# FACTORS CONTRIBUTING TO ATTITUDINAL GAINS IN INTRODUCTORY ASTRONOMY COURSES

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## Introduction

It is traditional, when evaluating the effectiveness of an academic course, to quantify its impact on students using various measures of learning gains. This is a reasonable approach when evaluating courses that build upon one another, where it is necessary for a student to master the material in one course before proceeding to the next. Introductory astronomy is different, however. It is often the last science course a student is ever be exposed to, frequently taken by non-science majors to fulfil an institution's core curriculum science requirement. For such students, we argue that it is less important to measure their mastery of this or that specific astronomical concept (e.g., being able to recall the details of the interior structure of Jupiter, or being able to compute orbital parameters using Kepler's laws) than it is to probe the impact of the course on their attitudes toward astronomy in particular, and toward STEM fields in general.

We describe the results of our analysis of surveys returned by a total of 749 students at the ends of 4 semesters in 2014-2015, at 10 institutions that employed, in whole or in part, the introductory astronomy lecture and lab curriculum we first implemented at the University of North Carolina at Chapel Hill (UNC-CH) in 2009. The surveys were designed to measure each student's attitude, and to probe the correlation of attitude with their utilization of, and satisfaction with, various course components, along with other measures of their academic background and their self-assessed performance in the course. We find, not surprisingly, that students' attitudes are significantly positively correlated with the grade they expect to receive in the course, and with their rating of the overall effectiveness of the course. To a lesser degree, we find that students' attitudes are positively correlated with their mathematical background, with whether they intend to major or pursue a career in STEM, and with their rating of the effectiveness of the instructor. We find that students' attitudes are negatively correlated with the amount of work they perceived the course to involve, and, surprisingly, with the size and reputation of their home institution. We also find that, for the subsets of students who were exposed to them, students' attitudes are positively correlated with their perception of the helpfulness of the lecture component of the course, and of telescope-based labs that utilized UNC-CH's Skynet Robotic Telescope Network.

## Project Intro Astro

In 2009, we introduced a new introductory astronomy lecture and lab curriculum at UNC-CH. At most universities, introductory astronomy is taught as a two-semester sequence, but at UNC-CH it had always been taught in a single semester, which for the students was akin to drinking from a fire hose. In 2009, we split the old course into two new courses:

**ASTR 101: The Solar System**

*Celestial motions of Earth, the sun, the moon, and the planets; the nature of light; ground and space-based telescopes; comparative planetology; Earth and the moon; terrestrial and gas planets and their moons; dwarf planets, asteroids, and comets; planetary system formation; extrasolar planets; the search for extraterrestrial intelligence (SETI).*

**ASTR 102: Stars, Galaxies, and Cosmology**

*The sun; stellar observables; star birth, evolution, and death; novae and supernovae; white dwarfs, neutron stars, and black holes; Einstein's theory of relativity; the Milky Way galaxy; normal galaxies, active galaxies, and quasars; dark matter and dark energy; cosmology; the early universe.*

This created time to explore the material more thoroughly and more enjoyably, to introduce new material (e.g., a week of relativity in ASTR 102), and to introduce in-class demonstrations. Altogether, we developed over 50 in-class demonstrations, which we found to be particularly effective at conveying otherwise difficult concepts and at generating discussion, even in the largest classes. We have now taught these courses successfully to as few as approximately 10 students and to as many as approximately 400 students, where so far success has been measured by end-of-course evaluations that are among the highest in our department, as well as by rapidly growing introductory astronomy enrollment.

The centerpiece of our new introductory astronomy curriculum has been the modernization of our introductory astronomy laboratory course, ASTR 101L. For decades, ASTR 101L made use of the theater of the Morehead Planetarium and Science Center on the UNC-CH campus, for five day labs and small telescopes on our campus observing decks for five night labs. However, both sets of labs were problematic. Measurements within the planetarium chamber suffered from often greater than 100% error depending on where you sat. The visual observing labs suffered from Chapel Hill's weather, bright skies, proximity to athletic field lights ruining dark adaptation, inability to see the north star, which is necessary to properly align the telescopes, outdated and difficult to use telescopes, and a weak set of backup labs. Finally, neither set of labs strongly reinforced the lecture curriculum. Feedback from these labs was generally negative.

We developed a series of eight new labs, two of which are two-week labs, and six of which utilize UNC-CH's Skynet Robotic Telescope Network. After an introductory lab in which students learn how to use Skynet, the labs strongly reinforce both the new ASTR 101/102 lecture curriculum and one another. Among other things, students use Skynet to collect their own data to distinguish between geocentric and heliocentric models using the phase and angular size of Venus, to measure the mass of a Jovian planet using the orbit of one of its moons and Kepler's third law, to measure the distance to a main-belt asteroid using parallax measured simultaneously by Skynet telescopes in different hemispheres, and to measure the distance to a globular cluster using an RR Lyrae star as a standard candle. More is done with archival data that takes longer than a semester to collect (e.g., Cepheid stars, Type Ia supernovae, etc.)

In addition to the lecture, demo and lab curricula, we developed a set of multiple-choice homework problems and detailed solutions for both Astro 101 and Astro 102 within the WebAssign framework. Also, in an effort to explore the effectiveness of "flipping the classroom", we developed a complementary set of in-class polling questions, and an easy- and free-to-use e-polling tool that allows students to submit not only multiple-choice responses, but numerical responses (e.g., -1/3, 5.7e9) from their phones, and allows the instructor to display and analyze these responses in real-time. We also provided all students free online access via YouTube to a complete archive of videotaped Astro 101 and Astro 102 lectures compiled from previous semesters.

After implementing this curriculum at UNC-CH in 2009, lab enrollments increased over 150%, all introductory astronomy enrollments increased over 100% – now one in four UNC-CH students take at least one of our courses – and astronomy-track majors and minors increased ≈300% (from ≈5 to ≈20 per year). Encouraged by this initial success, we soon began partnering with other regional institutions to help them adopt and adapt those parts of the lecture course, in-class exercises and demos, homework, and labs that were compatible with their broader curricula and educational philosophies. As of today, 14 institutions have adopted our curriculum in whole or in part, with a handful more scheduled to join in the coming year. In this report, we analyze student survey responses collected from 10 schools, ranging from 2-year community colleges to Research I universities, over 4 semesters in 2014-2015.

While we provided instructors at these partner institutions access to our full sets of homework, lab, e-book, e-polling, video, and other curriculum resources, they were free to accept, reject or adapt any element to best suit their institutional needs and educational goals. Table 1 summarizes the institutions that employed our curriculum in whole or in part, and whose students responded to the end-of-course survey, during the period of 2014-2015. Table 2 describes in greater detail the components of our curriculum that each instructor chose to implement in their section.

