UNC System Math Pathways' Digital Course Enhancement Collaboration to Improve Equity, Instruction, and Access During the COVID-19 Pandemic

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This study examines how faculty members and students evaluated, perceived, and used a digital course content collection developed to support high quality remote instruction during the Covid-19 pandemic. The collections were the result of a multi-institutional, collaborative effort within the University of North Carolina System to support its students and faculty. Using surveys from faculty and demographically identified students enrolled in their classes, the authors evaluate the perceived utility and impact of the open educational resource collections. Faculty members rated the collections highly and typically found utility in at least some of the components of the collections. They found activities, videos and assessments to be the most useful tools. Students generally responded positively to the classes using the collections. While students who identified as minority found the materials useful or beneficial, they did not do so in proportional numbers to non-minority students.

Keywords: open educational resources, digital course content, remote learning, pandemic, textbook costs, equity

INTRODUCTION

The UNC System's Digital Course Collection is the result of a system-supported effort to provide open access options to improve access and equity during the Covid-19 pandemic. It represents a large-scale collaborative effort to create, curate, and share alternative pedagogical approaches and tools for the instruction of mathematics. We describe the development process and evaluations from early adopters of the materials.

The UNC System's Math Pathways Task Force has engaged a group of faculty and staff from across the UNC System to improve the success of students in mathematics courses since 2017. In a final report disseminated in August 2019, (https://www.northcarolina.edu/wp-content/uploads/reports-and-documents/math-pathways-documents/unc_math_pathways_final_recommendations.pdf) the UNC System Math Pathways Task Force proposed 8 recommendations, including supporting background and ideas, be considered by UNC System institutions seeking to improve student success in required mathematics courses. Individual UNC System institutions adopted interventions, including specialized math pathways, improved placement, and co-requisite support courses that increased student success in entry-level mathematics courses, reduced the need for remedial classes, and closed equity gaps in the completion of college mathematics. The pandemic presented challenges that the Math Pathways recommendations were well-placed to address. Students needed enhanced support as they transitioned to remote and more independent learning, and faculty needed to shift their curricular and pedagogical approaches to an online environment quickly. The Math Pathways Initiative was and is uniquely positioned to leverage existing relationships across the UNC System to work collaboratively on resources that are valuable to both students and faculty.

As a response to the pandemic-driven migration to distance learning for all courses, over 70 experts from 14 UNC System institutions contributed to the work on the open-access Digital Course Enhancement Initiative. (https://www.northcarolina.edu/unc-system-course-collection-libraries/) The Digital Course Enhancement Collections were created to provide support for high-quality remote instruction and limit the effects of economic disparities on student success during the pandemic.

To maximize the efficacy of remote instruction in courses that are essential for timely progress within majors, the UNC System Office formed instructional teams of content experts, design experts, and librarians to compile, vet, develop, and distribute high-quality materials and tools to support high enrollment courses. By curating and disseminating fourteen content collections, the Digital Course Enhancement Collection provided instructors access to high-quality learning objectives and openly-accessible materials to support students in general and at-risk students in particular.

The guiding theoretical framework for the Digital Course Enhancement Initiative is the Model of Institutional Action for Student Success. (Tinto, 2006) Students are more likely to succeed when they are in settings that are committed to their success, hold high expectations for success, provide academic and social support, frequent feedback, and engagement with other students and faculty. (Tinto, 2006) In each content area, the development teams included content experts, specialists in instructional design, and university librarians collaborating to create or curate quality content that could be used in whole as the basis of an entire course or in part to augment existing course materials. Many of the librarians were previously part of the Open Education North Carolina (OENC) effort which focused on promoting the use of OERs at state institutions. (https://www.nclive.org/oenc) Previous collaborations around Math Pathways and OER initiatives laid the foundation for current efforts, helping the librarians to guide teams in the selection and vetting of high-quality open educational course materials. OERs were identified as a best practice for the development teams to help minimize costs for students while maximizing access to high-quality materials. (Colson, 2017) They were also selected to help provide common materials that were not tied to a particular textbook, given the many different textbooks being used across the UNC System. Ten initial courses were selected, with three courses added when additional funding became available. (Table 1) The initial course collection development teams included two math teams that focused on developing and curating materials for Calculus I and Introductory Statistics and were led by Math Pathways co-chairs. Course collection development followed a backwards design process in which the learning outcomes were identified and then activities were identified, collected, or developed to support student achievement of the identified objectives. Typical content in the collections included: an introductory webinar for faculty interested in using the collection, an implementation guide, information on the design process, online textbook resources, and course modules including video resources and activities. Some assessments were developed or recommended; however, they were developed as options to support faculty members and not as tools for course evaluation or comparison. Due to the various learning management systems in use across the UNC System, care was taken to ensure that materials could be migrated to a wide range of hosting sites including Blackboard, Canvas, and Moodle.

