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Teaching and Learning Experiences with Enhanced Books in Engineering Math and Science Courses

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Abstract

This study focuses on understanding the implementation of three interactive digital products in the first-year foundational courses (General Chemistry, Physics I & II, Calculus I & II) at the Faculty of Engineering, and the perceptions of teaching and learning experiences with those products. The data were gathered from the instructors, students and Distance Education Unit Coordinator through in-depth interview of purposeful sample of the academics, student online survey and product platform usage data. The study reveals the nuances of the institutional change prompted by the initiatives for advancing teaching and learning through the integration of technology. The study findings are discussed through themes that address the benefits of integrating digital products as well as challenges experienced by the instructors, students, and by the institution during this period of transition to digital technologies. The findings assisted in identifying the related set of recommended actions for improving the implementation of digital products and strengthening their integration into academic programs.

Keywords: *blended learning, e-books, engineering education, math, science*

INTRODUCTION

Digital Textbooks and their Use in Higher Education

Current advanced technologies, tablets, e-readers and bigger screen smartphones offer a quite comfortable reading experience. The sale of digital textbooks or e-books are increasing and some big retail companies like Amazon are selling more e-books than printed books (Millar & Schrier, 2015). They are usually cheaper, easier to find and one can carry a ton of books in his or her smartphone, tablet or e-reader. They also offer rich media options like videos, high-resolution pictures, animations and similar new technologies. This is an important aspect regarding today's university students since they are more comfortable with new technologies and becoming more tech-savvy every year (Weisberg, 2011). On the other hand, there are some discussions on whether digital textbooks will be dominant in higher education and if students will prefer digital over print. Development and rapid growth of technology provides a ground and make it easy to be happen that people prefer to use digital materials. Recent studies and reports on digital versus printed books give insights like a-large scale e-textbook implementation in a high school, preferring e-textbooks due to having high cost printed ones, and having high advantages on distribution of the digital on what students' or faculties' preferences will be (Joo, Park, & Shin, 2017; Martin, Belikov, Hilton III, Wiley, & Fischer, 2017; Reynolds, 2011) and digital is getting ahead.

With open educational resources (OER), the cost of printed textbooks students have to deal with is reduced (Fischer, Hilton, Robinson, & Wiley, 2015). In addition, most recently eLearning compatibility standards, like the latest cmi5, have provided powerful tools for any student in an online or computer-based learning environment and made the delivery of the content quicker and robust and again at a lower cost. With digital textbooks' ease of use and having the powerful tools they bring to the classroom, literature showed that digital textbooks contribute to innovative teaching and learning practices (Benoit, 2018).

In today, even with advanced technologies and their benefits, adopting e-books over their printed options remains as an issue. While some studies suggested that digital textbooks were adopted by students, mainly because of affordability and accessibility (Fischer et al., 2015; Weisberg, 2011), other studies revealed that printed textbooks were still preferred over digital counterparts (Benoit, 2018; Millar & Schrier, 2015; Strother, Brunet, Bates, & Gallo III, 2009). It was also shared that digital textbooks made studying more difficult (Strother, et al., 2009) and printed books were more convenient than digital textbooks (Millar & Schrier, 2015).

Blended Learning

Graham (2010) defined blended learning (BL) as the combination of instruction from two historically separate models of teaching and learning as in face to face (F2F) learning and distance learning systems, with the emphasis on the central role of computer-based technologies. F2F is the typical learning environment where teacher interacts with the learner face to face. Whereas distance learning systems provide learners with a self-paced learning environment where they have access to asynchronous or also synchronous self-paced learning materials. Blended learning should be distinguished from other forms of learning environments that also incorporate online components with the integration of the two main components (F2F and internet technology) in a way that should not be just adding on to the existing dominant approach (Garrison & Kanuka, 2004). Blended learning requires a spectrum shift in the curriculum structure, the role of the teacher and the engagement of the student (Francis & Shannon, 2013).

More and more institutions are adopting blended learning with the utilization of learning management systems (LMS) which have already become an indispensable tool for universities to facilitate web-based teaching. In higher education, colleges and universities have been reducing the time spent in the classroom and moving some –in many cases most– learning activities to online platforms and enrollment in online courses is increasing according to the latest report from National Center for Education Statistics in USA (U. S. Department of Education, 2019). Most studies on blended learning courses revealed that they improve student learning outcomes, provide freedom and flexibility, are cost effective, more satisfying, and they increase access and decrease drop-out rates (Alonso, Manrique, Martinez, & Vines, 2011; López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011; Porter, Graham, Spring, & Welch, 2014; Vaughan, 2007).