**Table 1: Summary of institutional participation, by institution. Institution types: 1 = 2-year community college; 2 = 4-year college or university; 3 = Research I university**

| Institution | Type | Semesters | Sections | Instructors | Responses |
|---|---|---|---|---|---|
| Ashland Community & Technical College (ACTC) | 2 | 2 | 3 | 1 | 12 |
| Francis Marion University (FMU) | 2 | 1 | 1 | 1 | 6 |
| Fayetteville State University (FSU) | 2 | 3 | 6 | 1 | 34 |
| Glenville State College (GSC) | 2 | 1 | 1 | 1 | 5 |
| High Point University (HPU) | 2 | 2 | 2 | 1 | 15 |
| North Carolina Agricultural & Technical State University (NCAT) | 2 | 3 | 3 | 2 | 29 |
| North Carolina State University (NCSU) | 3 | 2 | 2 | 1 | 6 |
| University of North Carolina at Chapel Hill (UNC-CH) | 3 | 4 | 11 | 2 | 427 |
| University of Virginia (UVa) | 3 | 2 | 2 | 1 | 28 |
| Wake Technical Community College (WTCC) | 1 | 4 | 10 | 5 | 187 |
| Total=10 | NA | 4 | 41 | 16 | 749 |

**Table 2: More detailed breakdown of student survey responses by section, including number of UNC-CH labs and homeworks each instructor utilized, whether they used any of the Skynet-based telescope labs, and whether the section was online.**

| Semester | Institution | Instructor | Responses | UNC Labs | UNC HWs | Used Skynet | Any Lab Component | Online |
|---|---|---|---|---|---|---|---|---|
| 2014 S | ACTC | Riggs | 7 | 8 | 0 | Y | Y | Y |
| 2014 S | FSU | Mattox | 8 | 1 | 9 | N | Y | N |
| 2014 S | FSU | Mattox | 4 | 0 | 9 | N | Y | N |

| Semester | Institution | Instructor | Responses | UNC Labs | UNC HWs | Used Skynet | Any Lab Component | Online |
|---|---|---|---|---|---|---|---|---|
| 2014 S | GSC | O'Dell | 5 | 5 | 0 | Y | Y | N |
| 2014 S | HPU | Barlow | 10 | 2 | 0 | Y | Y | N |
| 2014 S | NCAT | Schuft | 16 | 0 | 8 | N | N | N |
| 2014 S | WTCC | Chilton | 18 | 0 | 0 | N | Y | N |
| 2014 S | WTCC | Converse | 22 | 0 | 0 | N | N | N |
| 2014 S | WTCC | Wetli | 11 | 5 | 0 | Y | Y | N |
| 2014 S | UNC-CH | Law | 46 | 8 | 9 | Y | N | N |
| 2014 S | UNC-CH | Reichart | 5 | 8 | 9 | Y | Y | Y |
| 2014 S | UNC-CH | Reichart | 22 | 8 | 9 | Y | Y | N |
| 2014 S | UVA | Murphy | 24 | 0 | 0 | N | Y | N |
| 2014 S | ACTC | Riggs | 1 | 8 | 0 | Y | N | Y |
| 2014 F | FSU | Mattox | 7 | 1 | 9 | N | N | N |
| 2014 F | FSU | Mattox | 8 | 0 | 9 | N | Y | N |
| 2014 F | FMU | Bryngelson | 6 | 7 | 0 | Y | Y | N |
| 2014 F | NCAT | Schuft | 12 | 0 | 5 | N | Y | N |
| 2014 F | WTCC | Converse | 34 | 2 | 0 | Y | Y | N |
| 2014 F | WTCC | Wetli | 8 | 4 | 0 | Y | Y | N |
| 2014 F | UNC-CH | Reichart | 193 | 8 | 9 | Y | Y | N |
| 2014 F | UNC-CH | Reichart | 11 | 8 | 9 | Y | Y | Y |
| 2015 S | UNC-CH | Reichart | 4 | 8 | 9 | Y | Y | Y |
| 2015 S | HPU | Barlow | 5 | 2 | 0 | Y | Y | N |
| 2015 S | NCSU | Frohlich | 4 | 8 | 0 | Y | Y | N |
| 2015 S | WTCC | Converse | 16 | 2 | 0 | Y | Y | N |
| 2015 S | WTCC | Wetli | 7 | 4 | 0 | Y | Y | N |
| 2015 S | NCAT | Kebede | 1 | 8 | 9 | Y | Y | N |
| 2015 S | UNC-CH | Reichart | 21 | 8 | 9 | Y | Y | N |
| 2015 S | UVA | Murphy | 4 | 7 | 0 | Y | N | N |
| 2015 S | WTCC | Chilton | 32 | 2 | 0 | Y | Y | N |
| 2015 F | ACTC | Riggs | 4 | 8 | 0 | Y | N | N |
| 2015 F | FSU | Mattox | 5 | 1 | 9 | N | N | N |
| 2015 F | FSU | Mattox | 2 | 0 | 9 | N | Y | N |
| 2015 F | WTCC | Converse | 29 | 2 | 0 | Y | Y | N |
| 2015 F | NCSU | Frohlich | 2 | 3 | 0 | Y | Y | N |
| 2015 F | UNC-CH | Reichart | 109 | 8 | 9 | Y | Y | N |
| 2015 F | UNC-CH | Reichart | 9 | 8 | 9 | Y | Y | Y |
| 2015 F | UNC-CH | Reichart | 7 | 8 | 9 | Y | Y | Y |
| 2015 F | WTCC | Sivayogan | 10 | 4 | 0 | Y | Y | N |

## Survey Structure, and Definition of Dependent and Independent Variables

Near the end of each semester, students in participating sections were provided with a link to a Qualtrics survey about their experience in Introductory Astronomy. For the four semesters analyzed in this report, we received an initial total of 827 completed surveys. After eliminating incomplete or obviously fraudulent instances, we arrived at a final dataset of 749 responses.

The survey consists of 43 multiple-choice and short-answer questions, some of which consist of multiple parts. The questions include basic demographic information and assessments of a student's background and preparation for the course, but are primarily geared toward determining a student's opinion of the course and their attitude toward specific course components and toward astronomy and science in general. Some questions ask students to rank their opinion of a course component, or their level of agreement with a statement, on a four- or five-step scale (quantitative questions). A number of these quantitative survey questions consist of multiple sub-questions. A few questions are in yes/no format, or otherwise establish whether or not a student engaged with particular components of the course (binary questions). A full sample survey is reproduced in the Appendix.