TABLE 1
TARGETED COURSES FOR MATERIAL DEVELOPMENT OR CURATION

Introductory Statistics	Anatomy & Physiology	Chemistry I
Quantitative Reasoning	Microeconomics	Chemistry II
Precalculus	Macroeconomics	Organic Chemistry
Calculus I	Intro. Financial Accounting	General Biology
Calculus II		

The course content collections were made available through the UNC System website (https://www.northcarolina.edu/unc-system-course-collection-libraries/) during Summer 2020, to provide support for the Fall 2020 semester. The collections are freely available and accessible to any individual on the website. Each of the collections was evaluated by instructors in the discipline ("early adopters") not affiliated with the development process. Indicators of success include wide dissemination of materials, adoption by faculty, and student perception of improved course quality.

LITERATURE REVIEW

In the Spring of 2020, the Covid-19 pandemic resulted in a near total switch from in person to remote delivery of services. Though the pandemic impacted students at every level in all parts of the world, it did not impact students equally. Historically, students from higher socioeconomic backgrounds and with more advanced academic preparation and access to better technology have been known to face fewer hurdles than students from lower socioeconomic standard (SES) backgrounds. (Walpole, 2003) Issues such as access to computers, access to high-speed internet, a stable internet connection, individual space in the home, and access to academic support put different strains on various groups of students. (Walpole, 2008) The Covid-19 pandemic increased disparities typically present among college students. In response to the pandemic, emergency protocols were rapidly developed and invoked as courses throughout the academic pipeline were forced online. (Adedoyin, 2020, Yeo 2021, Moundy, 2021, Scuitto, 2021) Faculty adapted courses and adopted new materials in an attempt to support students' paths towards graduation. Instructors who had never taught online before, nor developed any materials to do so, were now faced with the need to acquire or develop content to assist their students. Course redesign processes that routinely lasted over a semester of development time occurred over a weekend. Although online courses previously existed, students typically enrolled in them by choice. Prior to the global shutdown, many instructors who developed and taught online courses also did so by choice. The pandemic created a new category of students and instructors. Students and instructors who previously had not opted for an online delivery system had to quickly adjust to the new paradigm. (Scuitto, 2021) Students who had never considered taking a distance learning course were forced to adjust to using technology as the primary conduit for learning. For some students, the move represented more of an inconvenience, while for others it had the potential of negatively impacting their lives with long-term consequences. Previous inequities were exacerbated when students were required to leave campuses in response to the pandemic. Leaving campus compromised students' abilities to access traditional support mechanisms which may have impacted at-risk students more than other students. Available resources, stress, resiliency, coping mechanisms, and grit all played roles in how students were able to cope with the "new normal." (Bono, 2020, Garris, 2020) Financial resources impacted students' access to workspace, health care, academic assistance, and textbooks, raising equity concerns. (Irfan, 2020, Adedoyin, 2020, Avery, 2014, Chirikov, 2020, Lebens, 2021) Regular in-semester activities such as textbook purchase and acquisition became non-trivial obstacles for students and campus bookstores. (Moundy, 2021, Reinhold, 2020, Wittkower, 2020, Yeo, 2021) Beyond the immediate concerns relating to content delivery mechanisms and supporting technology access for students, there was an issue of access to quality digital course materials for many faculty members.

