**Online Learning for Higher Education to Enhance
Access, Student Experiences, and Course Outcomes**

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Abstract

This paper presents a pedagogical approach and assessment of student performance in a Stellar Astronomy course taught in an online class section and a traditional class section at the Bronx Community College of the City University of New York. The two-year Associate in Arts and Sciences degree program at Bronx Community College offers an astronomy course to fulfill the core science course requirement. The use of an online learning environment in Astronomy for the core science course requirement offers many advantages for students, especially for working students, to enhance their science learning experience. The use of smart technology for a quicker assessment of students' performances in promptly graded weekly submissions and access to technology-rich Smartwork Astro tours, Astro dictionary, and Nebraska simulations overcomes the various pedagogical challenges of face-to-face classroom settings. Access to online learning allows more students to be reached within a limited time as well as the maintenance of detailed records of student interactions, weekly submissions, and the comprehensive assessment of student performance. Online learning access for a core science course requirement in

undergraduate education mitigates barriers to higher education, encourages student-centered

learning, and advances teaching in the digital age of the 21st century.

Keywords: online learning, pedagogy, assessment

I. Introduction

Online education is critical to the long-term strategies of higher education institutions in

the United States. By fall 2011, the number of students taking at least one online course

increased to 6.7 million – 32% of all college students – including community college students

(Allen & Seaman, 2013). Community colleges are pathways to higher education for many

minority students who are academically and financially challenged (Mendoza, Mendez, &

Malcom, 2009; Rajasekhara & Hirsch, 2000) and for first-generation college students. Many

community college students attend college classes, work, and care for dependents while juggling

tough financial, academic, and personal challenges (Goldrick-Rab, 2012). The 2011 Community

College Institutional Survey (CCIS) reported that 67% of full-time students and 78% of part-time

students work at least part-time while taking classes, and 53% of full-time students and 60% of

part-time students also care for dependents (CCCSE, 2012). The completion rate of learning

online by nontraditional students aged twenty-five and older, overcoming challenges related to

work schedules or dependent care at two-year community colleges, was found to be higher than

that of traditional student groups aged 17-21 (Newell 2007). Online courses allow students to

study course materials on their own time and at their own pace (Bjork, Dunlosky, & Kornell,

2013). Access to online resources has also redefined traditional learning interactions (Anshari,

Alas, Yunus, Sabtu, & Hamid, 2016). Online learning can promote self-learning (Rausch &

Crawford, 2012), greater student-instructor interaction (York & Richardson, 2012), innovative instructional strategies (Lally & Wallington, 2002), and varied learning styles (Wichadee, 2013), which can lead to better learning outcomes.

The Bronx Community College (BCC) of the City University of New York (CUNY) is a Hispanic-serving Institution located in Congressional District 15, one of the most impoverished districts in the United States. Based on the BCC Spring 2017 survey data from the CUNY Institutional Research Database (IRDB), BCC-CUNY serves a student population comprising 98% ethnic minorities; 55% of students were first-generation college students, 51% were employed, and 25% were supporting children. The Liberal Arts and Sciences curriculum in the Associate in Arts (AA) and Associate in Sciences (AS) degree programs at Bronx Community College require a core science course. Stellar Astronomy (AST 111), offered by the Department of Engineering, Physics and Technology, satisfies the core science course requirement and is offered in a traditional classroom setting as well as an asynchronous (100% online) course offering.

This paper presents the design, content, and innovative instructional strategies used in the online and traditional classroom sections of the Stellar Astronomy course to improve course outcomes. This paper discusses the assessment results of the core competencies – the use of mathematics, the scientific method approach, reasoning, and analysis – in the Stellar Astronomy course using assignments and exams as assessment vehicles in both the online section and the traditional classroom section.