In order to facilitate analysis, responses to all questions were reassigned to a uniform numerical scale ranging from -1 to +1. For binary questions, this is as simple as assigning a "Yes" answer the value +1, and a "No" answer the value -1. For quantitative questions, this required both renormalizing the numerical range of the responses, and, in some cases, flipping the sign of the response to correct for whether the question had a "positive" or "negative" attitudinal orientation.

The responses to some multi-part quantitative questions were averaged (after numerical range normalization and attitudinal orientation correction) to produce a single numerical index for that question. An illustrative example is the astronomy/science "Attitude Index", which serves as the single dependent variable in the analysis that follows. This Attitude Index is computed from the respondents' answers to 33 questions that were designed to probe their attitudes toward astronomy and science in general, after having taken introductory astronomy at their institution. Each question is in the form of a statement; students were instructed to indicate their level of agreement with each statement, from 1 (strongly disagree) to 3 (neither agree nor disagree) to 5 (strongly agree). By design, some statements were positively oriented (e.g., "I like astronomy", "Scientific concepts are easy to understand", "Scientific skills will make me more employable"), while some were negatively oriented (e.g., "Astronomy is irrelevant to my life", "I felt insecure when I had to do astronomy homework", "I find it difficult to understand scientific concepts"). Each response was converted to a numerical scale ranging from -1 (negative attitude) to +1 (positive attitude), taking into account the orientation of each question, and the results were averaged over the 33 questions, producing a single Attitude Index for each student respondent. The Attitude Index questions and orientations are summarized in Table 3.

**Table 3: The questions that were used to compute the astronomy and science Attitude Index dependent variable. Student responses to each statement were scaled from -1 = strongly disagree to +1 = strongly agree. The sign of responses was flipped for those statements with a science-negative orientation, and then all were averaged to arrive at the Attitude Index.**

| Attitude Index Question | Orientation |
|---|---|
| Astronomy is a subject learned quickly by most people. | + |
| I have trouble understanding astronomy because of how I think. | - |
| Astronomy concepts are easy to understand. | + |
| Astronomy is irrelevant to my life. | - |
| I was under stress during astronomy class. | - |
| I understand how to apply analytical reasoning to astronomy. | + |

| Attitude Index Question | Orientation |
|---|---|
| Learning astronomy requires a great deal of discipline. | - |
| I have no idea of what's going on in astronomy. | - |
| I like astronomy. | + |
| What I learned in astronomy will not be useful in my career. | - |
| Most people have to learn a new way of thinking to do astronomy. | - |
| Astronomy is highly technical. | - |
| I felt insecure when I had to do astronomy homework. | - |
| I find it difficult to understand astronomy concepts. | - |
| I enjoyed taking this astronomy course. | + |
| I made a lot of errors applying concepts in astronomy. | - |
| Astronomy involves memorizing a massive collection of facts. | - |
| Astronomy is a complicated subject. | - |
| I can learn astronomy. | + |
| Astronomy is worthless. | - |
| I am scared of astronomy. | - |
| Science is a part of everyday life. | + |
| Scientific concepts are easy to understand. | + |
| Science is not useful to the typical professional. | - |
| The thought of taking a science course scares me. | - |
| I like science. | + |
| I find it difficult to understand scientific concepts. | - |
| I can learn science. | + |
| Scientific skills will make me more employable. | + |
| Science is a complicated subject. | - |
| I use science in my everyday life. | + |
| Scientific thinking is not applicable to my life outside my job. | - |
| Science should be a required part of my professional training. | + |

In the analysis that follows, we explore the statistical dependence of Attitude Index (dependent variable) on a variety of other survey responses/indices (independent variables), using simultaneous multiple linear regression. After initially performing linear regression with 16 independent variables, we iteratively removed those independent variables that were uncorrelated with Attitude Index at the $p > 0.05$ level, refitting at each iteration. The results are summarized in Table 4. We found the following variables to exhibit **significant correlation** (in decreasing order of correlation coefficient):

- **Course Attitude Index (Q48 in original survey; see Appendix)**: measures a student's attitude to the course as a whole, based on an average of responses to 10 statements, scaled to -1=strongly disagree to +1=strongly agree. **Positively correlated**.
- **Grade Index (Q17)**: what grade students *expected to receive* in the course at the time they took the survey. -1 = F, 0 = C, +1 = A. **Positively correlated**.
- **Career Index (Q12)**: measures the degree to which a student's academic and career path is oriented toward STEM in general, and astronomy and physics in particular. -1 = planning a career in a non-STEM field; 0 = planning a career in a STEM field; 1 = Planning a career in a STEM field, and majoring or minoring in astronomy or physics. **Positively correlated**.

- **Instructor Index (Q64)**: measures a student's attitude toward the primary course instructor, based on an average of responses to 11 statements (Q64), scaled to -1=strongly disagree to +1=strongly agree. **Positively correlated**.
- **Math Index (Q8)**: measures a student's academic mathematics training background. Ranges from -1 = some algebra to +1 = beyond calculus. **Positively correlated**.
- **Institution Index (see Table 1)**: measure of the type of institution the course was offered at: -1 = 2yr college, 0 = 4yr college, +1 = Research I university. **Negatively correlated**.
- **Work Index (Q23)**: based on the response to the statement "I worked harder than I thought I would in order to meet the instructor's standards or expectations." -1 = strongly disagree to +1 = strongly agree. **Negatively correlated**.

The following independent variables were found to exhibit **no significant correlation** with Attitude Index at the $p < 0.05$ level:

- **Skynet Index (see Table 2)**: -1 = student was offered no Skynet-based labs; +1 = student was offered Skynet-based labs
- **Lab Index (see Table 2)**: -1 = no lab component to course at all; +1 = some lab component to course.
- **Online Index (see Table 2)**: -1 = traditional lecture course; +1 = online course.
- **Engagement Index (Q35)**: measures a student's level of engagement with the course, based on an average of their responses to 6 questions about how often they employed various study habits (doing readings, completing assignments, engaging in classroom discussion, etc.)
- **Hours Index (Q15)**: the number of hours the student spent per week on course-related work. Ranges from -1 = fewer than 3, to 0 = 7-9 hours, to +1 = 12 or more hours.
- **Credits Index (Q13)**: how many credit hours the student was enrolled in while taking the intro astro course. Ranges from -1 = 6 or fewer credit hours to 0 = 7-9 credit hours to +1 = 19 or more credit hours.
- **Year Index (Q19)**: the academic year of the student. Ranges from -1 = first year to +1 = 5th+ year.
- **Attendance Index (Q22)**: based on the question "It is possible to do well in this course without attending class regularly", ranges from -1 = strongly disagree to +1 = strongly agree.
- **UNC HW Index (see Table 2)**: measure of how many UNC-provided homework sets were assigned in the student's section. Ranges from -1 = none to +1 = all of the 9 available sets.