In one specific example of blended learning adaptation in engineering courses showed that it improved students' communication skills and it was also stated that blended learning provided an environment that facilitated the promotion of mathematical thinking (Kashefi, Ismail, & Yusof, 2012). The results of the study by Francis and Shannon (2013) demonstrated that students were advantaged in studio-based subjects containing dense technical material and their learning outcomes were improved significantly in a blended learning environment introduced in architectural engineering, design and architecture disciplines. A study on students' performance evaluation in traditional and blended Algorithm and Programming course in Computer Engineering Education, results depicted that education was more effective and students' achievements were better than expected in comparison to traditional education (Yigit, Koyun, Yuksel, & Cankaya, 2014). Martínez-Caro and Campuzano-Bolarín (2011) analyzed the differences in the level of satisfaction across traditional and blended learning methods and showed that student satisfaction was greater in blended courses due to the levels of class attendance, motivation and collaboration with classmates.

Implementation of blended learning, viewed from different perspectives, have its own issues and experiences. Universities throughout the world have been widely adopting blended learning and studies on these adoption processes and their related experiences are conducted. Graham, Woodfield, and Harrison (2013) organized their findings in three broad categories as Strategy, Structure and Support, with different stages of adoption to show how institutions engage in blended learning. They stated that barriers related to institutional policies, structures, and lack of support can prevent large-scale faculty adoption of BL and the accompanying institutional benefits. They suggested that institutions should be clear about their purpose for implementation and their definition of blended courses. Porter et al. (2014) also agreed with Graham et al. (2013) and Vaughan (2007) that institutions should be ready to face with the most important challenges as alignment of the goals and priorities they intend to achieve with blended learning, advocacy among administrators, faculty and institutional personnel, resistance to organizational change, and organizational structure and experience with collaboration and partnership.

Instructors at a university also have an important role in the adoption process of a blended learning course. Their existing knowledge and notions on novel technologies can both act as barriers and enablers to academic change, in particular, a community of instructors at a university working in unity can make a big difference (Evenhouse et al., 2018). With new technology emerging every day, there is always an element of surprise in educational technology. This highlights an important aspect in blended learning that is expert support to faculty and instructors. While using an LMS, instructors may benefit from an expert support anytime they need it. Moreover, the design of the platform, the pedagogical usefulness of the content, and the delivery method will sometimes necessitate a closer attention especially for older teachers who tend to be slower to adopt new technologies (Christie & Jurado, 2009). The role of instructor has not yet lost its significance but rather there seems to be a change. When he is in the classroom, he has his authoritative and facilitating persona (Demetriadis & Pombortsis, 2007) but in an online environment, especially in asynchronous courses, he cannot control the learners lack of stimulation immediately and cannot look into their eyes every time he asks a question. In blended learning, the instructor should be accessible in various ways and he must know when to slow down or add new tasks (Bonk & Kim, 2004). As Francis and Shannon (2013) suggested, teacher role shifts to facilitator and it requires support for the development of a pedagogical approach, as well as training in specific tool selection and use. They become content experts, instructional designers who assist with course design, and media specialists who assist with the technical creation of course materials (Garrison & Kanuka, 2004). One study revealed that blended learning added value and increased students' motivation only if the instructors were experienced as highly open, respectful, and understanding people (Derntl & Motschnig-Pitrik, 2005). An interesting observation from a study by Andersen, Geirsdottir, Thorsteinsson, Thorbergsson and Gudmundsson (2018) reported that the presentation style or the vocal accent of an online instructor can make a significant difference for students.

The purpose of this study was to examine the implementation of enhanced digital books in the selected courses [Calculus I / Calculus II, Physics I / Physics II, and General Chemistry], and to explore teaching and learning experiences in those courses. The study was developed around the university's and digital book provider's interest in understanding how the students used these products to engage in learning through completing the assignments, as well as in understanding how to continue improving the practice around integrating digital learning products into instruction.

METHODOLOGY

The study took the design of a multiple case study research across the courses (calculus, physics and chemistry) using enriched digital books. The use of multiple case study design procedures provided extensive opportunities to have in-depth understanding about all course situations (Yin, 2009). Each of the cases directed us to confirm or disconfirm the conclusions drawn from one another course. Each case study employed the determined mixed methods approach (Creswell & Plano, 2018) applicable across the three units to explore teaching and learning experiences in those courses using interview, survey and product platform usage data to provide more comprehensive views. Therefore, this study involved the concurrent collection and analysis of qualitative and quantitative data to best understand how such digital products were used.