II. Motivation

The author's primary motivation for teaching an online course was to reach students who were not able to register in the popular Astronomy course due to schedule conflicts, class timings, or other reasons that make it difficult for them to commute to campus during class time. The author received training in online course development conducted by BCC in 2015-16, developed this asynchronous AST 111 Stellar Astronomy course as part of the training, and has been teaching online every semester since.

Best practices in online learning and teaching strategies for educational productivity are well-documented in the pedagogical literature (Pelz, 2004; Kim & Bonk, 2006; The Hanover Research Council, 2009; U.S. Department of Education, Office of Educational Technology, 2012). In his latest book *Improving How Universities Teach Science: Lessons from the Science Education Initiative*, Carl Weiman, a physicist at Stanford University and 2001 Nobel Prize winner in Physics, discusses the way in which access to information technology provides obvious opportunities for dramatically changing teaching methods in colleges and universities, and in the process, making higher education far more effective and efficient (Weiman, 2017). As the online course was created, the author realized the need to reinvent the traditional classroom section that was not working in all practical senses. Students' engagement and excitement about learning new materials were limited in the lecture-based methodology that involved the use of a whiteboard, PowerPoint lectures, and standard tests during lectures. Online learning tools were also introduced into the traditional classroom section to supplement lecture-based pedagogy in classroom teaching. Student-centered learning on computers using the digital platform of

Smartwork by Norton publishers was implemented during the recitation period, a shorter class to review the lecture material. The Smartwork digital platform provided an opportunity to put students in the driver's seat and encouraged self-learning by using technology that goes beyond lecture-based learning. The online AST 111 Stellar Astronomy course was created, and at the same time, changes were made in the traditional classroom section of AST 111 to encourage self-learning among students during the recitation time.

Section III describes the methodology applied in the provision of online learning and the pedagogical approach to students' learning experiences. Section IV describes students' performance and assessment results in core competencies related to the use of mathematics, the scientific method, and reasoning and an analysis of learning outcomes. Section V provides a discussion of the results, followed by the conclusion in Section VI and future directions in Section VII.

III. Methodology

Course overview: The AST 111 Stellar Astronomy course covers early astronomy; astronomical coordinate systems; the structure and evolution of the sun, stars, and stellar systems; spectroscopy; the Milky Way and external galaxies; and cosmological models and implications. AST 111 Stellar Astronomy is a 3-credit course scheduled with 2 hours of lectures and a 50-minute recitation period. The AST 111 course requires prerequisites concerning basic math proficiency.

The asynchronous AST 111 Stellar Astronomy course was taught entirely online apart from two in-person class periods. The online course plan, including the lecture content, audio,

videos, Nebraska simulations, Astro tours, and Astro dictionary was delivered using the CUNY

Blackboard online platform and Smartwork digital system by Norton publishers. The textbook

Stars and Galaxies by Norton Publishers (Kay, Palen, & Blumenthal, 2016) was followed in the

AST 111 Stellar Astronomy course. The Nebraska simulations used in the astronomy course are

the interactive simulations from the University of Nebraska that allow one to manipulate

variables and see how physical systems work. The Astro Tours are interactive animations that

use art to help students visualize important physical and astronomical concepts. The Astro

dictionary provided the meaning of words and concepts used in the field of astronomy.

Learning outcomes: The following learning outcomes expected in this course were clearly

explained to the students during the first class:

- Identify principles governing astronomical phenomena, interpret astronomical evidence

  to characterize applicable physical laws, construct diagrams indicating correlations of the

  physical properties of stars, and classify and predict star evolutions according to intrinsic

  properties, such as stellar mass.

- Use algebraic calculations and graphing to predict, measure, and verify that physical

  principles apply to astronomical phenomena.

First, the in-person class provided an overview of the course plan, learning outcomes,

grading policy, lesson plan, and instructions regarding how to navigate on Blackboard and

Smartwork to access the syllabus, course materials, and assignments. A demo exercise

comprising a homework assignment, web-based writing assignment, and online discussion link

was created for submission during the first in-person class to establish the flow of online instruction.

