NC STATE UNIVERSITY Distance Education and Learning Technology Applications

# 2017 DELTA CPCR Assessment Summary

*CSC 316: Data Structures and Algorithms*

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| **Description of Project** | Dr. Jason King received a DELTA course redesign grant in fall 2016 to redesign *Data Structures and Algorithms* (CSC 316). This redesign project focused on improving inconsistencies in learning performance, increasing engagement, providing an effective presentation of online materials, and improving connections between this course and key Computer Science prerequisites. |
| **Assessment Timeframe** | The full report discusses outcomes associated with the redesign of CSC 316. Course assessment indicators from the redesigned section are examined and compared to pilot data from a section taught by the Principal Investigator (PI) in spring 2017. Results are based on redesign data gathered in fall 2017. Course grades analysis uses data from Dr. King's sections between spring 2016 and spring 2018. |
| **Desired Outcome/Goal** | There are four key challenges the project aimed to address: (1) *inconsistencies in learning performance* related to understanding how theory connects to object-oriented best practices; (2) *low engagement* as a result of large class sizes, difficulty grading assignments, and a heavy reliance on unskilled teaching assistants (TA); (3) *insufficient connections* between the course and its prerequisites; and (4) *ineffective presentation of online materials* that also needed to transition from Wolfware Classic to Moodle. Assessment of the CSC 316 Critical Path Course Redesign (CPCR) projects looks for evidence of the following key goals:<br><br>● *Improved course consistency and relevance*, as indicated by:<br>○ Instructor-provided comparisons<br>○ Course structure analysis<br>○ Student perceptions of connections to prerequisite courses<br>● *Increased student engagement*, as indicated by:<br>○ Student feedback on projects, materials, and assignments<br>○ Attitudes and self-efficacy related to in-class and project-based learning<br>● *Equivalent or improved student performance*, as indicated by:<br>○ Student self-efficacy ratings<br>○ Assignment, test, and overall course grades |
| **Related DELTA Goal** | As an organization, DELTA has a dual focus on (1) Distance Education (DE) enrollment growth and (2) providing "enterprise-level infrastructure and faculty support for the incorporation of learning technologies and pedagogically-sound principles into instruction." DELTA's 2017-2020 Strategic Plan states that "while online and distance education instruction continues to be an emphasis for NC State, future enrollment strategy manages growth in the context of limited resources."<br><br>To this end, DELTA's Goal One involves leveraging learning technologies to improve student success and establishes DELTA awards to fund course redesign initiatives throughout the university. This course redesign project explicitly furthers DELTA Goal One. |

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| **Project Background** | *CSC 316: Data Structures and Algorithms* is a 3-credit required course for the Computer Science major, Computer Science minor, and Computer Programming certificate. Prerequisites include CSC 216 (*Programming Concepts in Java*) and CSC 226 (*Discrete Mathematics for Computer Scientists*), and students are required to complete both with a grade of C or better. Major students are typically sophomores when they take CSC 316. This course is itself a prerequisite for CSC 326 (*Software Engineering*), which is required for all Computer Science majors. CSC 316 is also a prerequisite for 11 Computer Science electives. The course focuses on improving students' ability to select appropriate data structures and algorithms for real-world scenarios, as well as their ability to incorporate data structure and algorithm theory into the software development lifecycle. Approximately 300 students take CSC 316 each year in sections of up to 150 students. Each section is taught by one instructor with support from 1-3 graduate teaching assistants. A distance education section of CSC 316 is also offered each semester<br><br>Prior to this redesign project, CSC 316 was taught in two weekly 75-minute lecture sessions. Lecture slides were posted on the course's website - most of which used Wolfware Classic. PI King's course management was facilitated through Moodle even prior to this project. Though instructors of the course taught slightly differently, all sections were lecture-based and covered the same topics. Assignments in the course were different for each instructor, while projects across sections were very similar, in that they asked students to write code after they were told which data structures and algorithms to implement. Projects did not require students to design the software on their own. In spring 2016, Dr. King incorporated small in-class exercises to help students practice topics discussed in the lecture, and he required students to create written project proposals and final project reports. |
| **Assessment Tools** | Assessment of the CSC 316 CPCR project utilized the following data collection tools:<br><br>● Qualitative faculty feedback<br>● Student surveys<br>● Project grades<br>● Final course grades |
| **Population** | The population of interest for this CPCR assessment is all undergraduate students at NC State University who took CSC 316 for a grade between spring 2016 and spring 2018. Students in evening sections and students who audited the course were excluded due to differences in course format and requirements. For surveys, the population of interest is all undergraduate students at NC State University enrolled for a grade in CSC 316 in either spring 2017 (pilot) or fall 2017 (redesign). |
| **Sample (If Applicable)** | Because all data analysis centered on a combination of both survey responses and achievement in course-embedded assignments and tests, the population included in this analysis is the same as the population described above. That is, all students who completed assignments/exams in CSC 316 between spring 2016 and spring 2018 in the non-redesigned, pilot, or redesigned sections were eligible to participate in data collection |