Context and Participants

This study took place in one of the largest foundation universities in Istanbul, Turkey in partnership with the Distance Education Unit at the University. With the recent growth of the University, the administration recognized the need for transforming the university through the integration of digital technologies. The goal of the university transformation was to adopt the new products with eBooks through the "blended system of change", gradually introducing new components into teaching and learning without disrupting the current teaching and learning processes and experiences. The transformation through digital technologies was expected to take place in partnership with the digital product providers to ensure successful implementation of technologies.

Such enhanced books are distributed via the platform of the book providers in which there are more than 11 million student users annually. The selected platform tries to create learning experiences personalized and adaptive so that the instructor/educators can redesign their learning materials from the eBooks on the platform which are one of the most powerful elements of the product providers. The digital platform has lots of capacity to increase online learning experience and boost the delivery of the lecture to massive online learners. Some components of the platform can be entitled like online homework, tutorial and assessment products, question libraries (collection of questions gathered from different textbooks), videos, annotated deep links (useful links to related content or expanded topics), Learning Analytics (it provides real-time analytics via classroom discussion, promoting peer-to-peer learning, and assessment with classroom response system with 18 different question types), simulations, and a new feature (before or after the lecture, assigning some core points of the contexts to students

Table 1. Participants

	# of Students Enrolled in Three Courses	# of Students Participated to Survey
Calculus I	1026	8
Calculus II	1262	71
Physics I	1143	8
Physics II	1075	60
General Chemistry I	246	32
Total	4752	179

and it helps students to be ready for lecture and increases their confidence towards to the lecture).

The digital products, integrated into the foundational courses, were offered during the first year of Engineering academic programs through the digital-only adoption where the classes were taught in-person with students having access to the materials only in the digital format (both the eBook and the supporting digital learning materials and features) and were embedded into the University's learning management system. Most of these foundational courses spanned over two semesters (General Chemistry, Physics I and Physics II, Calculus I and Calculus II). The expectations of completion of assignments on the product platforms varied across three subject areas. Calculus I and II required completion of Quizzes, tying 10% of course grade to performance on the quizzes. The same expectations were placed for students in the General Chemistry course. On the other hand, the assignments were recommended as an approach for earning "bonus points" during the semester in Physics courses.

A purposive sample of students attending the courses that use three selected digital products, namely, students enrolled in Calculus I and II, Physics I and II, General Chemistry I courses during the academic year 2015-16 (see **Table 1**). A purposive sample of four instructors (two for Calculus, one for Physics and one for Chemistry) delivering the courses at the Engineering College and a coordinator of university's distance education unit (DEU) was selected to participate in semi-structured interviews. Instructors participated in the study have thought the same courses for over 5 years and they also used the selected digital products more than three years. DEU coordinator was an educational technology professor with more than 20 years of experience and who also have been coordinating the DEU for more than five years. All students attending the five courses using digital products in the Spring semester were also invited to participate in the online survey. Only 179 responses were received which represents a very small percentage of the overall student population. Of 179 participants, 146 indicated that they were able to access their digital course materials. Although these participants represent a limited sample that is not representative of the student population, the students completing the survey have provided valuable feedback on their experiences with assignments in digital products.

Data Collection and Analysis

Study data were obtained from the following sources: (1) opinions from four instructors of the selected courses and DEU coordinator, (2) platform data on student interaction with digital products in the selected course sections and (3) student feedback on the experiences with digital products. The institutional permission for the study was first obtained, followed by a period of setting up the study. Data collection started by conducting instructor and DEU coordinator interviews in Spring and Summer 2016. These semi-structured interviews were conducted by product provider team in Istanbul and the study researchers, in either English or Turkish language. The questions were mainly on instructors' experiences with the adopted digital product and its integration into their courses. Student online survey was administered in both English and Turkish languages during the Spring semester. The survey was embedded into university's learning management system in anonymous format, for the ease of administration. Questions in the survey were about students' experiences with the products and their satisfaction or disappointment while using product platforms. Product usage data were obtained in Summer 2016, as aggregated data for all sections of each of five courses. Data usage available through the product platforms/databases provided insight into how students used specific product features and analyzed the patterns of usage across the semesters.