## Baseline Model

As described above, we found that 7 of our independent variables were significantly correlated with the Attitude Index at the $p < 0.05$ level; the results are summarized in Table 4.

**Table 4: Multiple linear regression correlation coefficients for the entire survey data set ($N$ = 749), after iterative elimination of independent variables for which $p > 0.05$.**

| Variable | Coefficient | *p*-value |
|---|---|---|
| Course Attitude Index | 0.25 | 2.5E-26 |
| Grade Index | 0.16 | 1.6E-12 |
| Career Index | 0.11 | 2.0E-21 |
| Instructor Attitude Index | 0.073 | 5.4E-03 |

| | | |
|---|---|---|
| Math Index | 0.053 | 1.5E-04 |
| Institution Index | -0.048 | 6.1E-06 |
| Work Index | -0.10 | 7.8E-10 |

We consider each of these variables in turn, in descending order of correlation coefficient:

1. **Course Attitude Index**: It is not surprising that the Astronomy/Science Attitude Index's strongest and most significant correlation is with the student's attitude toward and opinion about the course overall. The questions that comprise the Course Attitude index (Q48 in survey) focus on whether a student feels that the course and the work involved were effective in helping them learn, whether sufficient feedback was provided on a student's progress, and whether the student found the course inspiring and challenging. As with all of these correlations, we must speculate on causal relationships with caution. Does a positive experience in the course create a positive attitude toward science, or are students who were predisposed to view science favorably more likely to appreciate a course in introductory astronomy in the first place? It's not possible to disentangle these two with this analysis, but we can at least infer that the most impactful strategy for an institution to take, if its goal is to increase positive attitudes toward science in general, is to foster positive attitudes toward the student experience of introductory course itself – its goals, pacing, feedback, and level of intellectual challenge.
2. **Grade Index**: It is also not surprising that a student's attitude toward science in general, after taking an introductory science course, would be correlated with the grade that they expect to receive. As with the previous index, it is not possible to say whether this is just correlation or causation. But by accounting for these strongly correlated Grade and Course Attitude Indices in the simultaneous multiple linear regression analysis, we can at least begin to unmask some of the subtler correlations that follow. We chose to explore the self-reported *expected* grade both because it is much easier, logistically and ethically, than attempting to assign *actual* grades to ostensibly anonymous surveys, and because, when it comes to attitudes, a student's self-perceived grade at the time of the survey is more likely to matter than what they actually end up getting.
3. **Career Index**: After Course Attitude Index, the STEM Career Index is the most significantly correlated independent variable. Again, as with the previous variables, it is not possible to say whether students who had already decided to pursue STEM careers are predisposed to have more positive attitudes toward science, or whether positive attitudes engendered by the course prompted some students to consider STEM careers for the first time. This is a case where giving the survey both at the beginning and at the end of the course would be helpful in interpreting the results. It is worth noting that 370 out of 749, or nearly 50% of the total respondents, indicated that they did not intend to pursue STEM-related careers. As a group, these non-STEM students receive a less positive impact on science attitude than do their general STEM-major peers, who in turn are impacted less than those who specifically plan careers in astronomy or physics.
4. **Instructor Index**: While it makes sense that students who view their instructor positively might emerge from the course with a more positive attitude toward science, it is interesting that the correlation, while positive, is both relatively low and marginally significant. Also, as discussed in the following section, when we look only at the subsets of students who attended a lecture course, or who were exposed to Skynet during the course, and include their ratings of these components' helpfulness as independent variables in the regression analysis, the correlation of

Attitude Index with Instructor Index disappears. The message seems to be that instructor quality helps to shape attitudes toward science, but not nearly as much as the perceived quality of the course curriculum and experience as a whole

5. **Math Index**: This is another correlation that is unsurprisingly positive but surprisingly weak. Having a more extensive mathematical coursework background corresponds to more positive science attitudes at the end of the course, but not by much. This would suggest that our Intro Astro curriculum (which requires only basic algebra) is relatively equally accessible and impactful to every student, regardless of mathematical background.
6. **Institution Index**: There is a weak but statistically significant negative correlation of Attitude Index with the type of institution the course is offered at, with 2-year community colleges doing better, in general, than 4-year colleges, and both doing better than Research I universities. This trend may reflect a dependence on class size and instructor availability, with the smaller, more personal environments typical of community college classrooms serving better to instill positive attitudes toward science than large auditorium-style lecture formats typical of major universities.
7. **Work Index**: Students who perceive the course to require more work than average emerge with more negative attitudes toward science. This would suggest that one straightforward way to boost science attitudes would be to reduce the workload in introductory science courses. It is important to keep in mind, however, that the very significantly positively correlated Course Attitude Index is partially a measure of how intellectually challenging and instructive the course is perceived to be. Make the course too easy, and you risk negatively impacting attitude toward the course, and so toward science in general.

## Baseline Model + Helpfulness of Course Components

Students were asked to rate the helpfulness of various components of their introductory astronomy courses, if present, which we scale from -1 = not helpful to +1 = extremely helpful (Q52). The students were given the option to indicate that any component was not applicable to their experience. The course components included:

- Attending class lectures
- Watching videos of lectures
- Supplementary notes (e.g., e-book on WebAssign)
- Homeworks
- In-class exercises/polling (e.g., clickers, polling cards, e-polling)
- Textbook
- Out-of-class exercises
- Office hours
- Online discussion forum (e.g., Sakai or Blackboard)
- Skynet-based telescope labs
- Other telescope labs (not part of UNC-CH's curriculum, but employed at some participating institutions)
- Non-telescope labs (e.g., UNC-CH's "Earth and the Seasons", or "Hubble's Law")

We found that the mere *presence* of any of these individual course components (included in the linear regression analysis as binary independent variables where -1 = not used in course and +1 = used in course) did not significantly impact the students' attitudes about science. However, we did find that for two components – (1) attending in-class lectures, and (2) doing Skynet-based labs – *how helpful* the students found these course components to be did matter. For the other course components, neither the existence of the component nor how helpful the students found it to be impacted the Attitude Index.

For each component, we analyzed the subset of non-N/A respondents and performed multiple linear regression on Attitude Index vs the same set of independent variables described earlier, but including the Helpfulness Index of that component, again iteratively eliminating independent variables for which the correlation significance was low. The Helpfulness Indices range from -1 = not helpful to my learning to +1 = extremely helpful to my learning.