Weekly folder: The weekly folder as per the BCC academic calendar was named according to the lecture date in the respective courses, for example, "Week 1_27 August 2016," and was provided on Blackboard. The weekly folder comprised two separate folders containing the lecture notes and assignment submissions. The lecture notes included lectures in PowerPoint and word documents, audio, video, Astro tours, flashcards containing astronomy vocabulary, Nebraska simulations, or astronomy news of the day. Figure 1 shows a sample of "Astronomy news of the day," which introduced students to current exciting news relevant to the subject of astronomy or content in the syllabus. The assignment submissions folder included an electronic link (e-link) to submitting Blackboard web-based writing assignments, online discussions, or Smartwork assignments "Test your Understanding" and "Process of Science" depending upon the lesson plan of the day.

Weekly assignments were provided to both the online section and the traditional classroom section on the CUNY Blackboard and Smartwork online system. However, in the traditional classroom section, the computer lab was used to supplement lecture-based teaching with Smartwork class assignments, Nebraska simulations, Astro tours, and Astro demonstrations in person. The course textbook and supporting resources were the same for the online section and the traditional classroom section. The online section had slightly more Smartwork homework assignments than the traditional classroom section. The Smartwork assignments for the traditional classroom section were split into homework assignments and classwork assignments to be attempted during the recitation period. The tests for the online section were restricted in

time using the online time limit settings on Smartwork, whereas traditional classroom sections

took tests in class. The weekly Smartwork assignments included multiple-choice questions,

numerical questions, match the following, fill in the blanks, true or false, and drag-and-drop

items that provided comprehensive practice on quantitative and analytic skills. The Smartwork

system provided students with a user-friendly computer experience, promptly graded

assignments, and allowed instructors to place more focus and time on the analytics of student

performance. Student-instructor and student-student interactions were encouraged with writing

assignments and discussions graded by the instructor on Blackboard.

Grading: The grading distributed between the weekly assignments, the midterm exam, and

the final exam were included in the syllabus. The traditional classroom section had a slightly

different grading policy that included class assignments using the Blackboard and Smartwork

online system in the grading distribution.

The last class: The last in-person class conducted during the final class of the semester

provided a review of the course plan, clear instructions for the final exam, and collected student

feedback on the course evaluation.

The two in-person classes, at the beginning and end of the semester, provided an opportunity

to connect as a class, between students, and between instructor and students

Welcome to Fall_the September 22 autumnal equinox

Posted on: Tuesday, September 20, 2016 3:33:00 PM EDT

Posted by: Monika Sikand
Posted to: 2016 Fall Term (1)
Stellar Astronomy AST 111
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September 22, Thursday is the official welcome of Fall season that is equal in day and night time. You read about seasons in Ch 2_Patterns in the Sky-Motions of Earth and the Moon.

What do you think, as an Astronomy student, the autumnal equinox means?

The autumnal equinox: The Sun is on the equator, moving southward. (Reminder: the Sun is always on the ecliptic; on this day, the Sun is at the place where the ecliptic crosses the equator). Day and night are of equal length. The autumnal equinox marks the beginning of fall in the Northern Hemisphere on or about September 22.

What is the ecliptic: The apparent path that the Sun follows against the background of the stars is called the ecliptic. For example, on September 1 the Sun is seen in the direction of Leo zodiac/constellation as viewed from Earth.

Course Link /Weekly Assignments/Week_2_1Sept_Ch_2_Patterns in the Sky-Motions of Earth and the Moon/Ch_2_Lecture Notes/CH 02 ASTRONOMY IN ACTION VIDEO - The Cause of Earth's Seasons

Figure 1: A sample of "Astronomy news of the day" posted on BCC-CUNY Blackboard online system in Fall 2016 semester.