An informed consent was obtained from students in all five courses and the interviews with instructors and administrators were scheduled at the times convenient for them. These participants were asked to consent to being interviewed and audio recorded during that process. Data analysis involved concurrent analysis of qualitative and quantitative data (Creswell & Plano, 2018). Two data sets from three data sources were presented separately in the findings, but they were merged by bringing the separate results together at the interpretative stage. The interview data from one-to-one interviews were analyzed through the content analysis approach, and coded and categorized into the themes, based on the common reflections, around the product implementation, teaching and learning experiences, student engagement and institutional-level processes. Product usage data relied on descriptive statistics reporting on the assignment level findings for each course and across all products. Student survey data were also analyzed using descriptive statistics and reported in aggregate format including responses from the participants using the products.

FINDINGS

The findings were first reported on reflections about teaching and learning experiences with digital technologies, followed by sections summarizing the students' product use and feedback on the experiences with digital products. Qualitative data collected from interviews were thematized and reported, and quantitative data on engagement of students with the digital products and assignments were also presented in detail in this section.

Interviews

Five themes emerged from the interviews on teaching and learning experiences with digital products and they were reported in sections below as the benefits and potential of digital technologies, challenges in changing the instructional culture, engaging the instructors with digital products, removing the possibility of cheating, engaging the students with digital products.

The benefits and the potential of digital technologies

The benefits of using digital products in the courses, as well as the future potential of these products in the overall teaching and learning experiences were highlighted by all interviewed instructors and DEU Coordinator. The benefit that was lauded by all instructors was the potential to provide students with structured and guided assignments that are aligned with the content covered in lectures, and more importantly, the value of the automatic grading of those assignments. The instructors recognized that the students need to practice the problems to fully grasp the content. However, they noted that they would not be able to offer graded feedback to students completing the practice without this automated grading feature available in the products. The value of digital products as the platform for extended practice with automated grading was even more important due to its timing, since the transformation of the university through integration of digital technologies coincided with the increasing student enrollment at the university. The instructors reported finding it difficult to grade any practice assignments beyond the mid-term and final exams, which take a significant amount of time in the instructor's schedule.

Students had access to eBooks, viewed as providing more modern and flexible access to the course materials. At the same time, it enabled the instructors to support student engagement with the content even with the large enrollment numbers as well as to engage their students with practice in an academic culture where the engagement was not necessarily expected: "In terms of the professors and educational aspect, such products make professors' job easier as they organize, and help create standardization, particularly in group courses. They serve as guidance for inexperienced academics through feedback and interactions with the content provided." (DEU Coordinator).

Challenges in changing the instructional culture through the products

While providing a vision for the transformation, the DEU also encountered some implementation challenges, particularly how to support the cultural and organizational change in viewing digital products and technology in teaching and learning processes: "First of all, changing the existing order with the addition of something totally new is a challenge on its own. Secondly, the students are not open to such a system and this is a problem. Thirdly, there are technical problems which make the professors anxious about using the product. We are trying to minimize such problems." (DEU Coordinator). The DEU Coordinator acknowledged the unrealistic expectations of instructors and students, and the "culture in general in Turkey," where it is expected to see an "immediate change" upon adopting a new process or tool. The lack of the perceived immediate results contributes to producing the "resistance to change" as described by the interviewed coordinator, which appears through several dynamics – changes in the instructional practices, and student engagement with the products.

Engaging the instructors with digital products

While the instructors had an overall positive attitude toward using the product platforms in their courses, it was revealed during the interviews that the instructors could expand their understanding of product features and could benefit from the additional resources on effectively using digital products in their courses. The instructors placed a lot of effort on creating multiple assignments to assist students and extend their practice time after the lecture periods. However, the instructors did not use the range of the features available in the platforms and were not aware of additional resources to assist them in selecting appropriate product features prompting student engagement with the product and its content. For example, the instructors were not aware what exactly students could see on their account after they submitted the assignments, or did not use the features such as the feedback option on the problems, randomizing the problems in the assignments, or changing the numbers within assigned problems to deter cheating practices. The instructors were also not familiar with the features of the eBook, nor whether students use the eBook. Some instructors resorted to the option of having a leader in their subject group who had an expert knowledge on how to handle the digital product. While this digital leader could attend to the needs of multiple courses with more expertise, it also lowered the level of motivation of some instructors to learn the product features themselves.