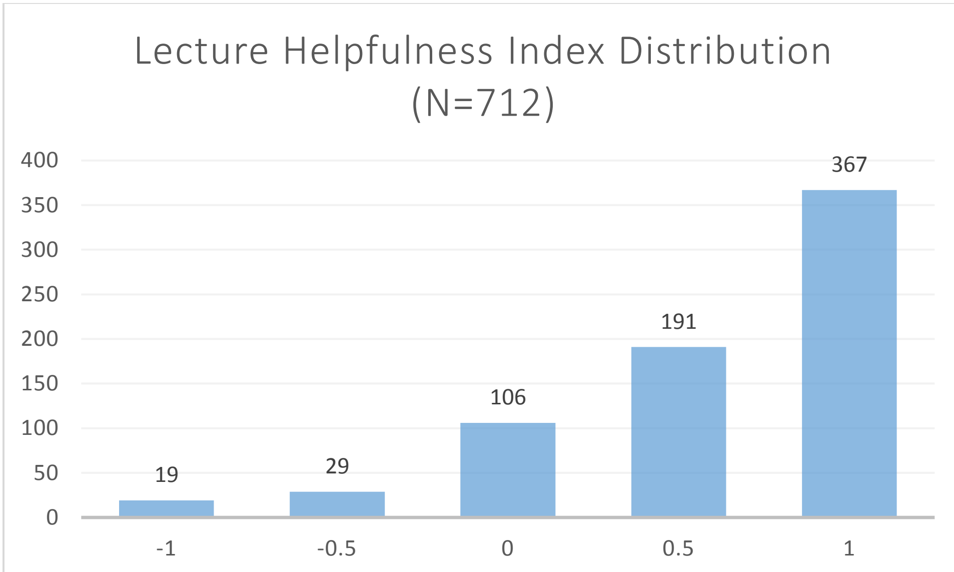
Out of the 749 total student responses to the survey, 712 students attended in-classroom lectures. The results of multiple linear regression on this subset are presented in Table 5. We find a statistically significant positive correlation between the Lecture Helpfulness Index and the Attitude Index: the more helpful a student finds attending class to be, the more positive their attitude toward science at the end of the course. However, note that the Instructor Attitude Index, which exhibited weak but significant positive correlation in the earlier baseline analysis (Table 4), is no longer significantly correlated in this subset ($p = 0.2$), when Lecture Helpfulness Index is included. This would seem to indicate that students' attitudes toward their instructors and toward the effectiveness of the lectures are largely measures of the same thing. Instructors who wish to improve their students' attitudes toward science would thus be well served by investing more effort into polishing the lecture component of their course.

**Table 5: Results of multiple linear regression on Attitude Index vs. significant variables, including Lecture Helpfulness Index, for the subset of *N* = 712 students who attended in-class lectures (with and without the Instructor Attitude Index, which is no longer significant).**

| Variable | Coefficient | *p*-value |
|---|---|---|
| Course Attitude Index | 0.24 | 1.3E-21 |
| Grade Index | 0.14 | 4.2E-10 |
| Career Index | 0.11 | 1.6E-18 |
| **Lecture Helpfulness Index** | **0.071** | **1.7E-04** |
| Math Index | 0.063 | 1.0E-05 |
| ~~Instructor Attitude Index~~ | ~~0.036~~ | ~~2.0E-01~~ |
| Institution Index | -0.048 | 6.6E-06 |
| Work Index | -0.11 | 1.0E-09 |

| Variable | Coefficient | *p*-value |
|---|---|---|
| Course Attitude Index | 0.26 | 2.2E-28 |
| Grade Index | 0.14 | 2.5E-10 |
| STEM Index | 0.11 | 2.6E-18 |
| **Lecture Helpfulness Index** | **0.077** | **2.1E-05** |
| Math Index | 0.064 | 7.7E-06 |
| Institution Index | -0.046 | 1.2E-05 |
| Work Index | -0.11 | 1.0E-09 |

**Figure 1: Distribution of our sample of 712 students who found the in-class lectures to be helpful. Those who did left the course with more positive attitudes about astronomy and STEM fields in general. Other than our Skynet-based labs, no other course component had a similar effect. The Helpfulness Indices range from -1 = not helpful to my learning to +1 = extremely helpful to my learning.**



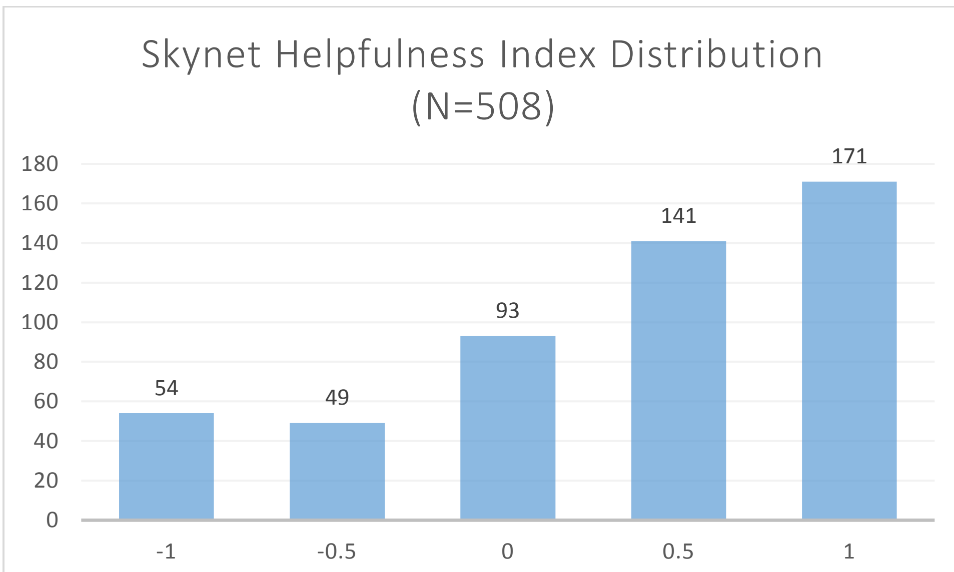

Out of the 749 total student responses to the survey, 508 students participated in at least one Skynet-based lab during the semester. The results of multiple linear regression on this subset are presented in Table 6. As with Lecture Helpfulness, we find a weak but statistically significant correlation between Science Attitude Index and Skynet Helpfulness Index for the subset of students who were exposed to Skynet-based labs. Those students who found these labs helpful, left the course with a more positive attitude toward science overall. Note that we performed this same analysis for the helpfulness of other lab components, including telescope labs not involving Skynet and non-telescope labs, and found no significant impact. Adding at least one Skynet-based lab (and working to present it and integrate it in a way that is perceived as helpful to students' understanding of the course material) appears to be one way to boost attitudes toward science for introductory astronomy students.