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| **Response Rate** | In the spring 2017 pilot sections, 143 students were eligible to participate in the DELTA survey. Of those, 80 (56%) completed the survey. During fall 2017 post-redesign data collection, 143 students were eligible to participate in the 4 surveys that were administered. Of those, 27 (19%) completed all 4 surveys, and 106 (74%) participated in at least one of them.<br><br>● Student Survey #1 (September, 2017): n = 92 (64%)<br>● Student Survey #2 (October, 2017): n = 65 (45%)<br>● Student Survey #3 (November, 2017): n = 56 (39%)<br>● Student Survey #4 (December, 2017): n = 37 (26%) |
| **Brief Summary of Results** | **(A) Course Consistency & Relevance**<br><br>Post-redesign, students had a positive view of the 4 key projects that were the main focus of the course. Agreement with the statement that "the proposal peer review activity on Moodle was set up clearly" ranged from 58% after Project 4, to 78% after Project 3, and respondents were neutral to positive regarding the overall project organization. For example, 46% *agreed* the project materials were well-organized, 43% said the projects were well-organized, and 38% said it was easy to find the information they needed during each project. The percent of neutral responses for these were 24% for each of the 3 statements. Though inferential analyses showed a decrease in mean ratings of connectedness between CSC 316 and its prerequisites between pilot and redesign data collection, ratings remained positive, with *moderate*, *very*, or *extremely connected* ratings of 62% for CSC 116, 86% for CSC 216, and 57% for CSC 226.<br><br>**(B) Student Engagement**<br><br>Data indicate largely positive student learning habits and engagement. After Project 1, survey respondents reported the highest mean agreement for the item, "I spent time thinking about which of the possible algorithms and data structures would work best for the project." Though mean agreement with this statement appears to have decreased with each project, it remained the most positive response throughout the semester. Statements regarding students' habits during the algorithm and software design portions of the projects remained the most steady, though mean agreement remained largely neutral to positive for all items across all projects. Students' self-reported time spent after each project discussing with their partner different algorithms and data structures and which ones to use was about 28 minutes across all 4 projects, and a majority of respondents made modifications to their proposals after peer review. These results indicate students are able to remain engaged with course topics and projects for the duration of the semester.<br><br>**(C) Student Learning Outcomes**<br><br>Overall, students in the redesigned course had positive reflections of their project-based learning and the overall project redesign. Respondents reported having clear reasons for choosing a particular algorithm or data |