The engagement of the instructors with the product was also affected by several institutional factors, including limited lecture time and lack of high-speed internet in classrooms. The instructors reported that due to the increasing enrollment numbers they were overwhelmed with the number of students in their classes and focused their efforts on delivering the lecture and grading the exams (midterm and final exams). They did not include digital products in their lectures as there was "no time for it" (Chemistry Instructor).These instructors reported that including time for practice with digital products during the lectures took away from the time needed to cover the course materials in a 14-week lecture period. Although, they expressed the desire to use the products and demonstrated some features and problems during the lecture period, the amount of time that would be spent on connecting to the product and projecting the materials on the classroom monitor would be too long. Therefore, even though the instructors shared that they were asked to use platforms in their lectures for at least five minutes every lecture, they reported they did not have time for dealing with the issues of setting it up to include digital resources into their lectures. This goal of the instructors to model the use of digital products in the classes was aligned with the perspective of DEU Coordinator who noted: "If the professors just talk about it but do not use it themselves in classroom, then it is unlikely that the students will be engaged. If the professors show them how beneficial it is, students will be encouraged to use it. They need to make the product stand out so that the students want to use it."

Removing the possibility of cheating

The adoption of digital technologies provided a new process for completing the practice assignments, but also challenged the instructors to reconsider their approach to creating the assignments and setting the expectations for their students. During the first year of implementation of the products, the instructors were not aware of the embedded features to remove the possibility of cheating/copying the results while completing the assignments out of the classroom. The Physics instructor shared that the students "started to share the questions on the Internet, copy and paste answers to the boxes without actually solving the questions." One of the Math instructors shared a similar experience:

> "Students were able to finish the quizzes in three minutes, which was not possible, not even for me. And they were able to get 100%... And we noticed that good students who perform really well in the midterms and quizzes did not perform that well, or they were kind of average. This is quite okay, but our problem was with the students who got zero to ten points out of one hundred in the midterms, and one hundred, in the quizzes. And they were taking that one hundred in a few minutes."

The incidents of widespread copying of the assignment results affected the weight of the grade placed on completing the assignments. For example, Math classes reduced the course grade's percentage points allocated to these assignments from 20 percent of the grade to 10 percent. The instructors cited that too much weight was placed on the grade for which they could not fully eliminate copying. Nevertheless, the instructors worked to reconsider the practice of creating the assignments to eliminate the possibility of copying the assignment results when completing them outside the classroom. Physics department sorted the problems in the problem bank into several categories and assigned students with varying questions out of these categories. Math and Chemistry instructors resorted to the practice of including one problem from the quiz into the final exam. In this way they encouraged students to practice every problem in their assignment, but also controlled how student performed on that item in their assignment and on the final exam.

Engaging the students with digital products

Students at the Faculty of Engineering were accountable for purchasing their books and supplemental materials, such as the access to eBook accounts for each semester. The percentage of students purchasing and activating those accounts varied by course and semester, with 63% of students activating accounts in the Fall semester, and 32% of students during the

Spring semester of the course sections where instructors were participating in the study. While the instructors expressed the expectation of higher student engagement with the product, they also noted that the students were not provided a structured guidance on the benefits of using these digital products and that only a low percentage of their grade was affected by the assignments completed on the products. Additionally, although all instructors believed that an engaging session explaining product features would likely help student engagement, their students received a very short introduction to the products by their instructors at the beginning of each semester.

All instructors claimed that students who wanted to study would do so with or without digital products. Moreover, they claimed that digital products primarily benefited already motivated students as they were likely to spend more time on the additional resources and practices. While the enrollment in the classes was large across semesters, the attendance or class participation was not required. Moreover, the instructors reported that the lack of attendance also led to lower engagement with the practice, they did not necessarily review the dashboards measuring students' engagement with non-assigned practice materials, nor did they keep track of student engagement in classroom. Overall, the instructors believed that "the use of products yielded limited benefits. An insufficient number of students used it, that's the problem" (Chemistry Instructor). The instructors did not believe that student engagement had significantly changed in general; they all reported that about 15% of students were working hard and others were simply working enough to pass the course or were repeating the course.

> "Students are not really excited about it when we tell them what to do, what section to check out or when we talk about extra applications in the classroom. What they want to do is to finish the homework, be done with it and get the points, only for the sake of grades. There are very few among them who are eager to learn in more detail or consider it a great opportunity. … They are solely focused on grades and exams. If we were to tell them that we would not grade assignments anymore, no one would take assignments, I think." (Physics Instructor)

The Range and Extent of Product Usage by Students

The student engagement with the assignments provided on product platforms was uneven across the five foundational courses, with some courses seeing majority of students engaging with the product, while in others a much smaller fraction used the product. However, those students who engaged with the practice provided by their instructors have completed their assignments. The obtained product data were aggregated at the course level; a segregation of this data at the individual instructor or course section level was not possible.