IV. Results

The assessment of learning outcomes provided students with feedback to guide their learning. Assessment was also helpful for faculty to guide their teaching and implement successful strategies to improve learning outcomes. One of the learning objectives in astronomy is for students to be able to understand the structure, dimension, and content of the universe. Overall student performance in the AST 111 Stellar Astronomy course in the online and traditional in-class sections was evaluated in three core competencies: use of mathematics, use of the scientific method, and reasoning and analysis. Table 1 highlights the assessment of these core competencies in both the online and traditional classroom sections of the AST 111 Stellar Astronomy course in fall 2016.

The final exam administered to both online and traditional classroom sections was used as an assessment vehicle. The sample size in the online course was smaller than that in the traditional classroom section due to different enrollment caps in these two courses. A benchmark

of 70% in all the core competencies was used as a criterion of success, that is, 70% of the students will score 1/1 point in multiple-choice, analytic, or numerical questions related to core competencies or 3.5 points out of 5 points or better in the writing question. The overall student performance in AST 111 during the semester was also assessed using assignments and tests as assessment vehicles.

Figure 2 highlights the class performance of the AST 111 online and traditional classroom sections in Fall 2016 and the online section in Spring 2017. The class performance in Smartwork weekly online assignments was averaged at 84% in the AST 111 online class section and 81% in the AST 111 traditional classroom section in Fall 2016. The midterm for the online section was provided online and restricted in time using Smartwork online settings. The traditional classroom section took the midterm exam in class. The midterm contributed 20% towards the final grade in both sections. The average class performance on the midterm exam in the online section was 19% higher than that of the traditional classroom section in Fall 2016. The average class performance on the final exam in the online section was 13% higher than that of the traditional classroom section. The overall class average performance was distributed between the assignments, midterm, and final exam. The overall class average performance was 7% higher in the online section than in the traditional classroom section in Fall 2016. The maximum number for student enrollment is capped at 20 in online course sections and 24 in traditional Astronomy classroom sections at Bronx Community College. A total of 3 out of 19 enrolled students in the online section and 2 out of 23 enrolled students in the traditional classroom section withdrew from the course during the Fall 2016 semester.

The average class performance in the online section of AST 111 Spring 2017 was also comparable to the Fall 2016 online section in Smartwork assignments, the midterm, and the final exam (figure 2). Of the 20 students enrolled in the AST 111 Spring 2017 online section, two students withdrew and the overall average class performance was 3% less than the Fall 2016 online section, but the average class performance in the online final exam was 5% higher than the Fall 2016 online section.
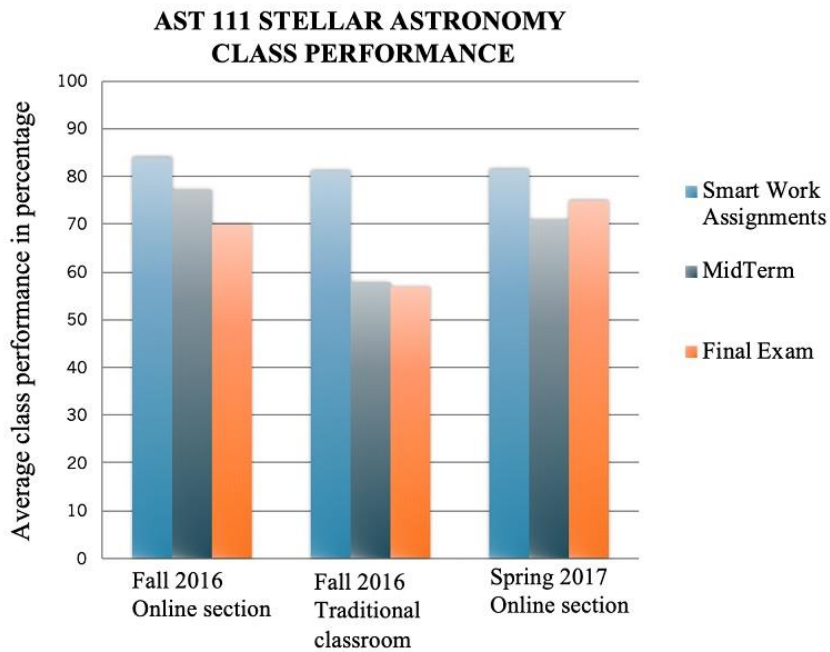

