering*	*Change*
Student Success (Final Grade A, B, or C)	91%	68%	+23%
Student Withdrawal	3%	10%	-7%
Student Satisfaction (End of Course Evaluation on a scale of 1-5)	4.55	4.41	+0.14

Table 13

Spanish II: Comparison of Student Success, Withdrawal, and Satisfaction in Redesigned Spring 2019 Course Compared to Last Section Taught Prior to Redesign

	Number of Students (n=91)		
Measurement	*Spring 2019*	*Previous Course Offering*	*Change*
Student Success (Final Grade A, B, or C)	87%	65%	+22%
Student Withdrawal	7%	20%	-13%
Student Satisfaction (End of Course Evaluation on a scale of 1-5)	4.46	4.00	+0.46

As reported in Table 12, the redesigned Spanish I course with adaptive instruction was first delivered to 67 students in Spring 2019 and the percentage of students who successfully passed the course with an A, B, or C increased by 23% over the previous term during which the course had been taught by the same instructor. The withdrawal rate decreased from 10% to 3%. The student satisfaction measure on the end-of-course evaluation fir the course taught the previous semester already had been relatively high at 4.41, but student satisfaction also increased after the course redesign.

The redesigned Spanish II course yielded similar outcomes. The student success rate increased 22% over the previous term taught during which the course had been taught by the same instructor, and the withdrawal rate went down 13 percentage points. Most noteworthy is the student satisfaction rating from the end of course evaluations which increased significantly from 4.00 to 4.46 on a scale of 1-5.

These results caught the attention of both administrators and colleagues within the academic departments, which led to conversations about scaling this redesign, program-wide, across 96 Spanish language course sections and 3,000+ students per year. The two original instructors will continue to revise and enhance the current redesigned courses with student course assistants and two additional instructors each semester until a refined active and adaptive course design is rolled out across the entire program. In parallel, instructors who teach other languages including Italian, German, French, and Portuguese plan to use the Spanish course designs as a model for building adaptive instruction in their programs.

Discussion and Future Directions

This article sought to address two questions across multiple adaptive learning cases studies: What do students perceive are the benefits to the implementation of adaptive courseware? How does the deliberate alignment between adaptive courseware and course organization and structure impact student experience?

Benefits

As can be seen from the case study examples, there were some early indicators of increased student success, particularly as measured by student pass rate and course completion. Student feedback indicated the perceived benefits of accountability, real-time feedback, and opportunities for frequent knowledge testing. Students also appreciated the additional preparation for classes, preparation for exams, and the ability for adaptive courseware to identify specific areas of strength and areas needing more work or assistance.

BARRIERS

Although student feedback on perceived benefits was positive across case studies overall, data also revealed barriers to effective incorporation of adaptive instruction into courses. For example, students in several courses desired more targeted real-time feedback and guidance connected to adaptive lessons, particularly when encountering roadblocks, or lack of progression with course concepts. Students also reported some technical challenges, including issues with navigating some components of the adaptive courseware. For some students, the costs associated with platforms were challenging, while for others, the time associated with completing adaptive lessons was a barrier to completing all assigned sections. Two primary adaptive learning experiences were expressed *both* as a benefit and barrier: real-time feedback with frequent knowledge checks, and the perceived alignment, or integration of adaptive courseware into course organization and instruction, to be discussed further below.

FEEDBACK AND KNOWLEDGE CHECKS

Knowledge checks and feedback built into adaptive courseware may enhance the opportunity for 'practice at retrieval' (Halpern & Hakel, 2003; Karpicke & Blunt, 2011), a process in which students repeatedly access and apply information as part of the learning experience, thus reinforcing and deepening comprehension and retention of material. Therefore, when students were not progressing in a given area, more targeted feedback may have assisted in understanding the gaps that prevented successful retrieval of relevant information needed.

ALIGNMENT BETWEEN DIGITAL AND CLASSROOM EXPERIENCES

Students' perspectives on the alignment, or integration of adaptive courseware with other aspects of courses revealed several common themes. Students noted when they experienced a disjuncture between digital and classroom learning, very often perceived as confusing or frustrating. Alternatively, students also expressed appreciation when digital and classroom learning were aligned, particularly when instructors made transparent the class's progress, and/or how class sessions would reflect what had happened in the adaptive platform coursework prior to class. A related pattern noted across courses in the PSU study was that students who perceived adaptive and classroom learning as aligned were also more likely to agree or strongly agree with survey items connected to benefits for learning, such as identifying strengths and weaknesses, and feeling more prepared for classes and exams.

The purposeful integration of digital with other course elements has been addressed in literature on blended learning (Garrison & Vaughan, 2008). Blended learning, broadly defined, is a blend, or mix of digital and face-to-face contexts. The incorporation of digital learning via adaptive platforms into traditional classroom-based courses can be seen as one form of blended learning (Kakosimos, 2015). Blended learning scholars and practitioners have observed that integrating various components - achieving the blend - is one of the most difficult challenges for instructors when planning and teaching in blended formats (Caufield, 2011; Linder, 2017). Qualitative student data were replete with observations about integration. The faculty members in the adaptive projects also commented on the complexity of integrating to get the right blend.

Graham and Robison (2007) described a continuum of blended courses according to the type and nature and course organization and activity. *Enabling blends* combine classroom and technology-mediated formats primarily for purposes of convenience and access. *Enhancing blends* are undertaken for purposes of enhanced pedagogy, more active learning, and/or for increased student or instructor productivity. *Transforming blends* align digital and classroom learning such that effective blended practices are highly integrated throughout multiple dimensions of courses, and are deliberately undertaken for pedagogy focused on more engaged learning (p. 90). The researchers wondered whether enabling and enhancing blends could become stepping stones to more transformational course practices, or whether they were "final destinations" for integrating technology into existing course practices.

Deliberate integration in blended formats often requires some departure from previous teaching assumptions and practices for some faculty. Shadiow (2013) observes that making significant changes to teaching practice is often a lengthy, iterative process. Across the campus case study experiences, some course design changes were implemented readily, while others were more challenging and/or took much more time to incorporate. It is reasonable to assume that practices implemented initially in adaptive courses were those perceived as most relevant and valuable, based on instructors' previous experiences and practice. Below we conclude with questions for additional investigation regarding blended adaptive learning models that could further promote student engagement and success.

QUESTIONS FOR FURTHER INVESTIGATION

Future investigation of courses that incorporate adaptive learning could focus on which elements of course design are having the greatest impact on student learning. For example, are there specific aspects of adaptive platforms that are particularly helpful or challenging? Are there specific classroom activities that help students connect their prior knowledge from adaptive work and extend that knowledge in class?

Another direction for further research is to explore what best practices for course redesign might be most useful for faculty as a guide or goal. For example, design models might benefit from more discipline-relevant examples of alignment practices specific to adaptive courseware. Instructors may benefit from direct experience with applied examples of classroom activities that reinforce or extend students' digital learning progress, as well as examples of how learning analytics across a large enrollment course can be quickly assessed and used to modify lesson planning.

Finally, how are faculty making use of assessment in adaptive classroom models, and what are the challenges in responding to analytic platform data? Future research could explore the more useful analytic data points that faculty use to make informed decisions regarding their teaching.

Adaptive courseware holds much potential for a more personalized digital learning experience, and the cases presented here demonstrate that incorporating these learning technologies into courses can also necessitate revisiting some assumptions about course development and design, including assumptions about student engagement. Adaptive blended courses with student engagement at the core multiplies opportunities afforded by emerging technologies within blended course design.

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