As summarized in **Table 2**, 35% of students from these five courses practiced at least some assignments, though the actual engagement varied across courses, ranging between 25% and 69% of students completing the assignments provided on the product platforms. Calculus courses saw the largest percentage of their students practicing the assignments (more than 60% of students), with Physics II offered in the Spring semester having only a quarter of its students. The term "completing the assignment" refers to student practice on the assigned problems and submitting them through the "submit" button; in this process, a student could have completed all assigned problems, or only select ones. It is also worth noting that the five courses integrating the products had a different number of the recommended assignments, with the number of assignments ranging from 3 to 10 per course; the assignments also varied in length due to the number and type of problems included. Students practicing on the assignments tended to complete assignments on time, while spending on average 44 minutes per assignment. However, there is no consistent pattern of the same students continuing to complete the

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Table 2. Engagement with digital products across five courses

Course	No. of Graded Assignments	No. of Students Completing Assignments	Percentage of Students Completing Assignments	Total Number of Completed Assignments	Percentage of Assignments completed by Due Date	Score (Percentage correct)	Average Time Spent on Assignment (minutes)
General Chemistry I (N = 246)	7	96	39%	346	83%	58%	85
Physics I (N = 1143)	10	466	41%	2064	92%	69%	42
Physics II (N = 1075)	10	268	25%	1068	95%	63%	35
Calculus I (N = 1026)	4	709	69%	1970	n/i	n/i	43
Calculus II (N = 1262)	3	776	61%	1421	n/i	n/i	37
Total (N = 4752)	34	1646	35%	6869	n/i	n/i	44

Table 3. Engagement with Assignments in General Chemistry

Assignment	No. of Students Completing Assignments	Percentage of Assignments completed by Due Date	Score (Percentage correct)	Average Time Spent on Assignment (minutes)
Introductory	22	n/a	n/a	14
Spring Homework 1	88	59%	50%	94
Spring Homework 2	39	100%	66%	79
Spring Homework 3	54	100%	58%	99
Spring Homework 4	44	100%	65%	82
Spring Homework 5	34	100%	67%	81
Spring Homework 6	31	100%	80%	144
Spring Homework 7	34	100%	71%	62
Total	346	94%	58%	85

Table 4. Engagement with Assignments in Physics I & II

Assignment	No. of Students Completing Assignments		Percentage of Assignments completed by Due Date		Score (Percentage correct)		Average Time Spent on Assignment (minutes)	
	Physics I	Physics II	Physics I	Physics II	Physics I	Physics II	Physics I	Physics II
Introductory	167	51	n/a	n/a	n/a	n/a	25	18
Homework set 1	300	184	100%	100%	77%	65%	55	38
Homework set 2	288	140	100%	100%	74%	57%	55	38
Homework set 3	257	134	100%	100%	71%	70%	58	45
Homework set 4	198	112	100%	100%	61%	62%	39	39
Homework set 5	166	124	100%	100%	85%	73%	35	30
Homework set 6 & 7	179	155	100%	100%	74%	66%	54	37
Homework set 8	137	64	100%	100%	60%	61%	44	41
Homework set 9	138	67	100%	100%	83%	75%	29	40
Homework set 10	140	37	100%	100%	67%	83%	37	31
Homework set 11 & 12 (Bonus)	94		100%		75%		59	

assignments, as data showed that students also skipped some assignments, but returned to completing other assignments at a later time.

The additional details available in **Table 3** and **Table 4** summarize the engagement with Chemistry and Physics assignments. Overall, about a third of the students practiced assignments in Chemistry and Physics courses. Those students completed their homework assignments on

Table 5. Engagement with Assignments in Calculus I & II

Assignments	No. of Students Completing Assignments	Average Time Spent on Assignment (minutes)
Calculus I*		
Quiz 1	575	49
Quiz 2	536	50
Homework 1	492	34
Homework 2	275	41
Calculus II**		
Quiz 1	692	43
Quiz 2	421	34
Homework 1	228	28

*Additional 23 Assignments were completed by an average of 4 students per assignment.
**Additional 16 Assignments were completed by an average of 5 students per assignment.

time, with the introductory assignments not having a deadline for completion. On average, students scored over 60% correctly on the problems included in the assignments. The time spent on completing the assignments varied by class, from the average of 35 minutes per assignment in Physics II to the average 85 minutes per assignment in General Chemistry.