Prior to the pandemic, various groups engaged in collaborative efforts to reduce textbook costs for students. Many initiatives used or created open educational resources (OERs) to curtail the rising costs of textbooks for college students. Efforts such as the Open Textbook Initiative of the American Institute of Mathematics and the Openstax Initiative at Rice University work to improve access to quality textbooks for students. Groups such as the Affordable Learning Georgia Initiative, Open Education North Carolina, and Florida Virtual Campus represent state level efforts to create or promote the use of OERs in educating students. (Croteau, 2017, Doan, 2017, Florida Virtual Campus, 2016) Though current research evidence supporting the learning benefit of OERs is inconclusive, if OER use results in comparable learning benefits to traditional textbooks, then OERs should be available based on economic benefit to the student alone. (Grimaldi, 2019, Mardis, 2017, Santos-Hermosa, 2017, Nusbaum, 2020, Lovett, 2008, Derosa, 2020, Doan, 2017, Junco, 2015, Hodgkinson-Williams, 2017). The Digital Enhancement Initiative followed the model of other OER efforts by creating, or collecting and evaluating, openly available resources for instructors teaching high-demand courses. The current study was conducted to determine the extent to which access to these collections improved faculty and student experiences in the remote instruction of the supported courses and whether the use of these resources was equally helpful for students from underrepresented ethnic minority groups and other students.

METHODS

Design

The study used a mixed methods approach. Initiative evaluators from the University of North Carolina at Charlotte Office of Assessment and Accreditation met with the Initiative leadership to create an assessment plan examining: 1) The effectiveness of communications about the collections; 2) The evaluation of the collections by faculty who adopted them in classes; and 3) The responses of students to the resources. Assessment instruments included a survey for attendees of the introductory webinars, a rubric and qualitative feedback survey used by faculty to evaluate the collections, and a survey for students enrolled in a class integrating all or some of the collection materials. The evaluators also reviewed analytics tracking website usage from when the collections were made available through September 9th, the date by which most university classes had begun.

Participants

Evaluations of the introductory webinars were received from 46 faculty at 14 different UNC System institutions. Respondents were primarily teaching faculty with 50% adjunct, teaching professor, or lecturer, 20% assistant professor, 17% associate professor, 13% full professor, and one graduate student. Sixty-nine faculty from 16 campuses agreed to use and evaluate the resources during the Fall 2020 semester for compensation. Another 15 faculty members used the resources without compensation resulting in a total of 84 early adopters. Of the early adopters, 58 completed evaluations.

All early adopters were invited to survey students in the class in which they integrated course collection resources. Faculty were encouraged, but not required, to offer a small amount of extra credit to students who completed the survey. Several faculty chose not to survey students for one of the following reasons:

1) they did not believe students would know which aspects of the course were using resources from the collection; 2) they did not feel they had used enough resources to make the survey results meaningful; or 3) their class was a short class or summer class that had already ended. The result was no survey responses were collected from students enrolled in Chemistry II, Organic Chemistry, Quantitative Reasoning, Pre-Calculus, or Introductory Financial Accounting. A total of 979 survey responses were received from students enrolled in the other courses that integrated resources from the collections. The responses included students from eight system schools. Students who chose to identify their race or ethnicity reported their race and ethnicity as 45% White, 27% Black or African American, 10% Asian, 9% mixed, 8% Hispanic or Latinx, and less than 1% Native American or First Nations. Forty-five percent of students reported that the current semester was their first semester at the institution, and 70% reported that they had not previously taken an online course in the subject area of their current course. Students were generally able to access course materials using a desktop computer (18%) or laptop computer (79%). However, 2% of students relied primarily on a phone or tablet. At the time of the survey, student self-reported grade expectations showed 37% expecting a grade of "A", 42% expecting grades of "B," 17% expecting grades of "C," 2% expecting grades of "D," and 1% expecting grades of "W" or "F." The expectation proportions for grades of A,B, C were somewhat higher than the rates typically found in these courses.

RESULTS AND DISCUSSION

Faculty Responses to the Initiative

Attendance at the introductory webinars used to launch the collections varied, ranging from 24 at the Macroeconomics webinar to 64 at the Introductory Statistics webinar. (Table 2) Attendees reported that they heard about the webinars from their department chair (39%), colleagues (39%), the System Office (30%), center for teaching and learning (13%), or chief academic officer (11%). The webinars attracted faculty with a range of previous experiences teaching online. One respondent had never taught online, 47% first taught online in Spring 2020 when they switched to remote instruction mid-semester, and 47% had previously taught partially or fully online.