**Table 6: Results of multiple linear regression on Attitude Index vs. significant variables, including Skynet Helpfulness Index, for the subset of *N* = 508 students who participated in Skynet-based telescope labs (with and without the Instructor Attitude Index, which is no longer significant).**

| Variable | Coefficient | *p*-value |
|---|---|---|
| Grade Index | 0.21 | 4.1E-13 |
| Course Attitude Index | 0.20 | 5.8E-11 |
| Career Index | 0.11 | 1.1E-13 |
| ~~Instructor Attitude Index~~ | ~~0.057~~ | ~~6.5E-02~~ |
| **Skynet Helpfulness Index** | **0.044** | **1.5E-02** |
| Math Index | 0.036 | 5.1E-02 |
| Institution Index | -0.050 | 1.2E-04 |
| Work Index | -0.095 | 1.2E-05 |

| Variable | Coefficient | *p*-value |
|---|---|---|
| Course Attitude Index | 0.22 | 1.4E-14 |
| Grade Index | 0.22 | 1.1E-13 |
| Career Index | 0.11 | 1.2E-13 |
| **Skynet Helpfulness Index** | **0.047** | **8.8E-03** |
| Math Index | 0.037 | 4.6E-02 |
| Institution Index | -0.047 | 2.7E-04 |
| Work Index | -0.095 | 1.4E-05 |

**Figure 2: Distribution of our sample of 508 students who found the Skynet-based telescope labs to be helpful. Those who did left the course with more positive attitudes about astronomy and STEM fields in general. Other than in-class lectures, no other course component had a similar effect. The Helpfulness Indices range from -1 = not helpful to my learning to +1 = extremely helpful to my learning.**




## Conclusion

The majority of students do not enroll in introductory astronomy as part of their major; indeed, for many, if not most, it is the last science course they will ever take. And as such, it has great potential to shape students' attitudes toward STEM fields for the rest of their life. We therefore argue that it is less important, when assessing the effectiveness of introductory astronomy courses, to explore traditional curricular learning gains than it is to explore the effects that various course components have on this attitude. We first arrived at a baseline model (Table 4) describing the correlation, for the entire sample, of our Astronomy/STEM Attitude Index with a variety of independent variables describing students' attitudes, backgrounds, and plans. We then analyzed, one at a time, subsets of the sample that reported engaging with various course components, and included as a new independent variable their rating of each of these components' helpfulness.

We found that the only course components whose helpfulness index correlated with overall astronomy and STEM attitudes were (1) in-class lectures and (2) Skynet-based labs. While considerable effort has been expended to add new components to our introductory astronomy curriculum, from a new, in-class e-polling system and questions, to archiving videos of lectures for “flipped classroom”, online, and other uses, to writing supplementary e-book materials, we cannot say at this time that these components have had any effect on astronomy/STEM attitudes. That is not to say that they haven’t had any effect at all – they very likely improve traditional learning outcomes, for instance. But this analysis suggests that if the primary goal is to instead boost attitude outcomes, within the framework of an introductory astronomy curriculum, it is best to concentrate on improving the helpfulness of one’s lectures, and to offer and effectively integrate Skynet-based telescope labs.

From discussions that we have had with our students, and that the other instructors who participated in this survey had with their students, we hypothesize that Skynet-based labs (when perceived by the student to be helpful) boosted astronomy/STEM attitudinal outcomes where other telescope-based labs, and other labs in general (and other course components in general) did not, because:

- Students were excited by the experience of collecting “real” data with “real” telescopes (i.e., telescopes that were concurrently being used by “real” astronomers to do “real” science).
- Students were excited to be collecting their “own” pictures of these astronomical phenomena. Often, they posted their best pictures on their social media outlets, exhibiting both ownership of, and pride in, their work.

That said, finding root cause is beyond the scope of this survey. Rather, the purpose of this study was to identify correlations, both obvious and subtle, with positive astronomy/STEM attitudinal outcomes.

***Q6.***
**This study is being conducted by the Astronomy Department at UNC-Chapel Hill. The purpose of the study is to help Astronomy Instructors understand how changes to the course design will affect student learning and experiences.**

**The survey will take approximately 10 minutes to complete. You have the right to refuse to answer any question(s) for any reason. Your participation is completely voluntary, and the information you provide will be kept confidential.**

**Your instructor will NOT be provided access to your answers. Your answers on this survey will NOT, in any way, affect your grade in this class. There are no right or wrong answers; just answer as accurately and honestly as possible.**

**You will be asked to include your first name, last name, and Student Identification Number. Identifying information (name, Student ID) will only be used to combine the survey answers and the coursework data and will be deleted prior to any subsequent analysis.**

**Results will be reported only in aggregate form; your name will never be associated with your data.**

**If you have any questions about the research project or the survey itself, please contact Dan Reichart at reichart@physics.unc.edu. If you have any questions about your rights as a research participant, you may contact the University of North Carolina Institutional Review Board at 919-966-3113 and mention study number 12-2431.**

**To continue with the survey, select Yes, below.**

- (•) Yes
- ( ) No

***Q2.*** **Please enter your first name, last name, and school/institution identification number.**

| | |
|---|---|
| First Name | Stan Converse (THIS IS A TEST) |
| Last Name | THIS IS A TEST |
| Personal Identification Number (e.g. Student ID Number) | xxxxxxxxxx |

***Q4.*** **Please select your school and instructor from the list below.**

- ( ) Ashland Community and Technical College - Riggs
- ( ) Fayetteville State U. - Lecture - Mattox
- ( ) Fayetteville State U. - Lab - Mattox
- ( ) Florida State College at Jacksonville - Aidinejad
- ( ) High Point University - Barlow
- ( ) North Carolina Agricultural and Technical State University - Kebede
- ( ) North Carolina Agricultural and Technical State University - Schuft
- ( ) North Carolina State University - Frohlich/Kolb
- ( ) U. North Carolina - ASTR 101 - Law
- ( ) U. North Carolina - ASTR 101, Section 990-994 - LaCluyze
- ( ) U. North Carolina - ASTR102, Section 001 - Reichart
- ( ) U. North Carolina - ASTR102, Section 990-992 - Reichart
- ( ) University of Virginia - Murphy/Cromartie
- ( ) Wake Tech Community College - Chilton
- (•) Wake Tech Community College - Converse
- ( ) Wake Tech Community College - Wetli

***Q44.***
**The questions below are designed to identify your attitudes about astronomy and science. The item scale has 5 possible responses; the responses range from 1 (strongly disagree) through 3 (neither agree nor disagree) to 5 (strongly agree). Please read each question. From the**

**5-point scale mark the response that most clearly represents your agreement with the statement. Use the entire 5-point scale. Try not to think too deeply about each response; there are no correct or incorrect answers.**