Between 60% to 70% of students in Calculus I and Calculus II courses engaged with the assignments, which was much higher engagement than in Chemistry and Physics courses. However, the number of assignments was lower, with only 4 and 3 assignments in each course, respectively. As **Table 5** summarizes, the data available from Math platform provided less insight, than data for Chemistry and Physics platform; nevertheless, the students spent on average between 28 to 50 minutes on each assignment. As the scores were not available as percentage of the overall points, the comparison of the scores was not possible.

Overall, students who engaged with the assignments spent a reasonable amount of time on completing the work. Moreover, their efforts on completing the assignments were meaningful as the average scores on the assignments were well over 50% of the total. Higher completion rate of the assignments was in the courses that had fewer assignments. Nevertheless, the students completing the assignments in the courses with higher number of assignments were obtaining higher performance scores.

Student Feedback on the Experiences with Digital Products

The descriptive findings of this survey came from a group of 146 students who noted that they were able to access their digital course materials. Majority of the participants (78%) reported having high level of comfort of using technology. Additionally, 71% and 73% of these students said that it was easy to access their platform accounts or assignments, respectfully. Majority of students accessed their accounts on their computers; only 38% of the students reported accessing their accounts from smartphone or tablet. Additionally, 6% of these students reporting having access to their account also reported that they did not use the platforms during their courses.

Students reported spending up to an hour on digital assignments, weekly, which corresponded with the duration for assignment completion reviewed through usage data from the product platforms. Although 65% of students agreed or somewhat agreed that digital platforms provided them with access to a great variety of learning materials and assignments, only less than 40% of students showed agreement with the statements about the value of assignments on the platforms in their learning. Additionally, only 46% of students were satisfied with the content available for practice in digital platforms. Finally, 58% of students agreed that the product platforms have somewhat or very little impacted their learning in the courses, with 60% noting that they impacted their learning a lot.

Additionally, 69 students provided comments on the benefits of using digital products in their courses, or the challenges they experienced while using these products. Out of these, 20 students specified the benefits they received from using the products, noting one of the following: access to the additional course materials and eBook (*N* = 6), expanded practice time and possibility of practice at home (*N* = 8), better understanding of the course content (*N* = 3), possibilities to use digital technologies for learning (*N* = 3). However, 17 students noted that they did not see any benefit from using digital products in their courses. Students also provided more details on the challenges experienced with such products. The most common challenge was difficulty with accessing the accounts with 19 students listing the incompatibility with their operating system (most often MacOS) (*N* = 5), difficulty viewing account on their tablet, or mobile due to website configurations (*N* = 10), or have simply noted having difficulties accessing account without offering specifics (*N* = 4). Additionally, 12 students reported that the product syntax was not aligned with the scientific standards they were used to, and many also noted that the syntax was inflexible, marking the answers incorrect even due to small variations of the entered responses. Also, 16 students marked their general dissatisfaction with the products or the use of products in their class, with a few students offering some details, such as too few assignments given by their instructors, dissatisfaction with the content, or its alignment with the course lecture materials. Overall, while about a third of the students entered clear satisfaction with the product and identified benefits directly stemming from their use of the product, a larger number of students offering feedback focused on their challenges with using the product or expressed dissatisfaction the products.

DISCUSSION AND SUGGESTIONS

The study findings around product implementation as well as instructional and learning experiences can be grouped around three categories identifying what worked well as well as challenges within the process and assist in identifying the future actions leading to improving the implementation of digital products and advancement of teaching and learning experiences.

Extending Opportunities for Student Learning through Practice and Automated Grading

As literature suggests, institutions should be clear on their goals with implementation of digital products (Graham et al., 2013; Porter et al., 2014). The adoption of digital products met the initial outcomes of the university transformation through the integration of digital products by creating multiple benefits for both instructors and students. These benefits included:

- Student access to the quality practice and learning resources aligned with the course book to extend learning outside the classroom through blended learning (Alonso et al., 2011; López-Pérez et al., 2011; Porter et al., 2014; Vaughan, 2007).

- The automated grading function provided students with the feedback on their practice that the instructors otherwise would not be able to provide on these practice assignments having in mind large student enrollment (Francis & Shannon, 2013).