We tracked interest generated by the webinars by examining the total number of distinct downloads, views, or prints of the resources posted in each collection from the launch date of the resources on June 30th until September 9th (when students might begin accessing materials). The course collections are listed in order of distinct downloads, views, or prints in Table 2. Overall, the site generated a great deal of interest with visits from 5,979 unique users who downloaded, viewed, or printed 7,663 files. There was variability in the extent to which resources from different collections were used. As *Pre-Calculus, Calculus II,* and *Quantitative Reasoning* were only completed at the end of August, usage data is not available for these collections. The most frequently accessed materials were from *Chemistry I*, *Calculus I*, *General Biology*, *Anatomy and Physiology*, *Organic Chemistry,* and *Introductory Statistics*. The least frequently accessed materials were from *Macroeconomics* and *Microeconomics*. Taken together, the findings suggest that the quality of the communication around the Initiative was strong and that the communications resulted in a high participation rate from teaching faculty across system institutions. Participation in the webinars resulted in many visits to the digital resources which, in turn, resulted in the distribution of many of them.

TABLE 2
COURSE CONTENT COLLECTION INTERACTIONS AND EVALUATIONS

Collection	Number Attending Webinar	% of Attendees Completing Evaluations	Distinct Downloads, Prints, Views
Chemistry I	50	8%	1256
Calculus I	24	8%	831
General Biology	30	7%	679
Anatomy and Physiology	28	18%	642
Organic Chemistry	33	10%	639
Introductory Statistics	64	17%	503
Introductory Financial Accounting	27	22%	356
Chemistry II	48	4%	315
Microeconomics	28	0%	248
Macroeconomics	24	4%	79
Pre-Calculus	45	13%	No data available
Quantitative Reasoning	35	6%	No data available
Calculus II	27	7%	No data available

Faculty who viewed the webinars were asked to indicate which resources would be the most and least useful to them. (Table 3) The majority of respondents viewed activities, brief videos, and assessments to be the most valuable. Many respondents also valued assignments, faculty implementation guides, practice questions, curriculum maps, and virtual labs. The least valued resources were meta-data tags and complete video lectures. The most common reasons for not using resources were that materials for the course were already completed, a faculty member preferred current materials, and the video lectures were too long. Overall, faculty who viewed the webinars believed the Digital Course Enhancement Initiative was a valuable initiative with 98% agreeing that the creation of the resources was very much or somewhat necessary. All faculty respondents reported the resources would improve their ability to deliver high-quality remote emergency instruction, 96% reported it would improve their ability to deliver high-quality online instruction on an ongoing basis, and 91% reported it would improve their ability to deliver high-quality in person instruction. Faculty reported strong interest in incorporating changes to future classes with 33% planning to integrate more than half of the collection content and 44% planning to integrate more than a quarter of the collection content. Only a single respondent indicated no plans for using the collection content. Overall, after participating in introductory webinars, faculty believed the resources would be very valuable and exposure to the resources resulted in a strong level of interest in making changes to classes.

TABLE 3
RATINGS OF UTILITY OF RESOURCES

Resource	% Viewing as Most Useful	% Viewing as Least Useful
Activities	74%	8%
Brief video demonstrations or explanations	54%	8%
Assessments	51%	8%
Assignments	49%	5%
Faculty implementation guide	42%	24%
Practice questions	37%	8%
Curriculum map	37%	19%
Virtual labs	37%	19%
Complete video lectures	28%	35%
Homework	26%	14%
Meta-data tags	2%	43%

Faculty who used the resources as early adopters also reported that the Initiative was valuable, with 97% agreeing that the creation of the resources was worthwhile and 77% reporting the resources would improve their ability to deliver high-quality instruction on an ongoing basis. In response to an open-ended question about the worth of the materials, nearly every response indicated the development of materials was worthwhile and provided a valuable collection of resources. A minority of responses indicated that much of the materials in the collections are already available online. Early adopters differed considerably in the proportion of resources they used from the collections: 10% used more than half, 34% used between a quarter and half, and 53% used less than a quarter. Nearly all reported that they used a "cafeteria" style model to adopt resources for courses based on where they most benefited their current course structure. Many reported that materials were used most often as supplemental materials. The resources most often mentioned as being incorporated into courses were videos and activities. Given that student engagement with online courses is a key challenge for educators, heavy use of activities is taken to be an important indication that the materials supported improved quality of online courses.