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Astronomy is a subject learned quickly by most people. | ○ | ○ | ◉ | ○ | ○ |
| I have trouble understanding astronomy because of how I think. | ○ | ○ | ◉ | ○ | ○ |
| Astronomy concepts are easy to understand. | ○ | ○ | ◉ | ○ | ○ |
| Astronomy is irrelevant to my life. | ○ | ○ | ◉ | ○ | ○ |
| I was under stress during astronomy class. | ○ | ○ | ◉ | ○ | ○ |
| I understand how to apply analytical reasoning to astronomy. | ○ | ○ | ◉ | ○ | ○ |
| Learning astronomy requires a great deal of discipline. | ○ | ○ | ◉ | ○ | ○ |
| I have no idea of what's going on in astronomy. | ○ | ○ | ◉ | ○ | ○ |
| I like astronomy. | ○ | ○ | ◉ | ○ | ○ |
| What I learned in astronomy will not be useful in my career. | ○ | ○ | ◉ | ○ | ○ |
| Most people have to learn a new way of thinking to do astronomy. | ○ | ○ | ◉ | ○ | ○ |
| Astronomy is highly technical. | ○ | ○ | ◉ | ○ | ○ |
| I felt insecure when I had to do astronomy homework. | ○ | ○ | ◉ | ○ | ○ |
| I find it difficult to understand astronomy concepts. | ○ | ○ | ◉ | ○ | ○ |
| I enjoyed taking this astronomy course. | ○ | ○ | ◉ | ○ | ○ |
| I made a lot of errors applying concepts in astronomy. | ○ | ○ | ◉ | ○ | ○ |
| Astronomy involves memorizing a massive collection of facts. | ○ | ○ | ◉ | ○ | ○ |
| Astronomy is a complicated subject. | ○ | ○ | ◉ | ○ | ○ |
| I can learn astronomy. | ○ | ○ | ◉ | ○ | ○ |
| Astronomy is worthless. | ○ | ○ | ◉ | ○ | ○ |
| I am scared of astronomy. | ○ | ○ | ◉ | ○ | ○ |
| Science is a part of everyday life. | ○ | ○ | ◉ | ○ | ○ |
| Scientific concepts are easy to understand. | ○ | ○ | ◉ | ○ | ○ |
| Science is not useful to the typical professional. | ○ | ○ | ◉ | ○ | ○ |
| The thought of taking a science course scares me. | ○ | ○ | ◉ | ○ | ○ |
| I like science. | ○ | ○ | ◉ | ○ | ○ |
| I find it difficult to understand scientific concepts. | ○ | ○ | ◉ | ○ | ○ |

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I can learn science. | ○ | ○ | ◉ | ○ | ○ |
| Scientific skills w ill make me more employable. | ○ | ○ | ◉ | ○ | ○ |
| Science is a complicated subject. | ○ | ○ | ◉ | ○ | ○ |
| I use science in my everyday life. | ○ | ○ | ◉ | ○ | ○ |
| Scientific thinking is not applicable to my life outside my job. | ○ | ○ | ◉ | ○ | ○ |
| Science should be a required part of my professional training. | ○ | ○ | ◉ | ○ | ○ |

***Q62.* Did you do astronomy labs this semester?**

○ Yes, as a separate course

○ Yes, as part of this course

○ No

***Q48.***
**Thinking about this course, including any astronomy labs you did as part of this course or as part of a separate but associated course, how much do you agree or disagree with the following statements?**

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| The instructional approach used in this course w as effective in helping me learn. | ○ | ○ | ◉ | ○ |
| The course topics, activities, reading, and assignments fit together in a w ay that helped me learn. | ○ | ○ | ◉ | ○ |
| The pace of this course w as appropriate for helping me learn. | ○ | ○ | ◉ | ○ |
| I received prompt feedback in this course that helped me to know w hat I've learned w ell and w hat I needed to keep w orking on. | ○ | ○ | ◉ | ○ |
| I feel like I learned a lot in this course. | ○ | ○ | ◉ | ○ |
| This course challenged me to do my best w ork. | ○ | ○ | ◉ | ○ |
| My w ork in this course made me more interested in this subject. | ○ | ○ | ◉ | ○ |
| My w ork in this course increased my confidence that I can do w ell in this subject. | ○ | ○ | ◉ | ○ |
| This course challenged me to think deeply about the subject matter. | ○ | ○ | ◉ | ○ |
| This course w as very exciting to me intellectually. | ○ | ○ | ◉ | ○ |

***Q50.* Please add any comments you'd like to make about how you responded to the previous items.**

THIS IS A TEST

***Q8.* What is the highest math course you have completed prior to taking this course? (Please select one).**

○ Algebra

○ Pre-Calculus/Trigonometry

○ Calculus I

◉

Beyond Calculus I

- ○ None of the above

***Q58.*** **How long ago did you complete that math course?**

- ○ Within the past 6 months
- ○ Within the past year
- ○ Within the past 2 years
- ○ Within the past 3 years
- ◉ Longer than 3 years ago

***Q10.*** **Are you currently taking a math course?**

- ○ Yes
- ◉ No

***Q11.*** **What math course are you currently taking?**

*This question was not displayed to the respondent.*

***Q12.***
**Which of the following best describes your career path/goal?**

- ○ Health or Medicine
- ○ Science or Math (do not include Social Sciences)
- ○ Technology or Engineering
- ◉ Teaching of One of the Disciplines listed above (items 1 through 3)
- ○ Other including undecided (Please Specify): __________

***Q59.*** **Are you planning to major or minor in Astronomy or Physics?**

- ◉ Major
- ○ Minor
- ○ No

***Q54.*** **What are you planning to major in? (e.g., Psychology, Biology, Sociology, Drama) [DO NOT ENTER MINOR HERE]**

| | |
|---|---|
| Major | |
| If more than 1 major enter here: | |

***Q56.*** **Do you plan to have a minor?**

- ○ Yes
- ◉ No

***Q58.*** **What are you planning to minor in? (e.g., Psychology, Biology, Chemistry)**

*This question was not displayed to the respondent.*

***Q13.*** **How many credit hours did you take this semester?**

- ○ Up to 6 credit hours
- ○ 7 to 10 credit hours
- ○ 11 to 14 credit hours
- ○ 15 to 18 credit hours
- ● 19 or more credit hours

***Q15.*** **Please estimate the average number of hours you spent each week (for the entire week including weekends) studying or preparing for this course (do not include your lab time).**

- ● Less than 3 hours
- ○ 4 to 6 hours
- ○ 7 to 9 hours
- ○ 10 to 12 hours
- ○ More than 12 hours

*Q60.*
Please estimate the average number of hours you spent each week (for the entire week including weekends) studying or preparing for astronomy labs you did as a part of this course or as part of a separate associated course.

*This question was not displayed to the respondent.*

***Q17.*** **What grade do you expect to receive in this course?**

- ● A
- ○ B
- ○ C
- ○ D
- ○ F

*Q61.* What grade do you expect to receive for the lab component of this course?