- Student accessed to eBook rather than paper textbook that represented access to the course content in the digital format (Fischer et al., 2015; Weisberg, 2011). In this way, students could access the book from multiple digital sources, identify the content through search functions, as well as engage with the features of enhanced eBooks such as highlighting the content in the eBook, making notes, and reviewing the media links available in these products. This ease of use and powerful possibilities students benefit from, contributes to innovative learning practices for students (Benoit, 2018).

The instructors encouraged students to engage with the digital content on the platforms by tying a small percentage of the course grade or bonus points to the performance on the assignments. However, as the findings in the other categories suggest, the additional efforts on engaging students with the digital products could be beneficial to students as well as contribute to the institutional efforts for transformation of instruction and learning.

Advancing Instructional Practices through the Integration of Digital Products

The integration of digital products relies heavily on the technical implementation of those products in the courses and pedagogical methods that effectively employ these products. However, several factors affected the instructors' use of digital products:

- Instructors reported relatively low familiarity with the product features. For example, the instructors were not familiar with the student interface of the product or how students experienced the work assigned by them.

- The changes in the instructional approaches after adopting digital products in these five courses were minimal. The instructors did not mention what changes they were making in their pedagogical approaches in the classes using digital products and have discussed their courses as keeping the traditional lecture style. While all instructors acknowledged their current inability to use digital products in the classroom, they also spoke about the importance of in-person lecture, the use of the whiteboard instead of digital slides or media, and the value of hand-written practice of the scientific problems.

The instructors and students have not shared the evidence of how they received and understood the university-level communication about the value of digital learning products and the guidance on the effective use of those products. Data collection in the study did not focus on the institutional level policies around digital learning technologies, nor the communications with the instructors and students about the institutional expectations on the use of these resources in teaching and learning. Based on the feedback shared in interviews and surveys, the instructors and students could benefit from the improved communications around the institutional vision on integrating digital technologies and the value these products have for them, personally.

The process of advancing instructional practices with digital products could be strengthened through additional product training for instructors focusing on product features and implementation practices, as well as through the professional development opportunities geared toward pedagogical approaches effectively integrating technologies. However, understanding the product is only a part of the effective integration of digital products; increasing the understanding of the pedagogical approaches to integrate digital products into teaching and learning processes is the necessary component of the overall transformation with digital learning technologies. Therefore, it is as important to provide the instructors with the professional development opportunities to reshape their classes to include digital products within the existing course enrollment numbers.

Tackling the Challenges of Student Engagement

The process of increasing student engagement with digital product is multilayered and dependent on both institutional resources and policies as well as instructional approaches. From the intersections of perspectives of DEU Coordinator, instructors and students, the following factors contributed to reportedly low student engagements with the digital products:

- Students had limited knowledge of product features and their potential benefits. The instructors and students reported that the product training offered to students was minimal, leaving students to explore product and its features on their own.

- Students were unaware of the university expectations around the use of digital products. Although the course syllabus instructed students to obtain the products with the relevant eBook as a course text, the grades were minimally (if at all) affected by the assignments completed on the product platforms.

- Majority of students were perceived as having low engagement with learning. The instructors reported that "good students" used digital products and completed their practice, but that they would do so with any type of resources they had on hand; they also believed that these students represented a small percentage of students, with a large portion of students not willing to practice regardless how that practice was offered.

The results also showed that students and faculty members should get at least a basic support and orientation possibly at the beginning of the given course. As Christie and Jurado (2009) state, it is important to offer support by experts and the design of the platform or the pedagogical use of its capacity should be considered even in the simplest tasks like file transferring.

Student engagement with the product is likely to be affected by the actions recommended for advancing the institutional technological capacity and instructional approaches. Providing structured product training for students is an important first step in helping students understand the products and their features. The improved communication about the institutional expectations around the use of digital products and the instructional practices encouraging student engagement with these products would also assist students to see the value of digital products in their learning and achievement. As the instructors and DEU Coordinator noted, if the use of the product was modeled in the lectures on a continuous basis demonstrating the value of various product features and learning resources, students might have been more willing to follow that model after the lectures. Additionally, by seeing the portion of the grade affected by their practice, more students might have seen the value of these products in their learning. Overall, practicing aforementioned procedures with smaller classes assists in testing the process, as well as understanding the value of these practices and working toward enabling the use of digital products in large classrooms as well.

It is clear that change takes time, and that instructors, as well as students, need to not only adopt digital products but also engage with them to enhance the instruction and learning. The continuous improvement in the practices and university capacities have potential to help both instructors and students to see the usefulness of the products and their value in teaching and learning.

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