Early adopters were positive in their evaluation of the resources they used. A large majority reported that the student learning outcomes (SLOs) in the collections were clear (100%), well-aligned with their class (91%) and well-aligned with content (98%), activities (97%), and assessments (97%). Importantly, they viewed the materials as well-suited to remote instruction (92%) and appropriate for diverse groups of students learning remotely (88%). They reported that faculty implementation guides were helpful (97%), content could be used without extensive modification (84%), content organization was logical (96%), and curriculum maps were comprehensive (95%). They reported that the resources were accurate (92%), high-quality (97%), user-friendly (89%), useful (93%), and unique (92%). Many mentioned that they appreciated exposure to high-quality OER textbooks and praised the implementation guides for providing useful curation of available content and good tips about ways to use the materials in classes.

Student Responses to the Initiative

Students were asked to compare elements of their current course to other online courses they have taken. Because students had different levels of experience with similar online courses, each comparison allowed students to say they did not hold any opinion. When asked to compare the overall quality of the current course with other online classes the student had taken, 8% reported no opinion, 17% reported the current course was worse, 40% reported the current course was equally good, and 36% reported the current course was better. Although the responses may not appear positive, they should be interpreted in the context of the question being asked. The courses being evaluated are difficult classes in which many students struggle. It is possible that many students are comparing these classes with other, less difficult, online classes they have taken. For example, one student wrote, "It was better as far as the teacher but the information that was being taught was harder, so I feel an in person class would be better for the subject." Another wrote, "This is my worst class when looking at my grade in comparison to my other online courses." Additionally, students did not choose to take these courses remotely but were forced to do so because of the pandemic. This also might account for somewhat less positive responses to the courses. In this light, it is believed that 76% of students rating the classes as better than or equal to other online classes is a positive finding. The interpretation is supported by students' responses to ten more specific questions about aspects of the courses. Across the ten questions between 34 and 60 students opted not to express an opinion. Table 4 omits these responses. As can be seen in Table 4, about half of respondents reported that the courses were better or much better at providing instructional materials that fully covered the required content, adapting content and assignments for remote instruction, and providing accurate content. In explanation, one student wrote, "This class does a good job at assigning content that allows us to learn the material we are given. I really like how we aren't overloaded with work. Each assignment is worth my time and contributes to my learning process." Over half reported that the student learning outcomes were more clear, helpful, and tightly linked to activities and assignments in the current class than in other online classes. For example, one student wrote:

> I feel like compared to some other classes that this class was structured in a much better way. The videos and the explanations they provide along with other studying and learning materials in this course allow me to actually learn and understand the subject. It is almost like being in the in person class at times.

Students appreciated access to multiple resources to support their understanding. One student wrote:

> There are more resources and connections to this class like our discussion boards, online lectures, additional YouTube videos and reading assignments. I understand the material better because I had many different resources to help me as opposed to just reading and then an online lecture.

Another student wrote, "This class makes other online classes look like they don't know what they are doing. Everything is laid out very clearly and is taught very efficiently." Providing just in time information to minimize the effects of differential preparation in the creation of equity gaps is a best practice for improving equity in educational outcomes. (Montenegro, 2017) Accordingly, we view these responses from students as supporting the potential of these collections to support equity in student achievements. The lowest ratings were seen in response to a question about opportunities to interact with other students. In response to this item, 30% of students reported their current class was worse than other online classes and 39% reported it was better. The split in responses suggests that individual courses probably varied in the extent to which they successfully created opportunities for student interactions and may point to a need to focus closely on developing additional ways to allow students to engage with each other in all of the resource collections.

