MasteringAstronomy

School Name Binghamton University, State University of New York, Binghamton, NY

Course Name Family of the Sun, Stars, and Galaxies

Course Format Face-to-face

Key Results Student data in this study showed a strong positive correlation between average MasteringAstronomy scores and average lecture and lab course scores (r = .67 and r = .8).

Submitted by
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Course materials
MasteringAstronomy and *The Cosmic Perspective* (custom), Jeffrey O. Bennett, Megan O. Donahue, Nicholas Schneider, and Mark Voit

Setting

Binghamton University was initially founded as Triple Cities College in 1946 to serve the needs of local veterans of World War II. The college soon was incorporated into the State University of New York system. In 2015, the university reported that enrollment had topped 16,000 undergraduate and graduate students and that nearly 91 percent of freshmen had returned for a sophomore year. Students of color represented 28.9 percent of the student population, and international students composed 15.9 percent. The average SAT score range was 1773–2055; the average ACT score range was 27–30.[1]

Christopher Taylor, adjunct lecturer, teaches Family of the Sun, Stars, and Galaxies, an introductory astronomy course covering the study of the universe. Taylor is interested in physics and astronomy education, and teaches at both the high school and college levels.

Family of the Sun, Stars, and Galaxies starts with understanding the night sky and learning about the history of ideas that have led to that understanding, and culminates with the current understanding of how the universe works. The course serves as an introductory science for students interested in the physical and historical sciences, and provides a broad overview of astrophysics, historical astronomy/history of ideas, and the current events in astronomy. The physics and math in this course are kept at a reasonable level for a university-level, introductory science course.

This four-credit course has a separate, optional lab. Approximately 90 percent of students who take the course are non-science majors seeking to satisfy a general education lab requirement. Both face-to-face and online options are offered for the lecture portion. Approximately 800 students per year take the lecture course and approximately 600 students take the lab.

The lecture is delivered in a large lecture hall, and is also simulcast to satellite locations across campus. During 2013/14, an additional 40 students participated in the course as a result of the simulcast; that format was continued as an option in 2015.

The lab is a one-credit course designed to provide students with (1) an understanding of the methods scientists use to explore natural phenomena, including the formulation and testing of hypotheses and the collection, analysis, and interpretation of data, and (2) knowledge of concepts and models in one of the sciences. To take the lab, students must be concurrently enrolled in the lecture or have completed it in a previous semester.

Challenges and Goals

Because of the high course enrollments, Taylor's biggest challenges were managing and addressing individual student needs. In addition, large class sizes made grading paper-and-pencil homework time-consuming, further limiting the kind of timely feedback students need to prepare for exams. As a result of these challenges, MasteringAstronomy was implemented to provide online homework and other activities with the goal of generating instant feedback, automatically grading homework, and offering additional resources to address diverse student needs.

[1] https://www.binghamton.edu/about/accolades.html.

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Implementation

MasteringAstronomy is used in both lecture and lab. In spring 2015, the lecture course included the following resources and graded activities:

Lecture notes. Taylor provided students with a packet of lecture notes at the start of the semester that students were expected to bring to each class. Lecture moved fairly quickly through concepts, and the notes were meant to both supplement learning and be an integral part of the course content.

Clickers. In-class clicker questions were used during each class session to both take attendance and administer five to seven quiz questions worth two to three points each. Points from iClicker participation accumulated until a student reached 125 out of an available 175 points per semester.

MasteringAstronomy. The lecture supplement homework comprised 10 required MasteringAstronomy assignments, with one due per week starting at week three. Students received partial credit on some questions, and extra-credit questions were available. Late homework earned an automatic reduction of 20 percent per hour past the deadline.

Exams. There were three midterm exams and an optional comprehensive final exam. If students took all four exams, the lowest score was dropped. The exam material was based on lecture concepts, supplemental MasteringAstronomy assignments, and assigned reading from the text. Students were allowed to bring one standard sheet of handwritten notes for exams 1–3, and three sheets of handwritten notes for the final exam. Exam questions were multiple-choice, true/false, or matching, and some questions (less than 35 percent) required brief calculations. The cover sheet on each exam included all the relevant constants, equations, and diagrams required to complete the exam.

Alternate exam grade option (AEGO). The AEGO was a series of MasteringAstronomy assignments that was offered as a replacement for one exam grade. Students could access the assignments starting at the beginning of the semester, and required due dates were set throughout the semester. Due dates were firm and not changed or extended for any reason. If students chose this option, they had to do the work in a timely manner during the semester.