Figure 2: The average class performance in AST 111 Stellar Astronomy course during Fall 2016 and Spring 2017 semester. The average class performance in weekly Smartwork assignments (blue bar), the midterm (grey bar), and the final exam (orange bar) during the semester is compared in three sections – Fall 2016 Online Section, Fall 2016 Traditional Classroom Section, Spring 2017 Online Section.

V. Discussion

The average class performance in Smartwork weekly online assignments was 3% higher in the online section than in the traditional classroom section of AST 111 Fall 2016. The online section was relatively more proactive than the traditional classroom section in submitting weekly homework assignments on time. The automated due dates set up in accessing the weekly

homework assignments and penalties for failing to submit work on time could be a contributing

factor to timely submissions. The traditional classroom section was keener on submitting in-class

assignments completed during the recitation period in the computer lab.

The average class performance on the midterm was 19% higher in the online section than

in the traditional classroom section. The higher performance could be the result of the open-book

possibility in the online section. The online class was provided with relatively less time to

attempt the midterm online to accommodate the possibility of open-book access by students

during the exam. The exam, once started, had to be finished in one sitting within two hours in the

online section. In comparison, the traditional classroom section took a closed-book midterm

exam within 2 hours and 50 minutes. The 13% higher final exam performance of the online

section than the traditional classroom section could also be due to the open book possibility

during the exam. The final exam assessment in the online section shows that only 61% of

students responded correctly to the mathematics equation-based question, and 48% answered

correctly to the unit conversion question in the final exam (Table 1). On the other hand, the

traditional classroom section was able to perform better in mathematics skills. The traditional

classroom section received more in-person attention to practice mathematics skills during lecture

time, which could be a contributing factor in this performance. The performance in mathematics

skills in the online section did not meet the benchmark of 70% despite regular assignments,

including practice in mathematical skills.

TABLE 1: AST 111 STELLAR ASTRONOMY COURSE ASSESSMENT IN FALL 2016

Course	AST 111 (Online Section)	AST 111 (Traditional Classroom Section)
Learning outcomes aligned with BCC's General Education Student Learning Outcomes	• Use of mathematics • Use of the scientific method • Use of reasoning and analysis	• Use of mathematics • Use of the scientific method • Use of reasoning and analysis
Assessment Vehicle	Final Exam in AST 111	Final Exam in AST 111
Benchmark	70 %	70%
Sample Size	16	21
Results	1. Use of mathematics: All three outputs: 57% • 61% mathematical equation • 48% mathematical unit conversion • 61% graphical information 2. Use of the scientific method: 65% 3. Reasoning and analysis: 70%	1. Use of mathematics: All three outputs: 68% • 71% mathematical equation • 90% mathematical unit conversion • 43% graphical information 2. Use of the scientific method: 67% 3. Reasoning and analysis: 76%
Interpretation of Results & Action Plan	1. Use of mathematics needs regular practice and improvement. 2. Use of the scientific method approaching benchmark. Continue to monitor the use of the scientific method. 3. Reasoning and analysis meeting benchmark.	1. Improved result in deducing information from the math equation but deducing information from the graph needs help. 2. Use of the scientific method approaching benchmark. Continue to monitor the use of the scientific method. 3. Reasoning and analysis meeting benchmark.

The online section performed 18% better in deducing information from graphs. The

relatively higher use of digital course materials such as Astro simulations, Astro tours, and other

online study aids for conceptual understanding of astronomy could have contributed to this

higher performance. The traditional classroom section, on the other hand, relied more on

textbook reading and lecture time to develop their conceptual understanding. The use of the

scientific method in developing conceptual understanding approached the benchmark in both the

online and traditional classroom sections. This area needs to be further monitored to improve the

outcomes of the astronomy course. The reasoning and analysis successfully met the 70%

benchmark in this course.