TABLE 4
% OF STUDENTS REPORTING THE EARLY ADOPTER CLASS WAS LESS GOOD, EQUALLY GOOD, BETTER OR MUCH BETTER THAN OTHER ONLINE CLASSES THEY HAVE TAKEN

Questions	Less Good	Equally Good	Better or Much Better
SLOs were clear	9%	39%	52%
SLOs were helpful	11%	39%	51%
Lectures and readings were clearly linked to SLOs	9%	31%	59%
Activities were clearly linked to SLOs	7%	36%	56%
Assignments covered material I had been taught	12%	37%	51%
Content worked well for remote instruction	17%	32%	51%
Content was accurate	4%	37%	59%
Included opportunities for interactions with students	30%	31%	39%
Instructional materials taught me everything I needed to succeed	16%	33%	51%
Assignments were appropriate for remote learning	11%	35%	54%

One objective of the Digital Course Enhancement Initiative was to combat inequities that were created by the transition to remote instruction. To investigate whether underrepresented ethnic minority (URM) students and other students responded similarly to modified courses, responses to the evaluation questions were disaggregated in Table V. URM students include students who identified themselves as Black, African American, Hispanic, Latinx, Native American, or Pacific Islander. Non-URM students include students who identified themselves as White, Asian, or Middle Eastern. Although it is somewhat difficult to interpret the disaggregated data without comparable data from online classes that were not supported by the Digital Course Enhancement Initiative, it appears the URM students were somewhat more negative than non-URM students in response to most questions. The largest difference was seen in response to a question about overall course quality to which 29% of URM students responded negatively compared to 14% of non-URM students. Despite somewhat more negative responses to the courses as compared to non-URM students, when URM student responses are examined independently, it is clear that the majority of URM students believed modified courses were as good or better than other online courses they had taken. There is need for more research to determine the extent to which the Digital Course Enhancement Initiative effectively supports students from different backgrounds, including URM students and low income students. However, on the basis of these preliminary findings, it appears the course modifications may increase both URM and non-URM students' feelings that the courses were well designed.

TABLE 5
STUDENT SURVEY RESPONSES BY URM CLASSIFICATION

Student responses to early adopter class disaggregated by race and ethnicity. Sample sizes are reported in parentheses.				
Questions	**Non-URM** (545)		**URM** (416)	
	Less Good	**Better**	**Less Good**	**Better**
SLOs were clear	7%	55%	13%	47%
SLOs were helpful	8%	53%	13%	46%
Lectures and readings were clearly linked to SLOs	8%	64%	11%	54%
Activities were clearly linked to SLOs	5%	54%	9%	50%
Instructional materials taught everything I needed	13%	53%	19%	47%
Content worked well for remote instruction	17%	53%	19%	46%
Content was accurate	2%	62%	4%	55%
Included opportunities for interactions with students	29%	39%	29%	37%
Assignments covered materials I had been taught	10%	53%	15%	46%
Assignments were appropriate for remote learning	9%	58%	14%	49%
Video quality was good	4%	65%	5%	63%
Overall course quality	14%	45%	29%	43%

CONCLUSION

The recent rapid move to remote learning created less than ideal educational scenarios for many instructors and students. Although research indicates that high-quality, equitable, remote learning is possible, successful remote pedagogy for high demand courses requires preparatory time for instructors. The Digital Course Enhancement Initiative carefully and intentionally developed and curated high-quality online course materials to support the rapid mounting of effective and equitable courses. Initial feedback indicates that instructors believe the collections improved their classes and will improve their ability to effectively teach future classes in a remote environment. Students also found materials helpful, noting the clarity of learning expectations and availability of high-quality information to support their learning. Because these features have been demonstrated to support equity in educational achievement, we hypothesize that these collections will contribute to equity in these classes. (Singer-Freeman, 2019). We hope to directly test this hypothesis in future work. Generally, larger proportions of non-URM students rated the materials positively than URM students. Nonetheless, large majorities of URM students reported that the supported classes were as good or better than other online classes they had taken. Given the challenging nature and historically high rates of failure in the classes that were supported, we believe these results are a strong endorsement of the efficacy of the supported classes for URM students. Further, we believe that looking at URM responses independently from non-URM responses is important in order to avoid taking a deficit approach. On the basis of our findings, we recommend that other institutions consider the creation of digital repositories that accumulate and capture best practices for remote instruction. In this way, experts in the creation of high-quality, accessible, aligned teaching can improve instruction across an institution or system.

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