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| | structure for a given project, and that they could easily recall the software development lifecycle stages. A majority of respondents (87%) *agreed* the projects were academically challenging, while nearly three-quarters (73%) *agreed* the project tasks required them to think critically. Across the projects, respondents had neutral to positive self-ratings for the majority of the data structure skills, and positive self-ratings for their algorithm skills. In addition, both pilot and redesign survey respondents indicated positive perceptions of skills related to the course embedded learning outcomes, with the percent of post-redesign *good* or *very good* ratings ranging from 67% to 81%. |
| **Contact Information for Further Details** | *For information regarding the assessment of this course redesign:*<br><br>Traci Temple, Ph.D.<br>Director, DELTA Research and Analysis<br>Distance Education and Learning Technology Applications (DELTA)<br>North Carolina State University<br>tltemple@ncsu.edu<br><br>*For information regarding the instructional design of CSC 316:*<br><br>Yan Shen, PhD<br>Instructional Designer<br>Distance Education and Learning Technology Applications (DELTA)<br>North Carolina State University<br>yshen8@ncsu.edu<br>919-513-7096<br><br>*For information regarding the course redesign of CSC 316:*<br><br>Jason King, Ph.D.<br>Teaching Assistant Professor<br>Department of Computer Science<br>North Carolina State University<br>jtking@ncsu.edu<br>919-515-8954 |
| **Interpretation of Results** | **(A) Course Consistency & Relevance**<br><br>The impact of the CSC 316 CPCR project on course consistency, especially when it comes to project structure, is mixed. Post-redesign, students had a positive view that "the proposal peer review activity on Moodle was set up clearly," with agreement ranging from 58% after Project 4, to 78% in the survey after Project 3. However, inferential analyses indicated that in general, students who provided feedback about the organization of project materials during the pilot had a more positive view than those in the fully redesigned course. This may in part be due to the explicit nature of the pilot, as students were aware that the projects and materials they were using were being changed based on their feedback, which may have led to some leniency in their feedback. The post-redesign relevance of the course to its prerequisites is also mixed, as for two of the three prerequisite courses (CSC 216 and 226), inferential analyses |

suggested a statistically significant decrease in mean connection ratings between pilot and redesign measurements, as well as higher levels of pilot cohort topic recall for skills/concepts from both of these courses that are reflected in CSC 316.

Differences in pilot and redesign student demographics might help explain some of these findings, as more students in the redesign cohort indicated this was not their first attempt at taking CSC 316 (1.4% in the pilot semester, compared to 16.7% post-redesign). Though analysis did not reveal statistically significant differences, post-redesign responses also indicated a lower percent of juniors compared to their pilot semester peers (28% vs. 42%), and a higher percent of seniors (28% vs. 10%) in the class demographics. Post-redesign students also exhibited slightly lower grade expectations, with 8% indicating they expected to earn a “D” or lower compared to only 4% who indicated as such in the pilot survey. Some of this could also be explained by unmeasured and/or random differences between spring and fall semester students in general.

**(B) Student Engagement**

Results indicate students are able to remain engaged with course topics and projects for the duration of the semester. After Project 1, survey respondents reported the highest mean agreement for the item, “I spent time thinking about which of the possible algorithms and data structures would work best for the project.” Statements regarding students’ habits during the algorithm and software design portions of the projects remained the most steady, though mean agreement remained largely neutral to positive for all items across all projects. Moreover, students’ perceptions and self-reported behaviors related to the peer review process that was embedded into each of the course projects was also positive. Survey participants were asked after each project if they had spent time with their partner discussing different algorithms and data structures and which ones to use, and if so, how many minutes they spent doing so. On average, respondents reported spending just under 29 minutes doing this during Project 1, and nearly 33 minutes during Project 2. This self-reported time spent in discussion was lowest for Project 4, with an average of 21.5 minutes, while the average across projects was under half an hour at 27.5 minutes.

**(C) Student Learning Outcomes**

*Project-Based Learning Reflections*

Overall, students in the redesigned course had mostly positive reflections of their project-based learning, including having clear reasons for choosing a particular algorithm or data structure for a given project and agreeing that discussing with their partner helped them think more critically in selecting an appropriate algorithm and data structure. Respondents were neutral to positive regarding the usefulness of feedback provided by peer reviewers. Thus, project-based learning reflections revealed a redesigned CSC 316 project structure and peer review process that engages students in critical thinking and provides useful resources throughout the different projects and project stages.