*This question was not displayed to the respondent.*

***Q19.*** **What year of school are you in?  Are you a...**

- ● First year student
- ○ Sophomore
- ○ Junior
- ○ Senior
- ○ Other (e.g., continuing education, returning to school, professional development)

***Q52.***
**The list below contains components that may have been used in this course. (NOTE: Your course may not have used all of these components.)**

**How helpful was each component for your learning in the course?**

| | Not helpful to my learning | A little helpful to my learning | Moderately helpful to my learning | Very helpful to my learning | Extremely helpful to my learning | N/A: Not used or not used enough to evaluate |
|---|---|---|---|---|---|---|
| Attending Class Lectures | ○ | ○ | ● | ○ | ○ | ○ |
| Watching Videos of Lectures | ○ | ○ | ● | ○ | ○ | ○ |
| Textbook | ○ | ○ | ● | ○ | ○ | ○ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Supplementary Notes (e.g., Ebook on WebAssign) | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Homeworks | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| In-class Demos | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| In-Class Exercises/Polling (e.g., clickers, polling cards, e-polling) | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Out-of-Class Exercises | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Skynet-Based Telescope Labs | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Other Telescope Labs | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Non-Telescope Labs | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Office Hours | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Online Discussion Forum (e.g. Sakai, Blackboard) | ( ) | ( ) | (•) | ( ) | ( ) | ( ) |
| Other (Please Specify): | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| Other (Please Specify): | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |

***Q54.*** **Thinking back from the beginning of this course to now, what components from the previous question have been the most helpful to your learning? Why?**

***Q22.***
**How much do you agree or disagree with the following statements.**

**It is possible to do well in this course without attending class regularly.**

( ) Strongly agree

( ) Agree

(•) Neither Agree nor Disagree

( ) Disagree

( ) Strongly Disagree

***Q23.*** **I worked harder than I thought I would in order to meet the instructor's standards or expectations.**

( ) Strongly agree

( ) Agree

(•) Neither Agree nor Disagree

( ) Disagree

( ) Strongly Disagree

***Q24.*** **Did you watch any of the online lecture videos?**

( ) Yes

(•) No

( ) There were no online lecture videos.

*Q62.*
How helpful were these videos for each of the following activities?

*This question was not displayed to the respondent.*

***Q58.***
**Please add any comments about this course, including any astronomy labs you did as part of this course or as part of an separate associated**

**course, and how it could be improved to help your learning.**

***Q35.*** **For this course, how often did you do the following? How often did you...**

| | Very often | Often | Sometimes | Never |
|---|---|---|---|---|
| **...complete the readings?** | ○ | ● | ○ | ○ |
| **...not complete an assignment on time?** | ○ | ● | ○ | ○ |
| **...ask questions or contribute to class discussions?** | ○ | ● | ○ | ○ |
| **...work with classmates to prepare class assignments?** | ○ | ● | ○ | ○ |
| **...discuss ideas from the course with others <u>not taking the course</u> (other students, family members, co-workers, etc.)?** | ○ | ● | ○ | ○ |
| **...help a classmate better understand the course material?** | ○ | ● | ○ | ○ |

***Q64.*** **How much do you agree or disagree with the following statements about this course?**

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| The instructor clearly communicated what was expected of me in this class. | ○ | ○ | ○ | ○ |
| I was able to get individual help when I needed it. | ○ | ○ | ○ | ○ |
| The instructor evaluated my work fairly. | ○ | ○ | ○ | ○ |
| The instructor showed concern about whether students learned the material. | ○ | ○ | ○ | ○ |
| The instructor expressed ideas clearly. | ○ | ○ | ○ | ○ |
| The instructor showed enthusiasm for the subject matter. | ○ | ○ | ○ | ○ |
| The instructor showed enthusiasm for teaching this class. | ○ | ○ | ○ | ○ |
| The instructor was one of the best I have had, fully deserving of a teaching award. | ○ | ○ | ○ | ○ |
| The instructor handled questions well. | ○ | ○ | ○ | ○ |
| The instructor used examples that had relevance for me. | ○ | ○ | ○ | ○ |
| The instructor encouraged students to participate in this class. | ○ | ○ | ○ | ○ |

***Q65.*** **If you did astronomy labs as part of this course or as part of a separate course, were the labs taught by a teaching assistant (TA)?**

○ Yes

○ No

○ N/A

***Q67.*** **How much do you agree or disagree with the following statements about this course?**

*This question was not displayed to the respondent.*

***Q60.*** **Please add any other reflections, comments, or suggestions that would help us to improve this course.**

*Q57.*
**Please tell us about yourself.**

**Remember, you have the right to refuse to answer any question(s) for any reason. There are no right or wrong answers; just answer as accurately and honestly as possible.**

*Q58.* **Ethnicity, Race, Age, and Gender**

**What is your race/ethnicity?**

- Hispanic/Latino - A person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race.
- White (Not Hispanic or Latino) - A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.
- Black or African American (Not Hispanic or Latino) - A person having origins in any of the black racial groups of Africa.
- Native Hawaiian or Other Pacific Islander (Not Hispanic or Latino) - A person having origins in any of the peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
- Asian (Not Hispanic or Latino) - A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian Subcontinent, including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
- American Indian or Alaska Native (Not Hispanic or Latino) - A person having origins in any of the original peoples of North and South America (including Central America), and who maintain tribal affiliation or community attachment.
- Two or More Races - All persons who identify with more than one of the above five races.

*Q41.* **I identify my gender as...**

- Female
- Male
- Transgendered
- Other (Please Specify): ____
- Prefer not to disclose

*Q43.* **How old were you on your last birthday?**

- 16 or younger
- 17
- 18 - 19
- 20 - 21
- 22 or older

*Q45.*
**Language**

**What was the primary language used in your home when you were growing up?**

- English
- Not English

*Q47.*
**Parent Education and Work History**

**What is your mother's or primary caregiver's highest year of school or degree completed? (MARK ONE RESPONSE)**

- Up to 12th grade but no diploma
- High school diploma or equivalent (GED)
- Associate's Degree/Technical Certificate

- Bachelor's Degree
- Graduate or Professional Degree

***Q49.***
**What is your father's or other caregiver's highest year of school or degree completed? (MARK ONE RESPONSE)**

- Up to 12th grade but no diploma
- High school diploma or equivalent (GED)
- Associate's Degree/Technical Certificate
- Bachelor's Degree
- Graduate or Professional Degree

***Q55.*** **Have you at any time during this semester worked for pay or income?**

- Yes
- No

Q57. About how many hours per week did you work for pay or income?

*This question was not displayed to the respondent.*

Q59. Approximately, how many weeks this semester did you work for pay?

*This question was not displayed to the respondent.*