In order for students to be eligible for the AEGO, they had to take a minimum of three of the four exams. Assuming their AEGO score was higher than their lowest exam score, the AEGO replaced the exam score. If a student attempted all four exams *and* the AEGO, the lowest two of the five scores were dropped. Students were told that the AEGO would take approximately three to six additional hours throughout the semester.

Each week, students were expected to complete at least 9.5 hours of course-related work on their own, in addition to lecture and discussion. This included completing assigned readings, MasteringAstronomy homework, participating in lab sessions, studying for tests and exams, completing internship or clinical placement requirements, and other course work.

For spring 2015, the lab portion of the course included the following resources and graded activities:

In-class labs. Assigned labs were set up in MasteringAstronomy, and students were required to log on and work from the program during lab. MasteringAstronomy tutorials were also assigned as part of lab homework. As students completed these tutorials, they were directed to additional assigned questions from the textbook, and they completed the answers to those questions in their lab notebooks.

Lab notebook. Students recorded the 16 lab assignments (worth six points each) in a written lab notebook that included supplemental telescope activities to replace some labs. In addition, students could earn 60 points by completing 12 MasteringAstronomy tutorials (worth five points each) plus additional built-in extra credit.

Lab quizzes. Three MasteringAstronomy quizzes were given during the semester, each worth 10 points. Quizzes varied per section, and were based on previously conducted labs. Quizzes were available only during that lab, the lowest of the three quiz scores was dropped, and no makeups were allowed.

Final exam. The paper-and-pencil final lab exam comprised 24 multiple-choice questions and counted for 24 points of the overall grade. It covered all course content, including one or two questions from each lab. Students were allowed two 8.5 x 11 hand-written reference sheets. If students did not take the final lab exam, they lost 10.9 percent of their grade.

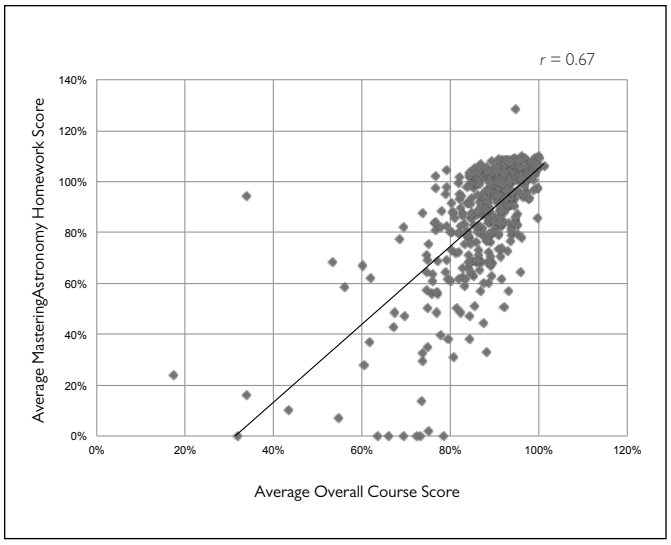

Figure 1. Correlation between Average MasteringAstronomy Homework Scores and Average Overall Course Scores, Spring 2015 Lecture (*n* = 428)

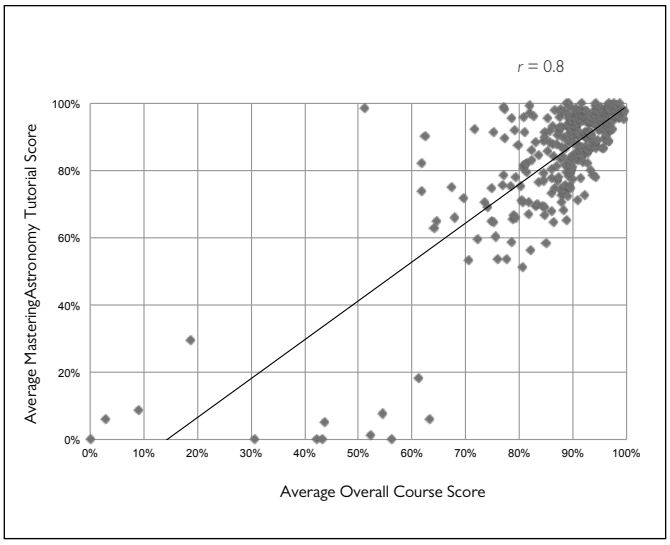

Figure 2. Correlation between Average MasteringAstronomy Tutorial Scores and Average Overall Course Scores, Spring 2015 Lab (*n* =428)