TABLE 2: STUDENT EVALUATIONS IN AST 111 STELLAR ASTRONOMY FALL 2016 ONLINE CLASS SECTION ON A 4-POINT SCALE WITH 1=LOWEST AND 4= HIGHEST.

Item	Question	Survey count	Section mean	Course mean
1	Course requirements were clearly stated in the course outlines/syllabus.	13	3.8	3.6
2	The instructor encouraged students to ask the questions.	13	3.8	3.6
3	The instructor used appropriate examples to get points across in class.	13	3.8	3.6
4	The instructor encouraged class participation.	12	3.8	3.6
5	The instructor stimulated the intellectual curiosity	12	3.9	3.6
6	The instructor's explanations were clear	13	3.9	3.5
7	The instructor followed his/her stated outline/syllabus	13	3.8	3.7
8	The instructor gave tests and quizzes that covered material assigned/presented in the course	13	3.9	3.7
9	The instructor's methods of evaluating my work were explained clearly.	13	3.9	3.6
10	The instructor reviewed exams and assignments with comments so that learning was reinforced	12	3.8	3.5
11	The instructor made my responsibility for success in this class clear to me	13	3.8	3.6
12	My overall impression of the instruction offered in this section is satisfactory	13	3.9	3.6

Student Evaluations in the Course/Faculty Report

Student ratings of instruction are widely used in universities to measure teaching

effectiveness (Dresel & Rindermann, 2011). Table 2 highlights some of the students' responses

in the course/faculty report administered by BCC-CUNY at the end of the Fall 2016

semester. The course/faculty report provides data on a 4-point scale with 1=lowest and

4=highest. Table 3 highlights some of the students' comments related to enhanced student

learning experiences in the course/faculty report of the Fall 2016 online section.

VI. Conclusion

Online learning in higher education is an important alternative to traditional classroom learning and provides students with potential savings in costs and time. The availability of an online learning environment for a core science course requirement offers many advantages for students, especially working students, to enhance their science learning experiences. The use of ubiquitous technologies to improve knowledge and skills is imperative in the digital age of the 21st century. The assessment of this astronomy course showed that students performed as well in an online section as they did in a traditional classroom section, and that online pedagogical elements could be integrated into the traditional classroom section. It is important that colleges recognize the potential of online learning for requisite core courses as an integral part of colleges' functions and mission in providing access to enhance students learning experiences and improve course outcomes.

TABLE 3: SOME OF THE STUDENT COMMENTS FROM COURSE/FACULTY REPORT OF FALL 2016 AST 111 STELLAR ASTRONOMY ONLINE SECTION

Student Comments from Course/Faculty Report of Fall 2016 AST 111 Stellar Astronomy Online Section
The online course was excellent, very self-explanatory and the communication from the instructor was great and useful.
Smart Work is a great way for me to learn. I am more of a visual learner so the videos are extremely helpful. I understand Astronomy better online than in class.
I really enjoyed this online class. It has allowed me to become comfortable working with computer. I would recommend this class to others.
I was scared in the beginning but after a while getting the hang of it being able to work on my own time frame is amazing.

VII. Future outlook

Students' performance in one of the core competencies – mathematical skills – did not meet the

benchmark despite regular assignments that included practice in mathematics skills. Innovative

strategies must be included in practice to improve students' performance in mathematics.

Norton's "At Play in the Cosmos" video game for Introductory Astronomy is one such hands-on

activity that may be utilized in upcoming semesters. A lesson plan based on quantitative

reasoning and involving unit conversion in mathematics could be infused into this course at the

beginning of the semester. The assessment of student performance in the lesson plan will help set

the pace of numerical efficiency and mathematics skills for the rest of the semester.

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