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| | *Overall Project Design*<br><br>Post-redesign students were also asked about the overall project redesign, and data show mixed results students' perception of the impact they had on their learning. A majority of respondents (87%) *agreed* the projects were academically challenging, while nearly three-quarters (73%) *agreed* the project tasks required them to think critically. However, students in the pilot section showed more positive ratings of the overall project design than those in the post-redesign section for 3 of the 5 items administered. One reason this might have occurred is because the students in the pilot semester were made aware of the fact that the projects were being piloted and that their feedback was being sought to improve them. Spring 2017 students, therefore, may have rated them higher simply because they are more aware of the redesign.<br><br>*Perceptions of Learning*<br><br>Overall, analysis of the CSC 316 course redesign project shows a neutral impact on students' learning perceptions, which remained positive between pilot and redesign phases. Across the projects, respondents had neutral to positive self-ratings for the majority of the data structure skills, and positive self-ratings for their algorithm skills. In addition, both pilot and redesign survey respondents indicated positive perceptions of skills related to the course embedded learning outcomes, with the percent of *good* or *very good* ratings ranging from 63% to 85% in the pilot, and from 67% to 81% post-redesign. Learning perceptions for departmental learning outcomes also remained positive between pilot and redesign survey administrations. Finally, inferential analyses showed no statistically significant difference in pilot and redesign grade estimations, and these estimations were found to correlate positively with earned course grades.<br><br>*Student Performance*<br><br>Finally, project analysis included an examination of student performance and retention data in pre-redesign, pilot, and post-redesign semesters. Inferential analyses highlighted statistically significant differences between all cohorts in mean grades earned on a majority of project parts and total project grades, where between pre- and post-redesign cohorts grades appear to have decreased for a number of project-based grades, but were statistically higher than those earned during the pilot semester. This might be because fall 2017 projects were presented in a consistent format, while they were iteratively developed and finalized in spring 2017 and thus could have led to less-than-optimal learning opportunities for those students. In addition, pre- and post-redesign exam 1 and 2 grades decreased slightly, though final exam scores remained unchanged, and inferential analyses showed a small but statistically significant decrease in mean course average between pre- and post-redesign cohorts, and significant differences in overall grade distributions. |
| **Decisions Made Because of These Results** | Dr. King implemented the first iteration of the CSC 316 redesign in fall 2017. Since then, he and other faculty who have taught the course have continued using the redesigned course materials and structure. In the |

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| | 2017-2018 academic year, another Computer Science course, CSC 326 (*Software Engineering*), was awarded a DELTA grant, and in the 2018-2019 academic year, the PI for CSC 113 (*Introduction to Computing - MATLAB*) began working with DELTA to redesign that course as well. These projects were pursued in part because of the success of this and prior Computer Science CPCR projects, and they will complete the process of integrating similar structures and strengthening connections between the key courses within the program. |
| **Timeframe to Take Actions Found from Assessment Results** | The Computer Science department will review the findings of this report, as well as Dr. King's personal notes and thoughts on the redesign project overall. A key goal of this project was to improve connections between key Computer Science courses, and to increase the excitement and engagement of students enrolled in CSC 316. One of the course goals is to provide active learning opportunities based on real-world scenarios so that students become familiar with the types of professional roles they may assume upon graduation. Once review of these findings are complete, the department will make its own decisions on how best to move forward, though as noted above some decisions have already been made in regards to pursuing additional DELTA grants.<br><br>The results provide DELTA with statistical evidence to promote course redesign across campus. When appropriate, reports are shared with faculty forging into redesigning large courses and critical path courses; it serves as encouragement and provides more than anecdotal evidence that course redesign using blended methods has the (reported) potential to improve consistency in teaching, increase course relevance to students, improve course efficiency and consistency in materials/structure, and positively impact student success. |