Assessments

Lecture

750 points	Exams (three + optional final)
125 points	Attendance and iClicker quizzes
125 points	MasteringAstronomy homework

Lab

156 points	Lab notebook (96 points) + MasteringAstronomy Web tutorials (60 points)
24 points	Final exam
20 points	Lab quizzes
20 points	Attendance

Results and Data

Spring 2015 data was analyzed to understand the relationship between performance on MasteringAstronomy and course outcomes. Because of the variability with grading options, a correlation was calculated by examining MasteringAstronomy homework scores as related to overall course scores. MasteringAstronomy was worth 12.5 percent of the lecture score, influencing the correlation between MasteringAstronomy homework and the final course grade. However, the exams accounted for a large percentage of the course grade. In spring 2015, there was a strong positive correlation between average MasteringAstronomy homework scores and overall course scores for the lecture portion, with $r = .67$ (Figure 1).

For the lab, a correlation was calculated by examining the MasteringAstronomy tutorial scores as related to overall course scores. Twelve lab tutorials were worth approximately 27 percent of the course score, influencing the correlation between MasteringAstronomy tutorials and course scores. However, Taylor believes the tutorials should help students understand the concepts needed to attempt the lab activities, MasteringAstronomy quizzes, and the final exam, and were therefore an important learning resource. Data showed a strong positive correlation between the MasteringAstronomy tutorials and the overall course score of $r = .8$ (Figure 2).

The Student Experience

Students in the spring 2015 lecture and lab courses were surveyed about their experience using MasteringAstronomy. Seventeen percent of students responded (75 students). Their comments include the following:

"I found the hints, as well as the explanation of why certain answer choices were wrong, very helpful. This system helped me to remember key ideas, concepts, etc. and to gain a new perspective on how to answer certain questions, which in turn helped me score better on exams overall."

"I liked that it taught me many things that I would not pay attention to if I just read the textbook."

"It was really easy to use and it was a good chance to bring up our grades for the class. I also liked being able to go back to the homeworks, especially the math problems, and redo them as a way to prepare for tests."

[Taylor] observed that, on the whole, students who seemed to put effort into the assignments both performed better in the course and appreciated the opportunity to work on their own in MasteringAstronomy.

"They gave you an explanation about why the answer is right, and if you did not get the right answer on the first try, it tried to guide you in the right direction without giving the answers away."

Conclusion

Teaching large lecture and lab courses can be a challenge because of the inability to personally work with each student. Taylor feels it is important to have a resource that can facilitate student engagement with the concepts and enable student learning on their own time. Taylor also finds it can be a challenge to cover all of the content during class time, which further necessitates students' working and learning on their own.

In the book *Student Engagement in Higher Education: Theoretical Perspectives and Practical Approaches for Diverse Populations,* the editors state, "Those who are actively engaged in educationally purposeful activities, both inside and outside the classroom, are more likely than are their disengaged peers to persist to graduation…."[2] Taylor received student feedback that they used the MasteringAstronomy homework and activities both inside and outside of class to help learn concepts and understand what they didn't know, and at the same time it stretched their understanding of concepts beyond what can be achieved in lecture. Taylor designed some of the MasteringAstronomy homework with this objective in mind. He observed that, on the whole, students who seemed to put effort into the assignments both performed better in the course and appreciated the opportunity to work on their own in MasteringAstronomy.

Taylor plans some changes to the lecture portion of the course in the future. He has added challenging materials, and has changed the grading format. The new format will make the final exam compulsory, revise how the lecture grade is calculated, and slightly change the weighting of course components. In 2014/15, there was a significant drop in attendance once exam 2 was completed due to students' being able to drop the lowest exam score. The goal with this change is to keep students attending class and working until the end of the semester. In addition, Taylor has revised some of the MasteringAstronomy homework to include additional assignments due as the semester approaches the last weeks. He will continue to evaluate course results to see what impact this has on student performance and behavior.

[2]Stephen John Quaye and Shaun R. Harper (eds.), *Student Engagement in Higher Education: Theoretical Perspectives and Practical Approaches for Diverse Populations,* 2nd ed., New York: Routledge, 2014, p. 49.

Implementation and results case studies share actual implementation practices and evaluate possible relationships between program implementation and student performance. The findings are not meant to imply causality or generalizability within or beyond these instances. Rather, they can begin to provide informed considerations for implementation and adaptation decisions in other user contexts. For this case study, mixed-methods designs were applied, and the data collected included qualitative data from interviews, quantitative program usage analytics, and performance data. Open-ended interviews were used to guide data collection.